



RESEARCH BRIEF

Clean Wisconsin Environmental Health Initiative

Wildfire Smoke in Wisconsin: Effects on Health

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SUMMARY – Smoke from distant wildfires in the Western United States and Canada has created unhealthy air quality in Wisconsin and represents an increasingly important health concern. This smoke is primarily made of fine particulate matter (PM_{2.5}), which can penetrate deep into the lungs and enter the bloodstream, affecting various body systems. Fine particulate matter exposure can cause or exacerbate a variety of heart and lung conditions (e.g., asthma, stroke), damage the nervous system, result in adverse birth outcomes, cause cancer and result in early death. In this brief, we examine the harm associated with exposure to wildfire smoke, how it has increased in Wisconsin, and what can be done to reduce exposure.



Key Takeaways from this brief include:

- Fine particulate matter (PM_{2.5}) is the most concerning air pollutant present in wildfire smoke, but it also carries precursor pollutants like nitrogen oxides that can be converted to ground level ozone, which also damages the lungs and respiratory system.
 - There is evidence that particulate matter from wildfire smoke is more harmful than particulate matter from other sources like fossil fuel combustion.
- Wildfire smoke exposure is estimated to account for approximately 10,000 deaths per year in the United States, with around 250 premature deaths annually in Wisconsin.
 - It is also responsible for hundreds to thousands of visits to the emergency room or hospital for respiratory problems each year in the Midwestern US.
- Climate change is a driving force behind the increase of wildfire smoke PM_{2.5}. Hotter temperatures, prolonged droughts, and strong winds contribute to ideal conditions for more frequent, intense, and longer-lasting wildfires in North America.
- The number of days when Wisconsin's air quality is affected by wildfire smoke has risen over the past 15 years.
 - On average between 2010 and 2020, wildfire smoke caused PM_{2.5} levels to be unhealthy in Wisconsin for less than one day per year.
 - Since 2020, wildfire smoke has caused PM_{2.5} levels to be unhealthy for an average of 9 days per year.
- What can be done?
 - Addressing climate change is necessary to decrease the frequency and intensity of wildfires that cause harmful, travelling smoke plumes.
 - Individually, be aware of the air quality index (AQI) to know when to take measures that prevent exposure to wildfire smoke.
 - Expansion of air quality monitoring systems can allow for more accurate, local, real-time warning systems for poor air quality due to wildfire smoke.

Definitions

- **Air Quality Index (AQI):** A numeric scale designed by the Environmental Protection Agency (EPA) to indicate the risk of health impacts based on the concentration of air pollution detected at a given time and place.
- **Ground-level Ozone (O₃):** An air pollutant formed when sunlight and heat trigger a chemical reaction between nitrogen oxides and volatile organic compounds. O₃ is a major component of smog and can irritate the lungs, causing worse respiratory conditions at high concentrations.
- **Hazardous Air Pollutant (HAP):** A general class of air pollutants that are identified by the EPA for causing serious health effects like cancer and respiratory issues, but for which there are no air quality standards.
- **Nitrogen oxides (NO_x):** A group of gaseous chemicals that contain nitrogen and oxygen that are produced during combustion. These chemicals are considered primary pollutants, as they are emitted directly from combustion. Nitrogen oxides are precursors for ground-level ozone formation.
- **Oxidative stress:** Biological process where an excess amount of reactive oxygen damages cells and tissues, causing inflammation and harm to the body. It can be triggered by pollutants like particulate matter.
- **Particulate Matter (PM):** A mixture of tiny solid particles and liquid droplets of pollution found in the air, including dust, soot, and smoke. PM is classified by size: PM₁₀ measures at 10 micrometers (µm) in diameter or smaller, while PM_{2.5} measures at 2.5 µm in diameter or smaller. PM_{2.5} can penetrate deep into the lungs and cross into the bloodstream, posing increased risk of various health harms.
- **Volatile organic compounds (VOCs):** A group of organic chemicals that easily turn into a gaseous state and disperse in the air. These compounds are considered primary pollutants, as they are emitted directly from combustion. VOCs are precursors for ground-level ozone formation.

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Introduction

Smoke from wildfires causes a wide range of health effects in humans, posing an increasing public health concern. Wisconsin has seen the impact of the wildfires in Canada particularly since 2021, and residents across the Midwest are facing recurring air quality challenges due to smoke plumes travelling long distances from large-scale wildfires in Canada

and the western United States (Zhang et al. 2025). It is important to understand what wildfire smoke contains, why it is harmful to human health, and what mitigation measures can be taken to both reduce the risk of wildfires occurring and reduce exposure to wildfire smoke.

What is Wildfire Smoke and why is it Harmful?

Overview

Smoke from wildfire contains a variety of pollutants in the form of gases and particles that result from the combustion of vegetation, houses or buildings, and other materials. The contents of wildfire smoke depend on what is being burned in the wildfire. Fires limited to forests and other undeveloped areas burn natural vegetation, while smoke from wildfires that are also burning homes can include toxic materials present in many buildings. In this brief, we will be focusing on forest fire smoke, which more frequently impacts Wisconsin air quality.

In general, wildfire smoke contains primary pollutants (released directly from the fire) including particulate matter, carbon monoxide, nitrogen oxides, and sulfur oxides (Liggett 2025). These primary pollutants can then react with atmospheric conditions, like sunlight, to produce secondary pollutants, such as ground-level ozone (Liggett 2025).

Particulate Matter

The main pollutant that is a public health threat through exposure to wildfire smoke is particulate matter (PM). PM is a mixture of solid particles and liquid droplets of pollution found in the air. These particles vary in size and are measured in micrometers (μm). PM_{10} are particles that are small enough to inhale, measuring $10\mu\text{m}$ in diameter or smaller. PM_{10} includes air particles such as dust, pollen, and mold. $\text{PM}_{2.5}$, also known as fine particulate matter, are particles that are even smaller, measuring smaller than $2.5\mu\text{m}$ in diameter, or about $1/30^{\text{th}}$ the width of a human hair. These particles travel deep into the lungs and, because of their small size, can cross into the bloodstream to affect various body systems through oxidative stress (US EPA 2025; Stearbourne 2025). Oxidative stress causes inflammation in the body due to reactive oxygen presence from pollutants such as PM. $\text{PM}_{2.5}$ includes particles formed during combustion, including from wildfire smoke. Approximately 90% of total particle mass emitted from wildfires consists of $\text{PM}_{2.5}$ (Vicente et al. 2013; Groß et al. 2013 as cited in AirNow n.d.).

Exposure to fine particulate matter can cause a wide range of symptoms and health effects. These include

but are not limited to eye and throat irritation, coughing, phlegm, wheezing, reduced lung function, asthma attacks, worsening chronic obstructive pulmonary disorder symptoms, risk of heart failure, heart attack, stroke, adverse birth outcomes, and even premature death (AirNow n.d.; MNDH 2025).

The U.S. EPA has set an average annual standard of $\text{PM}_{2.5}$ at 9.0 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). This standard represents the maximum acceptable annual average concentration of fine particulate matter to protect public health. In the case of the 2023 Canadian wildfires, the fires accounted for an average increase of 1.49 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) in annual $\text{PM}_{2.5}$ concentrations across the USA (Zhang et al. 2025) So, the particulate matter pollution from wildfire smoke alone accounted for 17% of the annual standard. The Midwest saw higher than average annual mean $\text{PM}_{2.5}$ increases than the country as a whole, with the Midwest having an increase of 3.13 $\mu\text{g}/\text{m}^3$ as a result of the 2023 Canadian wildfires (Zhang et al. 2025), representing over one-third of the $\text{PM}_{2.5}$ annual air quality standard.

Importantly, there is evidence that exposure to particulate matter from wildfire smoke is more harmful than exposure to particulate matter from other sources like vehicles or other fossil fuel combustion (Aguilera et al. 2021, Wie et al. 2023, Alari et al. 2025). This is thought to be due to the different chemical compositions of wildfire smoke, including higher concentrations of carbon and other compounds with higher oxidative potential. This means that PM_{2.5} from wildfire smoke may cause more inflammation and oxidative stress once in the body. (Liggett 2025; Stearbourne 2025; Aguilera et al. 2021a).

Studies of California wildfire smoke exposure report that PM_{2.5} from wildfire smoke can be ten times more dangerous than exposure to particulate matter from other urban sources with respect to respiratory hospitalizations (Aguilera et al. 2021a) and pediatric emergency room/urgent care visits (Aguilera et al. 2021b). Another study in Europe found that short-term exposure to wildfire-related PM_{2.5} was more strongly associated with overall, cardiovascular, and respiratory mortality rates than PM_{2.5} from other sources (Alari et al. 2025).

There is also the potential that wildfire smoke increases the black carbon-to-PM_{2.5} ratio. This means that PM_{2.5} is increasingly saturated with black carbon, a highly toxic component of PM_{2.5}. One study found that the black carbon-to-PM_{2.5} ratio rose by 2.4% per year between 2000 and 2024 in the United States due to wildfire smoke increasing (Wei et al. 2023).

Volatile Organic Compounds, Nitrogen Oxides and Ground-Level Ozone

Volatile Organic Compounds (VOCs) are compounds that easily turn into gas. Nitrogen oxides (NO_x) are gaseous primary pollutants (released directly from combustion) that contain harmful forms of nitrogen and oxygen. Wildfires, which release VOC as they burn trees, shrubs, grass and other vegetation, represent the second-largest source of VOC emissions globally (Jin et al. 2023). VOCs and NO_x contribute to the formation of ozone when exposed to sunlight and heat (AirNow n.d.).

Ground-level ozone is another concern from wildfire smoke. This is a secondary pollutant, since it is formed when the primary pollutants in wildfire smoke (PM, NO_x, VOCs) react with sunlight and warmer

temperatures (MNDH 2025; AirNow n.d.). NOAA research found smoke that still contained precursor pollutants capable of producing ozone even though it was days old and over 1,000 miles away from the original wildfire (Stein 2024). The health implications of exposure to ground-level ozone, even for healthy individuals, include coughing, wheezing, chest pain, and reduced lung function (AirNow n.d.).

Hazardous Air Pollutants

Hazardous air pollutants refer to a diverse set of pollutants that are found in the air which are known to cause cancer and other health effects, but for which the Clean Air Act does not establish air quality standards (Rice et al. 2021). HAPs are different from the criteria air pollutants (PM_{2.5}, PM₁₀, ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead) for which the Clean Air Act provides national ambient air quality standards (NAAQS). In their analysis of concentration of HAPs from 2006 to 2020 in the Western US, Rice et al. (2021) found that HAP concentrations (namely acetaldehyde, acrolein, chloroform, formaldehyde, manganese, and tetrachloroethylene) were significantly elevated in the air on days where smoke was present compared to days where there was no smoke. Furthermore, one study found that wildfire-smoke HAPs accounted for one-third of the total national average risk for cancer from all HAPs exposure (O'Dell et al. 2020).

However, it is unclear how long the HAPs persist in the distant wildfire smoke plumes reaching Wisconsin. Some estimates claim certain HAPs only last for a few hours, while some HAPs can be present in wildfire smoke for days (O'Dell et al. 2020).

Sensitive Groups

There are certain groups of people who are particularly vulnerable to the health effects of air pollution, including wildfire smoke.

Children are considered a sensitive group because they inhale more air (and thus, smoke) per pound of body weight compared to adults, especially when they are engaging in vigorous activities outside, which affects their developing lungs (EPA 2025b).

People aged 65 and over are considered a sensitive group because they tend to have a higher prevalence of lung and heart diseases, and the body's defenses decline with age (AirNow n.d.; EPA 2025).

People with breathing or heart conditions, such as heart disease, COVID-19, asthma, or chronic obstructive pulmonary disease (COPD), are considered a sensitive group (EPA 2025b; US Department of Agriculture 2020). These conditions increase their risk of cardiovascular-related events triggered by exposure to smoke (EPA 2025b).

People who work outdoors are considered a sensitive group because they spend more time exposed to wildfire smoke (EPA 2025b).

People who are pregnant are considered a sensitive group due to physiological changes during pregnancy (e.g., increased breathing rates), which may increase vulnerability to air pollution. Furthermore, the fetus may experience increased vulnerability to these exposures at certain points of development (EPA 2025b).

People who are under-resourced (i.e. people who are unhoused or in a low socio-economic group) are considered a sensitive group because they are more likely to have less access to healthcare, thus a higher chance of having untreated or unknown health conditions (such as asthma or diabetes), which can exacerbate the health effects of exposure to wildfire smoke. People who are under-resourced also may lack access to measures that can reduce exposure to wildfire smoke, such as shelter and air filtration (EPA 2025b).

Estimated Health Burden of Wildfire Smoke Exposure

A recent study found that exposure to PM_{2.5} from wildfire smoke in the United States between 2007 and 2020 is attributable to over 10,000 deaths a year from a variety of conditions including cardiovascular disease, digestive issues, endocrine issues, mental illness, and chronic kidney disease (Ma et al. 2024). The highest exposures were in the western, southeastern, and north central states, including Wisconsin. In Wisconsin, wildfire smoke was attributable to around 250 premature deaths a year.¹ We note that this study only looked at smoke impacts through 2020, and Wisconsin's smokiest summers

have occurred since then (see following section). As wildfire smoke incursions into the state increase in frequency and severity, the number of premature deaths attributable to smoke will increase.

Another study looked at the health impact of the 2023 Canadian wildfire smoke in the United States and estimated that it resulted in over 35,000 premature deaths from the fine particulate matter exposure (Zhang et al. 2025). Midwestern states were the most impacted, with the smoke increasing fine particulate matter concentrations the most in those states, including Wisconsin.

O'Dell et al. (2021) assessed the health risks of exposure to smoke from western U.S. fires from 2006 to 2018 and found that most asthma-related emergency department visits and hospital admissions attributable to wildfire smoke PM_{2.5} occur outside of western states. Between 2006 and 2018, the Midwest region (Wisconsin, Minnesota, Illinois, Michigan, Ohio, and Indiana) had anywhere from 200 – 1,200 annual emergency department visits and 50 – 400 annual hospitalizations as a result of smoke PM_{2.5} (O'Dell et al. 2021).

Most of the research on the health impacts of wildfire smoke focuses on short-term exposure. However, long-term exposure to toxicants in wildfire smoke may contribute to lifetime risk of heart disease, lung disease, and cancer (AirNow n.d.). Because of this, experts say, take precautions against exposure to wildfire smoke; consistent exposure to smoke can have long-term, cumulative effects on the body (Liggett 2025).



¹ Calculated assuming a population of 5.7 million in Wisconsin and an attributable rate of 4-5 premature deaths per 100,000 people as shown in figure 3A of Ma et al. 2024

Wildfire Smoke in the Midwest

Mechanisms of Wildfire Smoke

Although wildfires occur most frequently in western North America, smoke plumes often travel thousands of miles, impacting air quality in the Midwest.

Wildfires begin as a result of three conditions: a heat source, fuel, and oxygen (AirNow. n.d.). Fuels like grass, trees, and structures feed fires, while wind supplies oxygen, increases intensity, and drives flames forward by preheating new areas. Heat sources such as lightning, campfires, or sparks ignite fuels.

Once started, fire behavior is shaped by fuel, weather, and terrain, which impacts the fire's spread, intensity, and thus, wildfire smoke (AirNow. n.d.).

Wildfire fuel type, the moisture content of the fuel, the amount of fuel to burn, and the phase of combustion can cause different amounts of smoke to be created. Forest fires typically cause more severe and long-lasting impacts on air quality as compared to brush or grass fires. This is especially true in remote areas of large forest areas, where fire management is more difficult. Efforts to reduce all wildfires led to decades of fire suppression and has caused a buildup of fuel in some areas (NASA 2025). The fuel buildup and climate-induced fire-feeding conditions increase the likelihood of extreme fires, and thus, harmful wildfire smoke.

While the poor air quality from smoke in Wisconsin are due to large fires in the western United States and the boreal forests of Canada, wildfires do occur in Wisconsin. According to Ready Wisconsin, most wildfires in Wisconsin occur in the spring, after snow melts, and potentially dry conditions make grass, pine needles, and leaves ideal sources of fuel for wildfires. In the summer months, Wisconsin experiences higher humidity, and vegetation is not too dry. However, very dry summers can also lead to conditions that are favorable for wildfires in Wisconsin to start and spread (Ready Wisconsin n.d.).

Wildfires in Wisconsin are relatively small and do not have the same severe air quality impacts as the smoke plumes from the western United States or Canada. For example, since 2012, wildfires have burned 36,000 acres in Wisconsin (Wisconsin DNR 2025a). In contrast, a single fire in Saskatchewan (the Candle Lake fire, one of the fires impacting Wisconsin

air quality in late July and early August of 2023) burned 1.4 million acres (CIRA 2025), burning 40 times more acres in one fire than has burned in Wisconsin over the last 13 years. For this reason, the impact on air quality in Wisconsin in recent summers has been a result of travelling wildfire smoke plumes from wildfires in Canada.

Carbon monoxide also becomes a potential concern of wildfire smoke exposure for those near the wildfire itself. Carbon monoxide, a primary pollutant of wildfire smoke, generally causes more harm to those in immediate proximity to the line of fire or people with cardiovascular diseases (CVD) compared to people further away from the fire or people without CVD (AirNow n.d.). Carbon monoxide particles are small enough to enter the bloodstream when inhaled and prohibit oxygen from being delivered to organs and tissues throughout the body. The health implications of carbon monoxide from wildfire smoke include headache, weakness, dizziness, confusion, nausea, disorientation, visual impairment, coma, and death, even in otherwise healthy individuals (AirNow n.d.).

Impact of Climate Change on Wildfires and Smoke

Climate change is reshaping the dynamics of wildfire risk, thus altering the factors that cause wildfires to ignite and smoke to spread, including into Wisconsin.

There have been trends showing that precipitation in the western United States and boreal Canada has become more concentrated in the winter months due to climate change. This decrease in year-round precipitation results in dry periods, causing evaporation from soil, which leads to an increase in flammable fuel for wildfires (Xu et al., 2020). At the same time, global warming causes greater land-sea temperature differences, which enables stronger winds that carry oxygen to the fire and make it harder for firefighting (Xu et al., 2020).

The results of one model shows that due to climate change, fire-prone areas in temperate (including the US) and boreal (including Canada) regions are expected to experience expansion and lengthening of the potential fire season at the end of the twenty-first century (Senande-Rivera et al. 2022). This means that wildfires are now starting earlier and ending later in the year. Because of this, there is a shorter timeframe

for which preventive measures, such as prescribed burning, are allowable. There is also evidence that these northern regions are also experiencing climate change at a faster rate than other parts of the world, which might explain why the boreal forests (such as in Canada) have been victim to 60% of total tree loss throughout the world related to forest fires from 2001 and 2024 (MacCarthy et al. 2025).

One study found that the increased risk of fire-favorable weather from 1979 to 2020 was twice as attributable to human-caused warming compared to natural variability global warming (Zhuang et al. 2021).

The 2023 wildfires in Canada burned through 45-million acres, doubling the area burned of the previous record year in 2019 (Latham 2025). By mid-2025, another 15 million acres had already burned across more than 3,000 fires, surpassing the 10-year seasonal average several times over (Latham 2025). Climate models used by NOAA suggest such extreme

conditions may become the norm, rather than the exception, by the 2050s (Stein 2024).

Hot, dry conditions are strongly linked to wildfire smoke (Burke et al. 2023), as hotter, dryer temperatures allow for bigger and more frequent wildfires (MacCarthy et al. 2025). Not to mention, high concentrations of carbon dioxide (CO₂) emissions occur during wildfires, with carbon emissions from wildfires in boreal forests of Eurasia and North America tripling between 2001 and 2023 (NASA 2025). This creates a feedback loop of global warming, climate change, wildfires, and CO₂ emissions from wildfire smoke.

Increasingly hot temperatures during Wisconsin's summers, driven by climate change, also means that air quality will worsen with the wildfire smoke—not only as a direct result of PM_{2.5} presence but also ground-level ozone (a secondary pollutant). This, as previously mentioned, happens because primary pollutants in wildfire smoke react with sunlight and heat to create ground-level ozone.

Wisconsin-specific Air Quality Impacts from Wildfire Smoke

Trends in Wildfire-smoke Impacted Air Quality Days

To examine trends in number of days when wildfire smoke has created unhealthy air quality in Wisconsin, we calculated the number of days each year when smoke has caused air quality index (AQI) value for particulate matter to reach unhealthy levels for at least one monitoring station in the state (see Appendix A for detailed methodology).

There has been an increase in the number of days that Wisconsinites are exposed to any level of harm due to PM_{2.5} from wildfire smoke presence since 2010

(Figure 1). This trend is consistent with what is known about the impact of climate change on increasing frequency and strength of wildfires in temperate and boreal forests.

Between 2010 and 2020, there were a total of 6 days where elevated levels of PM_{2.5} from smoke reached unhealthy levels, averaging less than 1 day of smoke-impacted poor air quality per year. Notably, there was only one day when smoke created unhealthy air quality for the general public.

Since 2020, there have been 44 days where elevated levels of PM_{2.5} from smoke reached unhealthy levels, averaging nearly 9 days per year. This includes 19 days when the air quality was unhealthy for the general public and 3 days when the air quality was very unhealthy.

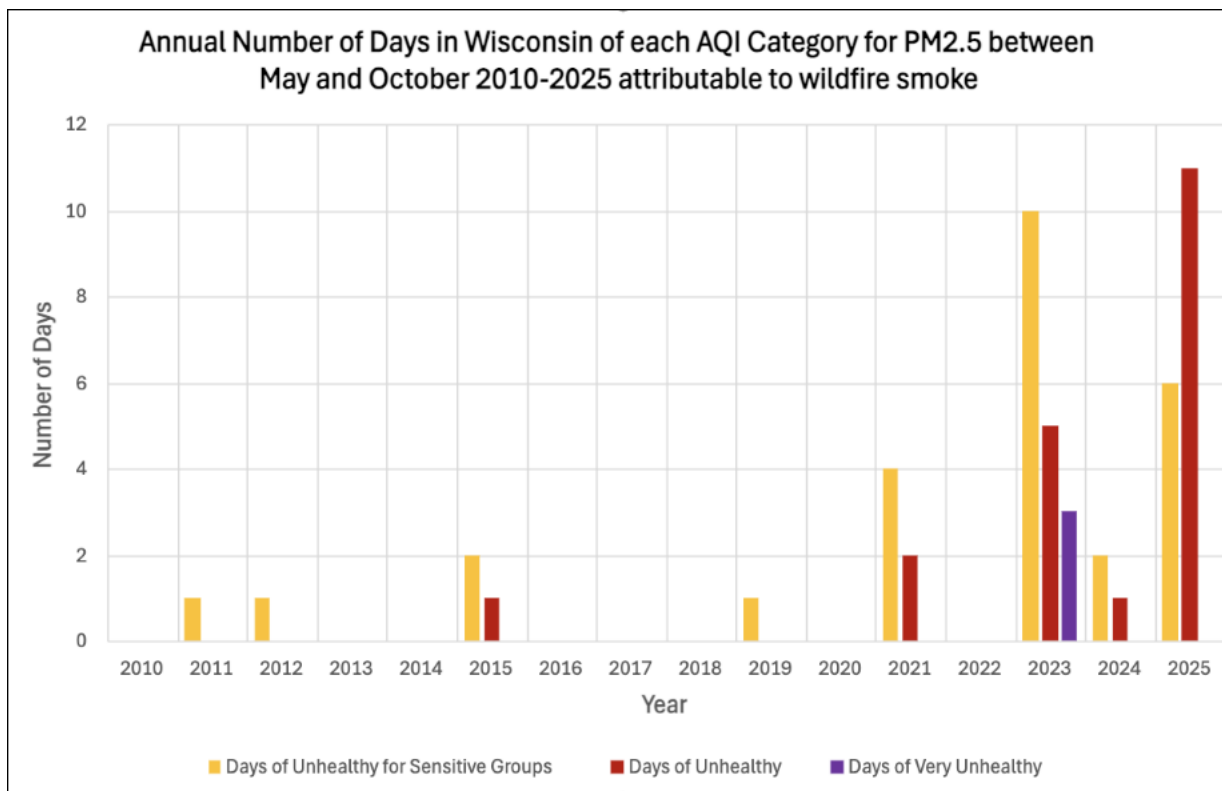


Figure 1. The number of days in each wildfire season (May through October) between 2010 and 2025 in which at least one air quality monitor throughout Wisconsin detected an elevated level of PM_{2.5} from wildfire smoke. The different colors identify the level of health concern of the poor air quality. PM_{2.5} AQI thresholds: (Orange, Unhealthy for Sensitive Groups; ≥ 101), (Red, Unhealthy for everyone; ≥ 151), (Purple, Very Unhealthy for everyone; ≥ 201).

Wildfires and Ground-level Ozone

The contribution of wildfire smoke to ground-level ozone concentrations in Wisconsin is of particular interest due to areas of seven counties in southeastern Wisconsin (Kenosha, Milwaukee, Ozaukee, Racine, Sheboygan, Washington, and Waukesha) not meeting ozone air quality standards. Indeed, in 2024, the United States Environmental Protection “bumped up” these ozone air quality violations from “moderate” to “severe”, which places additional restrictions on ozone precursor emissions from sources in the state. As of October 2025, this redesignation has been legally challenged and has not been put into effect, but it illustrates the importance of reducing ozone in the state.

As discussed above, wildfires can release ozone precursors which can travel with smoke plumes and contribute to ozone formation (“ozone enhancements”) in distant areas. However, the contribution to ozone formation is complex and

depends on a number of factors, making ozone enhancements from wildfire smoke incursions inconsistent. The fuel type and moisture content of the material being burned affects VOC and NO_x emissions from the fire, and NO_x emissions are highest in the initial flaming stage, so there is more production from a fast-spreading fire than a long smoldering fire (Lu et al. 2016; Langford et 2023, Cooper et al. 2024). Plume height during transport also affects distant ozone enhancement, as lower plume heights can provide more NO_x available for ozone formation (NO_x will transform into more stable peroxyacetyl nitrate, which then breaks down to NO_x again downwind of the fire) (Cooper et al. 2024). Finally, the meteorological conditions once the smoke reaches Wisconsin will impact ozone formation even if the precursor pollutants are present in the plume in sufficient quantities. Ozone production will be greatest in warmer, sunnier, and drier conditions with low winds (Lu et al. 2016; Langford et 2023, Cooper et al. 2024).

The May-June 2023 wildfire smoke incursion contained a confluence of conditions that led to historic ozone enhancement in Wisconsin and the rest of the Upper Midwestern United States (Cooper et al. 2024). The effect of those fires is clearly visible throughout the state with some of the highest ozone levels in the past 15 years coinciding with the presence of smoke from those fires in the state

(Figure 2). Other smoke-affected air quality periods do not consistently show the same enhanced ozone levels, underscoring the context-specific nature of wildfire ozone enhancement.

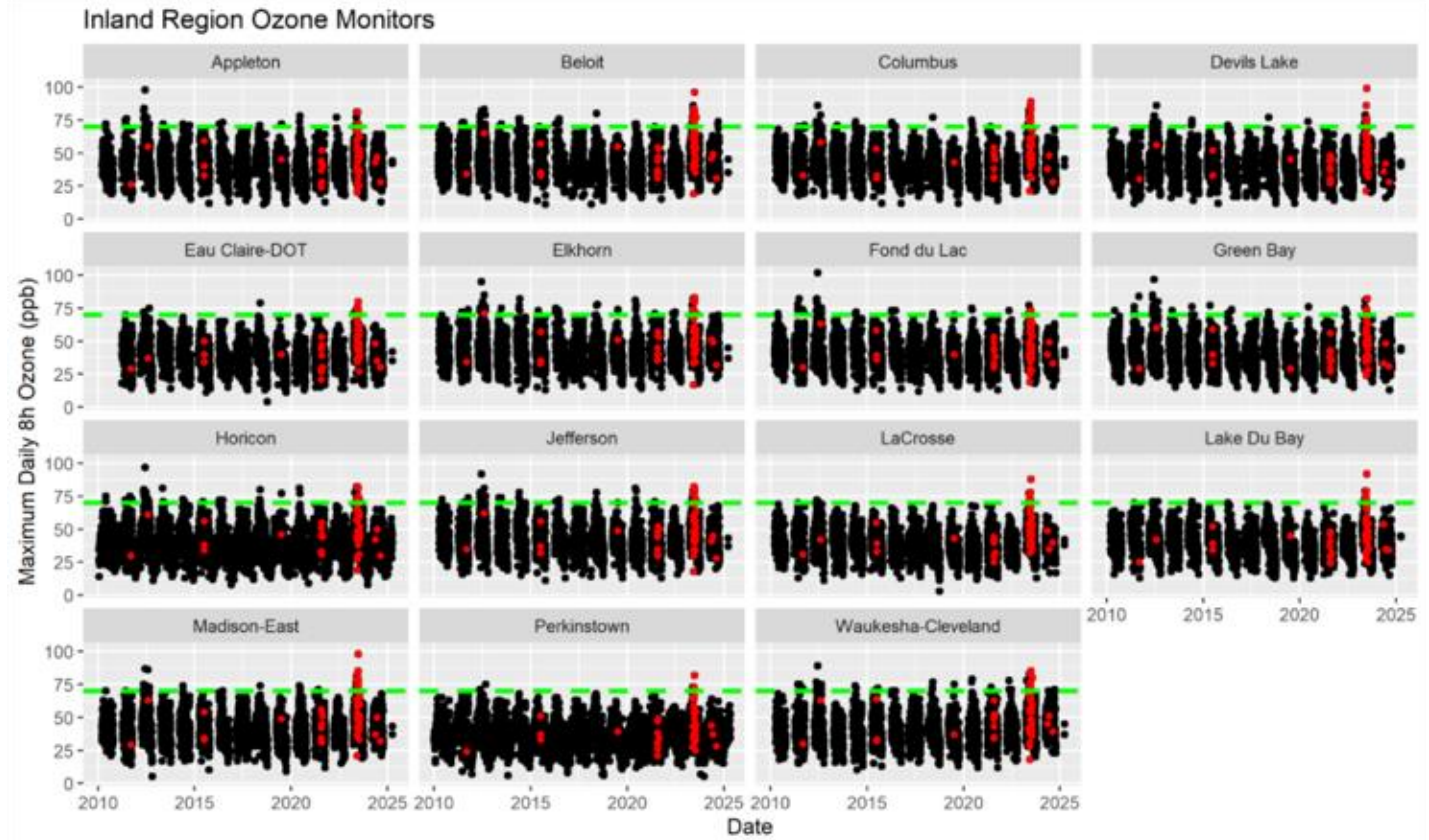


Figure 2. Maximum daily 8-hour average ozone concentrations at inland ozone monitors in Wisconsin since 2010. Red data points represent days where air quality in Wisconsin is impacted by wildfire smoke at or above levels unhealthy for sensitive groups. The green dashed line indicates the air quality standard of 70 parts per billion (ppb). Ozone enhancement from wildfire smoke is clearly apparent from the May-June 2023 smoke incursion, but inconsistent in other smoke-impacted days. Data from lakeshore and north region monitors is shown in Appendix A.

What can be done?

Air Quality Monitoring and Alert Systems

The Clean Air Act directs the U.S. EPA to set the primary National Ambient Air Quality Standards (NAAQS) at a level that protects public health. To track and measure the risk posed to the public from major air pollutants, especially ozone and PM_{2.5}, the EPA uses the Air Quality Index (AQI) standards, shown in Table 1.

Table 1. This table was created by AirNow (a partnership of the U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, National Park Service, National Aeronautics and Space Administration, Centers for Disease Control, and tribal, state, and local air quality agencies) to help visualize the levels of concern for air pollution of PM_{2.5} and ozone. Based on this table, higher daily AQI values indicate an increasing risk of effects on human health.

Air Quality Index		
AQI Category and Color	Index Value	Description of Air Quality
Good Green	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate Yellow	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups Orange	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy Red	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy Purple	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous Maroon	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

Wisconsin’s Department of Natural Resources (DNR) collaborates with the US EPA to issue smoke advisories and real-time air quality alerts based on both monitoring and forecasting based on these AQI levels (WI DNR 2025).

One way to mitigate the harmful effects on human health from exposure to wildfire smoke is to improve monitoring and ensure that people are aware of the

AQI status. Focusing on improving the accuracy of air-quality forecasting for pollution alert systems is a quick and cost-effective way to warn people about and prevent exposure to increased air pollution due to wildfire smoke (Zhang et al. 2025).

Because wildfire smoke plumes can travel over vast distances, international cooperation to monitor and prevent extreme wildfires should be considered

(Zhang et al. 2025). Systems similar to weather forecasting using predictive models are possible for wildfire smoke, especially with new technologies and expanded data sources (Air Oasis 2024; USFSRD n.d.). Developing robust and local early warning systems helps at-risk groups, local agencies, outdoor employers, and schools prepare for poor air quality days.

Enhancing these systems could include:

- Integrating satellite and local sensor data for faster and more precise smoke trajectory prediction (Air Oasis 2024; USFSRD n.d.).
- Expanding public notification systems (text/email alerts, local media partnerships) (Air Oasis 2024; USFSRD n.d.).
- Providing accessible guidance on both anticipated and real-time smoke exposure (Air Oasis 2024; USFSRD n.d.).

At the same time, localized air quality monitoring is increasingly recognized as crucial for understanding and addressing neighborhood-level health impacts from air pollution and wildfire smoke. Examples of such efforts include the MKE FreshAir Collective in Milwaukee, which deploys sensors to monitor specific neighborhoods, and the City of Madison's new sensor network partnered with local organizations to gather and share real-time, neighborhood-level air pollution data (City of Madison 2025; MKE FreshAir Collective n.d.). Allocating funding to initiatives like these expands awareness and access to solutions for poor air quality due to wildfire smoke and in general.

Protecting Against Wildfire Smoke Exposure

Residents can take steps for themselves to protect against the health impacts of wildfire smoke and poor air quality exposure. Make sure to stay up to date on the quality of air outside around where you live. When the AQI is at an elevated level, it is often best to stay indoors to avoid breathing in wildfire smoke particles directly (Wisconsin DNR 2025b). This might mean moving plans for outdoor activities to be indoors instead, especially if anyone in a sensitive group is planning to be there (Wisconsin DNR 2025b). Keeping the doors and windows of your home closed and running the air conditioning with a high-efficiency

air filter or purifier is also advised (Wisconsin DNR 2025b).

If going outdoors during elevated AQI due to wildfire smoke is necessary, consider using an N-95 mask or a respirator, checking the AQI throughout the day to know when the air quality is at increasingly harmful levels, and listen to your body to know when to go indoors (Wisconsin DNR 2025b). Seek medical attention for difficulty breathing, chest pain, persistent cough or sneezing, eye irritation, and dizziness or confusion (MNDH 2025).

Aside from these recommendations for the general population, there are also considerations to be made for protecting people who are in more sensitive, at-risk groups for health effects from wildfire smoke exposure.

Protecting children

Schools, childcare programs, and youth sports organizations play a key role in protecting children on poor air quality days by monitoring the local AQI, adjusting activities, and maintaining safe indoor environments. These organizations should check the AQI daily, especially in warmer months when wildfire smoke PM_{2.5} and ozone are more common (Wisconsin DHS 2025). Staff and coaches should receive guidance on adjusting activity type, intensity, and duration based on AQI levels: limit outdoor time when AQI is 101–150 (orange), move activities indoors at 151–200 (red), and hold all events indoors at 201–300 (purple). Facilities should also maintain HVAC filters rated MERV 13 or higher, create “clean air rooms” with HEPA air cleaners for high-risk students, and train staff to respond to respiratory symptoms while ensuring asthma action plans and medications are accessible (Wisconsin DHS 2025).

Protecting outdoor workers

Employers have a responsibility to monitor air quality, reduce exposure risks, provide training and rest areas, and supply protective equipment when necessary. Employers should monitor AQI daily, train workers on recognizing symptoms of smoke-related illness, and provide rest areas with filtered air (Wisconsin DHS 2025). When air quality is poor, they should reschedule or relocate outdoor tasks, reduce physical exertion, and supply N95 masks when necessary (Wisconsin DHS 2025). Work should be moved indoors to a clean-air space or postponed entirely

when the AQI reaches unhealthy levels to protect all workers from harmful exposure (Wisconsin DHS 2025).

Protecting other at-risk groups

In the same way that shelters open during extreme heat and extreme cold events to those who lack the resources, these shelters could also operate when the AQI is at unhealthy levels to ensure protection from poor air quality for people who lack resources for clean air.

Mitigating Climate Change

Climate models project that PM_{2.5} from smoke will rise with future warming if no action is taken (Burke et al. 2023). Since climate change has been shown to produce conditions that are favorable for wildfires, the biggest goal to reduce the risk of wildfires and smoke is to reduce greenhouse gas emissions that contribute to climate change from global warming.

Additionally, wildfires themselves contribute to global warming as a result of emitting large amounts of CO₂, which offset the climate-change mitigation efforts such as reducing carbon emissions. This is why it is so important to continue efforts that reduce climate change driven conditions that fuel wildfires. To end the feedback loop of wildfire smoke and global warming, global greenhouse gas emissions must be reduced (Thayer & McCarthy 2025; Xu et al. 2020), with net-zero carbon emissions.

In an effort to mitigate climate change and to reduce the future impact of wildfire smoke in Wisconsin, Clean Wisconsin is working hard to advocate for a faster transition to a carbon-free future. This includes transitioning from fossil fuel combustion like methane gas and coal for electricity generation in the state to more clean energy sources like solar and wind. It also includes responsible development of the necessary infrastructure to bring clean energy from wind-rich areas like Iowa, Minnesota, and the Dakotas into Wisconsin. In addition to these transitions, Clean

Wisconsin helps advocate for improved energy efficiency throughout the state, helping to reduce electricity production demands.

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Additional Resources

American Lung Association: [Wildfire smoke and lung health](#).

Centers for Disease Control and Prevention: [How wildfire smoke affects your body](#).

Clean Wisconsin: [Clean Water, Clean Air, Clean Energy - Clean Wisconsin](#).

Current wildfire and smoke conditions across North America: [AirNow Fire and Smoke map](#).

United States Environmental Protection Agency: [Health effects attributed to wildfire smoke](#).

Wisconsin DNR: [Wildfire Smoke](#); [Sign up](#) to receive air quality advisory notices to your email inbox or via text.

Appendix A

Methods: Identifying Smoke-impacted Poor Air Quality in Wisconsin

Fine particulate matter (PM_{2.5}) AQI Data from each of the monitoring systems in Wisconsin between 2010 and 2025 were downloaded from the United States Environmental Protection Agency (USEPA 2025c). The data were categorized by AQI level: 101-150 for unhealthy for sensitive groups, 151-200 for unhealthy for everyone, and ≥201 for very unhealthy for everyone. We then calculated the number of unique days each year where at least one monitor in Wisconsin had AQI for PM_{2.5} over 101. Only dates during the wildfire season, between May and October of each year, were included.

Next, we matched elevated PM_{2.5} concentrations with smoke presence to ensure that the days of elevated PM_{2.5} levels in our analysis could be attributed to wildfire smoke presence near the monitor. To do this, we cross-referenced dates of elevated PM_{2.5} detection with satellite-detected smoke plume data from NOAA's Hazard Mapping System (NOAA 2025) to identify dates with both unhealthy levels of PM_{2.5} and smoke plume near the monitoring station.

Methods: Identifying Smoke-impacted Ozone Enhancement in Wisconsin

We downloaded daily 8-hour average ozone from all monitoring stations since 2010 in Wisconsin from the Environmental Protection Agency (USEPA 2025e). From this dataset, we calculated maximum daily 8-hour average ozone concentrations. Days impacted by wildfire smoke were defined as days with smoke plume present in the state and air quality index >100 as described above.

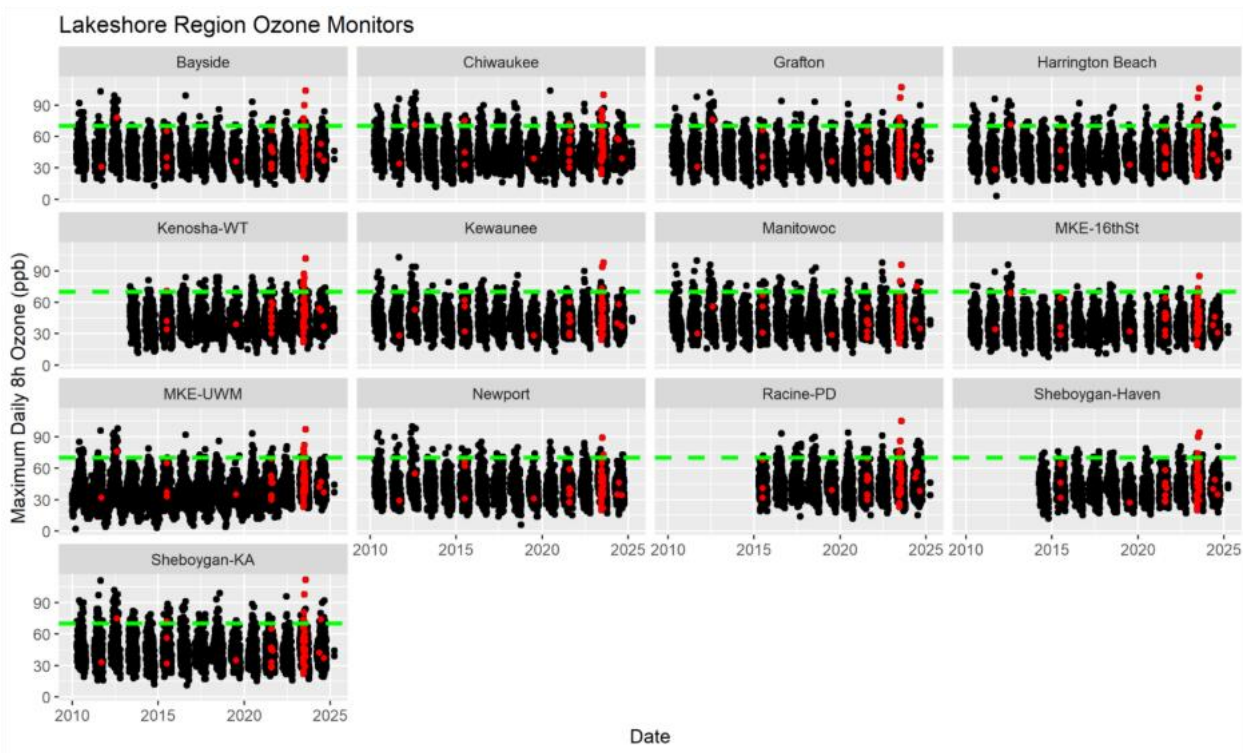


Figure A1. Maximum daily 8-hour average ozone concentrations at lakeshore ozone monitors in Wisconsin since 2010. Red data points represent days where air quality in Wisconsin is impacted by wildfire smoke at or above levels unhealthy for sensitive groups. The green dashed line indicates the air quality standard of 70 parts per billion (ppb). Ozone enhancement from wildfire smoke is clearly apparent from the May-June 2023 smoke incursion, but inconsistent in other smoke-impacted days.

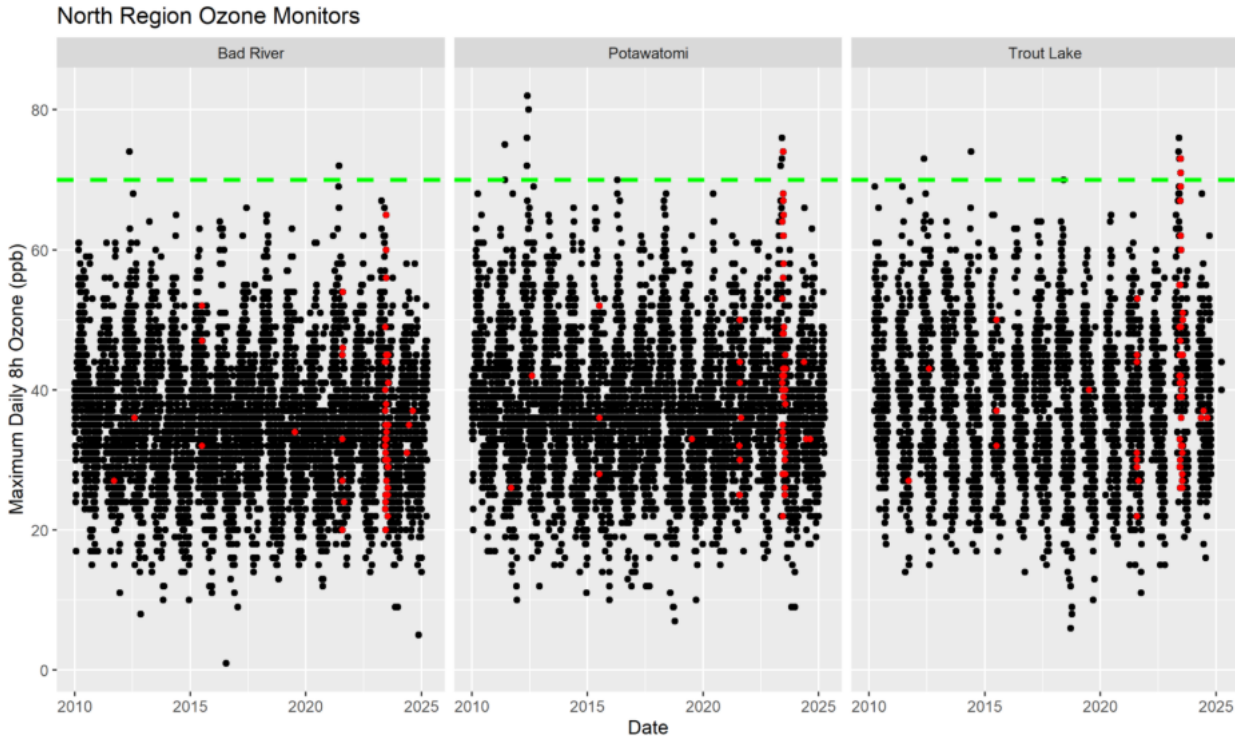


Figure A2. Maximum daily 8-hour average ozone concentrations at north region ozone monitors in Wisconsin since 2010. Red data points represent days where air quality in Wisconsin is impacted by wildfire smoke at or above levels unhealthy for sensitive groups. The green dashed line indicates the air quality standard of 70 parts per billion (ppb). Ozone enhancement from wildfire smoke is clearly apparent from the May-June 2023 smoke incursion, but inconsistent in other smoke-impacted days.