

Wildfire Smoke

A Guide for Public Health Officials

Revised May 2016



U.S. Environmental Protection Agency * U.S. Forest Service * U.S. Centers for Disease Control and Prevention * California Air Resources Board

NOTE: This guide, which was last revised in 2008, is designed to help local public health officials prepare for smoke events, to take measures to protect the public when smoke is present, and communicate with the public about wildfire smoke and health. The 2016 version has been updated with the assistance and expertise from a number of federal and state agencies. Please “test drive” this version during the 2016 wildfire season and send us feedback. Is the information in the guide clear? Are there additional materials, such as fact sheets, that would be helpful to you? Let us know what works well for you, and what doesn’t. We’ll use that feedback to create a new version, which we plan to distribute as early in the 2017 fire season as possible. The 2017 version will include additional features, such as downloadable fact sheets.

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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.

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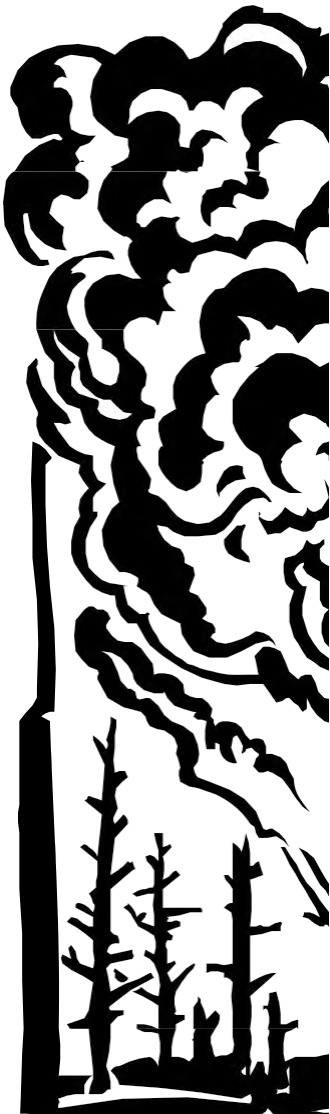
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Introduction

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 can occur without warning – but we can be prepared. This guide is intended to provide local public health officials with information they need to be prepared for smoke events and, when wildfire smoke is present adequately communicate health risks, and take measures to protect the public. This guide is the product of a collaborative effort by scientists, air quality specialists, land managers 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 how efficiently a fuel burns, 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 that are released as smoke when burned.

Particulate matter is the principal pollutant of concern from wildfire smoke for the relatively short-term exposures (hours to weeks) often 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 PM₁₀,

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_{10-2.5}, 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 therefore efficiently scatter light and impact visibility. Moreover, these particles are within the fine particle PM_{2.5} fraction and 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 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 with more smoke generated causing the potential of 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 combustion (flaming and smoldering). The smoldering phase of a fire when large rotten logs and duff consume, 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.

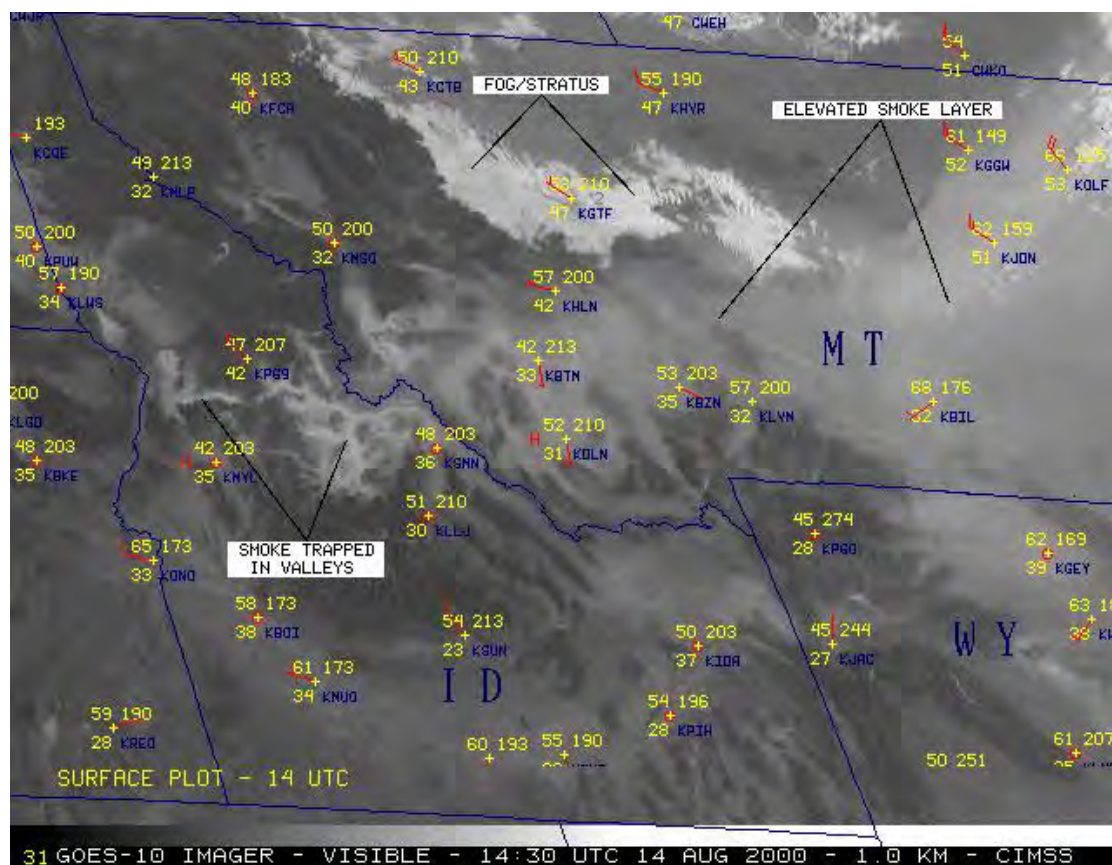


Figure 3. Dense smoke retained in valleys and low lying areas.

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. Please see "Additional Resources and Links" at the end of this Guide.

Unified response to wildfire smoke

Past practices of extinguishing every fire combined with impacts related to climate change are leading to larger, more intense, more frequent wildfires that threaten life, safety, and property. Wildfire smoke can result in significant air quality impacts to public health, particularly for at-risk groups, and impacts to safety and transportation through diminished visibility on roads and aviation corridors.

As wildfires and impacts of smoke have increased, there has been proactive response to this air quality impact to the health and safety of the public and fire personnel. The U.S. Forest Service (USFS) with many interagency partners such as the U.S. National Park Service (NPS) has developed the Wildland Fire Air Quality Response Program which directly addresses these risks posed by wildfire smoke. The Program has developed a national cache of smoke monitoring equipment that can be deployed to incidents to understand the magnitude of smoke impacts. The monitors were heavily used in western wildfires in 2014 and 2015. Smoke monitors which measure fine particulate matter, PM_{2.5} are tied into the GOES satellite system similar to Remote Automated Weather Stations (RAWS). The near-real time data is available to the public via the U.S. Environmental Protection Agency's (EPA's) AirNow website as well as smoke monitor data display systems developed by the Pacific Northwest Research Station's AirFire Team to support operational smoke forecasting. Generally, orders for monitors are tied to the overall emergency response to a wildfire and the interagency systems which support incident management teams.

The AirFire Team with their BlueSky smoke modeling system provides daily smoke impact modeling of active wildfires throughout the lower 48 states. Alaska BlueSky runs were added when wildfire smoke needs developed in 2015. The operational model products of BlueSky, which frequently utilize fine scale meteorological data supplied by U.S. National Oceanic and Atmospheric Administration (NOAA) for greater resolution and model performance, support active smoke and air quality impact forecasting downwind of large wildfires.

Combined with the monitoring data, these tools and products can be interpreted by technical specialists called Air Resource Advisors (ARAs) who craft messages for the public which are then coordinated with air quality and health agencies as well as other partners (see Appendix F for an example). These messages are routinely utilized by the incident public information officers in their fire information duties and outreach efforts as well as included in many state smoke blogs.

The ARA is a new type of technical specialist position which can operate as part of the incident management team on individual incidents as well as at larger, multi-fire scales depending on needs and availability of personnel. As the overall program is new and developing, shortages of ARAs are anticipated until the pool of qualified technical specialists is larger. The current pool of ARAs includes staff from the USFS along with many other agencies including EPA, U.S. Natural Resources Conservation Service (NRCS), U.S. Bureau of Land Management (BLM), NPS, U.S. Fish and Wildlife Service (FWS), as well as state, tribal and local governments. These technical specialists are trained in meteorology, atmospheric dispersion, smoke and fire modelling, air quality monitoring and the air quality effects of smoke to support their efforts in helping to craft public messages about the wildfire smoke impacts.

ARAs can be ordered as part of an incident management team responding to a wildfire or by the agency administrator for the land where the fire is occurring. All orders for ARAs are through the Resource Order and Status System (ROSS) used by wildland fire management agencies for movement of all emergency personnel. The Wildland Fire Air Quality Response Program is managed by the USFS, Fire and Aviation Management Program in Washington, D.C. Ultimately use and ordering of an ARA is dictated by the agency administrator who manages the land where the wildfire is occurring and is the key contact when wildfire smoke becomes significant and there is need for an ARA to be attached to the incident management team responding to the wildfire. When an ARA is deployed it will be posted at www.wildlandfiresmoke.net with contact information. This site will also be a repository for the daily one-page smoke impact forecasts and supporting information useful to others forecasting these impacts or for exceptional event demonstrations.

The monitoring and modeling of smoke impacts of wildfires can help fire managers, regulators, and the public understand the magnitude of current air quality impacts while the forecasting of future impacts allows development of effective messaging so that the public and fire personnel can respond accordingly and, when needed, take actions to reduce their exposure. Such air quality messaging and pre-exposure forecasting has been found to be effective especially for those who are at-risk to high air pollution levels. The focus on these serious wildfire smoke impacts has helped the public and governmental agencies become more aware of the risk air quality can pose to public health.

Health effects of smoke

Wildfires expose populations to a number of environmental hazards, e.g., fire, smoke, and the byproducts of combustion of wood, as well as, plastics and other chemicals that can be released from burning structures and furnishings, and also hazards such as psychological stress. During the acute phase, the major hazards are from the wildfire itself and associated smoke exposure.

Particulate matter exposure is the principal public health threat from short-term exposures to wildfire 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 heart failure, and premature death. Most of our understanding on the health effects of wildfire smoke are derived from studies of urban particulate matter, specifically fine particulate matter. These studies have found that short-term exposures (i.e., days to weeks) to fine particles, a major component of smoke, are linked with increased premature mortality and aggravation of pre-existing respiratory and cardiovascular disease. Children, pregnant women, and elderly are also especially vulnerable to smoke exposure. In addition, fine particles are respiratory irritants, and exposures to high concentrations can cause persistent cough, phlegm, wheezing, and difficulty breathing. Exposures to fine particles can also affect healthy people, causing respiratory symptoms, transient reductions in lung function, and pulmonary inflammation. Particulate matter may also affect the body's physiological mechanisms that remove inhaled foreign materials from the lungs, such as pollen and bacteria.



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 or 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. It is well characterized that smoke contains carcinogenic components with polycyclic aromatic hydrocarbons (PAHs) comprising the largest percent, and to a lesser extent benzene and formaldehyde. People exposed to toxic air pollutants, such as the ones mentioned above, 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 (i.e.,

over days to weeks) to carcinogens found in wildfire smoke are also small relative to total lifetime exposures to carcinogens in other, more common combustion sources. For example, epidemiological studies have shown that urban firefighters who are occupationally exposed to smoke over an entire working lifetime are at increased risk of developing lung cancer (Hansen 1990) and other cancers (Daniels et al. 2014).

It is important to recognize that not everyone who is exposed to thick smoke from wildfires will have health problems. The level and duration of exposure, age, individual susceptibility, including the presence or absence of pre-existing lung (e.g., asthma, COPD) or heart disease, and other factors play significant roles in determining whether someone will experience smoke-related health problems. The types of potential individual responses should be discussed in public warnings about risks and the need to avoid exposure to smoke.

Sensitive populations

Most healthy adults and children will recover quickly from smoke exposure and will not suffer long-term health consequences. However, certain sensitive populations may experience more severe acute and chronic symptoms. Key risk factors that individually and collectively shape a population's vulnerability to health impacts from extreme events include age, health status, socioeconomic status, race/ethnicity, and occupation. Much of the information about how fine particles affect these groups has come from epidemiologic studies involving airborne particles in cities; however, the studies examining the effects of exposure specifically to smoke suggest that the health effects due to exposure to wildfire smoke are likely to be similar (Naeher et al. 2007, Liu et al. 2015). It appears that risk to fine particle-related health effects varies throughout a lifetime, generally being higher in early childhood, lower in healthy adolescents and younger adults, and increasing in middle age through old age as the incidence of heart and lung disease and diabetes increases. Therefore, certain lifestages (e.g., children) and populations (e.g., people with pre-existing respiratory and cardiovascular disease) should take precautions to limit exposures to wildfire smoke. If individuals with heart or lung disease are concerned about the potential health implications of exposure to wildfire smoke and actions they can take to limit exposures, they should discuss this with their primary healthcare provider and also check the Air Quality Index (AQI, discussed below) each day for the air quality forecast and for information about ways to reduce exposure, if necessary. Overall, the potential for increased frequency and severity of wildfires due to climate change could have important population-level effects. The following sections provide more specific information on subsets of the population that may be differentially affected by exposure to wildfire smoke.

Children. All 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. Major hazards to children during or immediately following a wildfire include fire and smoke. Other environmental hazards include air pollutants from burning structures and furnishings. Wildfire smoke can persist for days or even months, depending on the extent of the wildfire. Symptoms from smoke inhalation can include coughing, wheezing, difficulty breathing, and chest tightness. Even children who do not have asthma could experience these symptoms. Air pollution from wildfire can make asthma symptoms worse and trigger attacks. Research has shown a higher rate of asthma admissions for children during and after wildfires.

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.

In addition to the overt health effects and underlying physiologic differences between children and adults, children may also experience significant emotional distress, resulting from anxiety and grief following a wildfire. Therefore, it is important to consider not only the potential health implications of wildfire smoke on children, but also the potential longer term psychological implications. See factsheets about children's health in Appendix E.

Pregnant women. Pregnant women are at increased risk of the adverse effects of wildfire smoke both as individuals and the potential for adverse effects to their fetus, during a critical window of human development. Numerous physiologic changes occur during pregnancy increasing a woman's vulnerability to environmental exposures, such as increases in blood and plasma volumes and increased respiratory rates. While there have been a limited number of studies examining the health effects of exposure to wildfire smoke on pregnancy outcomes, which tend to be exposures that do not encompass all of pregnancy, there is evidence of some health effects to other combustion-related air pollution exposures. Specifically, there is substantial evidence of low birth weight due to repeated exposures to cigarette smoke, including both active and passive smoking and an emerging body of literature on the health effects of prenatal exposure to ambient air pollution. Chronic maternal exposure to ambient particulate matter and indoor biomass smoke during pregnancy has been linked to adverse birth and obstetrical outcomes (e.g., decreased infant birth weight, preterm birth. Holstius et al. (2012) conducted the lone epidemiologic study that examined the effect of wildfire smoke on pregnancy outcomes in Southern California and reported some evidence indicating a potential reduction in birth weight due to exposure to wildfire smoke while in utero. Additionally, psychosocial stress exacerbated by wildfires is another mechanism through which wildfire events may affect health of pregnant women and their fetus (Kumagai et al. 2004).

Older Adults. The proportion of the U.S. population of older adults is projected to almost double by 2030. Older adults are considered to be at increased risk of health effects attributed to short-term exposures to wildfire smoke due to a higher prevalence of pre-existing lung and heart diseases. Older adults may also be more affected than younger people because important physiologic processes, including defense mechanisms, decline with age. Epidemiologic studies of short-term exposures to fine particles have often reported a greater risk of health effects, including hospital admissions and premature mortality, in older adults. Additional evidence from animal toxicological studies and human clinical studies provide biological plausibility, and further support that older adults should limit exposures to fine particle sources, such as wildfire smoke.

Individuals with asthma and other respiratory diseases. More than 36 million people including more than 6 million children in the US suffer from chronic lung diseases such as asthma and chronic obstructive pulmonary disease (COPD) (American Lung Association 2008, CDC 2014). 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. Additionally, minority and impoverished children and adults bear a disproportionate burden associated with asthma and other diseases, which may increase their susceptibility to the health effects of wildfire smoke (Brim et al., 2008; CDC, 2014). However, this disease affects all age and sociodemographic groups.

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 wildfire smoke. In addition, because COPD is usually the result of many years of smoking, individuals with this condition may also have heart and vascular disease, and are potentially at risk of a health effect due to wildfire smoke exposure from both conditions.

Individuals with cardiovascular disease. Diseases of the circulatory system include high blood pressure, heart failure, and vascular diseases, such as coronary artery disease, and cerebrovascular conditions, such as diseased 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, and sudden death due to a cardiac arrhythmia, 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 fine particulate matter to increased risks of heart attacks, heart failure, cardiac arrhythmias, and other adverse effects in those with cardiovascular disease. In response to exposure to particulate matter 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.

Low Socioeconomic Status (SES). SES is often defined in epidemiologic studies using a

variety of indicators, such as educational attainment, median household income, percent of population in poverty, race/ethnicity, and location of residence. Although a variety of individual indicators have been used as a proxy for SES, it is well recognized that SES is a composite measure that encompasses a number of individual indicators along with other factors. Epidemiologic studies of particulate matter using indicators of SES have provided initial evidence that individuals of low SES are at increased risk of mortality due to short-term exposures. With respect to wildfire smoke the evidence is much more limited, but Rappold et al. (2012) demonstrated that counties classified as having the lowest SES were at the greatest risk of health effects attributed to wildfire smoke.

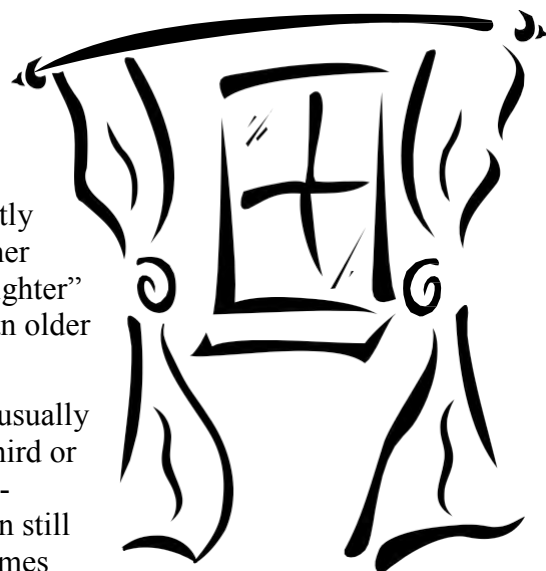
Additionally, SES may contribute to differential exposures to wildfire smoke across communities. For example, access to air conditioning reduces infiltration of particle pollution indoors. Less access to air conditioning due to SES may lead to greater exposure to wildfire smoke and greater sensitivity to extreme heat and subsequently health disparities across communities. Moreover, as noted above, minority and impoverished children and adults bear a disproportionate burden associated with asthma and other diseases, which may increase their susceptibility to the health effects of wildfires (Brim et al., 2008; CDC, 2014).

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 therefore provides 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 at least 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; however, more commonly the indoor concentrations of fine particles that come from outdoors are 50% or less of outdoor concentrations when windows and doors are closed. 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 who wish to clean their residences after or between wildfire smoke events should use cleaning practices that reduce re-suspension of particles that have settled, including damp mopping or dusting and using a high efficiency particulate air [HEPA] filter-equipped vacuum.

An important drawback of advising people to stay inside and close windows and doors of homes without air conditioning 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 and has been adapted to this document in Appendix A, which 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 closed 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 $\mu\text{g}/\text{m}^3$). Besides cigarette smoke, combustion sources that are not properly vented to the outdoors contribute most to indoor pollutant levels, and are of greatest concern. “Room-vented” or “vent-free” appliances such as unvented gas or propane fireplaces, decorative logs, and portable heaters can especially contribute substantial quantities of particles. Frying or broiling some foods also can produce high levels of particles in the kitchen and dining areas. These sources can also increase the levels of polycyclic aromatic hydrocarbons (PAHs), carbon monoxide, acrolein, and nitrogen oxides. Additionally, small sources such as candles and incense burning can produce surprisingly large quantities of particles and should not be used during fire events. To avoid re-suspending particles, do not vacuum during a fire event, unless using a HEPA-filter equipped vacuum. 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.



Use air conditioners and filters

Little is known about the impact of using various types of room air conditioners (e.g., window units) and their 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 heating and/or air conditioning systems (and some room air conditioners) contain filters that can remove some airborne particles with different degrees of efficiency. If possible, one should replace the central air handler filter with a pleated medium- or high-efficiency particle filter. Higher efficiency filters are preferred as they can capture more 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 ensure that the central system is able to handle the increased airflow resistance from a higher efficiency filter. Filters need to be replaced regularly, and should fit the filter slot snugly. If a filter upgrade has been performed (e.g., a filter

rated at MERV 8 or higher has been installed), during a wildfire smoke event, the central system's circulating fan can be set to operate continuously (i.e., fan switch on the thermostat set to "ON" rather than "AUTO") to obtain maximum particle removal by the central air handler filter, although this will increase energy use and costs. The thermostat should be reset back to "AUTO" after the wildfire smoke clears.

To facilitate preparedness, a central air handler filter upgrade can be performed well in advance of a wildfire event, and extra air filters can be stored for future use. This may especially be an advisable preparation in homes with susceptible occupants. Wildfire risk is typically discussed in the media and can be tracked on line where state and federal land management agencies routinely post such information. When the risk is high, the recommendation of preparing in advance, such as upgrading the central filter can be developed into a public service announcement for the area and messages passed to local health care providers.

In addition to high- and medium-efficiency filters, electrostatic precipitators (ESPs) or other electronic particle air cleaners 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. However, only ESPs that have been tested and documented not to produce excess ozone should be used.

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 or sealing off outdoor air intakes, 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 mechanical ventilation systems that intentionally bring outdoor air inside, and mechanical ventilation in new homes is now required by building codes in some jurisdictions. These may need to be turned off or adjusted during periods of high outdoor air pollution from wildfires to avoid entry of outdoor air pollutants. Mechanical ventilation systems used in public and commercial buildings differ, and are discussed further in Appendix A.

Use room air cleaners

Choosing to buy an air cleaner is a decision that ideally should be made **before** a smoke emergency occurs, particularly in homes with susceptible occupants. 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.

High-efficiency particulate air (HEPA) filter air cleaners and ESPs documented not to produce excess ozone 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 can be more effective than room air cleaners because they filter a larger amount of air, although two or more well-placed portable air cleaners can be equally effective and their cost may still be less than the cost of a large central air cleaner. A good portable air cleaner also may improve the air quality in a bedroom, for example, which may be helpful to an individual with asthma or COPD. Room air cleaners will provide the most protection when placed where people spend most of their time. Most air cleaners are not effective at removing gases and odors, although some specialized models are available that perform well. The two basic types for particle removal include:

- a) Mechanical air cleaners, which contain a fiber or fabric filter. The filters need to fit tightly in their holders, and cleaned or replaced regularly. HEPA filters (and Ultra-Low Penetration Air [ULPA] 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. 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). Only ESPs that have been tested and documented not to produce excess ozone should be used. Ionizers, or negative ion generators, cause particles to stick to materials (such as carpet and walls) near the device and are also often a source of ozone. Ionized particles deposited on room surfaces can cause soiling and, if disturbed, can be resuspended into the indoor air.

Room air cleaner units should be sized to provide a filtered airflow at least two to 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.

Only portable (room) air cleaners that do not produce excess ozone should be used. California Air Resources Board (CARB) certifies air cleaners that produce little or no ozone; see their list of certified air cleaners at: <http://www.arb.ca.gov/research/indoor/aircleaners/certified.htm>.

Devices that remove gases and odors can cost more than particle air filters, both to purchase and maintain. They force air through materials such as activated charcoal or alumina coated with potassium permanganate. However, with smaller-sized air cleaners, the filtering medium can become quickly overloaded and may need to be replaced often. Nevertheless, large such devices may be useful for sensitive individuals and may require less-frequent replacement of the filtering medium. New models that combine particle and gas removal are available in both portable and in-duct models.

Air cleaners can be used in combination with central air system filter upgrades described in the preceding section to maximize the reduction of indoor particles.

For more information about residential air cleaners:

<http://www.epa.gov/indoor-air-quality-iaq/guide-air-cleaners-home>

<http://www.arb.ca.gov/research/indoor/aircleaners/consumers.htm>

<http://www.cadr.org/consumer.htm>

Avoid ozone generators

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; in fact, ozone reacts with certain chemicals commonly found indoors to produce particles and formaldehyde.

California now prohibits sales of air cleaners that emit potentially harmful amounts of ozone.

A list of air cleaners that have been certified to emit little or no ozone is available at

<http://www.arb.ca.gov/research/indoor/aircleaners/certified.htm>

For more information about ozone generators marketed as air cleaners:

<http://www.epa.gov/indoor-air-quality-iaq/ozone-generators-are-sold-air-cleaners>

<http://www.arb.ca.gov/research/indoor/ozone.htm>

Create a clean room at home

People, especially at-risk individuals, who live in areas that are regularly affected by smoke from wildfires or who are in an area where the wildfire risk has been determined to be high, 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 anywhere in the house, unless using a HEPA-filter equipped vacuum.
- Do not smoke or burn anything anywhere in the house, including candles or incense.
- 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. 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 due to occupants’ exhaled breath (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 when smoke levels are low

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. The use of the term “mask” in this guidance document may cause confusion for public health officials and the general public. The term mask can refer to one-strap paper masks and surgical masks. Respirators and surgical masks are designed for different functions and do not provide the same types of levels of protection (NIOSH 2016). Surgical masks are typically loose-fitting and do not form a tight seal to the wearers face. Surgical masks are not designed to capture a large percentage of small particles and will not prevent the wearer from breathing in airborne particles such as contained in wildland smoke. Covering the mouth with a (damp or dry) bandana, handkerchief, or tissue also will not prevent the wearer from breathing in airborne particles. N95 particulate filtering facepiece respirators or respiratory protection devices with a higher level of protection are more appropriate for the public for this type of inhalation hazard. 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.

NIOSH has a searchable web site entitled “Approved N95 Particulate Filtering Facepiece Respirators” which includes access to NIOSH approved N95’s alphabetically by manufacturer. [http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/n95list1.html.]

NIOSH also maintains a “Certified Equipment List” which identifies respiratory protective devices which conform to the requirements of Title 42, Code of Federal Regulations, Part 84. [<http://www.cdc.gov/niosh/npptl/topics/respirators/CEL/default.html>]

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 (NIOSH, publication No. 2016-109).

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 indoors 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 non-disposable NIOSH-certified respirators, such as those used by painters, may also be beneficial; they have a tight-fitting flexible half-mask 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 May 2016, 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. Public health official should make the public aware that these types of products are not providing adequate inhalation protection to particulates in fire ash.

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, at:

https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9784 (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.

Public health officials can find additional information on the NIOSH Respirator Trusted-Source Information web site at:

http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/RespSource.html.

This includes web pages with the following information.

Use of NIOSH-Approved Respirators

- Respirator Fit Testing
- Respirator Safety
- Respirator User Notices
- Buyer Beware

Respirator Fit Testing

- What is Fit Testing
- Fit Testing Procedures
- OSHA Respiratory Fit Testing Video

Cleaner air shelters

Public health officials in areas at risk from wildfires 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.

Avoiding smoky periods

Smoke levels from wildfires often change substantially over the course of the day, so there is often opportunity to avoid the worst periods of smoke. Impacts at the surface are often forecasted and posted on state smoke blogs and can be found on the InciWeb site (see resources and additional links). During smaller events, impacts often follow a pattern such as nighttime smoke draining downhill into nearby communities and lifting out the next day. Either way, it's often possible to plan your day around the smokiest times in order to minimize exposure, using the visibility estimation tools in combination with NowCast values from nearby or representative monitors to identify and avoid the smokiest times of day (see section 4). Look for links to such forecasts and patterns in your local PSAs (see section 5). See also appendix F for an example of a smoke forecast from a large wildfire).

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 informing incident commanders if this situation could arise and supplying evacuees 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). It is important to consider smoke levels when allowing those evacuated for fire safety reasons to return. Medical capability to address smoke induced medical situations should be assessed if smoke levels are predicted to be high. Additionally, the smoke from smoldering natural and possibly manmade materials if structures are burned in fires pose additional hazards that should be considered.

Summary of strategies for exposure reduction

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. Foods stored for use during the fire season should not require frying or broiling, since these activities can add particles to indoor air. It is also important to have at least a five-day supply of medication for the same reason.

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 they might actually experience greater exposure during evacuation than staying at home and using other precautions described above. 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.

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). Additional protection in homes can be achieved by operating properly-sized air cleaners and upgrading the filtration efficiency of air filters in central air conditioning systems. When high efficiency filters (rated at MERV 8 or higher) are installed, central air conditioning fans can be set to operate continuously during a wildfire event, and not cycle on and off, although this will increase energy use and costs.

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. Vacuuming (except with HEPA filter-equipped vacuums) should also be avoided, since most vacuum cleaners disperse very fine dust into the air.

Smoke levels often change substantially over the course of the day, so it’s often possible to plan your day around the smokiest times in order to minimize exposure, using tools and information in this Guide.

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.

Communicating particulate matter levels

The goal of particulate matter (PM) measurement during a fire is to relay information to the public in a timely manner so people can make decisions about how to protect their health when smoke levels are high. PM levels are measured as micrograms (μg) of particles per cubic meter of air. Most particle monitors measure either PM₁₀ or PM_{2.5} (fine particles). Smoke particles will show up in either measurement.

Filter-based PM monitors take days to process, but continuous PM monitors give an instant reading of particulate matter concentrations, usually averaged in time periods such as one hour or a running 24-hour average. Areas without continuous monitors may be able to get temporary, portable continuous monitors through their federal, state, tribal, or local air quality agencies or the Forest Service.

Air Quality Index

The [Air Quality Index](#), or AQI, is a nationally uniform index promulgated by the EPA for reporting and forecasting daily air quality across the country. It is used to report information about the most common ambient air pollutants, including particulate matter (PM_{2.5} or PM₁₀) and ozone. 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). The index converts ambient concentrations ($\mu\text{g}/\text{m}^3$ or ppb) to an AQI category and number more easily understood by the public. The AQI uses a normalized scale from 0 to 500 and provides associated health-based descriptors for each category. An AQI value of 100 corresponds to the level of the short-term National Ambient Air Quality Standard for a given pollutant. An advantage of using the AQI value over the concentration ($\mu\text{g}/\text{m}^3$) for particulate matter is that the AQI value of 100 represents a clear demarcation between satisfactory and unhealthy air quality, at least with reference to the national standard, which is established at a level that will protect public health, including the health of at-risk groups. When AQI values exceed 100, air quality is considered to be unhealthy, at first for members of at-risk (or sensitive) group, then for everyone as AQI values increase.

AirNow

The AirNow website, at www.airnow.gov, is a multi-agency web site run by EPA that reports air quality using the AQI. The AirNow program accepts, stores, and displays data provided by air quality agencies. Agencies submit continuous PM data to AirNow from over 1200 PM_{2.5} monitors and 500 PM₁₀ monitors, plus temporary monitors, on an hourly basis. These data are available to the public via national, regional, and local maps on airnow.gov and through email notifications, widgets, and smart-phone apps. Media outlets and web developers can also access the data through AirNow's Application Program Interface (airnowapi.org).

NowCast. By definition, the AQI for PM_{2.5} and PM₁₀ is based on a full 24 hours of data, so hourly reporting requires a methodology called the [NowCast](#) to estimate the 24-hour AQI for each hour. The reported hourly value is what AirNow calls "current conditions."

The NowCast method for reporting each hour's current conditions is designed to be responsive to rapidly changing air quality such as occurs during a wildfire (Figure 7). The NowCast uses a weighted average of the previous 12 hours. When air quality is changing rapidly, the most recent hours are weighted more heavily. A longer average, approaching 12 hours, is used when air quality is stable. The NowCast ensures that AQI maps on AirNow more closely match what people actually see outdoors (Figure 8).



Figure 7. Overall concept of the NowCast.

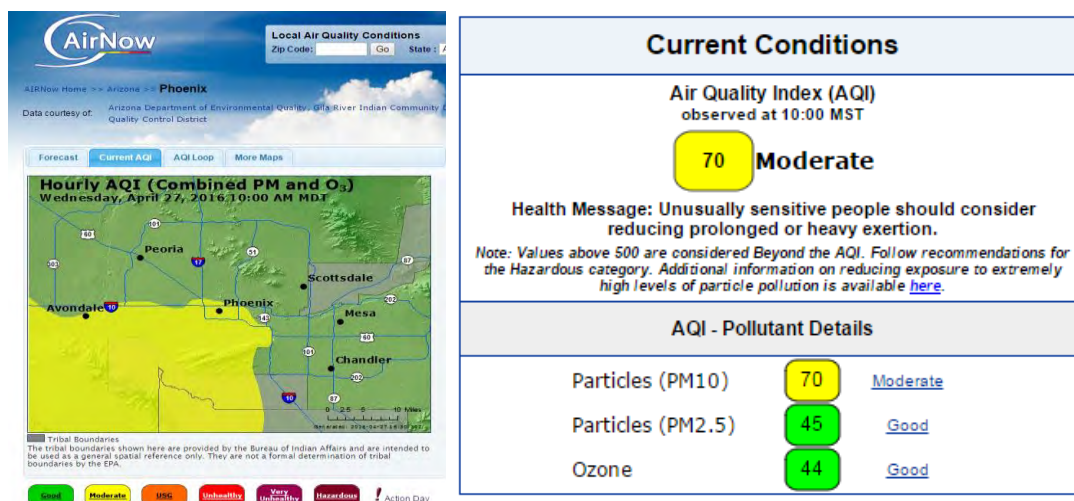


Figure 8. Sample AirNow map and AQI values.

Fires: Current Conditions Map. The wildfire map page on airnow.gov (http://airnow.gov/index.cfm?action=topics.smoke_wildfires) is a one-stop place where the public can assess current wildfire conditions across the country. The interactive map is a joint effort of the USFS, EPA, and state and local air quality agencies. The map displays several layers such as the current network of PM_{2.5} monitors as well as any temporary PM_{2.5} monitors deployed for a fire event. The monitors are shown in the color of their current AQI value. Other layers include active wildfires and smoke plumes. In addition, the page has important links to state advisories and smoke blogs, information about smoke and health, as well as a variety of external web resources pertaining to wildfires.

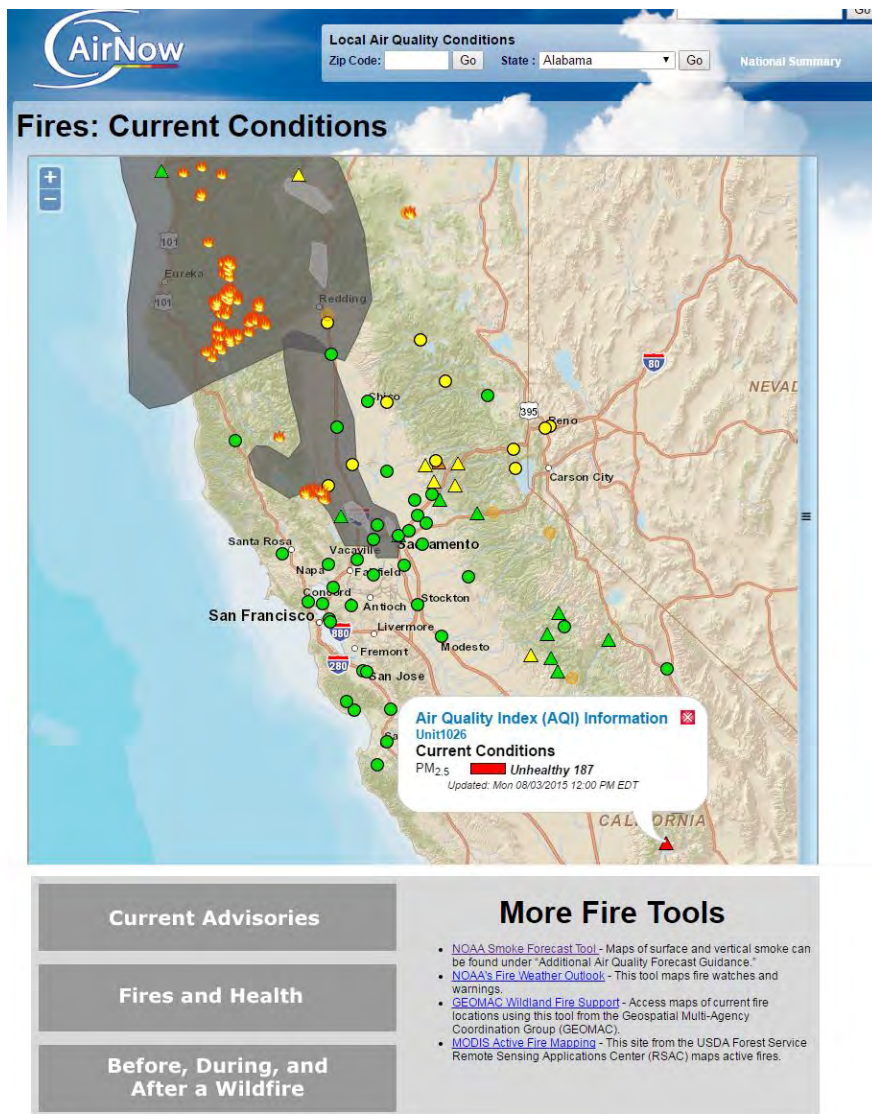


Figure 9. Sample AirNow Fires: Current Conditions map

Enviroflash. EnviroFlash is a system that sends the daily air quality forecast by email to anyone who signs up. It can also be used by state and local agencies to send an email alert during an event such as a fire, including suggested safety measures which are included when air quality is unhealthy. This service is provided by the state or local environmental agency and EPA. Information about Enviroflash is available at <http://www.enviroflash.info/>.

Outdoor Activity Guidance. The Air Quality and Outdoor Activity Guidance for Schools table, developed by the EPA and the US Centers for Disease Control and Prevention (CDC), shows when and how to modify outdoor physical activity based on the AQI. This guidance can help protect the health of all children, including teenagers, who are more sensitive than adults to air pollution. The activity guidance can be found at: <https://www3.epa.gov/airnow/flag/school-chart-2014.pdf>. Similar guides for ozone and for PM that include activity guidance for all ages can be found here: https://airnow.gov/index.cfm?action=flag_program.outdoorguid.

Air Quality Flag Program. The activity guidance can be used with the Air Quality Flag Program. The Air Quality Flag Program (https://airnow.gov/index.cfm?action=flag_program.index) is a visual way to alert schools and organizations to the local air quality forecast. Seeing the flag helps people take actions to protect their health and may be useful to alert the public to forecasted smoke events.

AirNow-Tech. AirNow has a decision support tool called AirNow-Tech (airnowtech.org), which allows partner agencies to manage, quality control, query, and visualize not only their data but also a national dataset of air quality, meteorological and satellite information. One powerful AirNow-Tech tool for wildfire evaluation is Navigator GIS. Navigator allows the user to overlay meteorological, fire, and satellite data over air quality observations. In addition, users can run HYSPLIT trajectories on any point of the display to see air parcel projections or for post wildfire event analysis.

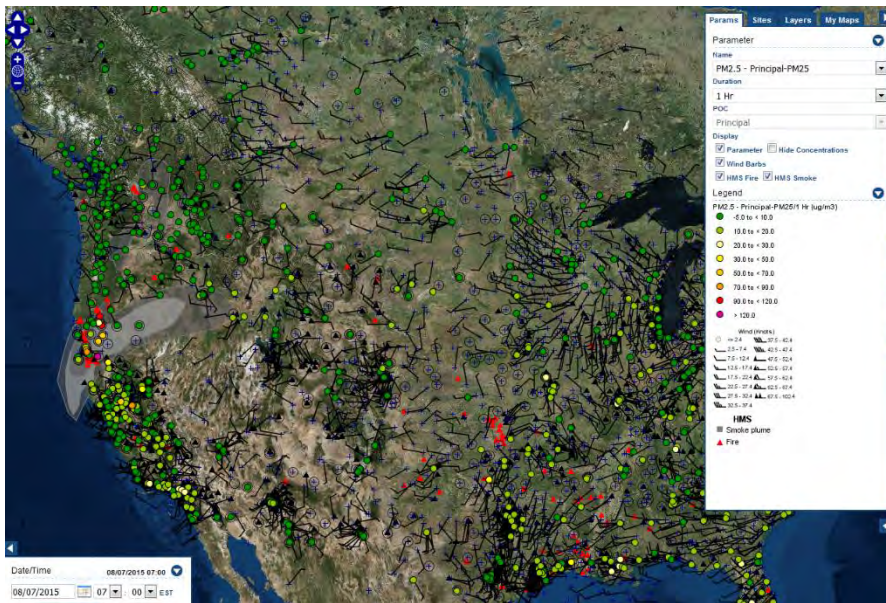


Figure 10. AirNow-Tech Navigator

U.S. Forest Service wildland fire air quality monitoring website tool

The Forest Service Wildland Fire Air Quality Monitoring Website Tool (<http://tools.airfire.org/monitoring>) developed by Pacific Northwest Research Station's AirFire Team provides easy-to-use, rapid access to air quality monitoring data from both publicly available permanent monitoring sites as well as temporary monitoring sites setup during wildland fire incidents. The tool allows a user to quickly select and view data from multiple monitors showing a selection of graphics including monitor location, time series, diurnal patterns and more. Different sets of graphics are available for different types of users who may have particular interests. Once a set of monitors of interest are selected, users can bookmark and share the site's URL to quickly return to this specific set of monitors and view the updated current data.

Currently the tool is set up to display fine particulate measurements (PM_{2.5}), but other measurements may be added in the future. The tool uses public data made available from EPA's AirNow-Tech system; as such there may be additional monitoring data that is not publicly available through the AirNow-Tech system (<http://airnowtech.org>). Additionally, as allowed by the originating agency, the tool adds data from temporary smoke monitors deployed from the Forest Service's national smoke monitoring cache and other sources. These include temporary monitors set up by the Air Resource Advisor community in their role as smoke specialists with the Incident Management Teams responding to wildfire incidents.

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.

Using visual range to assess smoke levels in the interior western United States

Many communities do not have access to continuous PM monitoring and may need other ways to evaluate local air quality. Visual range (i.e. how far can be seen?), like other instantaneous monitoring approaches can inform and help the public respond to smoky conditions. This is true even in areas that have continuous monitors, because smoke concentrations can vary widely within a couple miles and can change rapidly.

Basic Approach:

To determine visual range, one *must*:

- Use this method only during daylight hours (avoid sunrise and sunset).
- Use this method only if relative humidity is less than 65%.
- Focus on the darkest object (e.g. black is better than green)
- Determine the limit of visual 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 visual range in miles, use Table 1 to identify actions to take to reduce exposure.

Table 1. Visual Range and actions to take to reduce smoke exposure when wildfire smoke is in the air **

Distance You Can See	You are:		OR	You have:
	A Healthy Adult, Teenager, or Older Child	Age 65 and Over, Pregnant, or A Young Child		Asthma, Respiratory Illness, Lung or Heart Disease
> 10 miles	Watch for changing conditions and moderate outdoor activity based on personal sensitivity			
5-10 miles	Moderate outdoor activity	Minimize or avoid outdoor activity		
< 5 miles	Minimize or avoid outdoor activity	Stay inside or in a location with good air quality		

Often, it is difficult to assess “the point at which even high-contrast objects (e.g., a dark forested mountain viewed against the sky at noon) totally disappear.” Instead, it may be more useful to use known landmarks at a given distance away to assess possible visual ranges. For example, target A is 2 miles away and visible, but target B, which is 4 miles away, is not visible. Therefore the visual range is somewhere between 2 miles and 4 miles. Use Table 1 to identify the range of actions to consider to reduce smoke exposure.

Western United States: An important caveat is that the above visual range categories only apply in dry air conditions typically found in the interior west and inland of coastal areas. The combination of water and particulate matter in the atmosphere dramatically reduces visibility, therefore this method of estimation should not be used when relative humidity is greater than 65%.

Eastern United States and Higher Humidity Locations: Until this approach can be assessed for humid conditions, individuals may have to rely on common sense in estimating smoke conditions (e.g., mild, moderate, heavy smoke) and the kinds of protective actions that might be necessary to address personal response to the smoke.

Other Considerations: This method of estimating a visual range also contains much uncertainty (as discussed in Malm and Schichtel, 2013), further strengthening the need to use personal judgment when assessing smoke conditions. Smoke concentrations vary substantially from minute to minute. By comparison, continuous monitoring devices average their measurements over 3 or even 24 hours, so what is seen at a particular moment may not be representative of the average reported at a monitor. More uncertainty stems from sighting on

** Sensitivity to smoke can vary highly from person to person, and individuals can become more sensitive to smoke after extended periods of exposure. Individuals should pay attention to the advice of medical professional or local health officials, and adjust activity accordingly to your particular tolerance or sensitivity.

non-black bodies (e.g., green forested landmarks, snow-covered peaks), difficulty at judging when an object is just barely visible, variations in the atmosphere and thickness of the smoke across the line of sight, and assuming the atmosphere remains constant after using an instantaneous “look” to assess conditions. Furthermore, this method is not effective in early morning or twilight hours when the sun is low on the horizon.

The bottom line is that, no matter how far one can see, it’s always prudent to take measures such as discussed in this Guide to protect oneself if smoke exposure is a concern.

Recommendations for public health actions

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 smoke 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. PSAs are also useful during fire or smoke events to provide timely updates on the situation, along with advice on protective actions. Effective PSAs utilize simple, non-technical messages that people can remember, such as “stay indoors” or “limit outdoor activities.” News releases should be used to provide more detailed information, including information for the general public and for people with chronic diseases.

Consider also reaching out to weather forecasters and news reporters, who are a valuable resource for promoting your message. Their role as communicators on television, radio, print, and online outlets makes them an essential partner in any outreach strategy. When reaching out to news reporters and meteorologists to “pitch” your messages:

- Tell them who you are, what agency you represent, and that your campaign affects the health and safety of the community.
- Make sure they have your contact information, including e-mail address, telephone number, and if possible, cell phone number.

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, air quality forecasts, and changing smoke conditions.
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. When using one or more portable air cleaners, buy air cleaners that are appropriately sized for the intended rooms, as specified by the manufacturer, before a smoke emergency occurs. Be sure they are certified by California as low-or-no ozone models by checking the CARB website at <http://www.arb.ca.gov/research/indoor/aircleaners/certified.htm>.
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, and D.

Public advisories and protective measures

Areas with established air quality programs generally have several ways to alert the public about air pollution events using the AQI. One approach is to refer the public to the AirNow website (www.airnow.gov), which is used by states and many communities across the country. Other methods include state smoke blogs, 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, above) and the associated health effects (Table 2).

Table 2 provides a general list of health effects and cautionary statements for altering behavior for use in public advisories. The advisories are based on the AQI, as well as on experience and evidence from fire situations. *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.*

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 ambient PM levels. 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 $PM_{2.5}$ for the previous day is derived exclusively from measured 24-hour average $PM_{2.5}$ concentrations. The AQI for $PM_{2.5}$ that is reported by the media and on AirNow is the hourly estimate of the 24-hour AQI based on the NowCast. Although Table 3 provides ambient $PM_{2.5}$ concentrations, and the AQI values and descriptors associated with the categories (e.g., Good and Moderate), it is possible that concurrent publication of both the AQI values and the ambient $PM_{2.5}$ concentrations (in $\mu\text{g}/\text{m}^3$) 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.

Protection of Children

Protection of children is always a high priority in smoke events. The Air Quality and Outdoor Physical Activity Guidance for Schools, developed jointly by EPA and CDC, provides guidelines about when and how to modify outdoor physical activity based on the AQI. If a smoke event is forecasted, local officials should prepare for implementation of the guidance, including assessing the availability of indoor spaces with good indoor air quality for children to be active.

As air quality worsens, or is projected to worsen, additional protective measures may become necessary. These measures could range from allowing children with asthma, or other conditions that place them at greater risk, to stay home to closing schools entirely. Several location- and event-specific factors should be considered in making these decisions. Some of these factors include the forecast duration of the event, the relative indoor air quality of the homes and schools in the area, and the ability to transport children safely to and from school. In some locations, indoor air quality may be better in schools than in local housing stock, making school closure less beneficial from a public health perspective.

Protection of Other At-Risk Groups

Protection of other at-risk groups, including older adults, pregnant women, people with heart or lung disease and people of lower SES, is also a high priority for public health officials. Maintaining good indoor air quality, using the information provided above, is especially important in locations where these people are located, such as hospitals or residential facilities for older adults. To protect some at-risk groups, such as people of lower SES who may live in homes without air conditioning, or in locations where the use of air conditioning may not be common, it is advisable to consider setting up cleaner air shelters.

In general, these groups should be advised to remain indoors with windows closed if air quality is categorized as “very unhealthy.” Families should consider using a HEPA filter that will help to reduce indoor air pollution, as well as to avoid smoking tobacco, using wood-burning stoves or fireplaces, candles, and only using a vacuum with a HEPA filter.

Protection of Pets and Livestock

Many people ask how wildfire smoke affects pets and livestock. The effects of smoke are similar for humans and animals. High levels of smoke may irritate your animal’s eyes and respiratory tract. Strategies to reduce animals’ exposure to smoke are also similar to those for humans: reduce the time spent in smoky areas, provide animals with plenty of water, limit activities that will increase breathing and reduce exposure to dust or other air pollutants. If your pet or livestock is coughing or having difficulty breathing, contact your veterinarian. (OHA 8626, 4/14).

Actions for Consideration by Public Health Officials

The categories in Table 3 contain actions for public health officials to consider at the different AQI categories. Public health officials may want to take some or all of the recommended actions associated with these categories, based on a global assessment of the local situation. Some factors that also should be considered include:

- **Predicted fluctuations in PM_{2.5} levels.** Are the peaks of PM_{2.5} predicted to occur

relatively infrequently, interspersed with longer periods of good air quality, or to 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.

Build strong partnerships

To reduce potential public confusion, it's a good idea for health departments, air agencies and others responding to wildfire smoke to provide joint health advisories informing the public about smoke from wildfires, when possible. This is easier if you build partnerships in advance.

All agencies working on fire and smoke response should coordinate closely during the incident to ensure this consistent communication, and to leverage resources for developing and delivering information to the public. In addition to helping ensure the public receives consistent messages, this coordination can make it easier for the public to access them – through steps that can be as simple as cross linking websites to directing public and media inquiries to the appropriate agency and subject matter expert. And remember that while working with local media and posting information to the Web is important, it is not the only way to deliver information during an emergency. Sometimes, providing information through posters, door hangers or fliers also is effective. Coordinating with other agencies can help you leverage resources to create and/or deliver these materials when needed.

Resources to help with coordination include:

- **Existing websites:** The AirNow website (www.airnow.gov) provides the latest information on the national Air Quality Index, along with real-time data from state and local particle pollution and ozone monitors across the country, and next day air quality forecasts. The AirNow “Fires: Current Conditions” map provides additional data temporary particle pollution monitors deployed on fires, along with locations of active wildfires, and smoke plumes. State and local air quality monitoring sites, state smoke blogs, and some incident websites can provide up-to-the-minute monitor readings. Some sites include information such as how long smoke is expected to stay in your area, where it is likely to move, and where the highest levels of particle pollution are occurring or expected.
- **State and local air quality agencies** – Some states have emergency smoke response plans that outline contact points, roles and resources. These plans contain a range of information, such as roles and responsibilities, communication plans and establishment/activation of joint information centers. They also may include information to help agencies quickly find resources they need during an incident, such as how to access Air Resource Advisors (ARAs), air quality monitors, and HEPA air filtration system caches.

- **EPA Regional Offices** and the multi-agency **Wildland Fire Air Quality Response Program** may have monitors that can be deployed to smoky areas in some cases. The Wildland Fire Air Quality Response Program maintains a website (www.wildlandfiresmoke.net) with tools to help analyze the data from such emergency monitors and operational smoke model runs for use by ARAs, public health, and air quality personnel.
- **Federal and state land management agencies** – These agencies generally have the lead in responding to wildfires. In some states and during some large fires, these agencies and/or air quality agencies may hold daily air quality conference calls to coordinate messages and efforts, such as the placement of monitoring equipment. Participating in these internal calls can be valuable for public health agencies – both for sharing air quality information and coordinating protective messages. If an ARA has been assigned to an incident, that person also can be an additional source of information to help ensure consistent communication. If you are not sure whether an ARA has been assigned to a particular incident, check with your state or local air agency, check the www.wildlandfiresmoke.net website, or check the incident website for the fire found at inciweb.nwcg.gov.

In addition, during large wildfires, land management agencies' incident management teams frequently host public meetings, where smoke and appropriate responses may be discussed. These meetings can be a good forum for providing messages about smoke and public health.

- **U.S. EPA regional offices and federal land management agencies** – Federal agencies can help provide information to tribes if a fire is on, or smoke is affecting, lands in Indian country. Federal agencies have a trust responsibility to tribes and have established contacts who can help deliver information on wildfire smoke and health.

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.

Category (see Table 3)	Health Effects	Cautionary Statements ¹	Other Protective Actions
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.	<i>Sensitive Groups:</i> 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). • If a home has a central heating and/or air conditioning system, install higher efficiency filters if they can be accommodated by the system. If a filter upgrade has been performed (e.g., filters rated at MERV 8 or higher), the system's circulating fan can be temporarily set to operate continuously to obtain maximum particle removal by the central air system's filter, although this will increase energy use and costs. • Operate portable air cleaners to reduce indoor particle levels.
			• Avoid indoor sources of pollutants, including tobacco smoke, heating with wood stoves and kerosene heaters, frying or broiling foods, burning candles or incense, 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.

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.	<i>Sensitive Groups:</i> should avoid prolonged or heavy exertion <i>Everyone:</i> 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.	<i>Sensitive Groups:</i> Stay in a “clean room” at home (where there are no indoor smoke or particle sources, and use a non-ozone producing air cleaner). • Go to a “cleaner air” shelter (see Appendix D) or possibly out of area <i>Everyone:</i> 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.	<i>Everyone:</i> should avoid prolonged or heavy exertion Stay indoors, avoid exertion	<i>Everyone:</i> 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.	<i>Everyone:</i> should avoid any outdoor activity.	<i>Everyone:</i> If symptomatic, evacuate to cleaner air shelter or leave area, if safe to do so.

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

Table 3. Recommended Actions for Public Health Officials.

AQI Category (AQI Values)	PM_{2.5}¹ µg/m³ 24-hr avg	Recommended Actions
Good (0 to 50)	0-12	• If smoke event forecast, implement communication plan
Moderate (51 to 100)	12.1-35.4	• Prepare for full implementation of School Activity Guidelines (https://www3.epa.gov/airnow/flag/school-chart-2014.pdf) • Issue public service announcements (PSAs) advising public about health effects, symptoms and ways to reduce exposure • Distribute information about exposure avoidance
Unhealthy for Sensitive Groups (101 to 150)	35.5-55.4	• Evaluate implementation of School Activity Guidelines • 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)	55.5-150.4	• Full implementation of School Activity Guidelines • Consider canceling outdoor events (e.g., concerts and competitive sports), based on public health and travel considerations
Very Unhealthy (201 to 300)	150.5-250.4	• Schools move all activities indoors or reschedule them to another day. • Consider closing some or all schools² • Cancel outdoor events involving activity (e.g., competitive sports) • Consider cancelling outdoor events that do not involve activity (e.g. concerts)
Hazardous (> 300)	>250.5-500	• Consider closing schools • Cancel outdoor events (e.g., concerts and competitive sports) • Consider closing workplaces not essential to public health • If PM level is projected to remain high for a prolonged time, consider evacuation of at-risk populations

¹ If only PM₁₀ measurements are available during smoky conditions, it can be assumed that the PM₁₀ 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.

² See school considerations above. Newer schools with a central air cleaning filter may be more protective than older, leakier schools.

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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://inciweb.nwecg.gov/> Provides updates on all national fires, often several times a day.

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

AirNow Fires: Current Conditions.

https://airnow.gov/index.cfm?action=topics.smoke_wildfires

Satellite images of fires and smoke

NOAA Fire Events. <http://www.ospo.noaa.gov/Products/land/hms.html> 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/>

Smoke prediction tools: <http://tools.airfire.org/>

U.S. Forest Service AirFire Research Team: <http://tools.airfire.org/>

Wildland Significant Fire Potential Outlook:

<http://www.predictiveservices.nifc.gov/outlooks/outlooks.htm>

Weather information

National Weather Service:

Western Region <http://www.wrh.noaa.gov/>

Eastern Region <http://www.weather.gov/erh/>

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 AirNow: <http://airnow.gov/>

Current Advisories by State:

https://airnow.gov/index.cfm?action=airnow.news_item&newsitemid=93

Appendices

- Appendix A: Guidance on Protecting Workers in Offices and Similar Indoor Workplaces from Wildfire Smoke (Adapted from Cal/OSHA)
- Appendix B: Protect Your Lungs from Wildfire Smoke - Fact Sheet from California Department of Public Health
- Appendix C: Hazards during Cleanup Work Following Wildfires from National Institute for Occupational Safety (NIOSH)
- Appendix D: Identification and Preparation of Cleaner Air Shelters for Protection of the Public from Wildfire Smoke
- Appendix E: Children's Health Fact Sheets from the Pediatric Environmental Health Specialty Units (PEHSU)
- Appendix F: Example ARA Report - from Rough Fire, September 9, 2015

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

Guidance on Protecting Workers in Offices and Similar Indoor Workplaces from Wildfire Smoke

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. Eliminating or substantially reducing the outdoor air supply in office buildings and other indoor workplaces as a first step to reduce exposure to smoke is generally not recommended.

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.

HVAC systems should be operated continuously while occupied in order to provide the minimum quantity of outdoor air for ventilation, as required by the standards or building codes to which the building was designed. For many office buildings, this is often in the range of 15-20 cubic feet per minute (cfm) per person, although it could be less in older buildings.¹

Using the HVAC System(s) 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 systems' 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 systems, makes necessary repairs, and conducts appropriate

¹ 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 15 cubic feet per minute (cfm) per person.

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 systems, as specified by the manufacturer or system designer²@@@ . 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/aircleaners/consumers.htm> .

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. Temporary reductions in outdoor air flow rates might be considered 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 systems 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 should 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 systems are 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 systems are restored to maintain the minimum quantity of outdoor air for ventilation, as required by the standards or building codes to which the building was designed, no later than 48 hours after the particulate matter levels fall below the levels designated by the EPA as Unhealthy.

² Many existing HVAC systems should be able to accommodate pleated, medium-efficiency filters with particle removal ratings of MERV 6 to 11, and some may be able to use filters with ratings of MERV 12 or higher. 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 any additional information as required by State and local regulations. In California, 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://www.bepreparedcalifornia.ca.gov/Documents/Protect%20Your%20Lungs%20Respirator.pdf>.

Additional Information

The Lawrence Berkeley National Laboratory has produced a multi-page summary on air cleaning and its effects on health and perceived air quality, which can be found at: <https://iaqscience.lbl.gov/air-summary>.

Appendix B: Protect Your Lungs from Wildfire Smoke - Fact Sheet from California Department of Public Health



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: Hazards during Cleanup Work Following Wildfires from National Institute for Occupational Safety (NIOSH)

Cleaning up after a wildfire

The purpose of this document is to discuss some of the health and safety hazards that homeowners and workers may encounter after a wildland fire. This document is not designed to address health and safety for fire fighters or other emergency response workers during a wildfire or other emergency event.

After a wildfire has ended, cleanup and recovery activities are often needed. These activities may pose health and safety hazards that require necessary precautions. In most cases, it may be more appropriate for professional cleanup and disaster restoration companies, rather than homeowners or volunteers, to conduct this work. Although the types of hazards may be different for each wildland fire, some common hazards include:

- Contact with fire
- Burnt and unstable structures
- Burnt and unstable trees
- Confined spaces
- Carbon monoxide
- Electrical dangers
- Fatigue and stress
- Hazardous materials
- Hot environments
- Musculoskeletal injuries
- Wildfire smoke and ash
- Working with and around heavy equipment

Health and Safety Hazards after a Wildland Fire

1. Contact with Fire

After a wildfire, trained fire fighters will make sure the fire is completely out. If there is any chance the wildfire could reignite, leave immediately and notify emergency personnel.

2. Burnt and Unstable Structures

Be aware of unstable and damaged houses and other structures after a wildfire. Do not assume that these areas are safe or stable because damage may not be noticeable and can create a risk for serious injuries from slips, falls, punctures, or being struck by collapsing materials.

Safety Measures

To prevent injuries from burnt and unstable structures:

- Conduct a thorough inspection and identify and eliminate hazards before conducting any work. Avoid work around fire-damaged structures, including stairs, floors, and roofs, until an engineer or architect examines and certifies the structure is safe.
- Wear personal protective equipment, including long sleeved shirts and pants, hard hats, safety glasses, leather gloves, and steel toe boots, to reduce the risk of injury.
- Leave immediately if a structure shifts or makes an unusual noise that could signal a possible collapse.

3. Burnt and Unstable Trees

Another common hazard after a wildfire is unstable trees, known as ‘snags’ or ‘hazard trees,’ which can fall and injure homeowners and workers. It is important to assess the stability of all trees before working and driving around them.

Safety Measures

Always contact a professional to evaluate a tree’s stability and to safely remove any suspected hazardous trees from the property and along roadways before conducting cleanup work.

For more information about potential hazards from tree removal, see: [Preventing Chain Saw Injuries During Tree Removal After a Disaster](#)

4. Carbon Monoxide

Wildland fire cleanup activities may involve the use of gasoline or diesel powered pumps, generators, and pressure washers. This equipment releases carbon monoxide (CO), a deadly, colorless, odorless gas. It is important that homeowners and workers protect themselves from CO poisoning.

Safety Measures

To avoid the risk of CO poisoning:

- Never bring gas or diesel powered machines indoors.
- Only operate these machines in well-ventilated areas.
- Do not work near exhaust gases (CO poisoning can occur even outdoors near exhaust from engines that generate high concentrations of CO).
- Shut off the equipment immediately and seek medical attention if you experience symptoms of CO poisoning.

To learn more, visit NIOSH's webpages [Carbon Monoxide](#) or [Carbon Monoxide Hazards from Small Gasoline Powered Engines](#).

5. Confined Spaces

A confined space is an area that has limited openings for entry or exit, has limited air flow and is not designed for human occupancy. Examples of confined spaces include septic tanks, storage tanks, utility vaults and wells. These spaces may contain toxic gases, may not have oxygen, or may be explosive. In many cases, these hazards are not easily recognized without proper training and equipment.

Safety Measures:

- Never enter a confined space without proper training and equipment, not even to rescue a fellow worker. Contact the local fire department for help.

To learn more, visit NIOSH's webpage: [Confined Spaces](#).

6. Fatigue and Stress

A homeowner may experience emotional stress and mental and physical fatigue from cleanup and from loss of personal property or valuables. Fatigue and stress may increase the risk of injury and illness.

Safety Measures:

After a fire, homeowners or other workers may need to:

- Seek emotional support from family members, neighbors, and local mental health care workers to help prevent more serious stress-related problems.
- Set priorities for cleanup tasks and pace work over days or weeks to avoid physical exhaustion.
- Rest and take frequent breaks to avoid exhaustion.
- Begin a normal sleep and eating schedule as quickly as possible.

- Take advantage of disaster relief programs and services in the community.
- Understand physical and mental limitations.

To learn more, visit NIOSH's webpages: [Traumatic Incident Stress: Information For Emergency Response Workers](#) and [Stress at Work](#)

7. Electrical dangers

One common danger after a fire is a downed/damaged power pole with potentially energized power lines laying on the ground or hanging from the pole. **Any type of work with power lines or other electrical sources must only be conducted by trained professionals, such as electricians and utility workers. If a potential electrical danger or a downed power line is identified, avoid all electrical hazards by stopping work and immediately notifying the local utility company.**

Safety Measures

When working near power lines, it is important to follow these steps to prevent electrical injuries:

- Do not work or enter any area with any potential for electrocution from a power line or other electrical hazards.
- Treat all power lines and cables as energized until proven otherwise.
- When the power is off, never restore power until a professional inspects and ensures the integrity of the electrical system.
- Do not use electrical equipment that has been exposed to heat from a fire until checked by an electrician.
- Unless power is off, never enter flooded areas or touch electrical equipment if the ground is wet.
- Use extreme caution when equipment is moved near overhead power lines. For example, contact between metal ladders and overhead power lines can cause serious and often fatal injuries.
- Do not stand or work in areas with thick smoke. Smoke hides electrical lines and equipment.

To learn more, visit NIOSH's [electrical safety webpage](#).

8. Hazardous and Other Potentially Dangerous Materials

Many homes and other structures may contain or store hazardous materials and chemicals.

Some common materials include asbestos, lead, pesticides, propane, and gasoline. These materials may cause health effects, may be explosive, or may react with other chemicals. Before beginning cleanup activities, contact a professional who is familiar with hazardous materials to determine the different types of hazards that are present and how to safely clean up and dispose of them in accordance with local and state laws.

Safety Measures:

To reduce the chance of exposure to hazardous and other dangerous materials:

- Be cautious of chemicals, propane tanks, and other dangerous materials.
- Wear protective clothing and gear when handling hazardous materials.
- If exposed to hazardous materials, wash the affected area (e.g., skin, eyes) and contact your local poison control center or the American Association of Poison Control Centers at 1 (800) 222-1222. Seek medical care immediately if the exposure is severe or you experience symptoms.
- Homes built before 1980 may contain asbestos and lead. Contact your county health department to learn about local laws and regulations. Because disturbing lead and asbestos may result in serious health consequences, it is recommended that only trained professionals test for and clean up materials that contain lead or asbestos.
- Fires may also damage tanks, drums, pipes, or equipment that may contain hazardous materials, such as pesticides, gasoline, or propane. Before opening or removing containers that may contain hazardous materials, contact the local fire department or a hazardous materials team to help assess and remove hazardous waste.

To learn more about chemical safety, visit NIOSH webpages: [Pocket Guide to Chemical Hazards](#) and [Chemical Safety](#)

9. Hot environments

While working in hot weather, homeowners and cleanup workers could be at risk for heat-related illnesses, such as heat stress, heat rash, heat cramps, and heat stroke. It is important to be aware of the symptoms of heat related illness, how the illness can affect health and safety, and how it can be prevented.

Safety Measures

To reduce the potential for heat related illnesses, it is important to follow some basic work practices, such as:

- Wearing lightweight, light-colored, loose-fitting clothes,
- If possible, blocking out direct sun or other heat sources,
- Taking frequent breaks in cool, dry areas,
- Acclimatizing before working (getting used to weather conditions),
- Working during the cooler hours of the day when possible, and
- Maintaining hydration by drinking plenty of water and other fluids.

If a homeowner or worker displays any signs of heat related illness, it is important to immediately go to a cool, shaded place, sit or lie down, and drink water. If possible, cool water may be poured over the homeowner's or worker's head and

body. Seek medical attention immediately if the symptoms do not subside. To learn more, visit NIOSH's webpage: [Heat Stress](#)

10. Musculoskeletal Injuries

Homeowners and workers who may be involved in cleanup activities are at risk for developing stress, strain, and potential musculoskeletal injuries, which are injuries or disorders of the muscles, nerves, tendons, joints, cartilage, or spinal discs. These common injuries can occur when moving debris and materials, using hand-held equipment (e.g., chainsaws) due to repetition, force, vibration, or awkward postures.

Safety Measures

Some useful tips to prevent these injuries:

- Use teams of two or more to move bulky objects.
- Take breaks when conducting repetitive work, especially if experiencing fatigue.
- Avoid working in unusual or constricting postures.
- Use correct tools and equipment for the job and use them properly.
- Do not lift material weighing 50 pounds or more and use automated lifting devices for heavier objects.
- Be sure the area is clear of slip, trip and fall hazards.

To learn more, visit NIOSH's webpage: [Ergonomics and Musculoskeletal Disorders](#)

11. Wildfire Smoke and Ash

Smoke

Smoke from a wildland fire can pose health risks. Older adults, young children or individuals with underlying heart or lung disease are the most likely to be affected by inhaling wildland fire smoke. Healthy individuals may also experience short-term respiratory irritation symptoms, such as burning eyes and runny nose. If there is smoke in the area, homeowners and cleanup workers who are sensitive to smoke should consider leaving the area until the smoke clears.

Ash

Ash from wildland fires can be deposited on indoor and outdoor surfaces in areas around the fire and can be irritating to the skin, nose and throat, and may cause coughing.

Safety Measures:

To minimize the health effects that may occur due to exposure to smoke and ash:

- Always wear proper personal protective equipment (long sleeve shirts, pants, gloves and safety glasses) when working around ash. If you do get ash on your skin, wash it off as soon as possible.

Do not use leaf blowers or take other actions (e.g., dry sweeping) that will put ash into the air. Shop vacuums and other common vacuum cleaners do not filter out small particles, but rather blow the particles out the exhaust into the air. To clean up ash, use vacuums equipped with High Efficiency Particulate Air (HEPA) filters.

- Do not consume any food, beverages, or medication that has been exposed to burn debris or ash.
- Well-fitting respirators may provide some protection during cleanup. Please visit NIOSH's Respirator Trusted-Source Information web site at: http://www.cdc.gov/niosh/npptl/topics/respirators/disp_part/RespSource.html.
- If the presence of asbestos, lead, CO or other hazardous material is suspected, do not disturb the area. Dust masks or filtering facepiece respirators do not protect against asbestos or gases such as CO.
- Avoid burned items that may contain hazardous chemicals, such as cleaning products, paint and solvent containers.
- Avoid ash from wooden decks, fences, and retaining walls pressure treated with chromated copper arsenate (CCA) as it may contain lethal amounts of arsenic.

12. Working With And Around Heavy Equipment

Do not operate heavy equipment, such as bulldozers, backhoes, and tractors, unless you are properly trained. Serious and fatal injuries can occur when equipment is used improperly. To learn more about motor vehicle safety, visit NIOSH's webpages: [Motor Vehicle Safety](#) and [Fatality Assessment Control and Evaluation](#).

13. First Aid

First aid, even for minor cuts and burns, is extremely important as workers are exposed to smoke and burned materials. For more information, please visit NIOSH's webpage: [NIOSH's First Aid Procedures](#)

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 central air conditioning with filtration 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 rating of MERV 12 or higher 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.

* ASHRAE Standard 52.2-2012. “Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size”.

Appendix E: Children's Health Fact Sheets from the
Pediatric Environmental Health Specialty Units
(PEHSU)



PEHSU Information on Health Risks of Wildfires for Children Guidance for Parents and Community Members – Acute phase

The Pediatric Environmental Health Specialty Units (PEHSU) Network encourage families, pediatricians, and communities to work together to ensure that children are protected from exposure to environmental hazards.

Wildfires expose children to a number of environmental hazards like fire, smoke, psychological stress, and the byproducts of burnt wood, plastics, and other chemicals released from burning structures and furnishings. During or immediately after the wildfire, the major hazards to children are fire and smoke. Stress from seeing the fires and the emotional responses of those around them can also impact children during this time. Although some of the exposures children may encounter in this setting may cause or worsen health problems (described later), there are important ways that parents can protect their children.

Children, individuals with pre-existing lung or cardiovascular problems, pregnant women, elderly, and smokers are especially vulnerable to environmental hazards such as smoke. Children are in a critical period of development when toxic exposures can have profound negative effects, and their exploratory behavior often places them in direct contact with materials that adults would avoid.

The environmental hazards during or immediately after the wildfire are:

- **SMOKE** consists of very small particles, liquid droplets, and gases such as carbon monoxide, carbon dioxide, and other volatile organic compounds such as formaldehyde and acrolein. The actual content of smoke depends on the substance that is burning.
- **HEALTH EFFECTS OF SMOKE**: Symptoms from smoke inhalation can include chest tightness, shortness of breath, wheezing, coughing, respiratory tract and eye burning, chest pain, dizziness or lightheadedness, and other symptoms. Asthma symptoms may flare up. The risk of developing cancer from short-term exposures to smoke is very small.

RECOMMENDATIONS

- Stay indoors with windows and doors closed and any gaps in the building envelope sealed. Avoid strenuous activity.
- If available and if needed for comfort, run an air-conditioner on the “re-circulate” setting. Be sure to change the filter at appropriate intervals. Some electronic air cleaners and ozone generating “filters” can generate dangerous amounts of ozone indoors (see the *Wildfire Smoke – A Guide for Public Health Officials* resource). These ozone filtration systems do not remove harmful contaminants from the air and are not recommended.

- Never operate gasoline powered generators indoors – they produce dangerous carbon monoxide. Avoid smoking, using wood stoves, and other activities that add to indoor air contamination.
- If there is a period of improved air quality, open up (air out) the house and clean to remove dust particles that have accumulated inside.
- Humidifiers or breathing through a wet washcloth may be useful in dry climates to keep mucous membranes moist, although this does nothing to prevent inhalation of contaminants.
- When riding in a car, keep the windows and vents closed. If comfort requires air circulation, turn the air-conditioning on “re-circulate” to reduce the amount of outside air drawn into the car.
- Children with asthma, heart disease, and others considered at high risk from health effects from contaminant inhalation should be moved to an adequate “clean air” shelter, which may be in their home, in the home of a friend or relative, or in a publicly-provided “clean air” shelter.

Use of Masks

Paint, dust, and surgical masks are not effective obstacles to inhalation of the fine particles generated by wildfires. For information on use of respiratory protection for adults see “Wildfire Smoke – A Guide for Public Health Officials.”

Although smaller sized masks may appear to fit a child’s face, none of the manufacturers of masks recommend their use in children. If your child is in air quality severe enough to warrant wearing a mask, you should remove them to an indoor environment with cleaner air.

CLOSING OF SCHOOLS AND BUSINESSES may become necessary when air quality is so poor that even traveling outside from place to place puts people at risk. However, in some situations the school may be a relatively protected indoor environment with better air quality and where children’s activity can be monitored.

CONSIDERATION OF EVACUATION because of smoke should weigh the effects of smoke exposure during the evacuation versus what the exposure would be while resting quietly inside one’s home. A disorderly evacuation can increase the duration of smoke exposure. Remember to bring with you at least 5 days of any medications taken by family members.

ASH: Recent fires may have deposited large amounts of ash on indoor and outdoor surfaces. This ash may be irritating to the skin and may be irritating to the nose and throat and may cause coughing. The following steps are recommended:

- Do not allow children or animals to play in ash.
- Wear gloves, long sleeved shirts, and long pants when handling ash, and avoid skin contact.
- Wash any home-grown fruits or vegetables before eating.
- Avoid spreading the ash in the air; wet down the ash before attempting removal; do not use leaf blowers or shop vacuums.

PSYCHOLOGICAL EFFECTS ON CHILDREN: Parents and caregivers should also be alert to children's emotional health and psychological wellbeing. It is important to keep in mind the youngest members of our society may easily become saturated with graphic images and incessant talk of smoke, flames and destruction. Resulting stress and anxiety may be manifested in a variety of ways:

- Clinging, fears
- Uncooperative behaviors, irritability
- Nightmares
- Health complaints
- Changes in eating or sleeping patterns
- Regression to babyish behaviors
- Indifference

Parents and caregivers can support children in a number of ways:

- Maintain previously established routines as much as possible.
- Provide a listening ear for children; encourage the expression of feelings through music, art, journaling, and talking.
- Answer questions openly and honestly, remaining mindful of the age of the child.
- Reassure and hug when hugs are wanted; practice patience and have a peaceful demeanor, as children take their cues from their parents.

To contact your local Pediatric Environmental Health Specialty Unit with any questions about this fact sheet please visit www.pehsu.net

RESOURCES

More details on the health effects of wildfires and ash cleanup are available at the following sites, from which some of this material was adopted:

Fires and Wildfires (National Library of Medicine):

sis.nlm.nih.gov/enviro/californiafires.html#a1

National Association of School Psychologists: Helping Children after a Wildfire:

www.nasponline.org/resources/crisis_safety/wildfire_teachers.pdf

Acknowledgement: James M. Seltzer, M.D., Mark Miller, M.D., M.P.H., and Diane L. Seltzer, M.A., Pediatric Environmental Health Specialty Unit Region 9

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PEHSU Information on Health Risks of Wildfires for Children – Aftermath Guidance for Parents and Community Members

The Pediatric Environmental Health Specialty Units (PEHSU) Network encourage families, pediatricians, and communities to work together to ensure that children are protected from exposure to environmental hazards.

Wildfires expose children to a number of environmental hazards like fire, smoke, psychological stress, and the byproducts of burnt wood, plastics, and other chemicals released from burning structures and furnishings. During or immediately after the wildfire, the major hazards to children are fire and smoke (described in the fact sheet *Health risks of wildfires for children – acute phase*).

In the aftermath of wildfires – the recovery phase - children may be exposed to a different set of environmental hazards involving not only their homes, but also nearby structures, land, and recovery activities. Some of these are easy to see, such as broken glass and exposed electrical wires, and others are not, such as soil contaminated with hazardous materials like lead or persisting hot spots which can flare without warning. Stress from seeing the fires and the emotional responses of those around them can also impact children during this time. Although some of the exposures children may encounter in this setting may cause or worsen health problems (described later), there are important ways that parents can protect their children.

Children, individuals with pre-existing lung or cardiovascular problems, pregnant women, elderly, and smokers are especially vulnerable to environmental hazards such as smoke. Children are in a critical period of development when toxic exposures can have profound negative effects, and their exploratory behavior often places them in direct contact with materials that adults would avoid.

Key requirements for children to return to an area impacted by wildfires include restored drinking water and sewage removal, safe road conditions, removal of ash and debris, and structurally sound homes. Schools and outdoor play areas should be cleaned, cleared of hazards. Children, and whenever possible, teens, should only be permitted to return after affected areas have been cleaned up. Children should be the last group to return. These recommendations also apply to pregnant women.

BEFORE RETURNING TO YOUR HOME

- Know the location and status of your nearest medical treatment facility and verify the route to reach it is passable.

- Be sure a clean water supply, electricity, and communication system (including 911 access) is restored, reliable, and readily accessible.
- Be certain areas not yet cleaned or not safe are not accessible to children.
- Homes and outdoor areas where children play (e.g., parks, playgrounds, yards) should be clean and free of environmental hazards.
- Thoroughly remove ash at sites where pressure treated wood was present, such as wooden decks, play structures, and wood chips. Clean the area, as the ash may contain high levels of arsenic if these were pre-2002 structures.
- Carbon monoxide: NEVER use generators, space heaters, or any gas or kerosene appliances in enclosed spaces as this may result in carbon monoxide poisoning.

POTENTIAL HAZARDS FROM FIRE DAMAGE

- Ash: Recent fires may have deposited large amounts of ash on indoor and outdoor surfaces in areas near the fires. This ash may cause irritation of the skin, nose, and throat, and may cause coughing. Ash and dust (particularly from burned buildings) may contain toxic and cancer causing chemicals including asbestos, arsenic, and lead. For these reasons children should not be in the vicinity while cleanup is in progress. Even if you are careful it is easy to stir up dust that may contain hazardous substances.
- Debris: Broken glass, exposed electrical wires (whether or not they are "live"), nails, wood, metal, plastics, and other solid objects commonly found in areas of fire damage can cause puncture wounds, cuts, electrical injuries, and burns from smoldering materials.
- Watch for ash pits and mark them for safety. Ash pits are holes full of hot ashes, created by burned trees and stumps. Falling into ash pits or landing in them with your hands or feet can cause serious burns. This underscores the need for children to only enter areas that have been cleaned and examined for safety.
- Children should not be permitted in the residence or permitted to play on nearby fire- damaged buildings or structures until these have been cleared by their local authorities. Unstable building structures include: flooring, stairways, railings, balconies, roofing, and fire escapes.
- Materials in storage areas may have moved into unstable positions and could fall. Doors and entryways to storage areas should be opened carefully.

HAZARDS FROM WATER DAMAGE

- Water damage to building materials and personal belongings can release potentially hazardous chemicals that could cause rashes, infections, or exposures to toxic substances.
- Wet materials are breeding grounds for bacteria and fungi. Potentially harmful microorganisms grow readily on or in non-refrigerated food and liquids. They can also grow on damp building materials, personal belongings, and dead animals.

UTILITIES

- Water: In areas impacted by the fires water pressure may have been lost or entirely out for periods of time. Check with your water provider to be sure that your water is safe to drink. If your water comes from a private well that has had damage it may require disinfection. If you are uncertain of the cleanliness of your water you may heat it to a rolling boil for 1 minute to kill potentially harmful bacteria and other microscopic organisms before drinking. If your water looks dirty do not drink it.
- Electricity: Electrical hazards need to be repaired. Avoid downed or damaged electrical lines.
- Propane: If your home propane tank is damaged and leaking call 911 and your propane service provider. Do not transport leaking BBQ propane tanks in your car or dispose of them in the trash. Contact the hazardous materials section of your local health department for information.

PREVENTIVE MEASURES

- Personal hygiene: If your child has had contact with any potentially hazardous substance in a fire-damaged area, wash their hands and any other exposed body part thoroughly with soap and water or bathe them. Remove any exposed clothing and wash separately as soon as possible.

MASKS

- Use of protective masks is recommended for adults cleaning up areas at which ash particles cannot be controlled (see Respiratory Protection in *Wildfire Smoke: a Guide for Public Health Officials*). Although smaller sized masks may appear to fit a child's face, no manufacturer recommends their use in children. If your child is in an area that warrants wearing a mask, you should take them to an area with cleaner air.

FOOD

- Loss of power to refrigeration and freezer units can cause food to spoil, for example, meats, milk, and egg products. Do not feed children such

foods that have warmed close to room temperature for more than 2 hours. Immediately discard cooked and uncooked foods that may have spoiled. Frozen foods that have thawed to room temperature for more than 2 hours should also be thrown away. If food smells bad or looks bad, or if you're just not sure it's safe, throw it out. Also, discard any food that may have come in contact with hazardous materials, such as fire retardant or ash. When in doubt, throw it out!

PSYCHOLOGICAL HAZARDS

- During the recovery phase, children may experience significant anxiety and grief from the loss and trauma related to having lived through a natural disaster. Children may suffer from fears connected to the smell of smoke, feelings of anxiety when weather conditions indicate a potential for fires, or overwhelming guilt at having survived the wildfires with little or no damage to their property. If children experience the loss of a loved one or their home, their sense of personal safety and security is often destroyed as well.
- Parents and caregivers may observe children displaying one or several of the following reactions during the recovery stage:
 - Irritability, fatigue, indifference
 - Health complaints such as stomach aches, headaches, general complaints of feeling unwell
 - Clinging; difficulty separating, returning to "babyish" behaviors
 - Eating or sleeping too much or too little, nightmares
 - Difficulty concentrating or focusing at home and/or on school work
 - Aggression or outbursts of anger, fears
- Parents and caring adults can provide significant support to children during times of emotional distress. Even if the family relocates to temporary housing, the sooner routines previously in place are re-established, the more quickly children will begin to experience the return of feelings of security and safety. Parents should reassure children that their feelings and fears are normal and should encourage them to express their emotions with words, play and writing.

The following recommendations will help children experiencing significant emotional challenges as a result of the recent wildfires.

- Maintain continuity and familiar routines in the child's life, both at home and school.
- Listen, listen, listen with an open heart and mind, without judging or attempting to fix the problem.

- Imagine how the child feels; let children know their feelings are normal.
- Encourage expression of feelings through conversation, role-playing, music, visual art, and writing (letters, diaries, journals).
- Provide honest and accurate answers to the questions children ask, keeping in mind the child's age and ability to make sense of your response.
- Reassure them with words, for children gain confidence and comfort from your strength.
- Provide hugs and comforting touches, remembering children thrive on loving human contact.
- Practice patience. Children may need a bit more time and encouragement, as well as overall understanding at this time.
- Emphasize a child's personal strengths and help the child recognize his/her coping skills already in place.
- Help children to see there were heroes and helpers who tried to make things better for the community during a time of need.

To contact your local Pediatric Environmental Health Specialty Unit with any questions about this fact sheet please visit www.pehsu.net

RESOURCES

Safe Cleanup of Fire Ash: www.calepa.ca.gov/Disaster/Fire2003/FireAsh.pdf

Fire Response and Recovery: Cal/EPA Emergency Response and Disaster Preparedness: www.calepa.ca.gov/Disaster/Fire/#DebrisCleanup

U.S.D.A. Forest Service: Wildland Fire – chemical clean-up:
www.fs.fed.us/rm/fire/wfcs/documents/cleanup.pdf

National Association for the Education of Young Children: Helping Young Children After a Disaster:
http://www.naeyc.org/newsroom/Resources_on_coping_with_disasters

National Association of School Psychologists: Helping Children after a Wildfire:
www.nasponline.org/resources/crisis_safety/wildfire_teachers.pdf

National Association of School Psychologists: Responding to Natural Disasters: Helping Children and Families:
www.nasponline.org/resources/crisis_safety/naturaldisaster_teams_ho.aspx

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Appendix F: Example ARA Report - from Rough Fire, September 9, 2015

Forecast conditions represent impacts from smoke from the Rough Fire. Contributions from ozone and other pollutants are not reflected.

Fire: Fire activity increased yesterday with warmer temperatures and lower relative humidity. Most of the smoke produced was from interior islands that ignited. Fire remains active in the Converse Basin, near Cedar Grove, and in the area north of Buck Rock. The fire is 103,244 acres and remains at 31% contained.

Air Quality Today: Heavy concentrations of smoke are expected near the fire today. Smoke will be slow to lift and transport will be primarily terrain and diurnally driven. Light and variable transport winds are expected primarily from the southeast, with continued increased impacts expected in the San Joaquin Valley west of fire. Residual smoke that has not cleared the area will add to impacts from new smoke being produced. Unhealthy to Hazardous conditions are expected in communities near the fire.

Smoke Impacts from Local Fires

Site	Yesterday Observed Midnight- Midnight 24-Hr AQI September 8, 2015	Today Forecast 24-Hr AQI September 9, 2015	Tomorrow Outlook 24-Hr AQI September 10, 2015	Worst Time of Day Impacts 3-Hour AQI and Period
Trimmer	Unhealthy	Hazardous	Hazardous	Unhealthy, 12 A.M. to 1 P.M.
Prather	Unhealthy	Unhealthy	Unhealthy	Unhealthy, 12 A.M. to 1 P.M.
Shaver Lake		Moderate	USG	Unhealthy, 12 A.M. to 1 P.M.
Oakhurst	Moderate	Moderate	USG	Unhealthy, 4 P. M. to 8 P.M.
Wishon Reservoir	Unhealthy	Unhealthy	Unhealthy	Very Unhealthy, midnight. to 2 P.M.
Hume Lake	Very Unhealthy	Hazardous	Very Unhealthy	Hazardous, 3 A.M. to 7 P.M.
Cedar Grove	No data	Hazardous	Hazardous	Hazardous, Midnight to 2 P.M.
Grant Grove	Moderate	Unhealthy	Unhealthy	Unhealthy, Midnight to Noon
Garnet Spike		Hazardous	Hazardous	Hazardous, Midnight to 2 P.M.
Devils Post Pile/Mammoth Lakes	Moderate	USG	Moderate	USG, 9 A.M. to 3 P.M.
Aspendell	Moderate	USG	Moderate	USG, 1 P.M to 7 P.M.
Bishop	Moderate	USG	USG	USG, 1 P.M. to 9 P.M.
Big Pine		Moderate	USG	Moderate, 3 A.M. to 9 A.M.
Independence		USG	USG	Moderate, 3 A.M. to 9 A.M.
Pinehurst	Moderate	Unhealthy	Unhealthy	Unhealthy, 7 A.M. to 10 A.M.
Montecito-Sequoia Lodge	Moderate	Unhealthy	Unhealthy	Unhealthy, 10 pm Midnight
Lodgepole	Good	Moderate	USG	Moderate 6 P.M. to 11 PM
Three Rivers	Moderate	Moderate	USG	USG, 7 PM to 11 PM
Ash Mountain	Good	Moderate	USG	USG, 7 PM to 11 PM
Kernville	Good	Good	Moderate	USG evening hours

Disclaimer: Conditions may change quickly, these projections are based on anticipated weather and fire activity. Sensitive groups including individuals with Asthma, lung or heart disease, children, older adults, and pregnant women should take precautions to avoid exposure to smoke. If you feel as though you are having health effects from smoke see your doctor or health professional as needed. In some cases your eyes are your best tools, if it is smoky outside you are being impacted. Use caution when driving in or around smoky areas.

AQI Index	Actions to Protect Yourself
Good	None
Moderate	Unusually sensitive people should consider reducing prolonged or heavy outdoor exertion.
Unhealthy for Sensitive Groups - USG	People with heart or lung disease, children and older adults should reduce prolonged or heavy outdoor exertion. Everyone else should limit prolonged or heavy exertion.
Unhealthy	The following groups should avoid all physical outdoor activity: People with heart or lung disease, children and older adults. Everyone else should avoid prolonged or heavy exertion.
Very Unhealthy	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors.
Hazardous	The following groups should remain indoors and keep activity levels low: People with heart or lung disease; children and older adults. Everyone else should avoid prolonged or heavy exertion

California Smoke Blog - <http://californiasmokeinfo.blogspot.com/>

Interagency Real Time Smoke Monitoring - <http://app.airsis.com/usfs/fleet.asp>

AirNow - <http://airnow.gov/index.cfm?action=airnow.main>