Wildfire Smoke

A Guide for Public Health Officials

Revised July 2008



Acknowledgements

This document was written by Michael Lipsett and Barbara Materna, California Department of Public Health; Susan Lyon Stone, U.S. Environmental Protection Agency; Shannon Therriault, Missoula County Health Department; Robert Blaisdell, California Office of Environmental Health Hazard Assessment; and Jeff Cook, California Air Resources Board, with input from individuals in several other government agencies and academia, in particular Jed Waldman, Lauren Wohl-Sanchez, and Lani Kent of the California Department of Public Health; Peggy Jenkins, Dane Westerdahl, Tom Phillips, Linda Smith, and Jim Behrman of the California Air Resources Board; Shelly DuTeaux and Richard Lam of the California Office of Environmental Health Hazard Assessment; Deborah Gold and Bob Nakamura of the California Division of Occupational Safety and Health (Cal/OSHA); Alisa Smith of the U.S. Environmental Protection Agency; and Dr. Michael Brauer of the University of British Columbia, Canada. Editorial support was provided by Latasha Speech, California Department of Public Health. This document was developed in part as a result of a workshop held at the University of Washington in June 2001, under the auspices of the U.S. Environmental Protection Agency, Region X, and the Department of Environmental Health, School of Public Health and Community Medicine of the University of Washington. Harriet Ammann, formerly with the Washington Department of Health, was a co-author of the first version of this Guide, which was written and disseminated in 2001-02. The document was revised in July 2008. The viewpoints and policies expressed herein do not necessarily represent those of the various agencies and organizations listed. Mention of any specific product name is neither an endorsement nor a recommendation for use.

Table of Contents

Introduction ……. 4

Composition of smoke ……. 4

Characteristics of wildfire smoke …….. 5

Health effects of smoke ……... 8

Sensitive populations……..……. 9

Specific strategies to reduce smoke exposure ……..... 11
- Stay indoors……... 11
- Reduce activity…….. 12
- Reduce other sources of indoor air pollution…… 13
- Air conditioners and filters…… 13
- Room air cleaners……. 14
- Ozone generators – a choice to avoid…… 15
- Create a clean room at home……. 16
- Humidifiers…… 16
- Inside vehicles…… 17
- Respiratory protection…….. 17
- Cleaner air shelters…… 21
- Closures……. 21
- Evacuation…….. 22
- Summary of strategies for exposure reduction…….. 23

Estimating particulate matter levels ……. 24

Recommendations for public health actions …… 25
- Preseason public service announcements…….. 25
- Public advisories and protective measures…… 26

Bibliography……..... 32

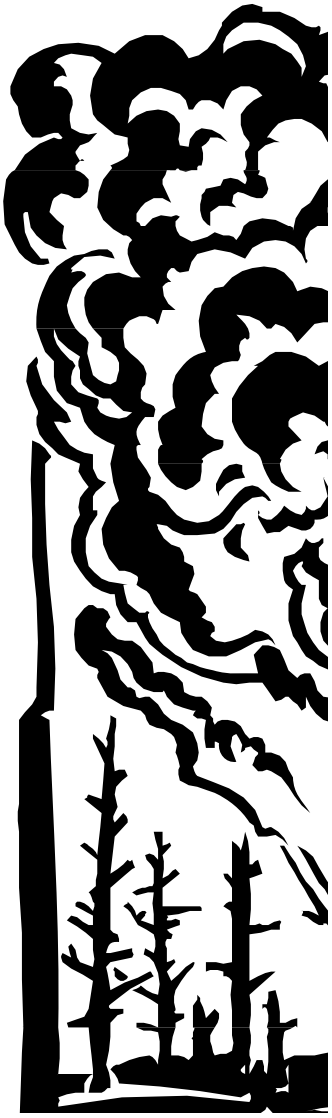
Additional resources and links …… 33

Appendices …… 34

Introduction

Smoke rolls into town, blanketing the city, turning on streetlights, creating an eerie and choking fog. Switchboards light up as people look for answers. Citizens want to know what they should do to protect themselves. School officials want to know if outdoor events should be cancelled. The news media want to know how dangerous the smoke really is.

Smoke events often catch us off guard. This guide is intended to provide local public health officials with information they need when wildfire smoke is present so they can adequately communicate health risks, and precautions to the public. This guide is the product of a collaborative effort by scientists, air quality specialists and public health professionals from federal, state, and local agencies.



Composition of smoke

Smoke is a complex mixture of carbon dioxide, water vapor, carbon monoxide, particulate matter, hydrocarbons and other organic chemicals, nitrogen oxides, and trace minerals. The individual compounds present in smoke number in the thousands. Smoke composition depends on multiple factors, including the fuel type and moisture content, the fire temperature, wind conditions and other weather-related influences, whether the smoke is fresh or "aged," and other variables. Different types of wood and vegetation are composed of varying amounts of cellulose, lignin, tannins and other polyphenols, oils, fats, resins, waxes, and starches, which produce different compounds when burned.

Particulate matter is the principal pollutant of concern from wildfire smoke for the relatively short-term exposures (hours to weeks) typically experienced by the public. Particulate matter is a generic term for particles suspended in the air, typically as a mixture of both solid particles and liquid droplets. The characteristics, sources, and potential health effects of particulate matter depend on its source, the season, and atmospheric conditions. Additionally, the size of particles affects their potential to cause health effects. Particles larger than 10 micrometers do not usually reach the lungs, but can irritate the eyes, nose, and throat. For purposes of comparison, a human hair is about 60 micrometers in

diameter. Small particles with diameters less than or equal to 10 micrometers, also known as particle pollution or PM_{10}, can be inhaled deep into the lungs; exposure to the smallest particles can affect the lungs and heart. Particle pollution includes "coarse particles," also known as $PM_{10\text{-}2.5}$, with diameters from 2.5 to 10 micrometers and "fine particles," also known as $PM_{2.5}$, with diameters that are 2.5 micrometers and smaller.

Particles from smoke tend to be very small, with a size range near the wavelength of visible light (0.4 – 0.7 micrometers), and are therefore nearly completely within the fine particle ($PM_{2.5}$) fraction. Thus, smoke particles efficiently scatter light and reduce visibility. Moreover, such small particles can be inhaled into the deepest recesses of the lung and may represent a greater health concern than larger particles.

Another pollutant of concern during smoke events is carbon monoxide, which is a colorless, odorless gas produced by incomplete combustion of wood or other organic materials. Carbon monoxide levels are highest during the smoldering stages of a fire, especially in very close proximity to the fire.

Other air pollutants, such as the potent respiratory irritants acrolein and formaldehyde, as well as the carcinogen benzene, are present in smoke, but at much lower concentrations than particulate matter and carbon monoxide.

Characteristics of wildfire smoke

A number of factors, including weather, the stage of the fire, and terrain can all influence fire behavior and the impact of the smoke plume on the ground. In general, windy conditions contribute to lower smoke concentrations because the smoke mixes into a larger volume of air. However, regional weather systems can spread fires quickly and result in large fires and even greater impacts. Strong regional weather systems can dominate a fire's behavior for days and be the determining factor of where and how smoke will affect an area. Santa Ana winds in California, for example, reverse the typical onshore flow patterns and blow strongly toward the coast from inland areas, which can result in smoke from mountain fires inundating the heavily populated communities to the west. Chinook winds in the Rocky Mountains represent another example of a well-entrenched system that can significantly affect fire behavior and smoke dispersion.

The intense heat, especially early in a fire, lofts smoke high into the air, where it remains until it cools and begins to descend. Initial fire plumes tend to be wind-driven events, which can facilitate prediction of the smoke impact area. As the smoke moves downwind, it becomes more dilute and often more widespread, eventually reaching ground level. The amount and type of fuel and its moisture content affect smoke production, as does the stage of fire suppression. The smoldering phase of a fire, for example, can sometimes result in very high particle emissions due to less complete combustion than when flames are present.



Figure 1 Discrete smoke plumes early in fire's evolution



Figure 2 Less dense but more widespread smoke after days of air movement

Terrain affects weather, as well as fire and smoke behavior, in several ways. For example, as the sun warms mountain slopes, air is heated and moves upslope, bringing smoke and fire with it. After sunlight passes from a slope, the terrain cools and the air begins to descend. This creates a down-slope airflow that can alter the smoke dispersal pattern seen during the day.

In the evening, especially in mountain valleys and low-lying areas, temperature inversions are common, in which the air near the ground is cooler than the air above. This prevents upward air movement. The lid effect of inversions, coupled with a drop in wind speed, can favor smoke and pollutant accumulation in valleys at night.

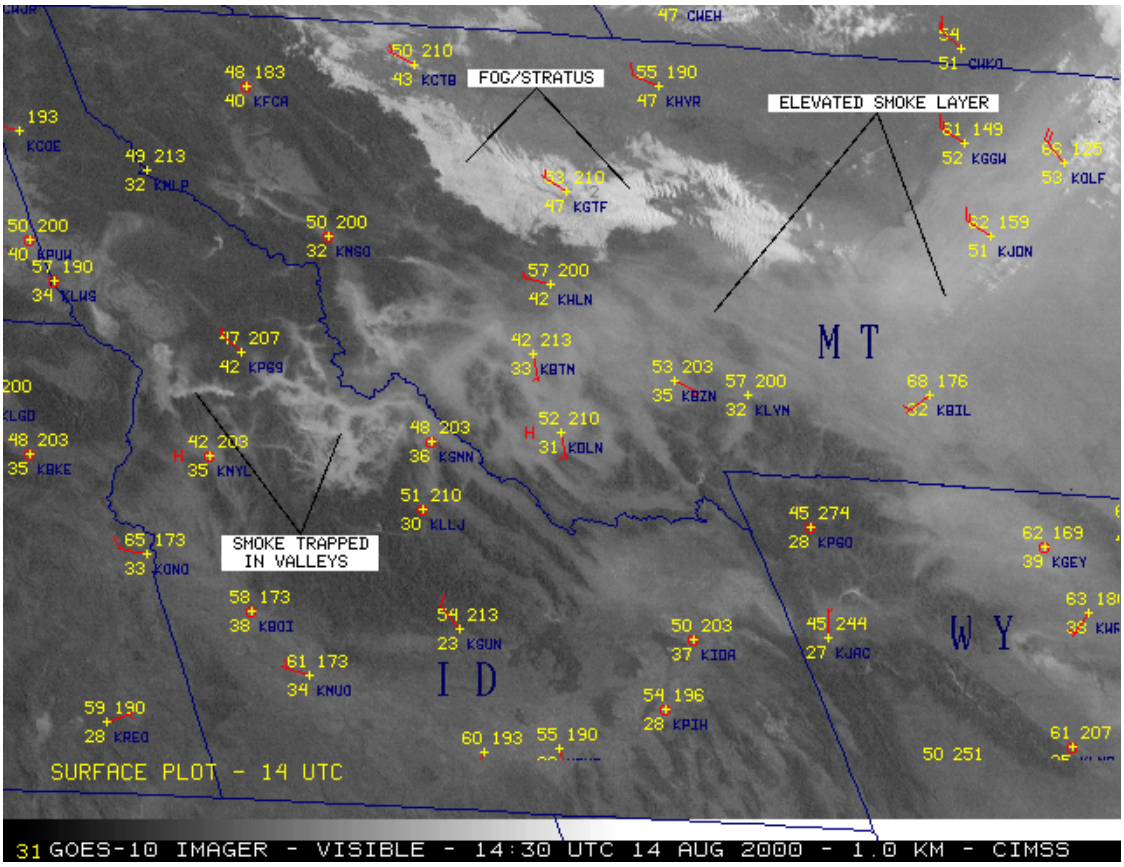


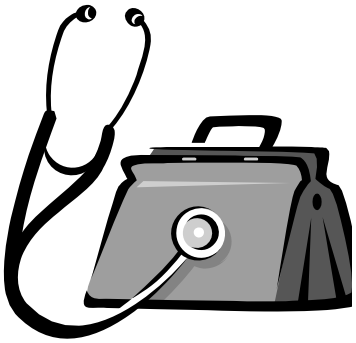
Figure 3 Dense smoke retained in valleys and low lying areas

Terrain also influences fire behavior by both blocking and promoting wind flow. Mountainous terrain causes turbulent air flow that can promote plume down-mixing and increased concentrations of smoke at ground level. Such terrain can inhibit smoke dispersion by diminishing wind speeds, or it can funnel winds through mountain passes, accelerating fire movement and smoke transport.

Thus, smoke behavior depends on many factors. Smoke levels in populated areas can be unpredictable: a wind that usually clears out a valley may simply blow more smoke in, or may fan the fires, causing a worse episode the next day. Smoke concentrations change constantly. Sometimes by the time public health officials can issue a warning or smoke advisory, the smoke may already have cleared. National Weather Service satellite photos, weather and wind forecasts, and knowledge of the area can all help in predicting how much smoke will come into an area, but predictions may not be accurate for more than a few hours. The National Weather Service's website has a lot of information, including satellite photos that are updated throughout the day. For the western United States, the Web address is www.wrh.noaa.gov. Other useful websites include: http://www.fs.fed.us/fcamms/ and http://marlin.cfr.washington.edu/website/bsr_cansac, as well as other sites listed under "Resources/Links" at the end of this Guide.

Health effects of smoke

The effects of smoke range from eye and respiratory tract irritation to more serious disorders, including reduced lung function, bronchitis, exacerbation of asthma, and premature death. Studies have found that fine particles are linked (alone or with other pollutants) with increased mortality and aggravation of pre-existing respiratory and cardiovascular disease. In addition, particles are respiratory irritants, and exposures to high concentrations of particulate matter can cause persistent cough, phlegm, wheezing, and difficulty breathing. Particles can also affect healthy people, causing respiratory symptoms, transient reductions in lung function, and pulmonary inflammation. Particulate matter can also affect the body's immune system and the physiological mechanisms that remove inhaled foreign materials from the lungs, such as pollen and bacteria. As noted earlier, particulate matter exposure is the principal public health threat from short-term exposures to wildfire smoke.



Carbon monoxide (CO) enters the bloodstream through the lungs and reduces oxygen delivery to the body's organs and tissues. CO concentrations typical of population exposures related to wildfire smoke do not pose a significant hazard, except to some sensitive individuals and to firefighters very close to the fire line. Individuals who may experience health effects from lower levels of CO are those who have cardiovascular disease: they may experience chest pain and cardiac arrhythmias. At higher levels (such as those that occur in major structural fires), CO exposure can cause headache, weakness, dizziness, confusion, nausea, disorientation, visual impairment, coma, and death, even in otherwise healthy individuals.

Wildfire smoke also contains significant quantities of respiratory irritants, which can act in concert to produce eye and respiratory irritation and potentially exacerbate asthma. Formaldehyde and acrolein are two of the principal contributors to the cumulative irritant properties of smoke.

One concern that may be raised by members of the general public is whether they run an increased risk of cancer or of other chronic health conditions (e.g. heart disease) from short-term exposure to wildfire smoke. People exposed to toxic air pollutants at sufficient concentrations and durations may have slightly increased risks of cancer or of experiencing other chronic health problems. However, in general, the long-term risks from short-term smoke exposures are quite low. Short-term elevated exposures to wildfire carcinogens are also small relative to total lifetime exposures to carcinogens in diesel exhaust and other combustion sources. Epidemiological studies have shown that urban firefighters exposed to smoke over an entire working lifetime have about a three-fold increased risk of developing lung cancer (Hansen 1990). This provides some

perspective on the magnitude of potential risks from short-term wildfire events. The major known carcinogenic components of smoke are polycyclic aromatic hydrocarbons (PAHs). Although other known carcinogens, such as benzene and formaldehyde, are also present in smoke, they are thought to present a lesser risk.

Not everyone who is exposed to thick smoke will have health problems. The level and duration of exposure, age, individual susceptibility, including the presence or absence of pre-existing lung or heart disease, and other factors play significant roles in determining whether someone will experience smoke-related health problems.

Sensitive populations

Most healthy adults and children will recover quickly from smoke exposure and will not suffer long-term consequences. However, certain sensitive populations may experience more severe short-term and chronic symptoms. Much of the information about how particulate matter affects these groups has come from studies involving airborne particles in cities, though a few studies examining the effects of exposure to smoke suggest that the health effects of wildfire smoke are likely to be similar (Naeher et al. 2007). More research is needed to determine whether particles from wildfires affect susceptible subpopulations differently.

Individuals with asthma and other respiratory diseases. More than 35 million people in the US suffer from chronic lung diseases such as asthma and chronic obstructive pulmonary disease (COPD) (American Lung Association 2008). Levels of pollutants that may not affect healthy people may cause breathing difficulties for people with asthma, COPD, or other chronic lung diseases. Asthma is a condition characterized by chronic inflammation of the bronchi and smaller airways, with intermittent airway constriction, causing shortness of breath, wheezing, chest tightness, and coughing, sometimes accompanied by excess mucus production. During an asthma attack, the muscles tighten around the airways and the lining of the airways becomes inflamed and swollen, constricting the free flow of air. Because children's airways are narrower than those of adults, irritation that might create minor problems for an adult may result in significant obstruction in the airways of a young child. However, this disease affects all age groups: the highest mortality rates from asthma occur among older adults.

A significant fraction of the population may have airway hyperresponsiveness, an exaggerated tendency of the large and small airways (bronchi and bronchioles, respectively) to constrict in response to respiratory irritants, cold dry air, and other stimuli. While airway hyperresponsiveness is considered a hallmark of asthma, this tendency may also be found in many individuals without asthma as well; for example, during and following a lower respiratory tract infection. In such individuals, smoke exposure may cause asthma-like symptoms.

Individuals with COPD, which is generally considered to encompass emphysema and chronic bronchitis, may also experience worsening of their conditions because of

exposure to wildfire smoke. Patients with COPD often have an asthmatic component to their condition, which may result in their experiencing asthma-like symptoms. However, because their lung capacity has typically been seriously compromised, additional constriction of the airways in individuals with COPD may result in symptoms requiring medical attention. Researchers have reported that individuals with COPD run an increased risk of requiring emergency medical care after exposure to particulate matter or forest fire smoke. Exposure to smoke may also depress the lung's ability to fight infection. People with COPD may develop lower respiratory infections after exposure to wildfire smoke, which may require urgent medical care as well. In addition, because COPD is usually the result of many years of smoking, individuals with this condition may also have heart disease, and are potentially at risk from both conditions.

Individuals with cardiovascular disease. Diseases of the circulatory system include high blood pressure, cardiovascular diseases, such as coronary artery disease and congestive heart failure, and cerebrovascular conditions, such as hardening of the arteries (atherosclerosis) that bring blood to the brain. These chronic conditions can render individuals susceptible to attacks of angina pectoris (transient chest pain), heart attacks, sudden death due to a cardiac arrhythmia, acute congestive heart failure, or stroke. Cardiovascular diseases are the leading cause of mortality in the United States: about 30 to 40 percent of all deaths each year. The vast majority of these deaths occur in people over age 65. Studies have linked urban particulate matter to increased risks of heart attacks, cardiac arrhythmias, and other adverse effects in those with cardiovascular disease. People with chronic lung or heart disease may experience one or more of the following symptoms: shortness of breath, chest tightness, pain in the chest, neck, shoulder or arm, palpitations, or unusual fatigue or lightheadedness. Chemical messengers released into the blood because of particle-related lung inflammation may increase the risk of blood clot formation, angina episodes, heart attacks, and strokes.

The elderly. Researchers have estimated that tens of thousands of elderly people die prematurely each year from exposure to particulate air pollution, as older adults are more likely to have pre-existing lung and heart diseases, and therefore are more susceptible to particle-associated effects. The elderly may also be more affected than younger people because important respiratory defense mechanisms decline with age. Particulate air pollution can compromise the function of cells involved in immune defenses in the lungs, potentially increasing susceptibility to bacterial or viral respiratory infections, which may carry a worse prognosis in older adults.

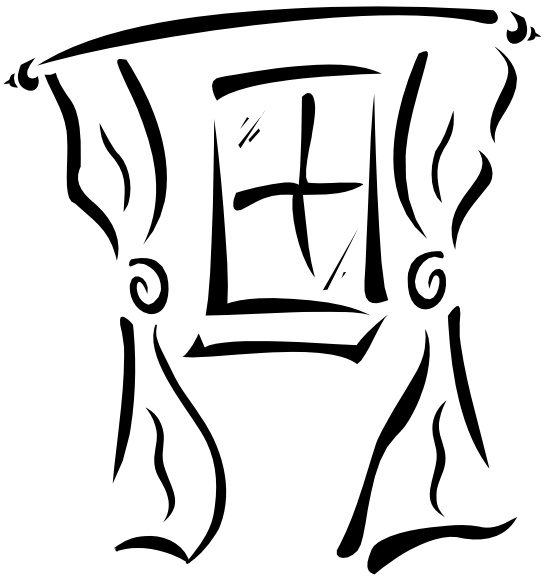
Children. Children, even those without any pre-existing illness or chronic conditions, are considered a sensitive population because their lungs are still developing, making them more susceptible to air pollution than healthy adults. Several factors lead to increased exposure in children compared with adults: they tend to spend more time outside; they engage in more vigorous activity; and they inhale more air (and therefore more smoke constituents) per pound of body weight. These are all reasons to try to limit children's vigorous outdoor activities during smoky conditions. Studies have shown that particle pollution is associated with increased respiratory symptoms and decreased lung function in children, including symptoms such as episodes of coughing and difficulty

breathing. These can result in school absences and other limitations of normal childhood activities.

Pregnant women. While there have not been studies of the effects of exposure to wildfire smoke on pregnancy outcomes, there is substantial evidence of adverse effects of repeated exposures to cigarette smoke, including both active and passive smoking. Wildfire smoke contains many of the same compounds as cigarette smoke. In addition, recent data suggest that exposures to ambient air pollution in cities may result in low birth weight, preterm birth, and possibly other more serious adverse reproductive effects, including infant mortality. Therefore, it would be prudent to consider pregnant women as a potentially susceptible population as well.

Smokers. People who smoke, especially those who have smoked for many years, have compromised lung function. However, due to adaptation of their lungs to ongoing irritation, smokers are generally less likely to report symptoms from exposure to irritant chemicals than are nonsmokers. Nevertheless, they may still be injured by wildfire smoke. Therefore, because they may not experience the same degree of irritation from wildfire smoke as nonsmokers, some smokers may unwittingly put themselves at greater risk of potentially harmful wildfire smoke exposures.

Specific strategies to reduce smoke exposure



Stay indoors

The most common advisory issued during a smoke episode is to stay indoors. The usefulness of this strategy depends on how well the building limits smoke from coming in from outdoors and on minimizing indoor pollution sources. Staying indoors may therefore provide some protection, especially in a tightly closed, air-conditioned home in which the air conditioner re-circulates indoor air. Generally, newer homes are "tighter" and keep ambient air pollution out more effectively than older homes.

Staying inside with the doors and windows closed can usually reduce exposure to ambient air pollution by about a third or more. Homes with central air conditioning generally re-circulate indoor air, though some outdoor smoky air can still be drawn inside (e.g., when people enter or exit). In homes without air conditioning, indoor concentrations of fine particles can approach 70 to 100 percent of the outdoor levels. In very leaky homes and buildings, outdoor particles can easily infiltrate indoors, so guidance to stay inside may

offer little protection. In any home, if doors and windows are left open, particle levels indoors and outdoors will be about the same.

Sometimes smoke events can last for weeks or (rarely) months. These longer events are usually punctuated by periods of relatively clean air. When air quality improves, even temporarily, residents should "air out" their homes to reduce indoor air pollution. People may also wish to clean their residences during such reduced smoke intervals, including damp mopping or dusting, and vacuuming (preferably with a high efficiency particulate air [HEPA] filter-equipped vacuum), in order to reduce subsequent re-suspension of particles that may have settled when the smoke was thicker.

An important drawback of advising people to stay inside during smoke events is the increased risk of heat stress. In many parts of the country, the fire season typically extends from mid-summer through the early fall, when high outside temperatures are common. In homes without air conditioning, in which individuals depend on open windows and doors for ventilation, remaining inside with everything closed can be dangerous. Older individuals and others in frail health run the risk of heat exhaustion or heat stroke, which could have dire consequences. If outdoor temperatures are very high, it would be prudent to advise those without air conditioning to stay with friends or with family members who do, to go to a cleaner air shelter in their community, or to leave the area. These and other options are discussed below.

Guidance on protecting workers in offices and similar indoor workplaces from wildfire smoke has been developed by the California Division of Occupational Safety and Health (Cal/OSHA), in consultation with technical staff from several other California agencies. This document (attached as Appendix A) addresses how to maximize the protection provided by heating, ventilating and air-conditioning (HVAC) systems common in public and commercial buildings, as well as other steps to protect occupants.



Reduce activity

Reducing physical activity is an effective strategy to lower the dose of inhaled air pollutants and reduce health risks during a smoke event. During exercise, people can increase their air intake as much as 10 to 20 times over their resting level. Increased breathing rates bring more pollution deep into the lungs. Furthermore, people tend to breathe through their mouths during exercise, bypassing the natural filtering ability of the nasal passages, again delivering more pollution to the lungs. They also tend to breathe more deeply, modifying the usual patterns of lung particle deposition.

Reduce other sources of indoor air pollution



Many indoor sources of air pollution can emit large amounts of pollutants, some of which are also present in wildfire smoke. Smoking cigarettes, using gas, propane and wood-burning stoves and furnaces, spraying aerosol products, frying or broiling meat, burning candles and incense, and vacuuming can all increase particle levels in a home and should be avoided when wildfire smoke is present.

For instance, in a standard room of 125 square feet, it takes only 10 minutes for the side-stream smoke of 4 cigarettes to generate indoor levels of particles in the hazardous ranges (644 micrograms of particles per cubic meter of air or $\mu g/m^3$). Frying or broiling some foods can produce even higher levels of particles in the kitchen and dining areas. Some of these sources can also increase the levels of polycyclic aromatic hydrocarbons (PAHs), carbon monoxide, and nitrogen oxides. Besides cigarette smoke, combustion sources that do not properly vent to the outdoors (including "room-vented" or "vent-free" appliances) contribute most to indoor pollutant levels, and are of greatest concern. Thus, reducing indoor air pollutant emissions during smoke events can decrease indoor particle levels, which may partially compensate for the increased particle loading from the outdoor air.

Air conditioners and filters

Little is known about the impact of using various types of room air conditioners and air filters on indoor smoke concentrations in homes. However, homes with central air conditioners generally have lower amounts of outdoor particles indoors compared to homes that use open windows for ventilation.

Most air conditioners are designed by default to re-circulate indoor air. Those systems that have both "outdoor air" and "re-circulate" settings need to be set on "re-circulate" during fire/smoke events.

Also, central air conditioners (and some room air conditioners) contain filters that can remove some airborne particles with different degrees of efficiency. If possible, one should replace the air-conditioner filter with a pleated medium- or high-efficiency particle filter. Higher efficiency filters are preferred as they can capture most of the fine particles associated with smoke and can further reduce the amount of outside air pollution that gets indoors. However, caution must be taken to assure that the air conditioning system is able to handle the increased airflow resistance from a higher efficiency filter. Filters need to be cleaned or replaced regularly, and should fit the filter slot snugly.

In addition to high- and medium-efficiency filters, electrostatic precipitators (ESPs) can sometimes be added by a technician to central air conditioning systems to keep particle levels in indoor air within acceptable levels during a prolonged smoke event.

For newer air conditioners with a "fresh air ventilation system" that brings in outdoor air continuously or semi-continuously, the “fresh air” component of the system should be turned off during smoke events. This may require closing the outdoor air damper, setting the system on “re-circulate” only, or turning off the energy- or heat-recovery ventilator or exhaust fans that are part of the system. If the control system instructions are not clear or accessible, residents should contact their builder or heating and cooling contractor to help temporarily adjust the system. However, residents should also place a reminder tag in a visible spot so that they reset the system once the smoke clears. Many newer homes currently have such mechanical ventilation systems and, starting in 2009, new homes in California will be required to have such systems. Mechanical ventilation systems used in public and commercial buildings differ, and are discussed further in Appendix A.

Room air cleaners

Choosing to buy an air cleaner is a decision that ideally should be made ***before*** a smoke emergency occurs. During a smoke emergency, it may be hazardous to go outside or drive in an attempt to locate an appropriate device, which may be in short supply. It is unlikely that local health officials will be able to buy or supply air cleaners to those who might need them.

HEPA filter air cleaners and ESPs can help reduce indoor particle levels, provided the specific air cleaner is properly matched to the size of the indoor environment in which it is placed. There are wide ranges of air cleaners and prices to choose from: air cleaners are available as either less expensive portable units designed to clean the air in a single room ($90 - $900) or as larger central air cleaners intended to clean the whole house ($450 - $1500). Central air cleaners have been shown to be more effective than room air cleaners, although a good portable air cleaner may improve the air in a bedroom, for example, which may be helpful to an individual with asthma or COPD. Most air cleaners are not effective at removing gases and odors. The two basic types for particle removal include:

(a) Mechanical air cleaners, which contain a fiber or fabric filter. The filters need to be sealed tightly in their holders, and cleaned or replaced regularly. HEPA filters (and ULPA or ultra-HEPA filters, which are not generally available for residential use) are most efficient at removing particles.

(b) Electronic air cleaners, such as electrostatic precipitators (ESPs) and ionizers. ESPs use a small electrical charge to collect particles from air pulled through the device. Ionizers, or negative ion generators, cause particles to stick to materials (such as carpet and walls) near the device. Electronic air cleaners usually produce small amounts of ozone (a respiratory irritant) as a byproduct, though some,

especially those that are combined with other technologies, may produce substantial levels of ozone (see next section on Ozone Generators).

Room air cleaner units should be sized to filter at least two or three times the room volume per hour. Most portable units will state on the package the unit's airflow rate, the room size it is suitable for, its particle removal efficiency, and perhaps its Clean Air Delivery Rate, or CADR. The CADR is a rating that combines efficiency and airflow.

The Association of Home Appliance Manufacturers (AHAM) maintains a certification program for air cleaners. The AHAM seal on the air cleaner's box lists three CADR numbers – one for tobacco smoke, one for pollen, and one for dust. The higher the numbers, the faster the unit filters the air. Choose a unit with a tobacco smoke CADR at least 2/3 of the room's area. For example, a 10' x 12' room (120 square feet) would require an air cleaner with a tobacco smoke CADR of at least 80. If the ceiling is higher than 8', an air cleaner rated for a larger room will be needed.

Consumer Reports recently published an educational review of air cleaning devices, which can be accessed at: http://www.arb.ca.gov/research/indoor/cr-12-2007.pdf. This article provides ratings for both portable and whole house air cleaners.

Devices that remove gases and odors are relatively costly, both to purchase and maintain. They force air through materials such as activated charcoal or alumina coated with potassium permanganate. However, the filtering medium can become quickly overloaded and may need to be replaced often. Nevertheless, such devices may be useful for sensitive individuals, and new models that combine particle and gas removal are available in both portable and in-duct models.

For more information about residential air cleaners:
http://www.epa.gov/iaq/pubs/airclean.html
http://www.arb.ca.gov/research/indoor/acdsumm.pdf
http://www.arb.ca.gov/research/indoor/ozone.htm
http://www.cadr.org/consumer.htm

Ozone generators – a choice to avoid

Some devices, known as ozone generators, personal air purifiers, "super-oxygen" air purifiers, and "pure air" generators, are sold as air cleaners, but the position of public health agencies, including the California Air Resources Board and U.S. Environmental Protection Agency, is that they do more harm than good. These devices are designed to intentionally produce large amounts of ozone gas. Ozone generator manufacturers claim that ozone can remove mold and bacteria from the air, but this occurs only when ozone is released at levels many times higher than those that are known to harm human health.

Relatively low levels of ozone can irritate the airways, causing coughing, chest pain and tightness, and shortness of breath. It can also worsen chronic respiratory diseases such as asthma, as well as compromise the body's ability to fight respiratory infections. As a

result, using an ozone generator during a smoke event may actually increase the adverse effects from the smoke. In addition, ozone gas does not remove particles from the air, and would therefore not be effective during smoke events. (Some ozone generators include an ionizer to remove particles, but it would be far safer to buy the ionizer by itself or a filter-based air cleaner.)

For more information about ozone generators marketed as air cleaners:
http://www.arb.ca.gov/research/indoor/ozone.htm
www.epa.gov/iaq/pubs/ozonegen.html

Create a clean room at home

People who live in areas that are regularly affected by smoke from wildfires would be well advised to create a "clean room" in their home. A good choice is an interior room, with as few windows and doors as possible, such as a bedroom. Some suggestions for maintaining a clean room:

- Keep windows and doors closed.
- Set up a properly sized room air cleaner (see above), which will help remove particles from the air while emitting no or minimal levels of ozone.
- Run an air conditioner or central air conditioning system if you have one. If the air conditioner provides a fresh air option, keep the fresh-air intake closed to prevent smoke from getting inside. Make sure that the filter is clean enough to allow good air flow indoors.
- Do not vacuum, because vacuuming stirs up particles.
- Do not smoke or burn anything, such as candles or incense, anywhere in the house.
- Keep the room clean.
- If it is too warm to stay inside with the windows closed, or if you are very sensitive to smoke, seek shelter elsewhere. Keep in mind that many particles will enter your home even if you take all of these steps.



Humidifiers

Humidifiers are not air cleaners, and will not significantly reduce the amount of particles in the air during a smoke event. Nor will they remove gases like carbon monoxide. However, humidifiers and dehumidifiers (depending on the environment) may slightly reduce pollutants through condensation, absorption and other mechanisms. In an arid environment, one possible benefit of running a humidifier during a smoke event might be to help the

mucous membranes remain comfortably moist, which may reduce eye and airway irritation. However, if not properly cleaned and maintained, some humidifiers can circulate mold spores. In any case, the usefulness of humidification during a smoke event has not been studied.

Inside vehicles

Individuals can reduce the amount of smoke in their vehicles by keeping the windows and vents closed, and, if available, operating the air conditioning in "re-circulate" mode. However, in hot weather a car's interior can heat up very quickly to temperatures that far exceed those outdoors, and heat stress or heat exhaustion can result. Children and pets should ***never*** be left unattended in a vehicle with the windows closed. The ventilation system of older cars typically removes a small portion of the particles coming in from outside, while newer models often have an air filter that removes most particles. Most vehicles can re-circulate the inside air, which will help keep the particle levels lower. Drivers should check the owner's manual and assure that the system is set correctly to minimize entry of outdoor smoke and particles. However, recent research has shown that carbon dioxide levels can quickly accumulate to very high levels (more than 5000 parts per million) in newer cars when vents and windows are closed and the recirculation setting is used. Therefore, if driving a recent model vehicle for more than a short period of time, it may be a good idea to briefly open windows or vents occasionally to avoid becoming groggy from carbon dioxide build-up. Finally, vehicles should not be used as a shelter, but as means to get to one or to leave the area.

Respiratory protection

This section addresses the use of masks and respirators by the public and workers to reduce inhalation of wildfire smoke, specifically harmful particles. Use of the term "mask" in this context may cause confusion for both public health officials and the general public, as it can refer to one-strap paper masks and surgical masks, which provide little if any protection, as well as N95 (defined below) and other respirators, which can be beneficial. This discussion emphasizes appropriate usage of the term "respirator;" however, in Appendix B, which provides guidance in lay language to the public on respiratory protection, the term "mask" is used.

In order for a respirator to provide protection, it must be able to filter very small particles and it must fit well, providing a tight seal around the wearer's mouth and nose. For example, adequate seals cannot be obtained for men with beards or for most children. Without having had a "fit test" while wearing a respirator, the individual user cannot be sure that it fits well enough to provide the expected protection. However, because disposable respirators (N95 or P100) are increasingly available in hardware and home repair stores and pharmacies, many people will purchase these devices and use them, either when going outdoors during smoke events or during fire ash cleanup. Therefore, health officials should consider providing guidance on the proper selection and use of respirators, which can provide some level of protection despite the lack of formal fit testing and training.

Respirators should only be used after first implementing other, more effective methods of exposure reduction, including staying indoors, reducing activity, and using HEPA air cleaners to reduce overall smoke exposure. Another option that should be considered for sensitive individuals is temporary relocation out of the smoky area if possible.

Filtering facepiece respirators are a type of respiratory protection in which the entire respirator is comprised of filter material. The most common types are called N95 (used in health care settings to protect against inhalation of infectious particles) and P100 (used to protect against toxic dusts such as lead or asbestos). Filter material rated "95" will capture at least 95% of very small particles, while material rated "100" filters out at least 99.97%. These respirators must be certified by the National Institute for Occupational Safety and Health (NIOSH), with the words "NIOSH" and the designation "N95" or "P100" appearing on the filter material. P100 respirators are more expensive than N95 respirators and will have somewhat higher resistance to airflow. The cost difference may make people reluctant to change them out when necessary, so N95 respirators may be preferable in wildfire smoke situations. Leakage around the respirator will result in more particles inhaled by someone wearing a respirator than passage through the filter material. Therefore, in practice, particularly without formal fit testing, N95s and P100s will provide similar levels of protection against wildfire smoke.



Figure 4 Two types of recommended N95 Disposable Particulate Respirators. Note the presence and placement of the two straps above and below the ears.

Other nondisposable NIOSH-certified respirators, such as those used by painters, may also be beneficial; they have a tight-fitting flexible facepiece and replaceable filter cartridges. These would provide similar protection from particles if they are used with N95 particulate filters or purple (P100 or HEPA) filter cartridges. This type of respirator may also be purchased with a combination filter and organic vapor cartridge, which can reduce exposure to irritating gases in smoke, such as aldehydes.

One drawback to the use of respirators by the public in an area affected by wildfire smoke is that people may not select or use them correctly and won't understand the importance of having a tight seal around the face. A one-page fact sheet, "Protect Your Lungs from Wildfire Smoke," which is designed for the general public, appears at the end of this Guide as Appendix B. In lay terms (including using the term "mask" instead of "respirator"), it describes how to correctly choose and use a disposable N95 or P100 particulate respirator. Guidance to the public on using respirators should include the following points:

How to Choose the Right Respirator:

- Disposable particulate respirators are sold at many hardware and home repair stores and pharmacies. These respirators only filter out particles. They do not protect against gases or vapors, and do not provide oxygen.
- Select a NIOSH-certified N95 or P100 particulate respirator with two straps that go around your head. The words "NIOSH" and either "N95" or "P100" will be printed on the filter material.
- Choose a size that will fit over your nose and under your chin. It should seal tightly to your face. If you cannot get a close face seal, try a different model or size. Fit testing is the best way to determine if the respirator fits you, but even without fit testing a respirator will provide some protection to most people.
- As of July 2008, respirators do not come in sizes that will fit young children. NIOSH does not certify any respirators for children.

How to Use the Respirator:

- Place the respirator over your nose and under your chin, with one strap below the ears and one strap above (see photo above). If you're wearing a hat, it should go over the straps.
- Pinch the metal nose clip tightly over the top of your nose.
- Facial hair will cause the respirator to leak, so you should be clean-shaven.
- It takes more effort to breathe through a respirator. It can also increase the risk of heat stress. If you are working outside while wearing a respirator, take frequent breaks, especially if you are working in the heat or doing heavy work.
- If you feel dizzy, lightheaded, or nauseated, tell someone, go to a less smoky area, remove your respirator, and get medical attention.
- People with heart or lung disease should consult with their doctor before using a respirator.
- Discard the respirator when: (1) it becomes more difficult to breathe through it, or (2) if the inside becomes dirty. If necessary, use a fresh respirator each day.
- Keep your respirator clean and dry. Be sure to read and follow the manufacturer's recommendations on use and storage.

As noted above, "mask" means different things to different people. For example, to some people "dust mask" describes a P100 particulate respirator used in the construction industry, and to others it means a one-strap paper mask that is NOT a respirator. A disposable particulate respirator has been certified by NIOSH to ensure that it can filter out harmful particles. Paper masks and surgical masks are not certified by NIOSH and

cannot provide the protection that respirators do. Commonly available one-strap paper dust masks, which are designed to keep larger particles out of the nose and mouth, typically offer little protection. The same is true for bandanas (wet or dry) and tissues held over the mouth and nose. Surgical masks are designed to filter air coming out of the wearer's mouth, and do not provide a good seal to prevent inhalation of small particles found in wildfire smoke. Incorrect use of respirators, or use of other, less protective face coverings, may give the wearer a false sense of security and encourage increased physical activity and time spent outdoors, resulting in increased exposures.



Figure 5 A one-strap paper mask is not a respirator and would provide little or no protection from smoke particles.



Figure 6 A surgical mask, which is designed to capture infectious particles generated by the wearer, is not a respirator and would provide little or no protection from smoke particles.

N95 and P100 respirators described in this section would also help to protect people involved in cleaning up fire ash. Additional guidance for the public on cleaning up ash safely appears as Appendix C. If respirators are not available during fire ash cleanup, simple paper masks or other face coverings may help keep grit and dust out of the nose and mouth, but they will not protect the lungs.

Use of respirators by workers generally must be under a comprehensive, OSHA-compliant respiratory protection program. These programs include medical evaluation of employees to ensure that it is safe and appropriate for them to use respirators; individual fit testing to select a model and size that fit; and training on respirator use. Employers who anticipate that their workers may need to wear respiratory protection are expected to put in place a full program prior to use. However, during emergency situations such as smoke events employees who work outdoors or indoors (who would not otherwise be required to wear respirators) may request to use respirators to protect against exposure to smoke, particularly when the local Air Quality Index (AQI) for PM is rated "unhealthy" or worse. As long as occupational particulate standards are not exceeded (which is unlikely for workers not performing firefighting duties), the OSHA respiratory protection standard permits employers to allow voluntary use of N95 or other disposable filtering facepiece respirators without requiring a medical evaluation or fit test. Employees must be provided with Appendix D of the federal OSHA respiratory protection standard (for workplaces under Cal/OSHA jurisdiction this is available at http://www.dir.ca.gov/Title8/5144d.html). Employers should also tell employees that the respirator will provide some protection against the particles in smoke, but without fit testing it may not provide the maximum level of protection. Although a medical evaluation is not required, the employer should advise employees to consult their doctor about potential exposures to smoke and respirator use, particularly if they have respiratory or heart disease.

Cleaner air shelters

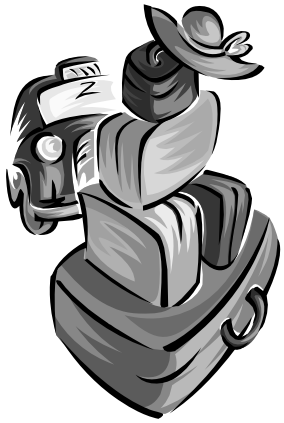
Public health officials in areas at risk from forest fires should identify and evaluate cleaner air shelters prior to the fire season. Guidance for identifying and setting up a Cleaner Air Shelter is provided in Appendix D. During severe smoke events, cleaner air shelters can be designated to provide residents with a place to get out of the smoke. Staying inside at home may not adequately protect sensitive individuals, since many houses and apartments do not have air conditioning, and depend on open windows and doors for cooling. Other homes may be so leaky that indoor pollution levels will quickly equal those outside. Cleaner air shelters can be located in large commercial buildings, educational facilities, shopping malls, or any place with effective air conditioning and particle filtration.

Closures

The decision to close or curtail business activities and public events will depend upon predicted smoke levels and other local conditions. One factor to consider is whether

pollutant levels inside schools and businesses are likely to be similar to or lower than those in homes. Children's physical activity may also be better controlled in schools than in homes. On the other hand, in some school districts smoky conditions may make travel to school hazardous. In many areas it will not be practical to close businesses and schools, although partial closures may be beneficial. Closures and cancellations can target specific groups (e.g., the sensitive populations described earlier) or specific, high-risk activities, such as outdoor sporting events and practices. Curtailing outside activities can reduce exposures, as can encouraging people to stay inside and restrict physical activity. A decision to restrict industrial emissions should be based on local air pollution and the emission characteristics of particular industries. Curtailment may not be necessary if eliminating industrial emissions will not markedly reduce local air pollution.

Evacuation



The most common call for evacuation during a wildfire is due to the direct threat of engulfment by the fire rather than by exposure to smoke. Leaving an area of thick smoke may be a good protective measure for members of sensitive groups, but it is often difficult to predict the duration, intensity, and direction of smoke, making this an unattractive option to many people. Even if smoky conditions are expected to continue for weeks, it may not be feasible to evacuate a large percentage of the affected population. Moreover, the process of evacuation can entail serious risks, particularly if poor visibility makes driving hazardous. In these situations, the risks posed by driving with reduced visibility need to be weighed against the potential benefits of evacuation. Therefore, in areas where fires are likely to occur, public health officials are encouraged to develop plans for local protection of sensitive groups.

Where individuals are evacuated to a common center because of fire danger, public health officials need to pay particular attention to the potential for smoke to affect the evacuation center itself. It is not always possible to locate evacuation centers far away from smoky areas, or to expect that evacuees will be able to take the steps necessary to reduce their exposures in their new surroundings. Public health officials should consider advising incident commanders if this situation could arise and ensure that evacuees are provided with information and materials to further reduce exposures, including provision of a cleaner air shelter within the evacuation center, if possible, as well as other means of respiratory protection. (See "Respiratory Protection" above).

Summary of strategies for exposure reduction

When wildfires are expected to create smoky conditions, people can pursue a number of strategies to reduce their exposure. Those with moderate to severe heart or lung disease might consider staying with relatives or friends who live away from the smoke during the fires. If smoke is already present in substantial quantities, such individuals may want to evaluate whether evacuation might actually cause greater exposure than staying at home using other precautions described above.

All people in a smoky area (except firefighters or emergency personnel) should avoid strenuous work or exercise outdoors. They should avoid driving whenever possible. If driving is necessary, people should run the air conditioner on the "recycle" or re-circulate mode to avoid drawing smoky air into the car.

Closing up a home by shutting windows and doors can give some protection from smoke. Most air conditioners are designed by default to re-circulate indoor air. Those systems that have both "outdoor air" and "re-circulate" settings need to be set on "re-circulate" during fire/smoke events to prevent smoke-laden air from being drawn into the building (note: this does not apply to HVAC systems in office and commercial buildings; see Appendix A).

Once people have closed up the building in which they live, they should avoid strenuous activity, which can make them breathe harder and faster. They should drink plenty of fluids to keep their respiratory membranes moist. They may even want to breathe through a moistened washcloth, as long as it does not interfere with their ability to breathe.

NIOSH-certified disposable respirators (N95 or P100) available in hardware or other stores may provide some level of protection from exposure to particles in smoke, as long as a close-fitting model and size is selected and they are used properly. One-strap paper masks, surgical masks, or other face coverings are likely to provide far less or no protection.

In preparation for the fire season or a smoke event, it is a good idea to have enough food on hand to last several days, so that driving can be minimized. It is also important to have at least a five-day supply of medication for the same reason. Foods stored for use during the fire season should not require frying or broiling, since these activities can add particles to indoor air. Vacuuming (except with HEPA filter-equipped vacuums) should also be avoided, since most vacuum cleaners disperse very fine dust into the air.

If smoke levels increase to very unhealthy or hazardous levels, it may be appropriate for some individuals to stay in a clean room in the home, relocate temporarily to a cleaner air shelter, or to leave the area entirely if it is possible and safe to do so.

Estimating particulate matter levels

Particulate matter levels are measured as micrograms (μg) of particles per cubic meter of air. Most particle monitoring devices measure either particulate matter with a median diameter of 10 micrometers or less (PM_{10}) or smaller particles with median diameters of 2.5 micrometers or less ($PM_{2.5}$, also known as fine particles).

Jurisdictions with particulate monitors, whether they are filter-based or continuous methods, will get a good idea of how bad the smoke was *after* the event. However, the goal is to relay information to the public in a timely manner, so they can make decisions about how to protect their health when the smoke levels are high. Continuous PM monitors give an instant reading of particulate matter concentrations and usually provide a number of averaging periods (e.g., one-hour and running 24-hour averages). Areas without continuous monitors may be able to get temporary, portable measuring devices through their state air quality program or the Forest Service.

Many communities do not have access to continuous PM monitoring, and therefore need other ways to estimate particle levels. This is true even in areas which do have continuous monitors, because smoke concentrations can vary widely within a couple miles and can change rapidly. Visibility can sometimes serve as a good surrogate. In addition, a visibility index gives the public a quick way to assess smoke levels for themselves.

Table 1 Estimating particulate matter concentrations from visibility assessment

Categories	Visibility in Miles	Particulate Matter Levels* (1-hour average, $\mu g/m^3$)
Good	11 miles and up	0 - 38
Moderate	6 to 10	39 - 88
Unhealthy for Sensitive Groups	3 to 5	89 - 138
Unhealthy	1 ½ to 2 ¾	139 - 350
Very Unhealthy	1 to 1 ¼	351 - 526
Hazardous	less than 1 mile	over 526

*In wildfire smoke, most particles are less than one micrometer, so the values obtained by measuring either PM_{10} or $PM_{2.5}$ are virtually interchangeable, and are treated as such in this document. Therefore, in the table above, the different particle levels can be measured using either PM_{10} or $PM_{2.5}$ monitors.

When using the visibility index to determine smoke concentrations, it is important to:

- Face away from the sun.
- Determine the limit of your visibility range by looking for targets at known distances (miles). The visible range is the point at which even high-contrast objects (e.g., a dark forested mountain viewed against the sky at noon) totally disappear.
- After determining visibility in miles, use Tables 2 and 3 to identify potential health effects and appropriate cautionary statements.

At times, the visibility index may be hard to use, especially if specific landmarks at known distances are not available for judging visibility range, or at dawn or dusk. *Furthermore, the above visibility categories for PM levels only apply in dry air conditions. For a given PM level, visibility decreases substantially at relative humidity above 65%, therefore, this method of estimation should not be used under conditions of high humidity.* Work is being done to incorporate humidity as a factor in the visibility index, and will be included in this guide when it is available. For now, in humid conditions, individuals may have to rely on common sense in assessing smoke conditions (e.g., mild, moderate, heavy smoke) and the kinds of protective actions that might be necessary. At night or during periods when visibility cannot be used to estimate smoke levels, intense smoky odor can be used to indicate potentially harmful levels.

Once a procedure is in place to determine current smoke levels, the next step is to predict future levels of smoke in a way that is useful to the public. Smoke events follow different patterns – some events have high smoke levels for a few hours a day, others have sustained smoke over a number of hours, and still others have elevated levels over a number of days. How the smoke behaves depends on a number of factors, such as how large and far away the fire is, topography, expected winds, and other weather conditions.

There are a number of on-line resources to aid in making smoke predictions, including information about current wildfires, satellite images and the National Weather Service. These websites are listed under "Resources/Links" towards the end of this guide.

Recommendations for public health actions

Pre-season public service announcements

In areas where fires are likely to occur, state and local public health agencies should consider running pre-season public service announcements (PSAs) or news releases to advise the public on how to prepare for the fire season. PSAs should be simple (e.g., the season for wildfires is approaching; there are things you can do now to help protect your health and prepare your home in the event of a wildfire), and should list a contact phone number or website for further information.

News releases should be used to provide more detailed information, including information for the general public and for people with chronic diseases.

General recommendations to the public should include at least the following:

1. Have a several-day supply of nonperishable groceries that do not require cooking, since cooking (especially frying and broiling) can add to indoor pollutant levels.
2. If you develop symptoms suggesting lung or heart problems, consult a health care provider as soon as possible.

3. Be alert to PSAs.
4. Be aware that outdoor events, such as athletic games or competitions, may be postponed or cancelled if smoke levels become elevated.

Recommendations for people with chronic diseases should include at least the following:

1. Have an adequate supply of medication (more than 5 days).
2. People with asthma should have a written asthma management plan.
3. People with heart disease should check with their health care providers about precautions to take during smoke events. They should do this prior to the fire season if they live in an area that has the potential for wildfires.
4. If you plan to use a portable air cleaner, buy one appropriately matched to room size, as specified by the manufacturer, before a smoke emergency occurs.
5. Contact a health care provider if your condition worsens when you are exposed to smoke.
6. A news release could also include recommendations for preparing residences to keep smoke levels lower indoors, and on the appropriate use of respiratory protection. See Appendices B, D, and E.

Public advisories and protective measures

Areas with established air quality programs generally have several ways to alert the public about air pollution events. One approach is to refer to the U.S. Environmental Protection Agency's (EPA's) Air Quality Index (AQI), which is used by states and many communities across the country (http://www.epa.gov/airnow/aqi_cl.pdf). Other methods include websites, hotlines, press releases, as well as emails and faxes to interested parties (such as sports team coaches and daycare providers). Some rural areas have used door-to-door dissemination of the visibility index (Table 1) and the associated health effects (Table 2).

The AQI is a nationally uniform index required for reporting and forecasting daily air quality in large urban areas. It is used to report information about the most common ambient air pollutants, including particulate matter. The AQI tells the public how clean or polluted the air is using standard descriptors (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very unhealthy, and Hazardous). This index converts sometimes difficult-to-interpret particulate mass per volume ($\mu g/m^3$) numbers to an AQI category and number more easily understood by the public. The AQI uses a normalized scale from 0 to 500 and associated health-based descriptors. An AQI value of 100 corresponds to the level of the National Ambient Air Quality Standard for a given pollutant. An advantage of the AQI over the $\mu g/m^3$ value for particulate matter is that the AQI level of 100 represents a clear demarcation between satisfactory and unhealthy air quality, at least with reference to the national standard, which is (in principle) established at a level that will protect public health. When AQI values exceed 100, air quality is considered to be unhealthy, at first for members of susceptible populations, then for everyone as AQI values increase.

One issue that public health officials may face is which averaging time to use when reporting smoke levels to the public. The AQI for particulate matter is based on predicted

or measured 24-hour average concentrations. However, using the 24-hour average does not adequately address very high, but short-term, peaks often associated with wildfire smoke. Health officials would like the public to reduce their exposure during these peaks because such transient pollutant spikes may cause some of the most serious health effects. Moreover, the public wants information to help make immediate decisions about whether to exercise, conduct athletic practice, or keep children indoors. On the other hand, several hours of very high levels may drive up the predicted 24-hour average; but the smoke may clear enough to safely allow outdoor activities. In addition, the 24-hour average does not mesh well with public perception. Since smoke is so effective at scattering light, visibility changes drastically as smoke concentrations increase. Even without being told, the public can tell when the smoke is getting worse, and they want authorities to respond to changes as they are happening. Therefore, this guide provides information related to shorter averaging times to give more flexibility in reporting smoke levels to the public (see below).

Table 2 provides a general list of health effects and cautionary statements for use in public advisories. The categories are based on the AQI, as well as on work done in Montana, California, and Washington. The recommended $PM_{2.5}$ concentrations (1- to 3-hour and 8-hr averages) at which local officials may wish to consider issuing these advisories are listed in Table 3. *If only PM_{10} measurements are available during smoky conditions, it can be assumed that the PM_{10} is composed primarily of fine particles ($PM_{2.5}$), and that therefore the AQI and associated cautionary statements and advisories for $PM_{2.5}$ may be used. This assumption is reflected in the column headings in Table 3.*

Table 3 provides guidance to public health officials regarding measures that can be taken to protect public health at different AQI categories and the corresponding PM levels for several averaging times. This information is intended to help health officials, the media, and the general public make decisions regarding appropriate strategies to mitigate exposure to smoke. As noted above, the official AQI value for particulate matter is derived exclusively from estimated or measured 24-hr average concentrations: this AQI for PM2.5 is reported by the media. PM levels for shorter averaging times in Table 3 are therefore not "official" AQI values, but have been mathematically derived from the AQI breakpoints for 24-hr concentrations. Although Table 3 also provides the AQI numerical ranges encompassed by the standard descriptors, of "Good," "Moderate," and so forth, it is possible that concurrent publication of both the AQI numbers and the $\mu g/m^3$ concentrations to describe air quality may lead to confusion among members of the public. To avoid such confusion, it may be preferable to publish just the AQI values.

There are no directly relevant epidemiological or controlled human exposure studies that offer guidance in the selection of particulate matter levels with averaging times less than 24 hours, in part because studies of short-term effects of particles generally have not been conducted and in part because the toxicity of smoke is related to gaseous as well as particulate components. However, these short-term levels (1- to 3-hr and 8-hr averages) were derived from the $PM_{2.5}$ AQI levels, which are based on a strong body of epidemiological evidence associating 24-hour $PM_{2.5}$ exposures with respiratory and cardiovascular morbidity and mortality.

The categories in Table 3 are tools that can be used as both descriptors and action levels. For example, when $PM_{2.5}$ levels have been 90 $\mu g/m^3$ for 2 or 3 hours, air quality can be described as "Unhealthy for Sensitive Groups." Public health officials may also want to take some or all of the recommended actions associated with this air quality designation, based on a global assessment of the local situation. Some factors that might be considered include:

- Fluctuations in $PM_{2.5}$ levels. Do the peaks of $PM_{2.5}$ occur relatively infrequently, interspersed with longer periods of good air quality, or do they occur multiple times per day, superimposed on higher-than-usual $PM_{2.5}$ levels?
- Predicted duration of high $PM_{2.5}$ levels. For instance, if air quality is predicted to be in the "Unhealthy for Sensitive Groups" range or worse for an extended period of time, public health officials might consider evaluating sites for cleaner air shelters or recommending evacuation plans for individuals with chronic lung or heart disease who cannot take adequate personal protective actions to reduce exposures.
- Potential indirect effects. High $PM_{2.5}$ levels can impair visibility and increase the risk of traffic accidents. This may be reason enough to cancel an evening indoor event at a local high school, for example.

Table 2 Health Effects and Cautionary Statements

Category (see Table 3)	Health Effects	Cautionary Statements [1]	Other Protective Actions
Good	None expected	None	None
Moderate	Possible aggravation of heart or lung disease	Unusually sensitive individuals should consider limiting prolonged or heavy exertion. ▪ People with heart or lung disease should pay attention to symptoms. ▪ If you have symptoms of lung or heart disease, including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, palpitations, nausea, unusual fatigue or lightheadedness, contact your health care provider.	▪ If symptomatic, reduce exposure to particles by following advice in box below.
Unhealthy for Sensitive Groups	Increasing likelihood of respiratory or cardiac symptoms in sensitive individuals, aggravation of heart or lung disease, and premature mortality in persons with cardiopulmonary disease and the elderly.	*Sensitive Groups:* People with heart or lung disease, the elderly, children, and pregnant women should limit prolonged or heavy exertion. ▪ Limit time spent outdoors. ▪ Avoid physical exertion. ▪ People with asthma should follow asthma management plan. ▪ If you have symptoms of lung or heart disease that may be related to excess smoke exposure, including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, heart palpitations, nausea, unusual fatigue or lightheadedness, contact your health care provider.	▪ Keep doors and windows closed, seal large gaps as much as possible. ▪ Avoid using exhaust fans (kitchen, bathrooms, clothes dryer, and utility room). ▪ Keep the garage-to-home door closed. ▪ If cooling is needed, turn air conditioning to re-circulate mode in home and car, or use ceiling fans or portable fans (but do not use whole house fans that suck outdoor air into the home). ▪ Avoid indoor sources of pollutants, including tobacco smoke, heating with wood stoves and kerosene heaters, frying or broiling foods, burning candles, vacuuming, and using paints, solvents, cleaning products, and adhesives. ▪ Keep at least 5-day supply of medication available. ▪ Have supply of non-perishable groceries that do not require cooking.

[1] Higher advisory levels automatically incorporate all of guidance offered at lower levels.

Table 2 Health Effects and Cautionary Statements (continued)

Category (see Table 3)	Health Effects	Cautionary Statements[1]	Other Protective Actions
Unhealthy	Increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population.	*Sensitive Groups:* should avoid prolonged or heavy exertion ▪ Stay indoors; avoid exertion. *General Population:* should limit prolonged or heavy exertion ▪ Limit time spent outdoors. ▪ If you have symptoms of lung or heart disease that may be related to excess smoke exposure, including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, palpitations, nausea or unusual fatigue or lightheadedness, contact your health care provider.	*Sensitive Groups:* Stay in a "clean room" at home (where there are no indoor smoke or particle sources, and possibly an air cleaner is used). ▪ Go to a "cleaner air" shelter (see Appendix D) or possibly out of area *General Population:* Follow advice for sensitive groups in box above. ▪ Identify potential "cleaner air" shelters in the community (see Appendix D).
Very Unhealthy	Significant aggravation of heart or lung disease, premature mortality in persons with cardiopulmonary disease and the elderly; significant increase in respiratory effects in general population.	*General Population:* should avoid prolonged or heavy exertion ▪ Stay indoors, avoid exertion	*General Population:* If symptomatic, evacuate to cleaner air shelter or leave area, if safe to do so.
Hazardous	Serious aggravation of heart or lung disease, premature mortality in persons with cardiopulmonary disease and the elderly; serious risk of respiratory effects in general population.	*General Population:* should avoid any outdoor activity.	*General Population:* If symptomatic, evacuate to cleaner air shelter or leave area, if safe to do so.

1 Higher advisory levels automatically incorporate all of the guidance offered at lower levels.

Table 3 Recommended Actions for Public Health Officials[2,3]

AQI Category (AQI Values)	$PM_{2.5}$ or PM_{10} Levels ($\mu g/m^3$, 1- to 3-hr avg.)	$PM_{2.5}$ or PM_{10} Levels ($\mu g/m^3$, 8-hr avg.)	$PM_{2.5}$ or PM_{10} Levels ($\mu g/m^3$, 24-hr avg.)	Visibility - Arid Conditions (miles)	Recommended Actions
Good (0 to 50)	0 – 38	0 – 22	0 – 15	≥ 11	If smoke event forecast, implement communication plan
Moderate (51 to 100)	39 – 88	23 – 50	16 – 35	6 – 10	• Issue public service announcements (PSAs) advising public about health effects and symptoms and ways to reduce exposure • Distribute information about exposure avoidance
Unhealthy for Sensitive Groups (101 to 150)	89 – 138	51 – 79	36 – 65	3 – 5	• If smoke event projected to be prolonged, evaluate and notify possible sites for cleaner air shelters • If smoke event projected to be prolonged, prepare evacuation plans
Unhealthy (151 to 200)	139 – 351	80 – 200	66 – 150	1.5 – 2.75	• Consider "Smoke Day" for schools (i.e., no school that day), possibly based on school environment and travel considerations • Consider canceling public events, based on public health and travel considerations
Very Unhealthy (201 to 300)	352 – 526	201 – 300	151 – 250	1 – 1.25	• Consider closing some or all schools (However, newer schools with a central air cleaning filter may be more protective than older, leakier homes. See "Closures", below) • Cancel outdoor events (e.g., concerts and competitive sports)
Hazardous (> 300)	> 526	> 300	> 250	< 1	• Close Schools • Cancel outdoor events (e.g., concerts and competitive sports) • Consider closing workplaces not essential to public health • If PM level projected to continue to remain high for a prolonged time, consider evacuation of sensitive populations

[2] These 1- and 8-hr PM2.5 levels are estimated using the 24-hr breakpoints of the PM2.5 Air Quality Index included in the February 7, 2007 issue paper (http://www.epa.gov/airnow/aqi_issue_paper_020707.pdf) by dividing the 24-hr concentrations by the following ratios: 8-hr ratio is 0.7, 1-hr ratio is 0.4. Visibility is based on 1-hr values. If only PM_{10} measurements are available during smoky conditions, it can be assumed that the PM_{10} is composed primarily of fine particles ($PM_{2.5}$), and that therefore the AQI and associated cautionary statements and advisories for $PM_{2.5}$ may be used. This assumption is reflected in the column headings for Table 3.

[3] Washington and Montana have developed more precautionary breakpoints, which can be found at: http://www.deq.mt.gov/FireUpdates/BreakpointsRevised.asp and http://www.ecy.wa.gov/programs/air/pdfs/WAQA.pdf

Bibliography

American Lung Association, Lung Disease Data: 2008, http://www.lungusa.org/site/c.dvLUK9O0E/b.4136273/k.16D5/Lung_Disease_Data_2008.htm#V

Barn P, Larson T, Noullett M, Kennedy S, Copes R, Brauer M. 2007. Infiltration of forest fire and residential wood smoke: an evaluation of air cleaner effectiveness. J Expo Sci Environ Epidemiol. 5 December 2007; [Epub ahead of pring] doi:10.1038/sj.jes.7500640.

California Air Resources Board, Fact Sheet on Air Cleaning Devices and the Home: Available at: http://www.arb.ca.gov/research/indoor/acdsumm.pdf

California Air Resources Board, Hazardous Ozone-generating "Air Purifiers"; Fact Sheet: Beware of Ozone-generating Air Cleaners; How to select an air cleaner; CADR link; Consumer Reports articles, and other information. Available at: http://www.arb.ca.gov/research/indoor/ozone.htm

Coefield J, Cain C. 2001. Forest Fire Smoke Categories. Montana Department of Environmental Quality, PO Box 200901, Helena, MT 59620.

Hansen, ES. A cohort study on the mortality of firefighters. Br J Ind Med 47: 805-809, 1990.

Henderson DE, Milford JB, Miller SL. 2005. Prescribed burns and wildfires in Colorado: impacts of mitigation measures on indoor air particulate matter. J Air Waste Manag Assoc. 55:1516-26.

Naeher L, Brauer M, Lipsett M, Simpson C, Koenig JQ, Zelikoff J, Smith KR. 2007. Woodsmoke health effects: a review. Inhal Toxicol 2007;19:67-106.

Reinhardt, Timothy and Roger Ottmar. 2000. Smoke exposure at western wildfires. Res. Pap. PNW-RP-525. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. Available at http://www.fs.fed.us/pnw/pubs/pnw_rp525.pdf

U.S. Environmental Protection Agency. 2001. Ozone Generators that are Sold as Air Cleaners: An Assessment of Effectiveness and Health Consequences. Available at http://www.epa.gov/iaq/pubs/ozonegen.html.

U.S. Environmental Protection Agency, 2000. The Air Quality Index Guide to Air Quality and Your Health. Research Triangle Park, NC. Available at http://www.epa.gov/airnow/aqibroch/

U.S. EPA. Air Quality Criteria for Particulate Matter (October 2004). U.S. Environmental Protection Agency, Washington, DC, EPA 600/P-99/002aF-bF, 2004. Available at http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=87903

U.S. Environmental Protection Agency. 2007. Guide to Air Cleaners in the Home. Office of Air and Radiation, Washington, DC, 20460. EPA 402-F-07-018. Available at http://www.epa.gov/iaq/pubs/airclean.html

Additional Resources and Links

Current active wildfire information

California Department of Forestry and Fire Protection. http://www.fire.ca.gov/index.php

Geographic Area Coordination Center's National Portal. http://gacc.nifc.gov/links/links.htm Provides links to regional geographic centers with specific information about fires in the region.

Incident Information Center. http://www.inciweb.org/ Provides updates on all national fires, often several times a day.

Forest Service Wildland Fire Morning Report**.** http://www.fs.fed.us/news/fire/

Satellite images of fires and smoke

NOAA Fire Events. http://www.osei.noaa.gov/Events/Fires Satellite images of fires

Geospatial Multi-Agency Coordination. http://geomac.usgs.gov/# A GIS-based site with the locations of fires throughout the country.

NASA images. http://modis.gsfc.nasa.gov/ Satellite images of fires and smoke

Smoke prediction tools: http://www.firedetect.noaa.gov/viewer.htm
http://www.fs.fed.us/pnw/airfire/
http://www.fs.fed.us/fcamms/
http://marlin.cfr.washington.edu/website/bsr_cansac

Weather information

National Weather Service:

Western Region	http://www.wrh.noaa.gov/
Eastern Region	http://www.erh.noaa.gov/
Southern Region	http://www.srh.noaa.gov/
Central Region	http://www.crh.noaa.gov/

Websites that report information on wildfire smoke and health effects

Environmental Protection Agency Air Now**:** http://airnow.gov/
California: http://www.fire.ca.gov/index.php
Montana: http://www.deq.state.mt.us/FireUpdates/index.asp
Washington: http://www.ecy.wa.gov/programs/air/pdfs/WAQA.pdf

Appendix A: Cal/OSHA Interim Guidance on Protecting Workers in Offices and Similar Indoor Workplaces from Wildfire Smoke

Cal/OSHA Interim Guidance on Protecting Workers in Offices and Similar Indoor Workplaces from Wildfire Smoke (July 2008)

Windborne wildfire smoke can be a hazard for people who work in office and commercial buildings many miles from evacuation zones. Environmental and public health agencies have advised people that they should consider setting air conditioners in their homes to recirculation mode, if possible, in order to reduce the intake of pollutants. Subsequently, people have asked whether this advice to limit the introduction of outdoor air applies to office and commercial buildings. Cal/OSHA does not generally recommend eliminating or substantially reducing the outdoor air supply in office buildings and other indoor workplaces as a first step to reduce exposure to smoke.

The ventilation systems in office buildings and other commercial buildings are more complicated than home air-conditioning systems. Changing the outdoor air supply in public and commercial buildings can adversely affect other essential functions of the building. These buildings typically have heating, ventilating and air conditioning systems (HVAC systems) that bring outside air into the building through filters, blend it with building return air, and thermally condition the air before distributing it throughout the building. These buildings also have exhaust air systems for restrooms and kitchens, and may also have local exhaust systems for garages, laboratory fume hoods, or other operations. These exhaust systems require makeup air (outdoor air) in order to function properly. Also, without an adequate supply of outdoor air, these systems may create negative pressure in the building. This negative pressure will increase the movement of unfiltered air into the building through any openings, such as plumbing/sewer vents, doors, windows, junctions between building surfaces, or cracks. In general, buildings should be operated at slight positive pressure in order to keep contaminants out, and to help exhaust air systems function properly.

Cal/OSHA regulations (8 CCR 5142) require that HVAC systems be operated continuously while occupied in order to provide the minimum quantity of outdoor air required by the state building code at the time the building permit was issued. (These regulations are currently found in the California Code of Regulations, Title 24, Section 121). For most buildings, this quantity is the largest of:

1. 15 cubic feet per minute (cfm) per person (it may be less in older buildings),
2. 0.15 cfm per square foot of conditioned floor space, or
3. The amount of air necessary to make up the air exhausted by exhaust ventilation systems in the building (such as restroom, kitchen, or local exhaust systems).

Using the HVAC System to Protect Building Occupants from Smoke

As a first step to protect building occupants from outdoor air pollution, including the hazardous conditions resulting from wildfire smoke, building managers and employers should ensure that the HVAC system filters are not dirty, damaged, dislodged, or leaking around the edges. Before the wildfire season, or during smoke events if necessary, employers and building operators should ensure that a qualified technician inspects the

HVAC system, makes necessary repairs, and conducts appropriate maintenance. Filters should fit snugly in their frames, and should have gaskets or sealants on all perimeter edges to ensure that air does not leak around the filters.

Building operators should consider installation of the highest efficiency filters that do not exceed the static pressure limits of the HVAC system, as specified by the manufacturer or system designer.[1] Pressure gauges should be installed across the filter to indicate when the filter needs replacing, especially in very smoky or dusty areas. Indoor contaminants can be further reduced by using stand-alone High Efficiency Particulate Air (HEPA) filtering units. For more information on air cleaners, see the California Air Resources Board webpage at: http://www.arb.ca.gov/research/indoor/particles.htm.

Cal/OSHA recognizes that in some circumstances it may be helpful to reduce the amount of outdoor air in order to reduce smoke pollution inside the building, while still maintaining positive pressure in the building. Therefore, Cal/OSHA will not issue citations during smoke events for temporary reductions in outdoor air flow rates that are below the requirements of 8 CCR 5142 when all of the following conditions are met:

1. The local outdoor air quality for particulate matter meets the Environmental Protection Agency (EPA) Air Quality Index definition of Unhealthy, Very Unhealthy, or Hazardous due to wildfire smoke.

2. A qualified HVAC technician has inspected the HVAC system and ensured that the filters are functioning properly, that the filter bank is in good repair, and that the highest feasible level of filtration has been provided. This must be documented in writing.

3. A qualified HVAC technician or engineer has assessed the building mechanical systems and determined, in writing, the amount of outside air necessary to prevent negative pressurization of the building, and to sufficiently ventilate any hazardous processes in the building (such as enclosed parking garages or laboratory operations).

4. The HVAC system is operated continuously while the building is occupied to provide at least the minimum quantity of outdoor air needed, as determined by the HVAC technician or engineer in Item 3 above.

5. The employer or building operator ensures that the system is restored to maintain the outdoor air supply levels required by Section 5142 no later than 48 hours after the particulate matter levels fall below the levels designated by the EPA as Unhealthy.

---

[1] California Air Resources Board staff has advised that most HVAC systems should be able to accommodate a pleated, medium-efficiency filter with particle removal ratings of MERV 6 to 11, and some may be able to use filters with ratings of MERV 13 or more. Consider a low-pressure HEPA filter (MERV 17 plus) if the building occupants have respiratory or heart disease conditions, or if the building experiences frequent wildfire episodes.

Other Actions to Protect Employees from Wildfire Smoke

In addition to assessing and if necessary modifying the function of the HVAC system, employers are encouraged to take other reasonable steps to reduce employee exposure to smoke, including alternate work assignments or relocation and telecommuting. Some buildings rely on open windows, doors, and vents for outdoor air, and some may have mechanical ventilation systems that lack a functioning filtration system to remove airborne particles. In these cases, the employees may need to be relocated to a safer location. Employees with asthma, other respiratory diseases, or cardiovascular diseases, should be advised to consult their physician for appropriate measures to minimize health risks.

Respirators, such as N95s and other filtering facepiece respirators, may provide additional protection to some employees against environmental smoke. Employees whose work assignments require the use of respirators must be included in a respiratory protection program (including training, medical evaluations, and fit-testing). However, employers may provide filtering facepiece respirators to employees who voluntarily choose to use them to protect themselves against environmental smoke; in this situation employers are not required to provide a medical evaluation or fit-test. Employers should tell these employees that the respirator will provide some protection against the particles in smoke, but that it will not provide complete protection, and that a respirator that has not been fit-tested may not provide the maximum level of protection. Employees should be told that the respirator does not protect against gases or vapors. Although a medical evaluation is not required, the employer should advise employees to consult their doctor about potential exposures to smoke and respirator use, particularly if they have certain health problems such as respiratory or heart conditions. Employees should also be provided with a copy of Cal/OSHA Regulation, Title 8, Section 5144, Appendix D (http://www.dir.ca.gov/Title8/5144d.html). The California Department of Public Health has prepared a fact sheet on the use of N95 respirators called "Protect Your Lungs from Wildfire Smoke," which can be found at: http://bepreparedcalifornia.ca.gov/epo/.

Additional Information

The Lawrence Berkeley National Laboratory has produced a multi-page summary of research results on the effectiveness, cost, and health benefits of filtration, which can be found at: http://eetd.lbl.gov/iep/viaq/v_filtration_1.html.

Appendix B: Protect Your Lungs from Wildfire Smoke

Protect Your Lungs from Wildfire Smoke





N95 respirators can help protect your lungs from wildfire smoke. Straps must go above and below the ears.



A one-strap paper mask will NOT protect your lungs from wildfire smoke.



A surgical mask will NOT protect your lungs from wildfire smoke.

Wildfire smoke can irritate your eyes, nose, throat and lungs. It can make you cough and wheeze, and can make it hard to breathe. If you have asthma or another lung disease, or heart disease, inhaling wildfire smoke can be especially harmful.

If you cannot **leave** the smoky area, good ways to protect your lungs from wildfire smoke include staying indoors and reducing physical activity. Wearing a special mask called a "**particulate respirator**" can also help protect your lungs from wildfire smoke.

How to Choose the Correct Mask to Protect Your Lungs

- Choose a mask called a "**particulate respirator**" that has the word "**NIOSH**" and either "**N95**" or "**P100**" printed on it. These are sold at many hardware and home repair stores and pharmacies.
- Choose a mask that has **two straps** that go around your head. **DO NOT** choose a mask with only one strap or with straps that just hook over the ears.
- Choose a size that will fit over your nose and under your chin. It should seal tightly to your face. These masks do not come in sizes that fit young children.
- Do not use bandanas (wet or dry), paper or surgical masks, or tissues held over the mouth and nose. These will not protect your lungs from wildfire smoke.

How to Use a Mask

- Place the mask over your nose and under your chin, with one strap placed below the ears and one strap above.
- Pinch the metal part of the mask tightly over the top of your nose.
- The mask fits best on clean shaven skin.
- Throw out your mask when it gets harder to breathe through, or if the inside gets dirty. Use a new mask each day if you can.
- It is harder to breathe through a mask, so take breaks often if you work outside.
- If you feel dizzy or nauseated, go to a less smoky area, take off your mask and get medical help.
- If you have a heart or lung problem, ask your doctor before using a mask.

For more information about protecting yourself from wildfire smoke, call your local health department.

June 30, 2008

Appendix C: Protect Yourself from Wildfire Ash

and

National Institute for Occupational Safety and Health Interim Fact Sheet: NIOSH Warns of Hazards during Cleanup Work Following Forest Fires

Protect Yourself from Wildfire Ash

Ash from wildfires can make you cough, and irritate your eyes, skin, nose, and throat. It is similar to ash in your fireplace, but may contain small amounts of chemicals that can cause cancer. If you need to clean up ash on your property, take these steps to protect yourself and your family:

- DO NOT let children touch, play in, or help clean up ash.
- Wear gloves, closed-toed shoes, long-sleeved shirts, long pants, and safety goggles. If you get ash on your skin or in your eyes, wash it off immediately. Change and clean your clothes and shoes after you finish.
- Wear a mask called a "particulate respirator" to help protect your lungs from ash.
  - Look for a mask that has two straps that go around your head and the words "NIOSH" and either "N95" or "P100" printed on the mask. These masks are sold at pharmacies, hardware, and home repair stores.
  - If you cannot get an N95 or P100 mask, one-strap dust masks or other face coverings may help keep ash out of your nose and mouth, but will not protect your lungs.
- Avoid doing anything that stirs up ash, including dry sweeping or using leaf blowers.
- Wet-mop floors and decks, and clean smaller areas with a wet cloth. Limit your use of vacuum cleaners unless they have a special "HEPA" or "high-efficiency" filter.
- With a wet cloth, gently clean toys, pet bedding and dishes, and any fruits and vegetables from your garden.
- DO NOT use a lot of water when cleaning and don't wash ash into storm drains.
- Collect ash in plastic bags and place them in the trash can.

Ash and debris from burned buildings, including houses, can be especially harmful to your health. If you are allowed to reenter your burned property, spend as little time there as you can and follow this advice:

- Avoid burned items that may contain hazardous chemicals, including:
  ☞cleaning products ☞paint and solvent containers ☞pesticides ☞batteries ☞plastics ☞computers ☞televisions ☞other electronic devices ☞melted metal ☞electrical wiring ☞chemically treated wood ☞ammunition ☞cars ☞tires ☞ insulation and roofing material ☞ water heaters and furnaces ☞ appliances
- Ash from wooden decks, fences, and retaining walls treated with CCA (formerly used because it prevents dry rot and insects) may contain lethal amounts of arsenic.
- DO NOT touch the above items or wood that may have been treated with CCA before contacting your local hazardous waste agency or health department.
- If you find items you want to keep that are not burned or are not on the list above, put them in a plastic bag until you can clean them with a wet cloth.

For more advice on protecting yourself and your family when cleaning up wildfire ash, call the Department of Toxic Substances Control at (916) 445-2625, or go to:
http://www.dtsc.ca.gov/HazardousWaste/upload/Fire_Emergency_Guidance_FS_1.pdf
http://www.dtsc.ca.gov/HazardousWaste/upload/Emergency-Guidance-on-Wildfires-2.pdf

INTERIM FACT SHEET

NIOSH Warns of Hazards during Cleanup Work Following Forest Fires

---

The National Institute for Occupational Safety and Health (NIOSH) warns workers and volunteers of the potential dangers involved with cleanup operations following the devastation caused by forest fires. Because the level of experience varies among these workers, cleanup crews must work together and look out for one another to ensure safety. NIOSH urgently requests your assistance in disseminating the following warnings to all those involved in cleanup work following forest fires. The potential work-related hazards listed here are described below in greater detail: Fire, Electrical Hazards, Carbon Monoxide, Musculoskeletal Hazards, Thermal Stresses, Heavy Equipment, Structural Instability, Hazardous Materials, Confined Spaces, Power Line Hazards, Agricultural Hazards, Stress and Fatigue. Additional key resources on health and safety hazards related to fire fighting can be found on the NIOSH web site under the "spotlights" section titled "Fighting Wildfires" (http://www.cdc.gov/niosh/topics/firefighting/).

General Considerations

Before cleanup operations are initiated, local and State government emergency policies and guidelines should be checked to determine if any restrictions exist (e.g., water use, discharge of waste water, disposal of debris).

POTENTIAL DANGERS INVOLVED IN CLEANUP OPERATIONS

Fire

Heat sources may remain as a result of smoldering wood or other debris that could reignite if contact is made with a combustible material or if oxygen becomes available. Workers and employers must therefore take extra precautions. At least two fire extinguishers, each with a UL rating of at least 10A, should be provided at every cleanup activity.

Electrical Hazards

NIOSH has investigated several work-related electrocution deaths following natural disasters. To prevent future electrocutions, NIOSH urges those involved in cleanup activities to take the following steps:

- If water has been present anywhere near electrical circuits and electrical equipment, turn off the power at the main breaker or fuse on the service panel. Do not turn the power back on until electrical equipment has been inspected by a qualified electrician. Never enter flooded areas or touch electrical equipment if the ground is wet, unless you are certain that the power is off. **NEVER** handle a

downed power line. No not use electrical equipment that has been exposed to heat from the fire until checked by an electrician.

- When using gasoline and diesel generators to supply power to a building, switch the main breaker or fuse on the building service panel to the "off" position prior to starting the generator. This will prevent inadvertent energization of power lines from backfeed electrical energy from the generators, and help to protect utility line workers from possible electrocution.

- If clearing or other work must be performed near a downed power line, contact the utility company to discuss de-energizing and grounding or shielding of power lines; maintain a safe distance from the power lines until they have been de-energized. Extreme caution is necessary when moving ladders and other equipment near overhead power lines to avoid inadvertent contact. If you are working on or near power lines, refer to the additional recommendations provided in that section below. Be aware of possible fire damage to poles and other structures carrying overhead power lines.

Unstable Work Surfaces

Cleanup activities may involve walking on unstable surfaces such as construction debris, trees and other vegetation. Piles of debris and other unstable work surfaces create a risk for traumatic injury from slips, falls, puncture wounds from nails and sharp objects, and collapsing materials. Extreme caution is necessary when working on these surfaces. Protective equipment, such as hard hats, safety glasses, leather gloves, and steel toe boots should be considered to minimize the risk of injury.

Carbon Monoxide

Cleanup activities may involve the use of gasoline- or diesel-powered pumps, generators, and pressure washers. Because these devices release carbon monoxide, a deadly, colorless, odorless gas, operate all gasoline-powered devices outdoors and **never** bring them indoors. It is virtually impossible to assess adequate ventilation. NIOSH has investigated several carbon monoxide poisoning deaths in the past caused by the use of gasoline-powered engines indoors or in confined spaces. Be aware that high levels of carbon monoxide may occur in confined spaces from the fires.

Musculoskeletal Hazards

Cleanup workers are at risk for developing serious musculoskeletal injuries to the hands, back, knees, and shoulders. Special attention is needed to avoid back injuries associated with manual lifting and handling of debris and building materials. To help prevent injury, use teams of two or more to move bulky objects, avoid lifting any material that weighs more than 50 pounds (per person), and use proper automated-assist lifting devices.

Thermal Stresses

Heat: Cleanup workers are at serious risk for developing heat stress. Excessive exposure to hot environments can cause a variety of heat-related problems, including heat stroke, heat exhaustion, heat cramps, and fainting. To reduce the potential for heat stress, drink a glass of fluid every 15 to 20 minutes and wear light-colored, loose- fitting clothing. Additionally, incorporate work-rest cycles into work routines, work during the cooler hours of the day, when possible, or distribute the workload evenly throughout the day. When air conditioning is unavailable, open windows and use fans.

Cold: If standing water is present from fire fighting be aware that working in water which is cooler than 75 degrees F (24 degrees C) will remove body heat more rapidly than it can be replaced, resulting in hypothermia. To reduce the risk of hypothermia, wear high rubber boots, ensure that clothing and boots have adequate insulation, avoid working alone, take frequent breaks out of the water, and change into dry clothing when possible.

Heavy Equipment

Only those properly trained should operate heavy equipment such as bulldozers, backhoes, and tractors. If you are operating this type of equipment, make sure you turn it off and block it against motion when not in use. Operators should be aware of the activities around them to protect other workers on foot from being struck by moving equipment. Heavy equipment operators should not exceed the load capacity of cranes and other lifting equipment and ensure that workers do not walk under areas where cranes and other heavy equipment are being used to lift objects.

Structural Instability

Fires can rearrange and damage natural walkways, as well as sidewalks, parking lots, roads, and buildings. Never assume that fire-damaged structures or ground are stable. Buildings that have been burned may have suffered structural damage and could be dangerous. Don t work in or around any building damaged by fire until it has been examined and certified as safe for work by a registered professional engineer or architect. Assume all stairs, floors, and roofs are unsafe until they are inspected. Leave immediately if you hear shifting or unusual noises as this may signal a possible collapse.

Hazardous Materials

Fires to commercial and residential buildings and water used to fight the fire can dislodge tanks, drums, pipes, and equipment, which may contain hazardous materials such as pesticides or propane. Containers may be damaged by fire and heat. Do not attempt to move unidentified dislodged containers without first contacting the local fire department or hazardous materials team. If working in potentially contaminated areas, avoid skin contact or inhalation of vapors by wearing appropriate protective clothing and respirators. Contact NIOSH for more information on the proper safety equipment. Frequently and thoroughly wash skin areas that may have been exposed to pesticides and other hazardous chemicals.

PREVENTION MEASURES

First Aid

First aid, even for minor cuts and burns, is extremely important. Immediately clean out all open wounds and cuts with soap and clean water. Most cuts, except minor scratches, sustained during cleanup activities will warrant treatment to prevent tetanus. If you are injured, contact a physician to determine the necessary type of treatment.

Protective Equipment

For most clean-up work activities, you will need the following personal protective equipment: hard hats, safety goggles, heavy work gloves, and watertight boots with steel toe and insole (not just steel shank). For information on what equipment you need for protection, contact your local OSHA office or NIOSH.

Excessive noise from equipment such as chain saws, backhoes, tractors, pavement breakers, blowers, and from heavy equipment (e.g., earth moving equipment, helicopters) may cause ringing in the ears and subsequent hearing damage. If working with any noise that you must shout over to be heard, you should wear earplugs or other hearing protection devices.

Working in Confined Spaces

If you are required to work in a boiler, furnace, pipeline, pit, pumping station, septic tank, sewage digester, storage tank, utility vault, well, silo, or similar enclosed structures, you should be aware of the hazards of working in confined spaces. A confined space has one or more of the following characteristics:

- limited openings for entry or exit;
- unfavorable natural ventilation; or
- is not designed for continuous worker occupancy.

Toxic gases, a lack of oxygen, or explosive conditions may exist in the confined area, resulting in a potentially deadly atmosphere. Because many toxic gases and vapors cannot be seen or smelled, never trust your senses to determine if safe entry is possible. Never enter a confined space unless you have been properly trained, even to rescue a fellow worker! If you need to enter a confined space and do not have the proper training and equipment, contact your local fire department for assistance.

Working On or Near Power Lines [Recommendations for Utility Workers-ONLY]

Several workers have died of electrocution following natural disasters. Workers and employers must take extreme caution while attempting to restore power or clear areas near downed power lines. In one instance, a worker lost his life while removing trees from a de-energized power line that had been knocked down by a storm. While inspecting the completed work, the man stepped on the line and was electrocuted by "feedback" energy from a portable backup generator at a nearby gas station. Feedback energy occurs when a de-energized line becomes energized by a secondary power source.

Another worker died cleaning branches from a power line, following a storm. He was electrocuted after falling from a tree onto a line thought to be de-energized. Although the workers had opened a fused switch on a transformer, the line remained energized through another transformer.

If you are working on or near power lines, the following steps may save your life:

- Treat all power lines as energized until you have followed the required procedures for personally de-energizing and testing them with an appropriate testing device. Do not rely on "fuzzing" to determine if a power line has been de-energized.
- Verifying that a line is not energized may not ensure your safety. You must also ground lines on both the load and supply sides of the work area. Grounding is necessary to protect you from the hazards of feedback electrical energy from a secondary power source, such as a portable generator.
- When restoring power in underground vaults, added precautions are necessary to avoid explosion hazards. As vaults containing electrical connections are drained or pumped out, and energized, potentially explosive gases may form. If you are required to work in a utility vault, refer to the Confined Spaces section of this Fact Sheet.

RESPIRATORY HAZARDS

If you are involved in cleanup efforts you may be exposed to ash, soot and fire decomposition products that may cause irritation and other respiratory effects. Spoiled and/or wet vegetation and other organic/agricultural materials often grow large amounts of bacteria and mold during warm weather. Breathing these organisms and the organic dust produced may cause lung disease. Use proper engineering controls to exhaust and replenish adequate fresh air if working indoors. A high efficiency particulate air (HEPA)-type vacuum is recommended when cleaning surfaces contaminated with dust. The use of a typical household vacuum should be avoided since it will re-suspend the collected dust into the air. When exposure to dusts cannot be controlled or avoided, exposure can be reduced by routine use of a well-fitted NIOSH-certified air-purifying respirator (such as an N-95 or more protective respirator).

STRESS, LONG HOURS, AND FATIGUE MAY INCREASE THE RISKS FOR INJURY AND ILLNESS

Continued long hours of work, combined with emotional and physical exhaustion and losses from damaged homes and temporary job layoffs, can create a highly stressful situation for cleanup workers. Workers exposed to these stressful conditions have an increased risk of injury and emotional crisis, and are more vulnerable to stress-induced illnesses and disease.

Emotional support from family members, neighbors, and local mental health professionals can help to prevent more serious stress-related problems in the difficult months ahead.
People working in all phases of cleanup work can reduce their risks of injury and illness in several ways:

- Set priorities for cleanup tasks and pace the work over several days (or weeks). Avoid physical exhaustion.
- Resume a normal sleep schedule as quickly as possible. Get plenty of rest and take frequent rest breaks BEFORE exhaustion builds up.
- Take advantage of disaster relief programs and services in your community.
- Be alert to emotional exhaustion or strain. When family members and neighbors are unavailable for emotional support, consult professionals at community health and mental health centers.

For more information about these or other occupational safety and health topics contact NIOSH at:

1-800-35-NIOSH (1-800-356-4674)
Fax: 513: 533-8573
E-mail: pubstaft@cdc.gov
www.cdc.gov/niosh

Appendix D: Identification and Preparation of Cleaner Air Shelters for Protection of the Public from Wildfire Smoke

Identification and Preparation of Cleaner Air Shelters for Protection of the Public from Wildfire Smoke

1. Identify one or more facilities with tight-sealing windows and doors and public access (for example, public schools, fire stations, or hospitals). As a rule of thumb, newer buildings will generally be more desirable than older ones.
2. At a minimum, a Cleaner Air Shelter should have a central air filtration system that is at least medium or high efficiency. If needed, filters should be upgraded prior to the fire season, after assuring that the system can handle the increased airflow resistance. Ideally, the ventilation system should also be capable of reducing outdoor air intake, if needed. For more information on operation of the HVAC system during smoke events, see Appendix A.
3. Install/inspect a room air cleaner or preferably a central air cleaner with sufficient capability, i.e., a Clean Air Delivery Rate (CADR) that is twice the room volume for room units, or ASHRAE filter efficiency greater than 80% for central air cleaners.* Ensure proper maintenance of air cleaners, keep spare filters on hand, and provide instructions on changing the filter to trained personnel.
4. Assure that the facility can handle the increased cooling load due to high occupancy.
5. Install a properly calibrated carbon monoxide (CO) alarm that has a digital display and battery backup function (available at most hardware stores).
6. Provide a radio for updates on fire status and access to a telephone in case of emergency.

* American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) Standard 52.1-1992. "Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter".

Appendix E: Smoke alert examples: North Coast Unified Air Quality Management District, Northern California, July 2008

North Coast Unified Air Quality
Management District
2300 Myrtle Avenue, Eureka, CA 95501
Telephone (707) 443-3093 FAX (707) 443-3099
http://www.ncuaqmd.org

Air Quality Alert Issued
7-20-08 10:30AM

For the following areas:

Humboldt County: Willow Creek and all areas proximal to the wildfires.

Trinity County: Burnt Ranch, Junction City, Helena, Big Bar, Big Flat, Weaverville, Covington Mill, Hayfork, Hyampom, Mad River, Zenia, and all areas near the wildfires.

Smoke levels in these areas have been classified as VERY UNHEALTHY. Individuals in these areas should follow all health protective guidelines for smoke conditions, including limiting activity and staying indoors. Please see the guidelines listed on the general Public Service Announcement issued today.

Hayfork and Hyampom may reach Hazardous conditions today. Please stay alert for further updates.

Lightning has ignited fires in Humboldt, Del Norte and Trinity Counties. Smoke accumulation near the fires is expected to remain heavy today and tonight. Overnight temperature inversions may cause heavier smoke concentrations in lower elevations and valleys. Because of the increased pollution levels, the North Coast Unified Air Quality Management District is issuing an **Air Quality Alert** for **Saturday July 20, 2008**.

All individuals, especially the elderly, young children, pregnant women, those with lung or heart disease, and anyone else who is sensitive to air pollution should limit **outdoor activities today.**

If you have symptoms of lung or heart disease that may have been worsened by smoke exposure, contact your health care provider immediately. These symptoms include repeated coughing, shortness of breath or difficulty breathing, wheezing, chest tightness or pain, palpitations, nausea, unusual fatigue or lightheadedness.

If you have lung disease (including asthma), heart disease, are elderly, or have children in your home, please consider a visit to your health practitioner now, to discuss any precautions you may wish to take should the smoke become worse in your area.

For 24-hour Air Quality Advisory Information, call toll-free at (866) 287-6329 and press (5) on your touch tone phone. For additional local information, please visit the North Coast Unified Air Quality Management District's Website at www.ncuaqmd.org . Please visit the CAPCOA website at www.airquality.org/smokeimpact for additional health information.

NORTH COAST UNIFIED AIR QUALITY MANAGEMENT DISTRICT
2300 Myrtle Avenue, Eureka, CA 95501
Phone: (707) 443-3093 Fax: (707) 443-3099

Saturday, July 20, 2008

WILDFIRE SMOKE WARNING
PUBLIC SERVICE ANNOUNCEMENT

Unhealthy levels of wildfire smoke are expected in the following areas:

- **Humboldt County** (Somes Bar, Orleans, Weitchpec, Hoopa)
- **Southern Del Norte County**
- **Trinity County**

Areas of smoke are expected at the Coast today.

Wildfire smoke has harmful chemicals that can affect your health. It can cause eye and throat irritation, coughing, and difficulty breathing. **People who are at greatest risk of experiencing symptoms due to smoke include those with chronic lung disease (such as asthma) and/or heart disease, young children, pregnant women, and older adults.** Even healthy adults can be affected by smoke. Seek medical help if you have symptoms that worsen or become severe.

If you smell or see smoke, take these steps to protect your health:

✓ Minimize or stop outdoor activities, especially exercise.
✓ Stay indoors with windows and doors closed.
  - o Do not run any fans that bring smoky outdoor air inside, including swamp coolers, "whole-house" fans or "fresh air ventilation systems."
  - o Run your air-conditioner only if it does not bring in smoke from outdoors. Change the standard air-conditioner filter to a medium or high efficiency filter. If you have a wall-unit or window-unit air conditioner, set it to "re-circulate."
  - o Do not smoke, fry food, or do other things that will create indoor air pollution.

✓ **If you have any chronic lung disease (including asthma) or heart disease, closely monitor your health and contact your doctor immediately if you have symptoms that worsen,** including repeated coughing, shortness of breath or difficulty breathing, wheezing, chest

tightness or pain, palpitations, nausea, unusual fatigue or lightheadedness. Consider going to an emergency shelter or leaving the area until smoke conditions improve.

If you do <u>not</u> have air conditioning, take these additional steps to protect yourself and your family from heat exhaustion, which can be especially dangerous for infants, children, the elderly, and people with chronic disease.

- ✓ Lower body temperature by using cold compresses, misting, and taking cool showers, baths, or sponge baths.
- ✓ Drink plenty of fluids. Don't wait until you're thirsty to drink. However, if your doctor has told you to limit the amount you drink or you are taking water pills, ask your doctor how much you should drink during the heat.
- ✓ Avoid drinks with alcohol or large amounts of sugar, as these can promote dehydration.
- ✓ Consider moving to location that has air conditioning.
- ✓ Do not exercise or do physical activity.
- ✓ Wear light-weight and light-colored clothing.
- ✓ Watch for signs of heat exhaustion, including fatigue, nausea, headache, and vomiting, and contact your doctor immediately if these occur.

Stayed tuned for additional <u>air quality emergency announcements</u>

Contact your doctor to discuss what you should do if smoke becomes worse in your area, especially if you have lung disease (including asthma), heart disease, are elderly, pregnant, or have children in your home.

For 24-hour Air Quality Advisory Information, call toll-free at (866) 287-6329 and press (5) on your touch tone phone.

For Further information, please visit the NCUAQMD website at www.ncuaqmd.org