IV. COMMUNICATING AIR QUALITY CONDITIONS DURING SMOKE EVENTS

An important goal of air quality monitoring during a wildfire smoke event is to relay information to the public in a timely manner so people can make decisions about how to protect their health. Filter-based PM monitors take days to process, but continuous PM monitors give a near real-time reading of PM concentrations every hour. This is an estimate of the 24-hour average PM AQI using the NowCast algorithm discussed below. Areas without continuous PM monitors may be able to get temporary, portable monitors through their federal, state, tribal, or local air quality agencies or the U.S. Forest Service, especially when associated with a wildfire incident with an assigned Air Resource Advisor.

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 those most relevant to wildfire smoke: particulate matter ($PM_{2.5}$ or PM_{10}) 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 ($\mu g/m^3$ or ppb) to a number and category 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 ($\mu g/m^3$) 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 groups (in the Air Quality Index, the term "sensitive groups" is used), then for everyone as AQI values increase. Another advantage is that the AQI provides actionable activity advice for at-risk groups, as well as the general public, to reduce smoke exposure.

Figure 7. Overall concept of the NowCast

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 state, local, and federal air quality agencies. Agencies submit continuous PM data to AirNow from over 1,200 $PM_{2.5}$ monitors and 500 PM_{10} monitors, plus temporary monitors, on an hourly basis. These data are available to the public via an interactive map 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). See Appendix C for a description of AirNow-Tech, a website that air quality organizations use for data analysis and management, including the Navigator tool for wildfire evaluation.

NowCast. The AQI for $PM_{2.5}$ and PM_{10} is a daily (midnight to midnight) 24-hour average, 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 air quality."

The NowCast method for reporting each hour's current conditions is 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,

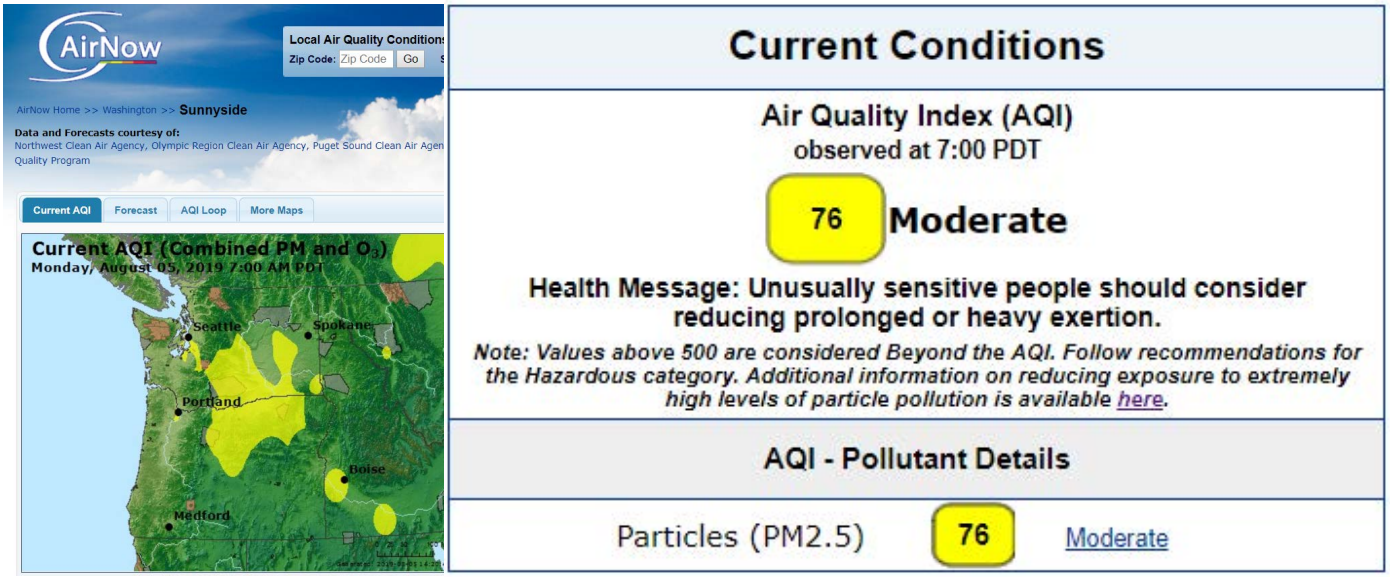

Figure 8. Sample AirNow current air quality data, map, and AQI values

is used when air quality is stable. The NowCast helps ensure that AQI maps and data on AirNow more closely match what people actually experience outdoors (Figure 8).

Fires: current conditions map. The wildfire map page on airnow.gov (https://fire.airnow.gov) is a one-stop place where the public can assess current wildfire activity and air quality conditions across the country (Figure 9). The interactive map is a joint effort of the U.S. Forest Service, 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, and a variety of external web resources pertaining to wildfires.

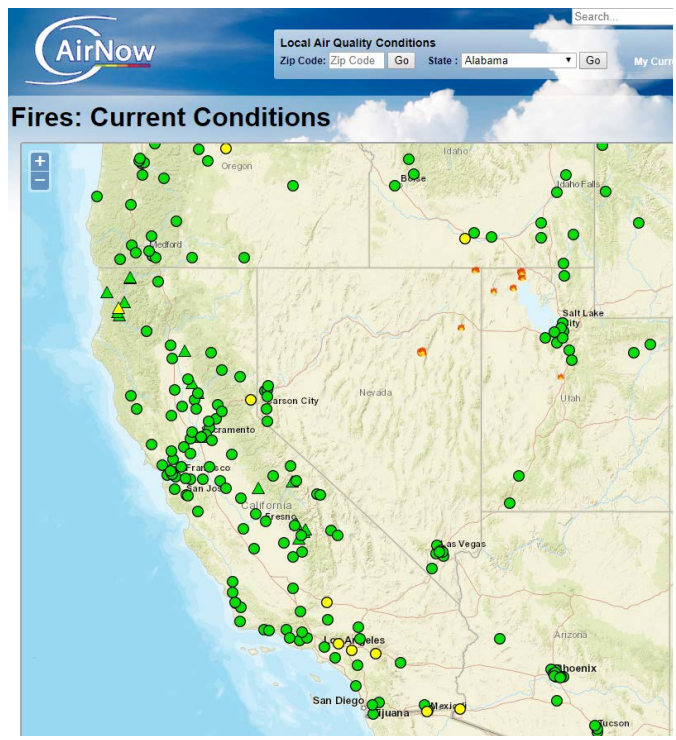

Figure 9. Sample AirNow Fires: Current Conditions map

Enviroflash. Offered in many areas around the country, 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 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. A similar guide for PM that includes activities for all ages can be found here: https://www3.epa.gov/airnow/air-quality-guide_pm_2015.pdf.

Air Quality Flag Program. The activity guidance can be used with the Air Quality Flag Program. The Air Quality Flag Program (https://www.airnow.gov/air-quality-flag-program/) is a visual way to alert schools and other organizations to the local air quality forecast. Seeing the flag alerts people about the local air quality so that they can take actions to protect their health.

Interagency Wildland Fire Air Quality Response Program and Air Resource Advisors

The Interagency Wildland Fire Air Quality Response Program (IWFAQRP, https://wildlandfiresmoke.net) is an interagency effort led by the U.S. Forest Service to provide enhanced information to wildfire incidents, agencies, and communities dealing with smoke issues. This need for predicting smoke impacts associated with wildfires and the role of the IWFAQRP was recognized and authorized by Congress in 2019. The IWFAQRP has several components including tools for enhanced monitoring and modeling of smoke; creating consistent smoke outlook forecasts in a simple format for sharing

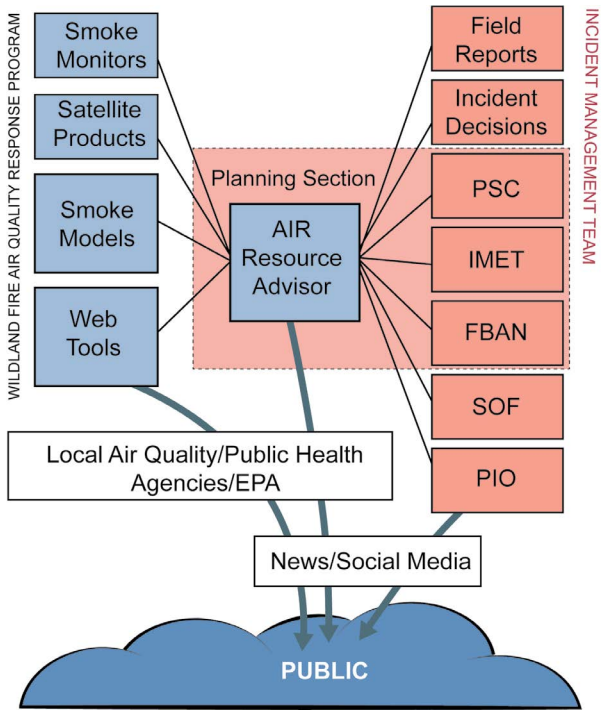

Figure 10. Elements of the Wildland Fire Air Quality Response Program supporting an Air Resource Advisor assigned to an Incident Management Team responding to a wildfire. Air Resource Advisors work under the Planning Section of an Incident Management Team with direct interaction with the Planning Section Chief (PSC), Incident Meteorologist (IMET), Fire Behavior Analyst (FBAN), Safety Officer (SOF), and Public Information Officer (PIO).

with the public; and messaging in conjunction with state, tribal, and local air quality agencies as well as health departments. Much of this work is done through the deployment of technical specialists called Air Resource Advisors (ARAs) working with either wildfire Incident Management Teams (IMT) or directly with land management agencies that request them as part of wildland fire management efforts. Deployed ARAs are a good resource for gaining insight into expected fire growth, emissions, and impacts. An ARA generally works in the planning section of the IMT and consults closely with experts in fire weather and fire behavior. ARAs are trained to use a variety of smoke dispersion models in conjunction with air quality monitoring to help build smoke forecasts and information products for the public.

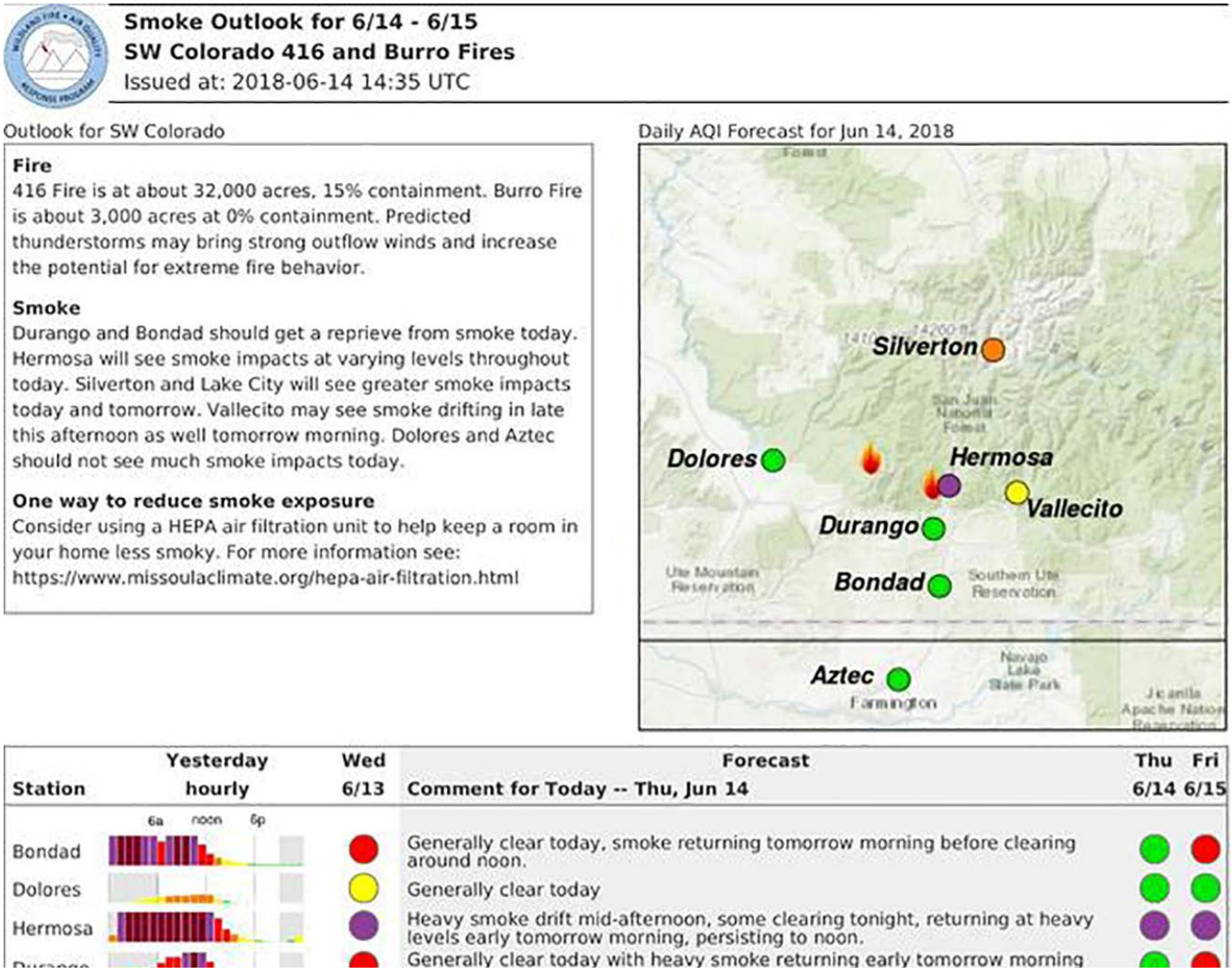

Figure 11. Example smoke outlook (partially shown) produced by an Air Resource Advisor assigned to the 416 Fire. Current smoke outlooks are available at https://wildlandfiresmoke.net/outlooks.

Air Resource Advisors use a national cache of deployable smoke monitors (typically E-SAMPLERS and E-BAMS with real-time telemetry capability) during wildland fire incidents to provide ground information to communities lacking existing monitoring capabilities. Enhanced smoke modeling including high resolution grids over affected areas can be requested of the National Weather Service by an ARA. Air Resource Advisor deployments and contact information are available at https://wildlandfiresmoke.net. ARA-developed outlooks are available at https://wildlandfiresmoke.net/outlooks. A collection of IWFAQRP related tools developed by the U.S. Forest Service Pacific Northwest Research Station's AirFire Team are shown in Appendix C and are available at https://tools.airfire.org.

New monitoring and air quality estimation technologies – a caution

In recent years, technology development has expanded the variety of information available about air quality. These emerging technologies include miniaturized $PM_{2.5}$ sensors stationed in outdoor or indoor environments, mobile air quality monitoring systems, air quality models that can estimate

concentrations in locations without nearby monitors, and data fusion products that blend together observational data and models. Still in a research phase, but likely to expand over time, are personal wearable devices or apps designed to estimate an individual's exposure to $PM_{2.5}$.

In many areas, these emerging technologies and their data are already part of the wildfire smoke dialogue. During a wildfire smoke event, communities lacking a centrally-located $PM_{2.5}$ monitor may rely on sensors as a primary source of air quality information. Citizens, especially those in at-risk groups, might make decisions based on localized estimates from emerging technologies to mitigate their smoke exposure.

Nevertheless, these data must still be regarded with caution. At this writing there are still many unknowns concerning the precision, accuracy, and reliability of readings from sensors, air quality models, and data fusion products, especially in extreme conditions like a wildfire smoke event. Although the technology is improving, it is important to recognize the limitation of using these as stand-alone devices and data products without a reference monitor nearby to evaluate the new technology's performance.

In cases where ARA-implemented monitors or official air quality network monitors exist and emerging technology is implemented, conflicts in air quality information may result. This does not mean that either information set is necessarily wrong, but reflects differences in the locations measured, how data are averaged, or how the AQI is computed. An additional cause for disagreement may be error in the measurement device or data fusion product.

Therefore, sensor data, models, and data fusion products should be considered as supplements to a larger package of information to make better informed decisions on smoke messaging. Comparing sensor data, models, or data fusion products with nearby reference monitors can help the public official understand how to consider this information in their assessment of smoke conditions and communications. These new sources of data may provide important information on the trends of $PM_{2.5}$, but they need to be put into context with the help of nearby regulatory monitors or short-term monitors implemented by an ARA, AQI estimates, satellite data, and from daily ARA Smoke Outlooks.

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 of miles and can change rapidly.

Basic Approach:

To determine visual range, one **must:**

- use this method only during daylight hours, avoiding 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, and
- after determining visual range in miles, use Table 3 to identify actions to take to reduce exposure.

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

Table 3. Visual range and actions to take to reduce smoke exposure when wildfire smoke is in the air.**

Distance seen	Population Type		OR	Specific Illness
	A Healthy Adult, Teenager, or Older Child	Older adults (≥65 years), Pregnant, or A Young Child		Asthma, Respiratory Illness, Lung or Heart Disease
> 10 miles	Watch for changing conditions and moderate outdoor activities based on personal sensitivity	Watch for changing conditions and moderate outdoor activities 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		

[1] Sensitivity to smoke can vary greatly 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 a medical professional or local health officials and adjust activity accordingly to their particular tolerance or sensitivity.

between 2 miles and 4 miles. Use Table 3 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 1, 3, or even 24 hours, so what is seen at a particular moment may not be representative of the average reported at a nearby monitor. More uncertainty stems from sighting on 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. Another commonly occurring problem with this method is that the concentration along the visual path is not constant, for example, when there is little smoke at the surface, but a thick layer of smoke aloft and the reference point being used is above that smoke layer such that the viewer is looking through it. In such cases these methods would be invalid. This method is also 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 is always prudent to take measures such as those presented in this *Guide* to protect oneself if smoke exposure is a concern.

V. RECOMMENDATIONS FOR PUBLIC HEALTH ACTIONS

This chapter includes specific guidance to public health officials on actions to take to protect the public and to advise the public during a wildfire event, preparations to make before fires occur, and recommendations for cleaning up after a fire. Because there are many factors to consider during a wildfire event, these recommendations should be adapted for each specific situation.

Public advisories and protective measures

Areas with established air quality programs typically have a communication plan for alerting the public about air pollution events. A communication plan includes details on who should be given specific information, when that information should be delivered, and what communication channels to use to deliver the information. An effective communication plan anticipates what information will need to be communicated to specific audience segments, such as schools or nursing homes.

One approach is to refer the public to the AirNow website (www.airnow.gov), which is used by states and most communities across the country. Methods for sharing information include state smoke blogs, websites, hotlines, press releases, and social media, 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 a visibility index (see Table 3) and the associated health effects.

Table 4 provides a general list of health effects and cautionary statements about altering behavior that can be used 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 therefore the AQI and associated cautionary statements and advisories for $PM_{2.5}$ may be used.*

Table 5 provides guidance to public health officials about 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 about appropriate strategies to mitigate exposure to smoke. As noted earlier, the official AQI value for $PM_{2.5}$ for the previous day is a 24-hour average of $PM_{2.5}$ concentrations measured from midnight to midnight. The real-time AQI for $PM_{2.5}$ reported by the media and on AirNow is the hourly estimate of the 24-hour AQI based on the NowCast. Although Table 5 provides ambient $PM_{2.5}$ concentrations and the AQI values and descriptors associated with the categories (e.g., Good, Moderate), concurrent publication of both the AQI values and the ambient $PM_{2.5}$ concentrations (in $\mu g/m^3$) 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.

Protecting children

Protecting children is always a high priority in smoke events. The factsheet 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 to implement 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 medical conditions that place them at greater risk from smoke 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, making school closure less beneficial from a public health perspective. Indoor air quality in schools should be assessed before the start of the fire season to assist in planning and decision-making.

Protecting other at-risk groups

Protecting members of other at-risk groups, including older adults, people with heart or lung disease, pregnant women, 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 gyms, senior centers, 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 addition, it is important to recognize that people of lower SES may experience social vulnerability due to socioeconomic and demographic factors (e.g., socioeconomic status, household composition and disability, minority status and language, and housing and transportation) that affect the resilience of communities (Flanagan et al., 2011). In disasters such as wildfires, the socially vulnerable are more likely to be adversely affected and less likely to recover.

In general, individuals in these groups should be advised to avoid or limit outdoor activities once air quality is characterized as "Unhealthy for Sensitive Groups" (orange on the AQI) and to remain indoors with windows closed if air quality is categorized as "Very Unhealthy" (purple on the AQI). Families should consider using an air cleaner with a HEPA filter that will help to reduce indoor air pollution, as well as to avoid adding particles by smoking tobacco, using wood-burning stoves or fireplaces, and candles, and only using a vacuum with a HEPA filter.

Protecting outdoor workers

Many workers have jobs that require them to work outdoors. Occasionally these workers may be exposed to wildfire smoke and other hazards due to wildfires. In addition to the workers who are directly involved with wildland fire management and suppression, there are also workers engaged in supporting fire response (e.g., at base camp or evacuation centers) or cleanup efforts (e.g., demolition crews) , and many others who continue to do their usual non-fire related outdoor jobs (e.g., agricultural workers, landscapers, park personnel) during an incident. Similar to the general public, outdoor workers may be at risk for adverse health impacts from smoke or ash exposure, particularly if they are in an at-risk group (described elsewhere in this Guide). However, some recommendations made to the public on how to reduce their exposures to wildfire hazards may not be relevant for outdoor workers who must continue to work. In addition, their employers may not have anticipated these hazards and may be ill equipped to implement effective protections. To better address these issues, employers and employees should prepare for and plan to implement procedures to protect outdoor workers.

The Occupational Safety and Health Administration (OSHA) is the regulatory entity for employee health and safety but, in about half of the states, a federal OSHA-approved state OSHA program regulates non-federal workplaces. There are currently no occupational standards specifically for wildfire smoke, except in California. On July 18, 2019, the California Safety and Health Standards Board adopted an emergency regulation for a Cal/OSHA standard to protect workers from hazards associated with wildfire smoke. This standard, Title 8 California Code of Regulations Section 5141.1, effective on July 29, 2019 and will be followed by a process to develop a permanent regulation (https://www.dir.ca.gov/dosh/doshreg/Protection-from-Wildfire-Smoke.

Although healthy adult workers may not be significantly affected by short-term exposure to smoke or ash while working outdoors, the risk of adverse health effects is dependent on the contaminant levels, type(s) of material burned, duration of exposure, level of physical activity, age of the worker, individual susceptibility (e.g., pre-existing heart or lung disease), as well as other factors (see Chapter 1). As a result, responses to exposures will vary.

Employers can take steps to protect healthy as well as more at-risk workers from the negative health impacts of unhealthy air quality. Some of the same recommendations listed in this document for the general public can apply when working outdoors

in a smoky environment. Options for limiting workers' smoke exposure include postponing or shortening time spent outdoors; focusing on only performing high priority tasks; relocating workers or rescheduling work tasks to smoke-free or less smoky areas or times of the day; reducing outdoor workers' physical activity and exertion levels; encouraging and ensuring workers take frequent breaks inside cleaner air spaces such as enclosed structures or vehicles with recirculating air; and encouraging and using air cleaners with HEPA (or other protective) filters in indoor working areas to reduce overall smoke exposure.

In some cases, the use of particulate respirators should be considered to protect workers who cannot implement the exposure reduction recommendations listed above when performing outdoor work (see additional information below). Workers involved in post-fire cleanup activities clearly must be protected from exposure to ash and all other hazards (see sections pertaining to after-fire hazards) by using a range of control methods (e.g., dust suppression, personal protective equipment).

When other measures are not sufficient to control a respiratory hazard, OSHA requires employers to provide respirators that are appropriate for the hazard and work situation. An OSHA-compliant respirator program names a qualified person responsible for administering the program and describes procedures for respirator selection, medical evaluation for safe respirator use, fit testing for tight-fitting respirators, training on topics such as how to use and maintain respirators, and program evaluation.

Pre-planning and preparing for how to best implement these recommendations in the workplace are critical. This is especially true in areas where wildland fire smoke exposure is common, and workers are required to perform their work outdoors, even when the air quality is considered unhealthy, very unhealthy, or hazardous. Working together, employers and employees can take steps to reduce their exposures to the hazards associated with a wildland fire.

Prolonged smoke events

For smoke events that last for more than a few days or that occur repeatedly over the course of fire season, public health officials should consider all options in communicating the importance of reducing smoke exposure. Messages should include actions individuals can take to reduce smoke exposure and should highlight the benefits of creating cleaner air spaces in homes. The longer a smoke event continues, the more people will start to experience adverse health effects. Therefore, exposure reduction measures that are recommended for short-term exposures to smoke become even more important to take with prolonged exposures. Prolonged smoke events may require consideration of additional measures to protect the public, especially people in at-risk groups.

If they haven't already, public health officials should consider partnering with external businesses, agencies, and non-profits to provide spaces with cleaner air for the public to go during the day if it becomes necessary. These cleaner air spaces could include schools, senior centers, libraries, and shopping malls. Making spaces with cleaner air available during the day can provide an alternative for people unable to reduce smoke levels in their homes, or unwilling or unable to evacuate to a designated cleaner air shelter or out of the area to reduce their smoke exposure. Before advertising or advocating for these cleaner air spaces, public health officials should confirm that the locations have adequate filtration for particles. This clean air protection may be provided by a MERV 13 or higher filter in the HVAC system or a properly sized portable air cleaner with HEPA filtration. Building managers should continue to ensure that the building is adequately ventilated and that fresh air intakes have high-efficiency (MERV 13 or higher) filters to clean the air entering the building. Altering the building pressure balance by reducing or stopping air intake could actually create indoor air quality issues that could offset any benefit of reduced smoke exposure. For more information, refer to Appendix D. Cleaner air spaces should also

have institutional controls to limit smoke infiltration, such as limited door and window use. Appendix B provides some guidelines for creating cleaner air in large spaces.

As smoke events continue, stress associated with increasing health concerns, loss of control over daily activities, reduction in physical activity, and isolation resulting from remaining at home indoors can cause mental health issues to arise. During a prolonged smoke event or repeated smoke events, make cleaner air spaces available where people can socialize. One beneficial strategy that has been reported consists of waiving fees for gym use, which allows people to get exercise and interact with others. Be aware of mental health issues in your jurisdiction and consider creating messages about mental health and available mental health services.

Protecting pets and livestock

Many people ask how wildfire smoke affects pets and livestock. As with humans, high levels of smoke may irritate animals' eyes and respiratory tract. Animals with heart or lung disease are especially at-risk and should be closely watched during periods of poor air quality. Strategies to reduce animals' exposure to smoke are like those for humans: reduce the time spent in smoky areas; if animals are indoors, keep indoor air clean; provide animals with plenty of water; limit physical activities that will increase the amount of smoke breathed into their lungs; and reduce exposure to dust or other air pollutants. If pets or livestock are coughing or having difficulty breathing, the owner should contact a veterinarian. Two factsheets, Protect Your Pets from Wildfire Smoke and Protect Your Large Animals and Livestock from Wildfire Smoke, are available for dissemination to the public.

Consider where pets and livestock could be housed if the evacuation of people from areas within your jurisdiction becomes necessary. For example, in some places, local shelters will house pets in carriers and it is not uncommon for temporary livestock shelters to be created in local fairgrounds or parking lots. Animals that are older or have a medical condition that increases sensitivity to smoke, may require sheltering facilities that can provide cleaner air or adequate medical attention. Animal accommodations are frequently set up with participation from local animal control, humane society or other animal rescue groups. For more information, check the American Veterinary Medical Association (AVMA) website: https://www.avma.org/public/EmergencyCare/Pages/Pets-and-Disasters.aspx.

Air quality cautionary statements and recommended public actions

Table 5 shows actions for public health officials to consider at the different AQI categories. Public health officials may want to recommend some or all of the recommended actions associated with these categories, based on an 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 multiple days to weeks, public health officials might consider opening cleaner air shelters or recommending evacuation plans for at-risk populations, including individuals with chronic lung or heart disease, who cannot take adequate personal protective actions to reduce exposures.
- **Potential indirect effects.** High $PM_{2.5}$ levels can impair visibility and increase the risk of traffic accidents. This may be reason enough to cancel an evening indoor event at a local high school, for example.

Table 4. Health effects and cautionary messages for at risk populations for each AQI category

AQI Category (AQI Values)	Health Effects	Cautionary Statements	Other Protection Messages
Good (0–50)	None expected	None	None
Moderate (51–100)	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. Individuals with 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, should contact a health care provider.	If symptomatic, reduce exposure to particles by following advice in box below.
Unhealthy for Sensitive Groups (101–150)	Increasing likelihood of respiratory or cardiac symptoms in sensitive individuals, aggravation of heart or lung disease, and premature mortality in people with heart or lung disease and older adults	Sensitive Groups: People with heart or lung disease, the elderly, children, and pregnant women should limit prolonged or heavy exertion. Limit time spent outdoors. Avoid physical exertion. People with asthma should follow their asthma management plan. Individuals with 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, should contact a health care provider.	Keep doors and windows closed, seal large gaps as much as possible. Avoid using exhaust fans (e.g., kitchen, bathroom, clothes dryer, and utility room exhaust fans). 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 (e.g., filters rated at MERV 13 or higher) if they can be accommodated by the system. Regardless of whether a filter upgrade has been performed, 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 appropriately sized 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 a 5-day supply of medication available. Have a supply of non-perishable groceries that do not require cooking.

Table 4. Health effects and cautionary messages for at risk populations for each AQI category. (continued)

AQI Category (AQI Values)	Health Effects	Cautionary Statements	Other Protection Messages
Unhealthy (151–200)	Increased aggravation of heart or lung disease and premature mortality in persons with heart or lung disease and older adults; increased respiratory effects in general population.	Sensitive Groups: Should avoid prolonged or heavy exertion Everyone: Should limit prolonged or heavy exertion Limit time spent outdoors. Individuals with 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, should contact your health care provider.	Sensitive Groups: 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 Everyone: Follow advice for sensitive groups in box above. Identify potential "cleaner air" shelters in the community (see Appendix D).
Very Unhealthy (201–300)	Significant aggravation of heart or lung disease, premature mortality in persons with heart or lung disease and older adults; significant increase in respiratory effects in general population.	Everyone: Should avoid prolonged or heavy exertion and stay indoors, preferably in a space with filtered air.	Everyone: If symptomatic, seek medical attention. If you are unable to create your own cleaner indoor air space to shelter in place, evacuate to a cleaner air shelter or leave the area, if it is safe to do so.
Hazardous (> 300)	Serious aggravation of heart or lung disease, premature mortality in persons with heart or lung disease and older adults; serious risk of respiratory effects in general population.	Everyone: Should avoid any outdoor activity, and stay indoors, preferably in a space with filtered air.	Everyone: If symptomatic, seek medical attention. If you are unable to create your own cleaner indoor air space to shelter in place, evacuate to a cleaner air shelter or leave the area, if it is safe to do so.

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

Table 5. Recommended actions for consideration by public health officials

AQI Category (AQI Values)	$PM_{2.5}$[1] µg/m³ 24-hr avg	Recommended Actions for Consideration
Good (0–50)	0–12	If smoke event forecast, implement communication plan.
Moderate (51–100)	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 (101–150)	35.5–55.4	Evaluate implementation of School Activity Guidelines If smoke event projected to be prolonged, evaluate and notify about possible sites for cleaner air shelters. If smoke event projected to be prolonged, prepare evacuation plans for at-risk populations.
Unhealthy (151–200)	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 (201–300)	150.5–250.4	Move all school activities indoors or reschedule them to another day. Cancel school physical activities (e.g., physical education, athletic practice) unless the school is able to provide cleaner indoor air for the students. Consider closing some or all schools Cancel outdoor events involving activity (e.g., competitive sports). Consider canceling outdoor events that do not involve activity (e.g. concerts).
Hazardous (> 300)	250.5>500	Consider closing schools[2]. Cancel outdoor events (e.g., concerts and competitive sports). Consider air quality in indoor workplaces and take measures to protect workers as needed[3] Consider curtailment of outdoor work activities unless the workers have a fully implemented respirator plan in place and clean air respite breaks. If PM levels are projected to remain high for a prolonged time, consider evacuation of at-risk populations.

[1] If only PM_{10} measurements are available during smoky conditions, assume 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.

[2] See school considerations in section on Protecting Children, above. Newer schools with a central air cleaning filter may be more protective than older, leakier schools. Also, being at school may mean children's activity levels can be better monitored. It is important to make schools a safe place for children.

[3] See Appendix C for guidance.

Public service announcements

This section discusses using public service announcements (PSAs) to deliver messages to the public in advance of wildfire season. Preparing for wildfire season includes planning what actions can be taken by individuals well in advance of a wildfire smoke event. In areas where fires are likely to occur, state and local public health agencies should consider running pre-season PSAs or news and social media announcements to advise the public on preparing for the fire season. The factsheet, Prepare for Fire Season, is available on the AirNow website. EPA's webpage Wildfires and Indoor Air Quality also provides general information on how to reduce exposure to wildfire smoke in residences. PSAs should be simple (e.g., "the season for wildfires is approaching; take action now to protect your health and prepare your home") and should list a contact phone number and 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 use simple, non-technical messages that people can remember, such as "stay indoors" or "limit outdoor activities." News and social media releases and website posts should be used to provide more detailed information, including information for the general public and for people with chronic diseases. When wildfire risk is high, the area federal, state, tribal, or local land manager is also likely initiating a public information campaign to prevent wildfires, providing a natural partner for messaging about smoke with these agencies.

Consider reaching out to weather forecasters and news reporters, who are a valuable resource for sharing information with the public. 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, and at least one telephone number.

General recommendations to the public

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

1. Prepare for wildfire season. 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. Have extra medications, such as asthma medicine. For more information for the public about steps to be ready – use the Prepare for Fire Season factsheet.
2. If you develop symptoms suggesting lung or heart problems, consult a health care provider as soon as possible.
3. Be alert to local announcements, air quality forecasts, and changing smoke conditions.
4. Be aware that outdoor events, such as athletic games or competitions, may be postponed or canceled if smoke levels become elevated.
5. During a wildfire smoke event, you can take steps to limit smoke infiltration and clean the air indoors with either the right-sized portable air cleaner with true HEPA filtration or a HVAC filter with a MERV rating 13+. See the EPA webpage Wildfires and Indoor Air Quality.

Recommendations for people with chronic diseases

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

1. These recommendations are for people with chronic diseases, including heart or lung disease. Have an adequate supply of medication (more than 5 days).
2. People with asthma should have a written asthma action plan. Check the EPA website for resources on asthma action plans: https://www.epa.gov/asthma/asthma-action-plan
   i. People with heart or lung 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.
   ii. Contact a health care provider if your condition worsens when you are exposed to smoke.
   iii. 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 California Air Resources Board website at https://www.arb.ca.gov/research/indoor/aircleaners/certified.htm.
   iv. A news release could also include recommendations for preparing residences to keep smoke levels lower indoors, and on the appropriate use of respiratory protection, as discussed above. See factsheets on Indoor Air Filtration and Protect Your Lungs from Wildfire Smoke or Ash, the webpage Wildfires and Indoor Air Quality, and Appendices B and D.

Use social media to raise awareness

Social media outlets, such as Twitter, Facebook, and Instagram, are a good way to raise awareness about wildfire smoke health protection. Keep in mind that you have many different audiences, so you will need to use many different media to share messages about smoky conditions in your community.

For information on how to use social media for health messages, visit the Centers for Disease Control and Prevention Health Communicator's Social Media Toolkit: https://www.cdc.gov/socialmedia/tools/guidelines/socialmediatoolkit.html.

Social media can attract and direct the public to a central website or document for distribution. This central website will provide complete wildfire smoke information. For social media success, post simple messages that reflect the community's needs at the time. Post different messages but always copy and paste the same link to direct the public to your webpage with the most complete, up-to-date information. Repeating the link to a central website is a good way to reach out and make more people aware of the information.

Prior to wildfire smoke season, create a template with a simple graphic element that is repeated on the central webpage and use the same look for any other wildfire smoke announcements, such as paper flyers, email, and social media, so that when the public sees it they will immediately recognize the information. Make the template usable in both electronic and print media. This can be something as simple as the health department or local government logo and a heading such as WILDFIRE SMOKE ALERT.

Social media messages, like any messages, require advance planning. You will want to find the right contact in your office or agency who oversees social media, ask them about the process for approving and posting messages, propose messages they can send out in a timely fashion, and evaluate the effectiveness of messages delivered over social media.

In the off-season, you can share messages from other sites by retweeting or sharing the information

previously posted on a reputable social media site such as the CDC or EPA. Messages can include topics such as brush cleanup around the perimeter of a home. You can look to the following resources to find messages to share:

https://twitter.com/AIRNow

https://www.facebook.com/airnow

https://twitter.com/CDCenvironment

https://twitter.com/CDCemergency

Preparedness

Preparation is key to effective response to wildfire smoke events. In the months leading up to fire season, the National Significant Wildland Fire Potential Outlooks (https://www.predictiveservices.nifc.gov/outlooks/outlooks.htm), developed by the National Interagency Fire Center (NIFC), can give an idea of the predicted severity of the coming months of the fire season. These assessments indicate which areas of the country are likely to see various levels of fire activity and are designed to inform decision makers for proactive wildland fire management. Outlooks are available for the current month, the month following and a seasonal look at the two months beyond that. However, long-range predictions can be uncertain. Also, even if the NIFC is predicting normal or below normal fire activity in your region, you may be downwind of an area that is likely to see heightened activity.

Before wildfire season arrives, public health officials should consider taking some or all of the following steps, especially if they are in an area predicted to be a higher risk of fire. This is a simple list, more detailed information about each of these steps can be found other places in the Guide.

Recommended steps for public health officials before fire season

Recommended steps for public health officials in areas likely to experience smoke to take before fires start include:

1. Check fire risk level in monthly outlooks at National Interagency Fire Center (NIFC) website and, especially if high, communicate risk to the public.
2. Consider how to implement the recommended actions in Table 5 above.
    - Identify locations that could serve as cleaner air shelters.
    - Identify locations that could serve as cleaner air spaces.
    - Check indoor air quality (IAQ) capabilities in places where at-risk populations congregate (e.g., schools, preschools and daycares; senior centers and nursing homes) and investigate approaches to improving IAQ, if necessary.
    - Have supply of NIOSH-approved respirators to disseminate to public; consider approaches to supplying portable air cleaners.
3. Prepare a communication plan.
    - Include approaches for quick dissemination of information to the public (e.g., social media).
    - Include approaches to reach members of at-risk populations.
    - Develop messages about mental health and available mental health services, since stress can cause mental health issues to arise.
    - Inform public about steps to be ready - use Prepare for Fire Season factsheet.
4. Form partnerships with important partners or stakeholders, for example: air quality agencies, local health providers, the media and others.
    - Help local health providers learn about the health effects of smoke and the populations at greatest risk using the EPA and CDC continuing education course about particulate matter, Particle Pollution and Your Patients' Health.

After the fire, the effectiveness of the response to a wildfire smoke event should be assessed so needed improvements can be identified. A season-ending discussion with partners and preparation of a "lessons learned" plan or report will help the partnership continue to grow and improve.

Build strong partnerships

Wildfires can start and spread rapidly, and a smoke event may descend on a community in a matter of hours. Ideally, relationships between health departments, air quality agencies, land management agencies, and other partners will be in place before a crisis begins. To reduce potential public confusion, partner agencies responding to a wildfire smoke episode need to begin working together right away to inform the public of smoke and health risks using consistent messages. A pre-existing partnership enables a rapid response to a serious smoke episode and allows everyone to quickly access and share vital information.

All agencies working on fire and smoke response should coordinate closely during the incident to ensure consistent communications and to leverage resources for developing and delivering information to the public. This can be achieved through steps such as cross-linking websites, and clearly directing public and media inquiries to the appropriate agency and subject matter experts. Some agencies may have the best experts for media interviews while another may have easy access to language translation services. One partner may be able to access communication material design experts while another contributes monitoring data analysis experts. Building a team that capitalizes on agency and individual strengths while breaking down agency boundaries is the most effective way to quickly serve the public in an air quality emergency.

Physicians and other health care providers often have a high degree of credibility with the public. Having a good working relationship with local health providers who are knowledgeable about the health effects of smoke can be very useful in getting health and exposure reduction information out to the public through the media. EPA has developed an on-line training course, Particle Pollution and Your Patients' Health (https://www.epa.gov/pmcourse), to educate health providers about the effects of particulate matter. The training includes a section on high-particulate matter events, such as wildfires, that is consistent with the information and recommendations in this guide. Physicians, nurses, and health educators can receive continuing education credits from CDC for taking this online training.

Remember that while working with local media and posting information online is important, it is not the only way to deliver information during an emergency. Other methods are effective such as posters, door hangers, fliers, or radio and television. Note that smoke and messaging needs frequently cross state and international boundaries so coordination needs to be developed beyond typical jurisdictions.

Putting together a wildfire smoke team

Responding to the needs of the public in case of a serious or prolonged wildfire smoke event will be far more effective if relevant state, local, and federal agencies and organizations are engaged and working together as a team. Some states have ad hoc wildfire smoke response teams that have already formed during wildfire smoke response efforts, other states or areas may need to start at the beginning to find and engage partners. Some states have prepared formal emergency smoke response plans that outline local points of contact, responsibilities of state agencies and other cooperators, and instructions for acquiring extra needed resources such as monitors or masks. In some states when wildfire smoke impacts are serious or prolonged, these agencies and other local cooperators hold daily or as-needed conference calls to share information and coordinate air quality messaging and public outreach efforts. Participating in these internal calls can be very valuable for public health agencies. Possible key partners in a public response effort include:

- **State and local clean air agencies –** State and local clean air agencies are expert at accessing and summarizing local air monitoring data and often have the ability to forecast upcoming

meteorology and dispersion conditions that will affect smoke movement and accumulation. State air agencies often work with the National Weather Service to have air pollution advisories issued when needed.

- **Federal and state land management agencies** – Typically, federal or state land management agencies have the lead in wildfire suppression and response. Any ARAs working in the area are likely assigned either to a wildfire incident management team or to a Federal Agency Administrator. ARA's are a very valuable source of information for the public health community and can help spread public health messages through ongoing communications. ARA efforts are improved through consultation and coordination with state public health entities. To see if an ARA is working in an area check www.wildlandfiresmoke.net.
- Incident management teams assigned to large wildfires are expert at connecting with local communities and frequently host public meetings where smoke and appropriate public responses may be discussed. These meetings can be an excellent forum for ARAs and public health agencies to deliver messages about smoke and public health.
- **Tribes –** Many tribal communities run their own air quality programs and have local information about supplemental monitors and effective outreach to their communities. EPA regional offices assist with tribal air programs. 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.
- **State and local public health agencies –** State and local health agencies are expert at communicating health risks and protective actions in simple language the public can understand and are well linked to organizations,such as assisted living facilities, hospitals, and clinics, that serve at-risk groups. Public outreach needs of public health agencies often mean they have language translation expertise so important health messages can reach non-English speakers.
- **EPA regional offices** and the **Wildland Fire Air Quality Response Program** may have por-table air quality monitors that can be deployed to smoky areas that are not well represented by existing state networks. The Wildland Fire Air Quality Response Program website (www.wildlandfiresmoke.net) also provides tools to help summarize monitoring data from state monitoring networks and from emergency monitors deployed to wildfires.
- **School systems –** School administrators are frequently anxious for advice on how to best protect their students from smoke. Schools can be invaluable channels for accessing not only children but entire families, particularly in regions where children may be more literate in English than older family members. In addition, schools can sometimes serve as temporary shelters for evacuees.
- **Faith-based and community-based organizations –** Faith-based and community-based organizations can help disseminate awareness messages and can potentially serve as partners for sheltering evacuated residents.

Cleaning up after the fire

Even after the worst of the fire and smoke is over there remain health and safety hazards that homeowners should be aware of. Exposure to lingering smoke and ash from a wildfire can cause significant health effects in both healthy individuals and those in at-risk groups. People may experience symptoms including respiratory irritation, heat-related illness, and even emotional stress after a fire. Physical stress from cleanup activities, exposure to toxic chemicals, damaged power lines, and equipment such as portable generators can cause injuries during clean up. To learn more about the health and safety hazards that people might encounter after a wildfire, refer to Appendix E.

Even after the fire is out, smoke and ash residue can affect the air quality in affected structures. Depending on the severity of smoke intrusion into the building and the length of exposure, some people may notice a lingering odor when they return to their homes, schools, or places of work. Removal of smoke odor is difficult, but there are ways to diminish the odor, including beginning with a thorough airing of any structure. If conditions permit, windows and doors can be opened and fans can be placed in rooms to circulate the air. If it is too warm or cold to open the doors and windows, a large portable air cleaner that has a high-efficiency filter (HEPA) can be used to ventilate the rooms and promote air exchange to help remove the odors. Any air cleaner used should meet ozone emissions and electrical safety requirements. Approved air cleaners can be found here: https://www.arb.ca.gov/research/indoor/aircleaners/certified.htm. Note that while HEPA filters will remove lingering fine particles in the air, they do not remove the gaseous chemicals that cause odors associated with wildfire smoke. These chemicals must be removed by using a portable air cleaner with an activated charcoal prefilter or a prefilter composed of alumina coated with potassium permanganate and replacing the prefilter frequently. Most prefilters on smaller portable air cleaners will saturate quickly and lose effectiveness in a smoky environment. Portable air cleaners with more robust odor removal are available but are frequently on the higher end of the price spectrum.

In addition to ventilation, it is also important to thoroughly clean the affected space. Every surface of the space that was exposed to smoke will need to be cleaned. If ash or other hazards are present, individuals performing cleanup work should wear protective clothing and equipment, such as a well-fitting N-95 respirator, leather gloves, safety glasses or goggles, long pants, a long-sleeved shirt, and shoes with rugged soles. Cleaning will include wiping down the walls, floors, windows, baseboards, doors, frames, cabinets, furniture, and other surfaces with a dilute solution of water and soap. Some people may choose to use additional cleaning products; however, it is important to note that some cleaners also impact indoor air quality. Those who choose to use additional cleaning products should be advised to read label instructions carefully and follow all instructions. Curtains, rugs, furniture covers, bedding, and anything that can be safely washed in a washing machine can be cleaned in this manner. Carpets will also need to be cleaned. This can be done professionally or by using a carpet cleaner rented from a local market or rental center. Often the building ductwork for the heating and cooling system will not be an issue because in many cases the power goes out during fire events and the AC systems do not circulate smoke- and ash-filled air through the ductwork for very long. In cases where ductwork does have smoke residue and is a source of odors, it is recommended to consult with a local smoke remediation company or HVAC contractor to see what options are available to clean it. EPA has a guide for consumers on duct cleaning: https://www.epa.gov/indoor-air-quality-iaq/should-you-have-air-ducts-your-home-cleaned.

The use of an ozone generator to remediate smoke odor is not recommended because ozone can create as many problems as it is intended to fix. Many of the chemicals that are broken up by ozone can produce byproducts that are also dangerous to health. Furthermore, ozone does not remove ash and other particles from the air and indoor surfaces. If an ozone generator is used to remove smoke odors it should be used only by a remediation professional. The space where the ozone generator is being used must be unoccupied during, and for a designated period after, its use to be sure that no one is exposed to the ozone. Finally, some companies claim to use "hydroxyl" generators for remediation. Hydroxyl radicals are highly reactive and can also create chemical byproducts. These devices should be used with the same caution as ozone generators.