Wildfire Smoke Trends and the Air Quality Index

May 2023

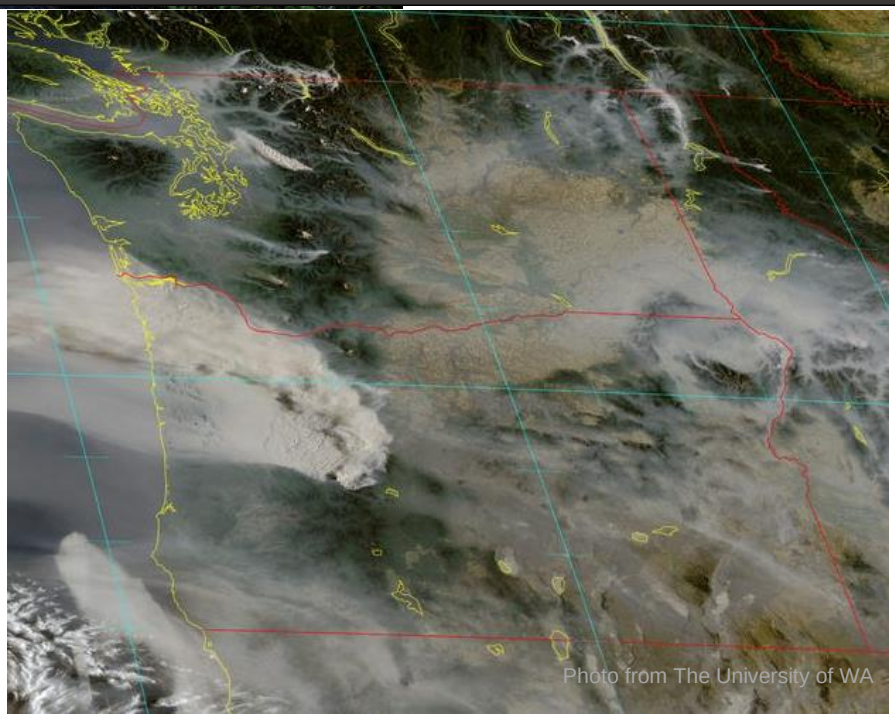

Photo from The University of WA

State of Oregon
DEQ Department of Environmental Quality

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Executive Summary

Large wildfires have been increasing across the western United States over the last decade and are expected to become more frequent, according to the National Interagency Fire Center. This report summarizes Oregon DEQ's air quality monitoring for particulate matter during wildfire season through 2022, how that information is translated into an Air Quality Index with categories of potential health effects, and what trends in the AQI are showing over the last several years.

State of Oregon Department of Environmental Quality

Across Oregon, smoke from wildfires is causing increases in AQI values that are **unhealthy for sensitive groups or worse, or ≥USG**, for short. Some examples from Eastern, Southern, and Western Oregon illustrate this.

- Eastern Oregon (Bend): From 1989 to 2016, Bend only had 10 days ≥ USG from wildfire smoke, or 0.4 ≥USG days/year. From 2017 to 2022, Bend jumped to 58 days ≥ USG or 9.7 ≥ USG days/yr. That is a 24.2 fold increase in days impacted per year. Bend also had hazardous AQI levels for the first time in 2020, with six days and 2021 with one day. In 2022 Bend had 5 days ≥ USG.
- Southeastern Oregon (Klamath Falls): From 1989 to 2014, Klamath Falls had 37 ≥USG days from wildfire smoke, or 1.4 ≥USG days/year. From 2015 to 2022, they have had 117 ≥ USG days, or 14.6 ≥USG days/yr. That is a 10.4 fold increase in days impacted per year. Klamath Falls had its first hazardous AQI day in 2020. In 2022, Klamath Falls had no ≥ USG days.
- Northwestern Oregon (Portland). Before 2015, Portland had not had a single day with air quality that was ≥ USG from wildfire smoke since air quality monitoring began in 1985. From 2015 to 2022, Portland had 26 ≥ USG days or 3.3 ≥ USG days/year. In 2020 Portland had its first days over the unhealthy AQI level with three very unhealthy and five hazardous days. In 2022, Portland had three ≥ USG days.
- Southwestern Oregon (Medford). From 1985 to 2012, Medford had 41 days ≥ USG from wildfire smoke, or 1.5 ≥ USG days/year. From 2013 to 2022, Medford had 127 days ≥ USG or 12.7 ≥ USG days/yr. That is an 8.7 fold increase in days impacted per year. Medford also had one hazardous AQI day between 1985 and 2012, and four from 2013 to 2022. In 2022 Medford had 6 days ≥ USG.

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Introduction

Oregon and surrounding states have temperate rainforests west of the Cascade Mountains and more arid ponderosa pine forests east of the Cascades. Fire is a natural part of the ecology of these forests and occasional burning is healthy for forests. However, fires in these forests have become more massive and burn more acres, according to the National Interagency Fire Center. Figure 1 shows increasing wildfire trends over the last decade for Oregon, Washington, and Northern California. The fire season starts earlier and ends later with larger fires than in the past. The 2022 fire data was published by the National Interagency Fire Center.

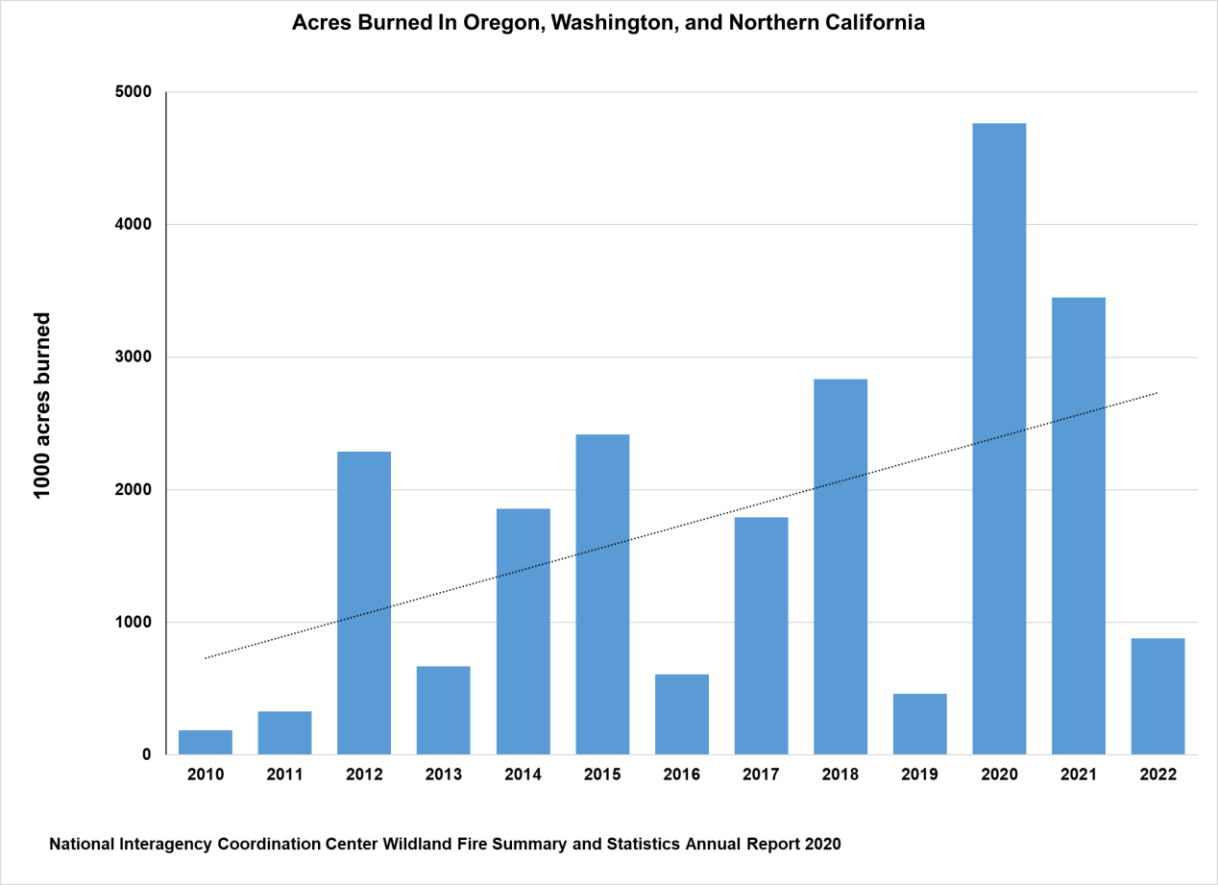

Figure 1. Acreage burned by wildfire in areas impacting the Pacific Northwest.

Scope of This Report

This report is limited to the presentation of AQI PM2.5 trends and associated categories of potential health impacts. The report can be used as a reference for more in depth discussion of the causes, prevalence, and impacts of wildfire smoke.

Wildfire Smoke Impacts

Oregon's wildfire season historically started in late July and continued into early September. More recently, there have been fires starting in mid-July and lasting until early October. Fires impacting Oregon have been mainly in the Southern, Central and Northeastern Oregon and Northern California mountains. Some recent impacts have come from British Columbia and Central Washington. In 2020 large fires also occurred in the Cascades and on the coast.

Wildfire smoke emits a wide variety of pollutants measured as particulate matter (PM2.5 and PM10), black carbon, nitrogen dioxide, carbon monoxide, volatile organic compounds, polycyclic aromatic hydrocarbons and metals. According to the Oregon Health Authority's publication, Wildfire Smoke and Your Health, of these pollutants, PM2.5 may represent the greatest health concern since it can be inhaled deeply into the lungs and a fraction may even reach the bloodstream. Volatile organic compounds can cause early symptoms such as watery eyes, respiratory tract irritation and headaches. Higher levels of ozone (smog) can also be formed from an increase in the precursor pollutants: nitrogen dioxide and volatile organic compounds.

Air Quality Index

PM2.5 is a criteria pollutant that is easily measured and has well established National Ambient Air Quality Standards (NAAQS). The U.S. EPA created the color-coded Air Quality Index, or AQI, which is used to convert pollutant concentrations into understandable health risk language. The AQI uses PM2.5, ozone, PM10, nitrogen dioxide, carbon monoxide and sulfur dioxide data to calculate health indices. In Oregon, PM2.5 and ozone measurements typically have the highest AQI and are therefore considered drivers of air quality related health risks. In the summer, the ozone AQI in urban areas is usually higher than the PM2.5 unless there is wildfire smoke.

Calculating AQI Trends

The AQI is useful for calculating trends of wildfire smoke impact on public health. The AQI used in the trends are calculated using PM2.5 measurements because PM2.5 has the highest AQI levels of any of the continuously measured pollutants during wildfire smoke intrusions.

DEQ measures PM2.5 using Federal Reference Method (FRM) filter samplers in several locations. These work by passing air through a filter for 24 hours starting at midnight and sampling every third day. The filter samplers are co-located with nephelometers that measure continuous, real-time light scattering due to particulate matter. DEQ uses linear regression to compare the light scattering from the nephelometer and the PM2.5 from the filter samplers to get a correlation between the two methods. The correlation equation is used to convert the nephelometer's light scattering into a real-time PM2.5 estimate. The 24-hour PM2.5 average is used to calculate the daily AQI presented in this report.

DEQ and Lane Regional Air Protection Agency have been updating the PM2.5 network with Federal Equivalence Method (FEM) monitors, which collect data hourly and operate continuously. The nephelometers are currently being correlated to the FEMs to update their calibration.

PM2.5 estimate calculations

To calculate the AQI, the PM2.5 FRM or FEM data is used when available. When there is no FRM/FEM data, the nephelometer derived PM2.5 estimates are used. Most days and locations do not have FRM/FEM data so the PM2.5 estimates consist of over half of the values. For this trend report, when no data was available for a monitor, DEQ used a nearby individual PurpleAir monitor and correlated that with the nearest DEQ nephelometer when both were running. The correlation was used to estimate PM2.5 during times the DEQ monitor was down.

For this trend report, DEQ used the 2013 to 2015 PM2.5 Federal Reference Method/nephelometer correlation equations to recalculate the nephelometer light scattering values. The PM2.5 estimates were updated using a more recent correlation equation to eliminate variations from changing correlations over the years. *Note that correlation equations change very little, but a small change can be significant if the PM2.5 estimate is near a break point between AQI categories.*

AQI calculations

The AQI was also updated using the most recent AQI breakpoints provided by EPA. The AQI breakpoints changed when EPA updated the PM2.5 standards in 2012. In order for past and present data to be comparable, all the data has to be recalculated using the same AQI breakpoints. The most recent breakpoints are based on the most current health information. The current EPA breakpoints are in Table 6 of the EPA's **Technical Assistance Document for the Reporting of Daily Air Quality – the Air Quality Index (AQI), September 2018.** The AQI calculation is Equation 1 in the document. The AQI categories and breakpoints are shown in Table 1 below.

Table 1. The PM2.5 Air Quality Index, breakpoints, and potential health effects.

AQI Category and Color	AQI value	PM2.5 ($\mu g/m^3$) 24-hr Aver.	Air Quality and Health
Good	0 to 50	0.0 to 12.0	Air quality is satisfactory. Air pollution poses little or no health risk.
Moderate	51 to 100	12.1 to 35.4	Air quality is acceptable; however, there may be a moderate health concern for a very small number of people. Respiratory symptoms are possible in people unusually sensitive to air pollution. Heart or lung disease (such as asthma) symptoms may be aggravated in people with cardiopulmonary disease and older adults. These groups should consider *reducing prolonged* or *heavy* outdoor exertion.
Unhealthy for Sensitive Groups	101 to 150	35.5 to 55.4	Members of sensitive groups may experience health effects. People with heart or lung disease may experience increased symptoms and premature mortality; older adults, pregnant women and children, are also among the groups most at risk of respiratory symptoms. These groups should *reduce prolonged* or *heavy* outdoor exertion. The general public is not likely to be affected.
Unhealthy	151 to 200	55.5 to 150.4	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects. These groups should *avoid prolonged* or *heavy* exertion: People with heart or lung disease, children, pregnant women and older adults. Everyone else should reduce prolonged or heavy exertion.
Very Unhealthy	201 to 300	150.5 to 250.4	Health alert: everyone may experience more serious health effects. These groups should *avoid all* physical activity outdoors: People with heart or lung disease, children, pregnant women and older adults. Everyone else should avoid prolonged or heavy exertion.
Hazardous	>300	>250.5	Health warnings of emergency conditions. The entire population is more likely to be affected. See EPA AirNow "Extremely High Levels of PM2.5: Steps to Reduce Your Exposure" when PM2.5 levels are "Hazardous" or above on the AQI.

Trends

DEQ compiled the wildfire AQI trends for “Unhealthy for Sensitive Groups,” “Unhealthy,” “Very Unhealthy” or “Hazardous” categories of the AQI. Collectively these categories are known as unhealthy for sensitive groups or worse, or **≥USG** for short. In Oregon, wildfire smoke occurs during the summer, so for this report values from June 1 to October 20 were selected. July 4 was removed from the trends because of outliers due to fireworks. DEQ evaluated summertime AQI trends up to 2021 for 24 communities in Oregon. A map of wildfire related AQI trends for various cities around the state is shown in Figure 2. The charts on the map show the ≥USG for each city.

To simplify the discussion in this report, only four of the cities from across the state are provided in the main body. They are Bend, Klamath Falls, Medford and Portland. The trends for the number of days ≥USG for these cities are provided in Figures 3 through 6. The graphs for the remaining cities are shown in the appendix.

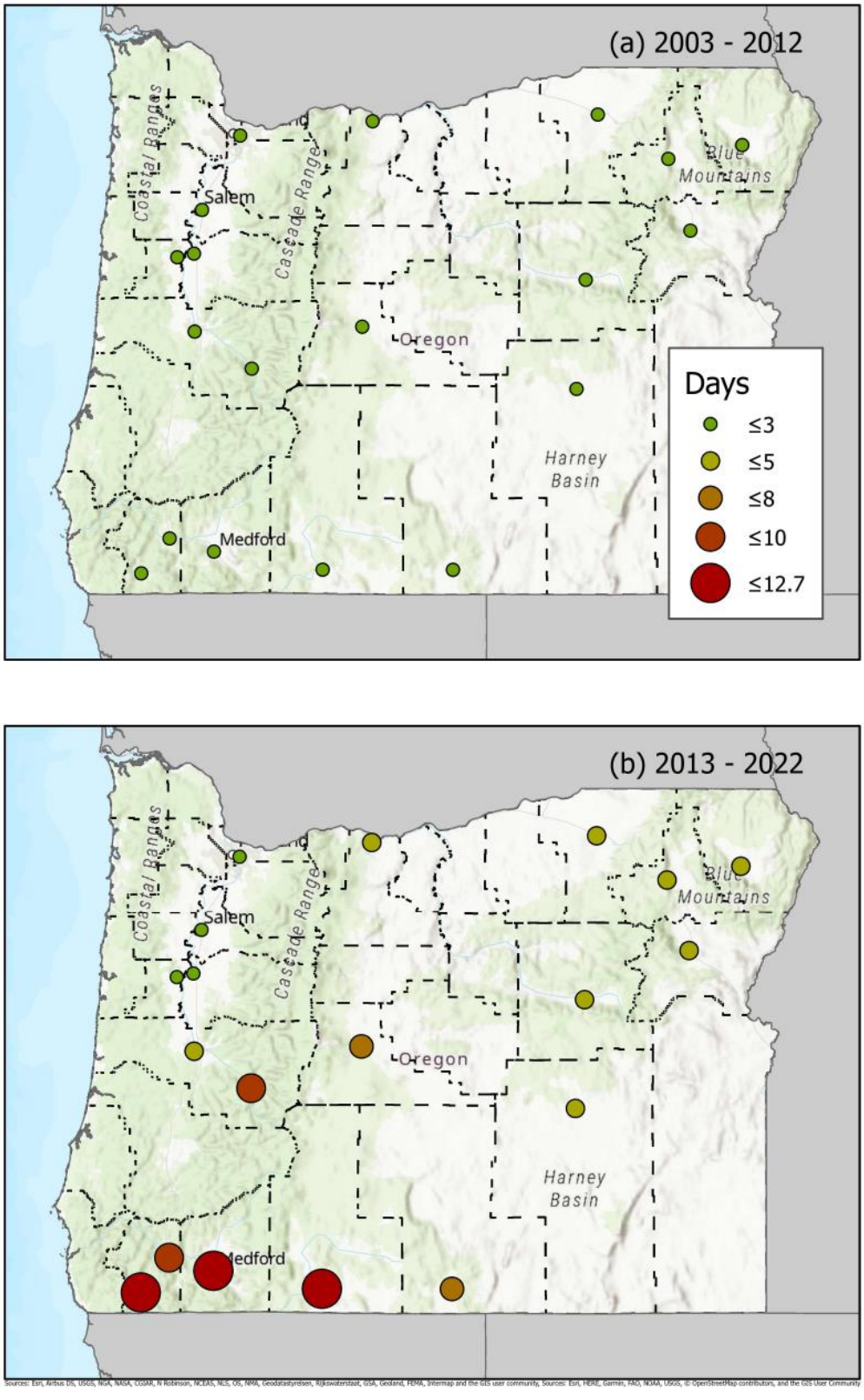

Figure 2. Average number of AQI days at USG or above from wildfire smoke, 2003 to 2022.

Discussion

Wildfire smoke impacts are increasing across the state. There are more ≥USG days per year and more years with at least one ≥USG event. The most significant impacts from fires are in Southern Oregon, however, smoke impacts Eastern Oregon the Willamette Valley, and Portland as well.

The 2022 wildfire season was less smokey than recent years in SW Oregon with two large fires, one in Oregon and one in California, at the border. The Rum Creek Fire in Josephine County started on August 17th and burned 21 thousand acres. It mainly impacted Grants Pass. The other large fire was the McKinney Fire just south of the Oregon border in Siskiyou County, California. It started on July 29th and lasted until September 7th, burning over 60 thousand acres. Its smoke mostly impacted SW Oregon communities like Medford.

The largest fire in Central Oregon was the Cedar Creek Fire just east of Oakridge, in the Western Cascades. It started on August 1st and burned into October. Its size increased rapidly in September when strong easterly winds and an unusually warm weather impacted Oregon. In total, 127 thousand acres burned and its smoke impacted communities such as Oakridge, Eugene, Springfield, Prineville, and Bend.

NE Oregon had a few large fires as well. The Double Creek Fire by Enterprise started on August 30th and burned into October. It charred over 171 thousand acres and the smoke impacted communities in NE Oregon. The Sturgill Fire just east of La Grande started on August 22nd and burned into October. It burned over 23 thousand acres impacting NE Oregon.

The Portland Metro area was impacted by smoke from Nakia Creek Fire in Clark County Washington just north of the border. The fire was only around two thousand acres but its close proximity to the Portland-Vancouver metro area created smokey conditions for around a week.

Even though 2022 was not as smokey as more recent years, there were still long-lasting fires producing USG to hazardous AQIs in communities across Oregon. The 2022 AQI data has been compiled into the following trends summaries.

- Between 1987 and 2014, Bend had three unhealthy days caused by wildfire smoke. Between 2015 to 2022, Bend had 22 unhealthy days, five very unhealthy days and seven hazardous days.
- Klamath Falls had 20 unhealthy days before 2015 and had 61 unhealthy days between 2015 and 2022 from wildfire smoke. Klamath Falls had two very unhealthy days before 2015, five between 2015 and 2022, and its first hazardous day in 2020.
- Medford had 18 unhealthy days between 1985 and 2014 and had 66 between 2015 and 2022 from wildfire smoke. Medford had nine very unhealthy days between 1985 and 2014, mostly in 1987. From 2015 to 2022 Medford had nine. Medford had one hazardous day in 1987 and did not have another one until 2017. It had three in 2020.
- Portland had no unhealthy days or worse between 1985 and 2014 from wildfire smoke. From 2015 to 2022 it had seven unhealthy, three very unhealthy, and five hazardous days from wildfire smoke. The very unhealthy and hazardous days occurred in 2020.

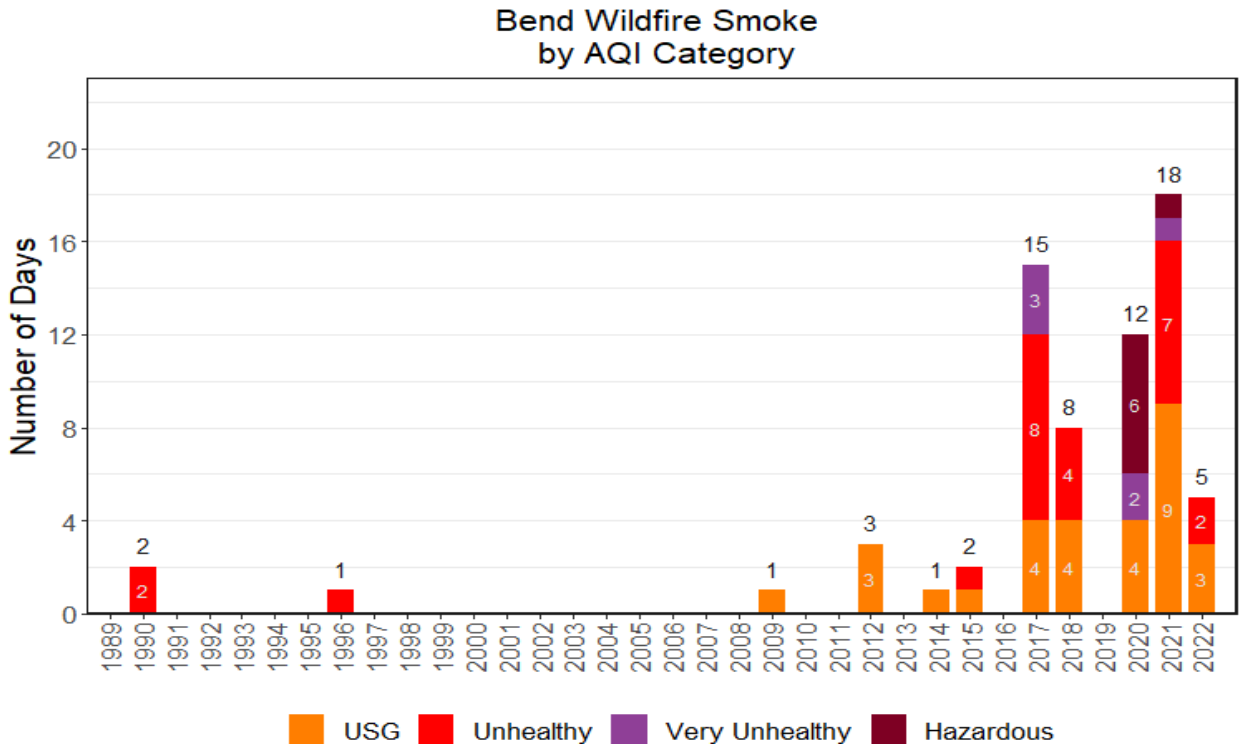

Figure 3. Bend ≥ USG AQI wildfire smoke trends.

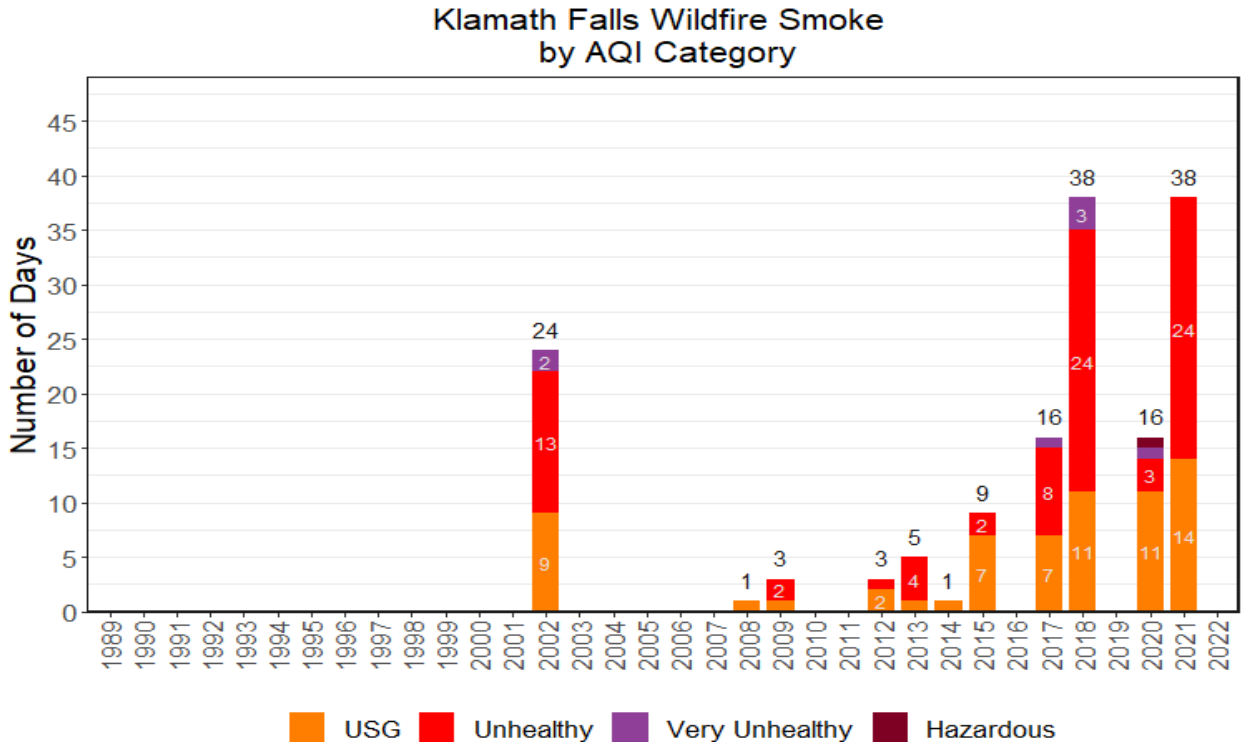

Figure 4. Klamath Falls ≥ USG AQI wildfire smoke trends.

Note: No data was collected during the summer from 1991 through 1995, 1997, and 1998.

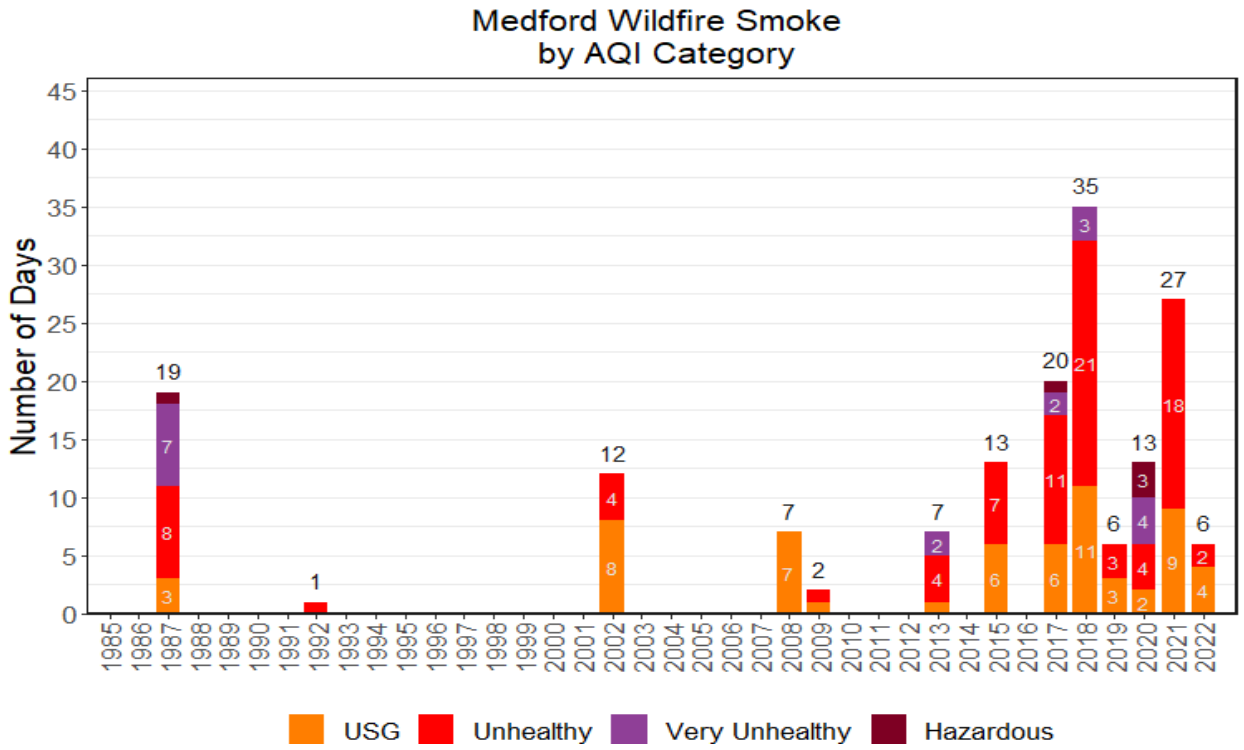

Figure 5. Medford ≥ USG AQI wildfire smoke trends.

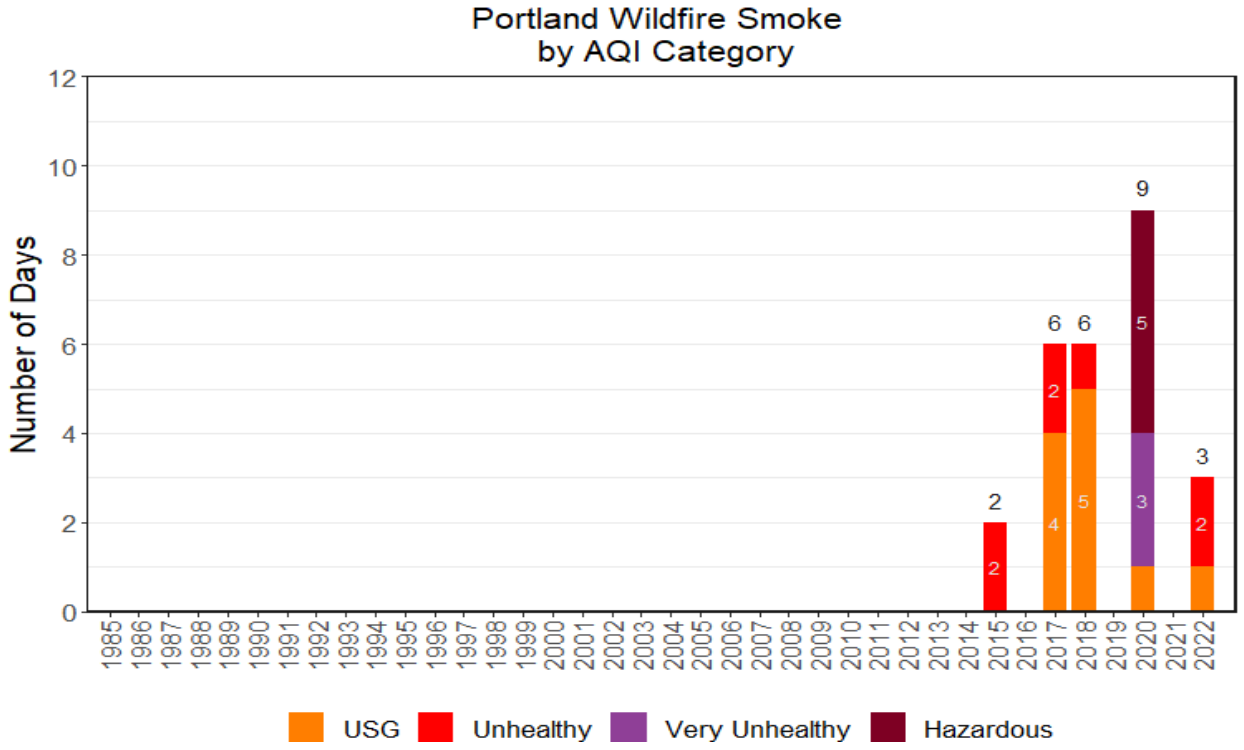

Figure 6. Portland ≥ USG AQI wildfire smoke trends.

Note: USG days not included: two in 1985, one in 1987, and one in 1990. These were likely from field burning.

Conclusion

This report is intended to explain the AQI and show AQI trends from wildfire smoke impacts. The data shows that AQI categories from wildfire smoke have been increasing starting around 2012, with more frequent days at more "unhealthy" or worse levels, including the record-breaking events of September 2020. If these trends continue, Oregon should expect to see an increasing number of days with an AQI ≥USG during the summer, and not just in Southern Oregon where it is more common, but across the state. This will include areas which have historically not seen significant smoke impacts, such as the north coast area, the Willamette Valley, and the Portland Metro area.

Learn More

EPA's Wildland Fire Publications, Fact Sheets and Other Resources

AQI – A Guide to Air Quality and Your Health

Track current air quality on DEQ's online Air Quality Index or the free Oregon Air app.

During wildfire season, you can also track air quality at OregonSmoke.org.

Wildfire Smoke and Your Health, Public Health Division, Oregon Health Authority.

Alternative Formats

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Appendix

Wildfire Trends for Individual Communities

The graphs below show the number of days with an AQI ≥USG for 20 communities with monitoring data. The horizontal axis (or date) varies for each chart depending on when monitoring was started.

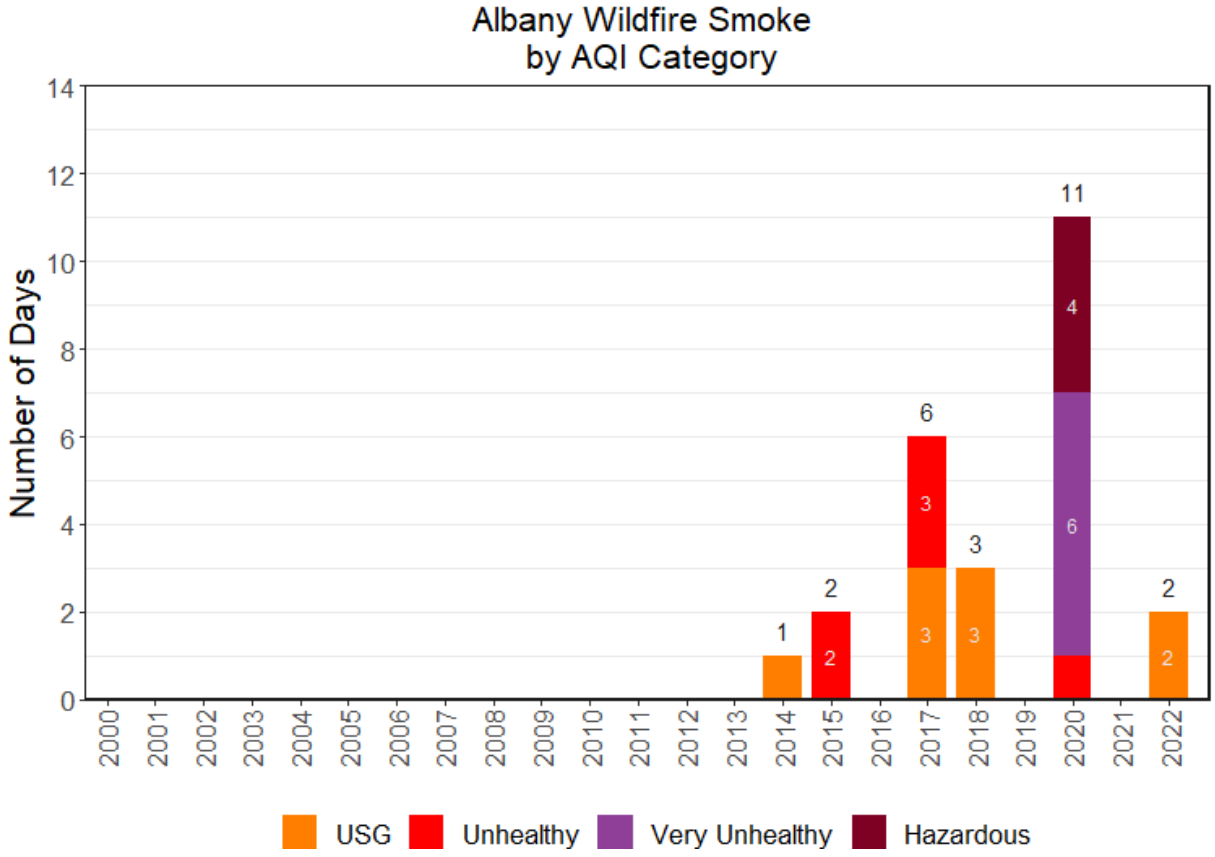

Figure 7. Albany wildfire ≥ USG AQI wildfire smoke trends.

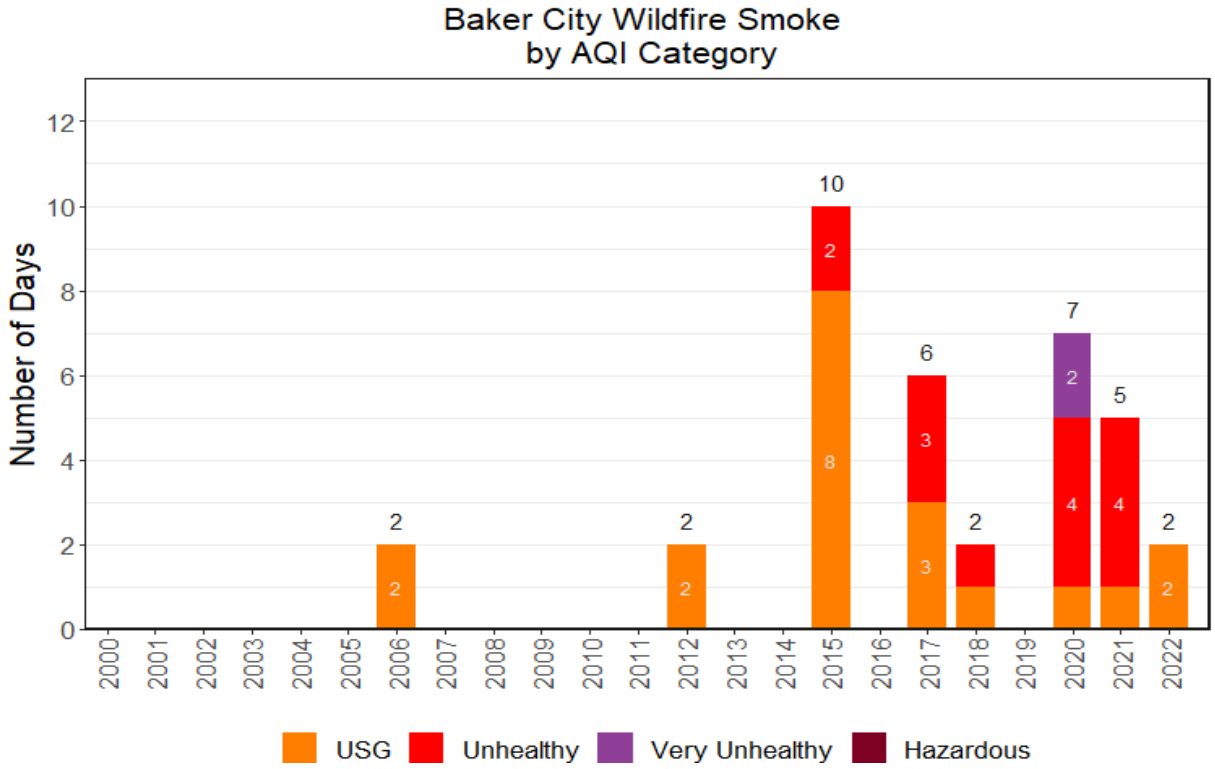

Figure 8. Baker City wildfire ≥ USG AQI wildfire smoke trends.

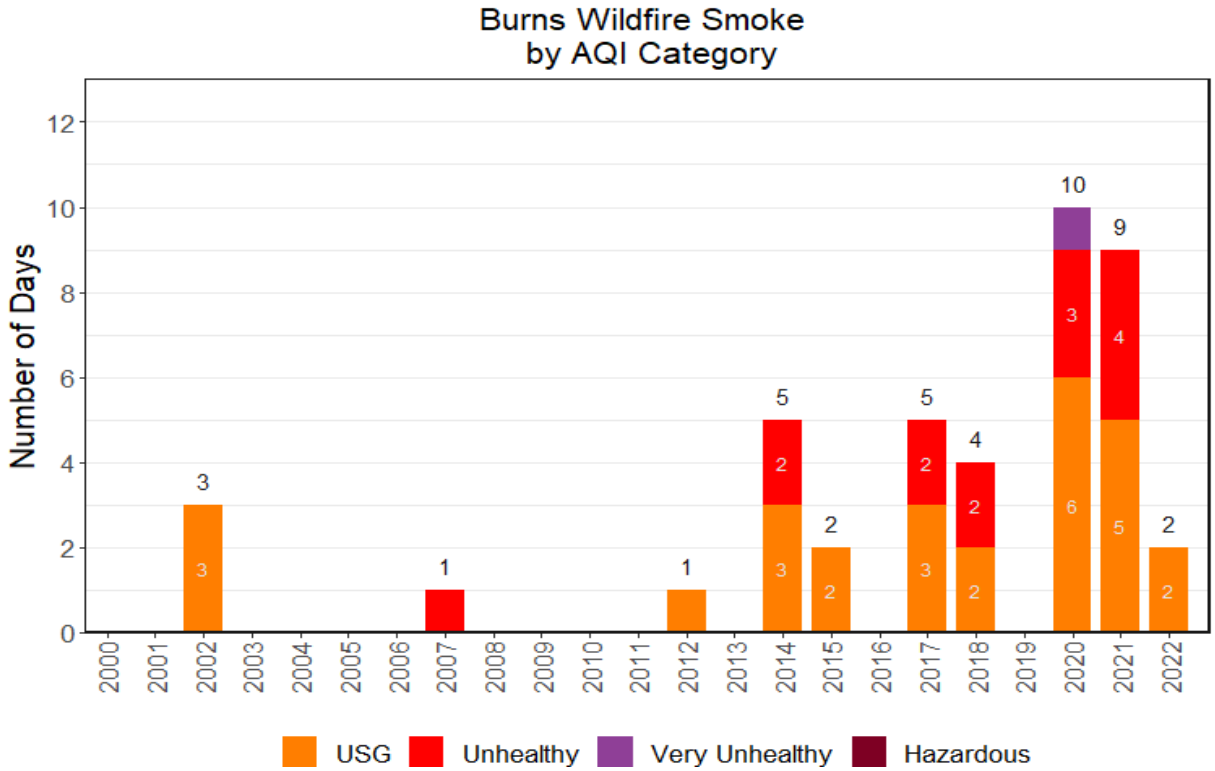

Figure 9. Burns wildfire ≥ USG AQI wildfire smoke trends.

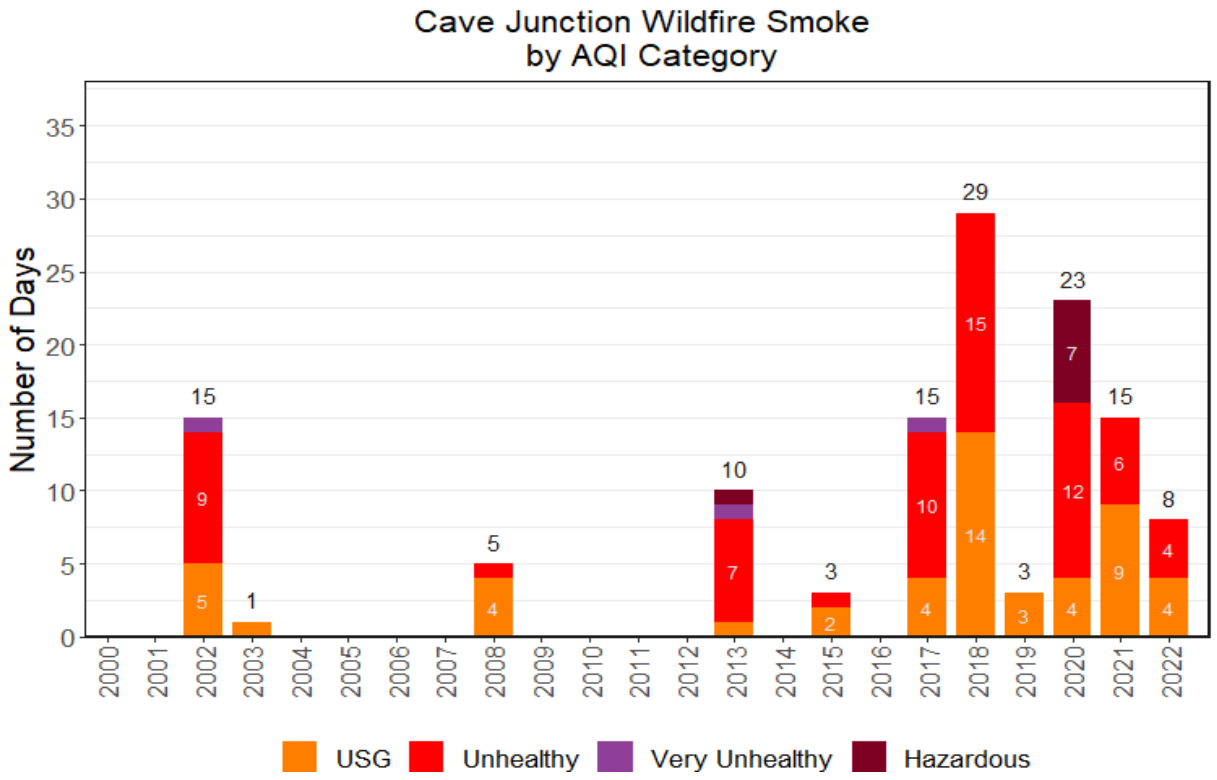

Figure 10. Cave Junction wildfire ≥ USG AQI wildfire smoke trends.

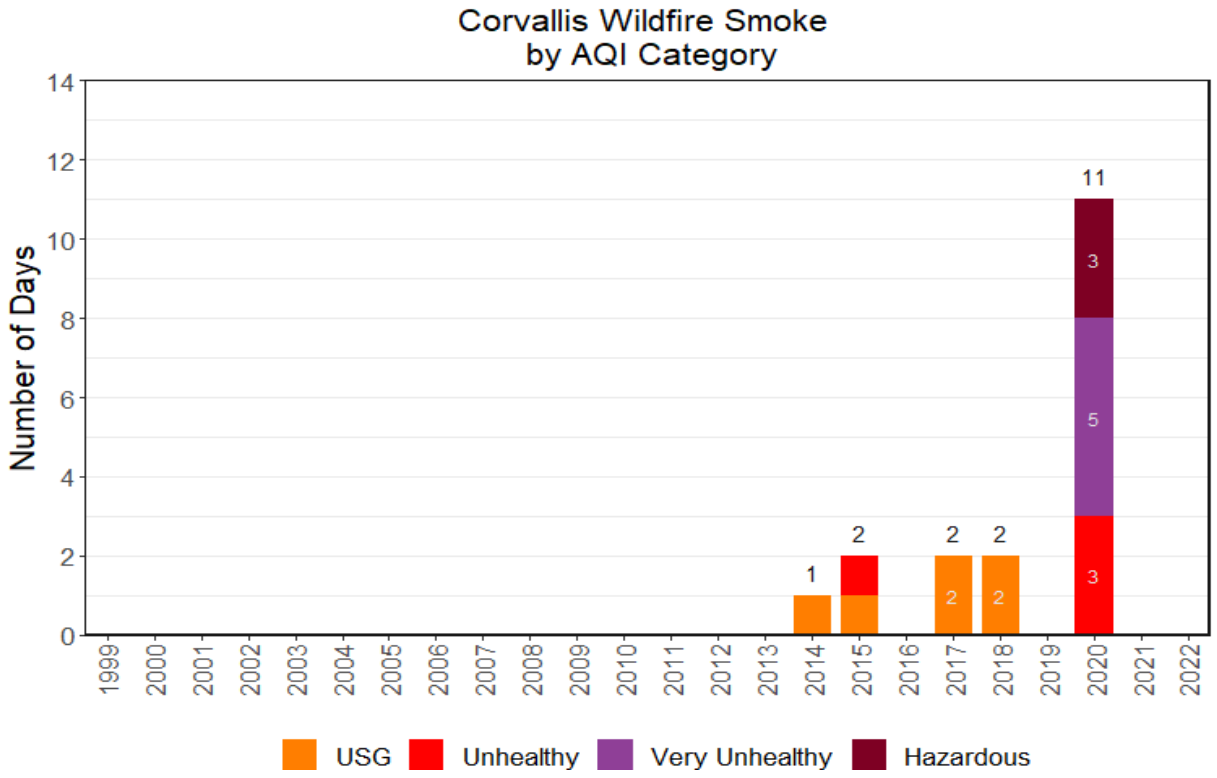

Figure 11. Corvallis wildfire ≥ USG AQI wildfire smoke trends.

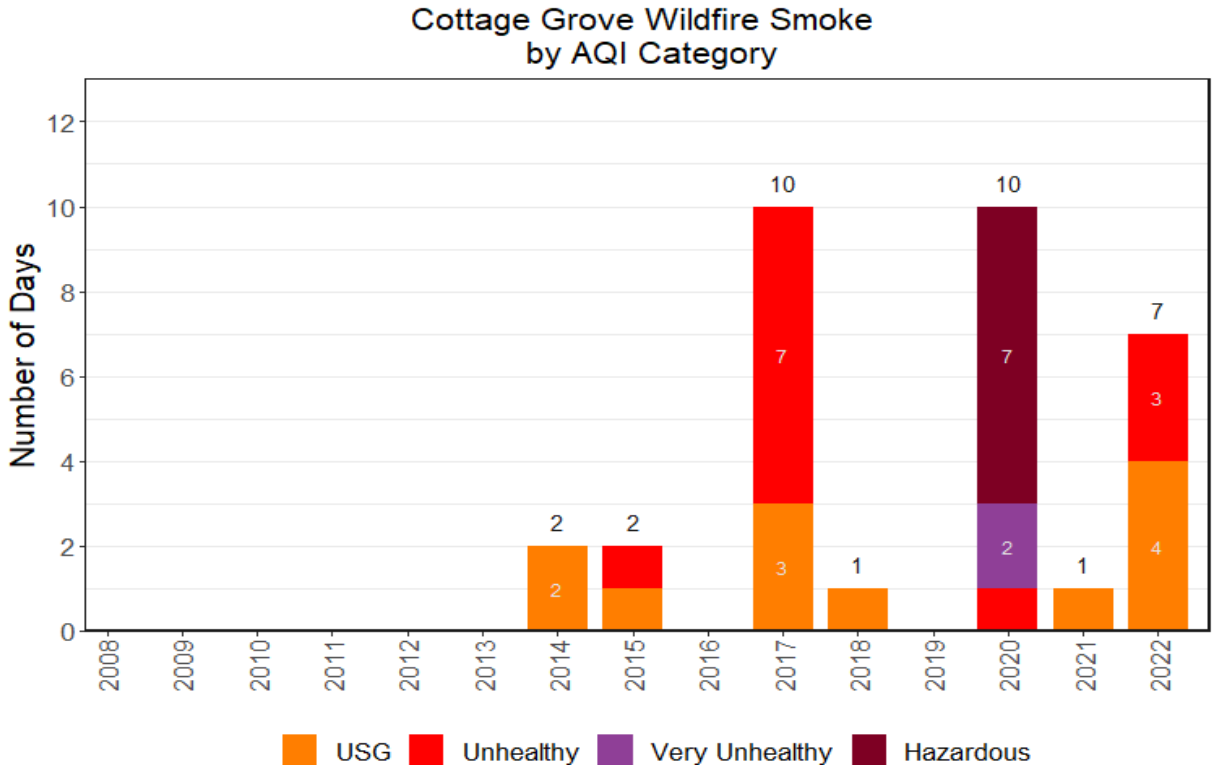

Figure 12. Cottage Grove wildfire ≥ USG AQI wildfire smoke trends.

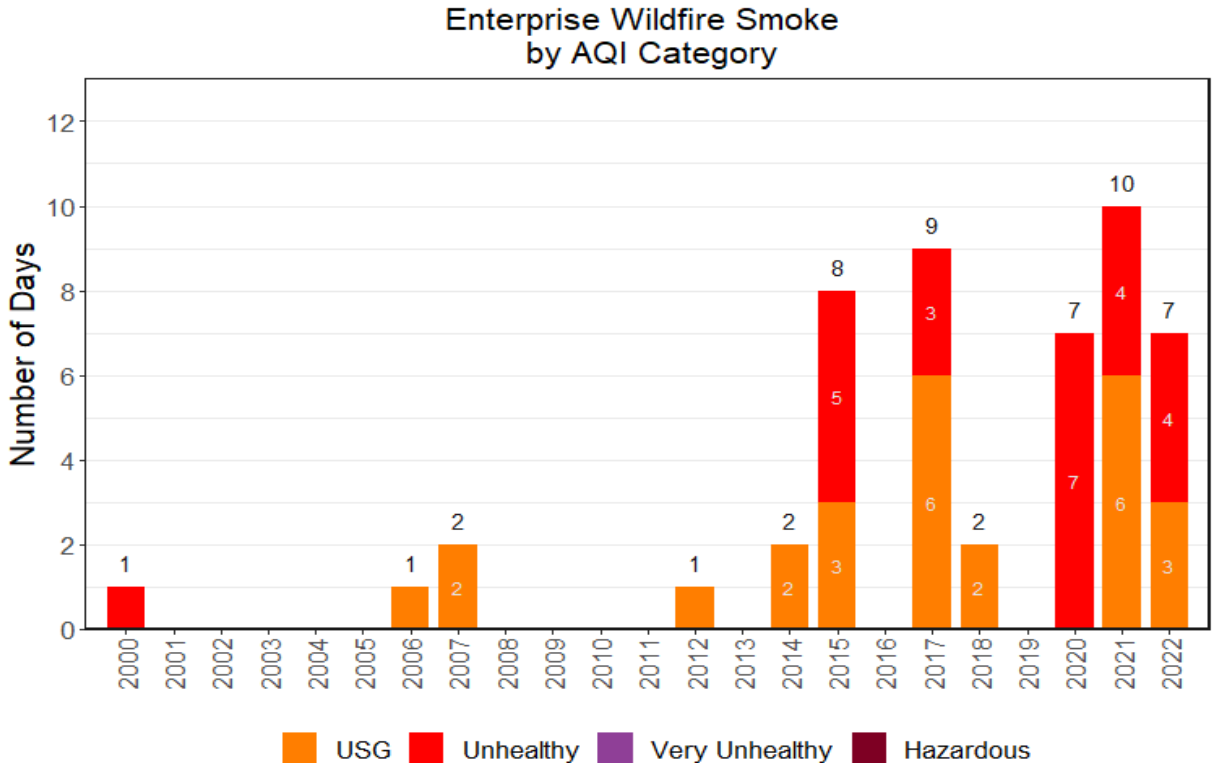

Figure 13. Enterprise wildfire ≥ USG AQI wildfire smoke trends.

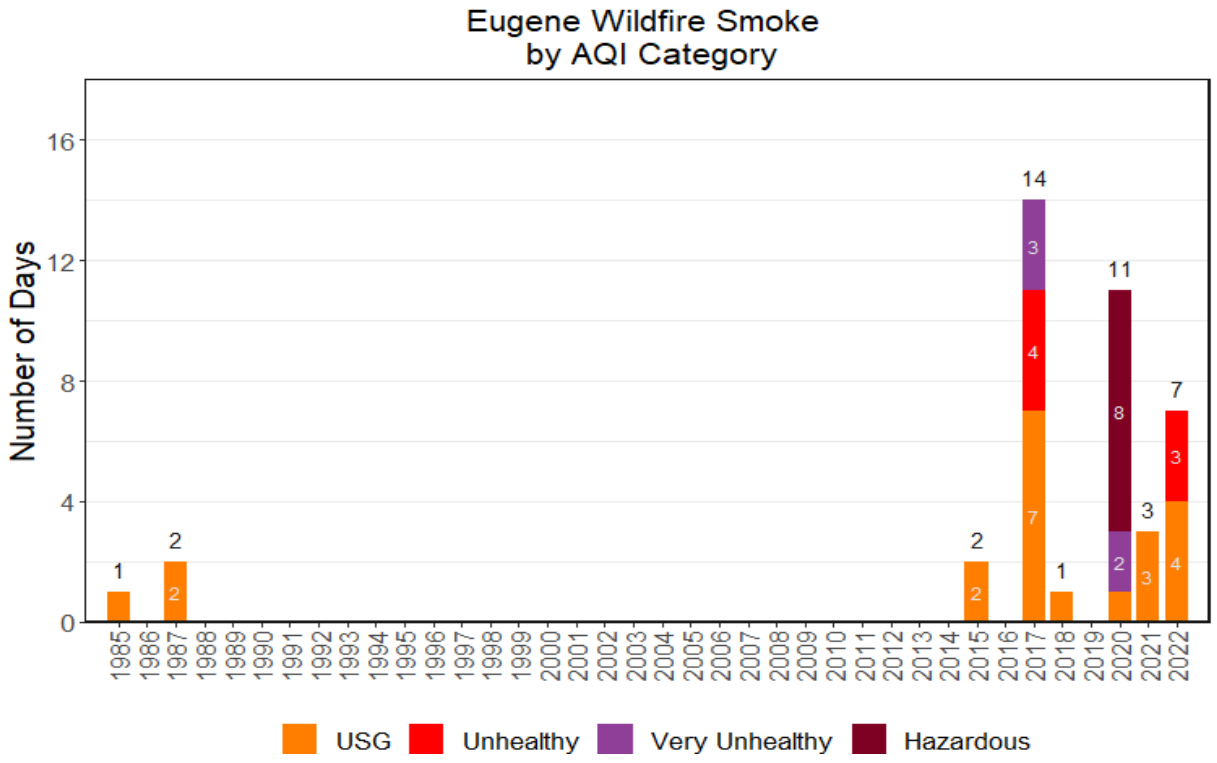

Figure 14. Eugene/Springfield wildfire ≥ USG AQI wildfire smoke trends.
1985 and 1987 were likely field burning.

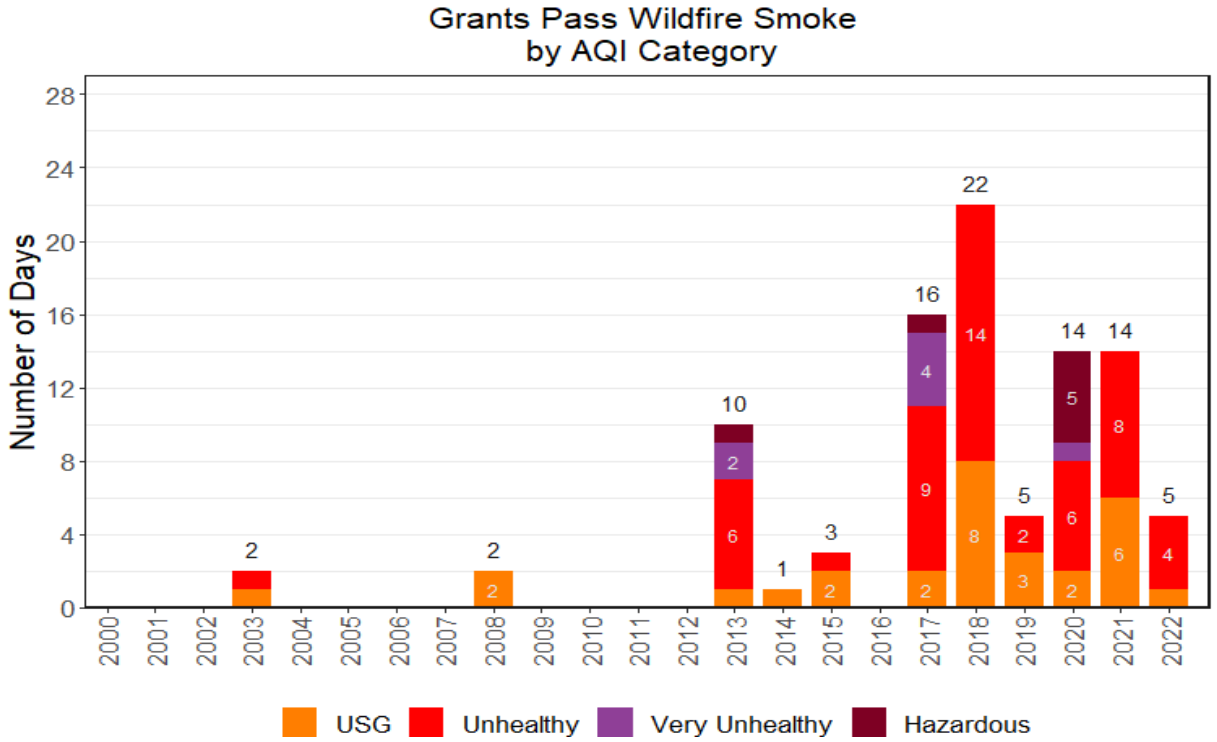

Figure 15. Grants Pass wildfire ≥ USG AQI wildfire smoke trends.

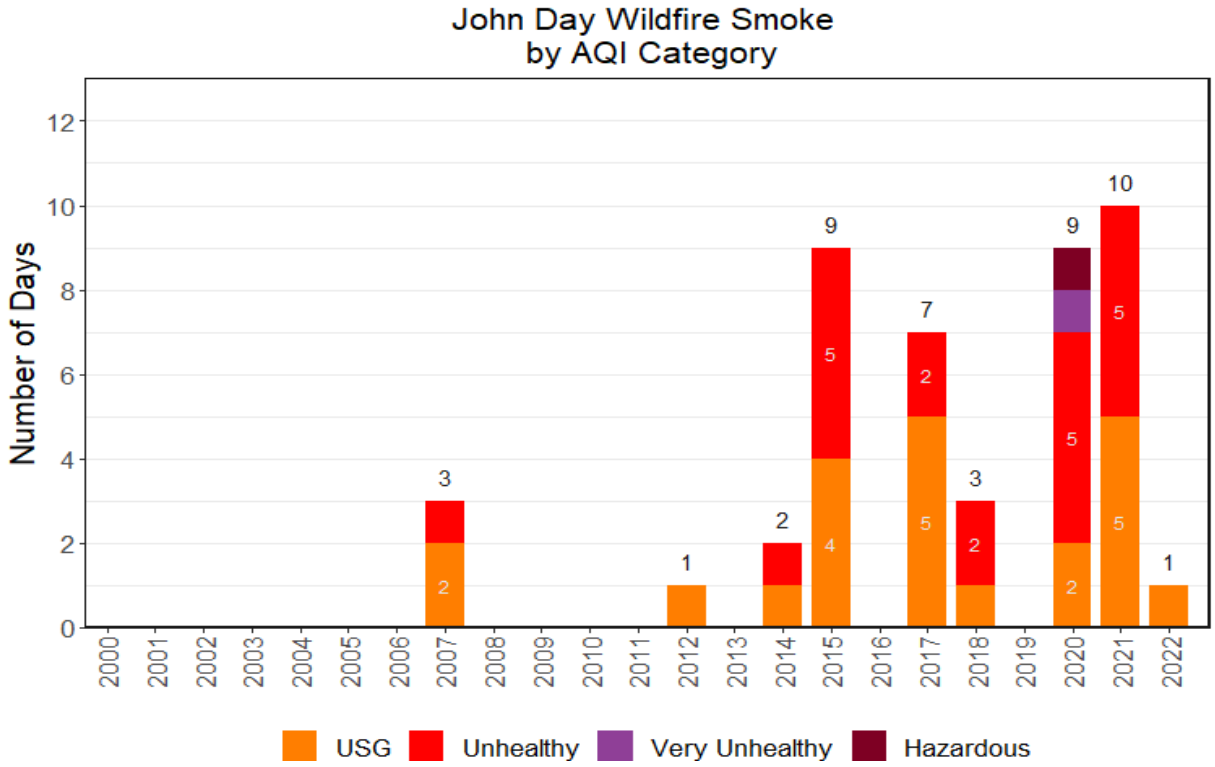

Figure 16. John Day wildfire ≥ USG AQI wildfire smoke trends.

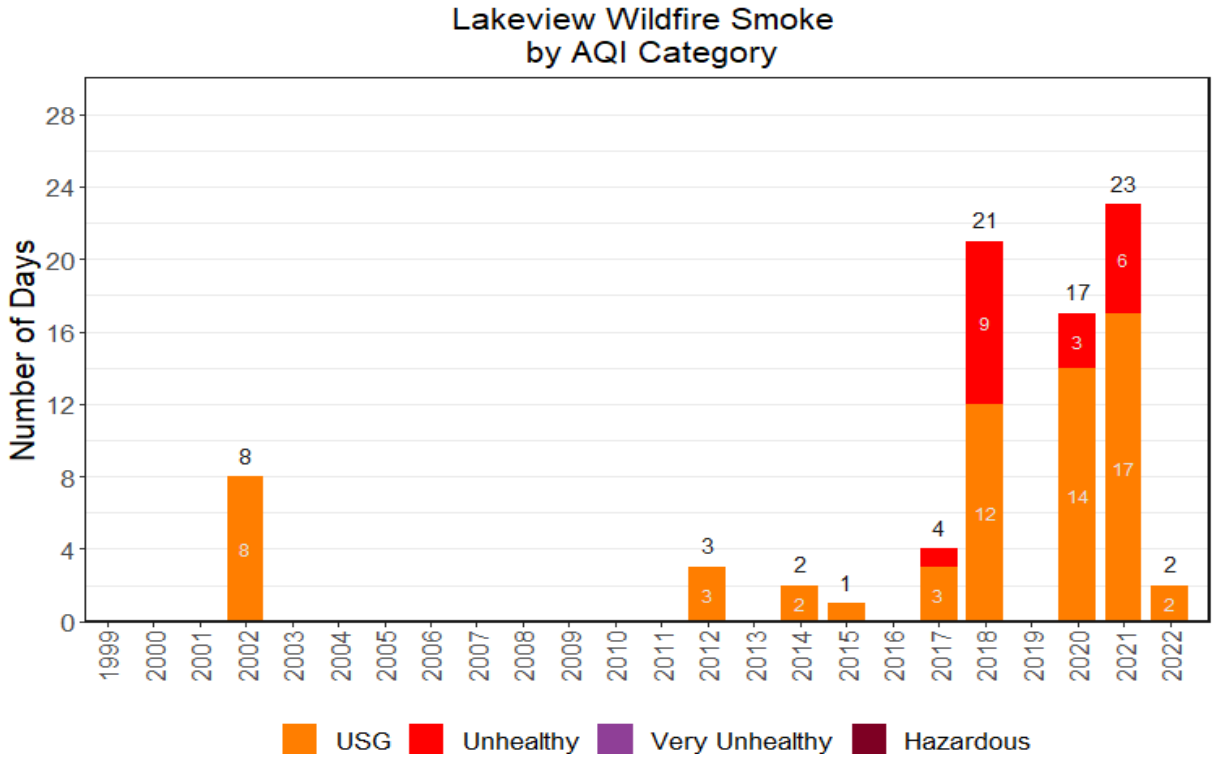

Figure 17. Lakeview wildfire ≥ USG AQI wildfire smoke trends.

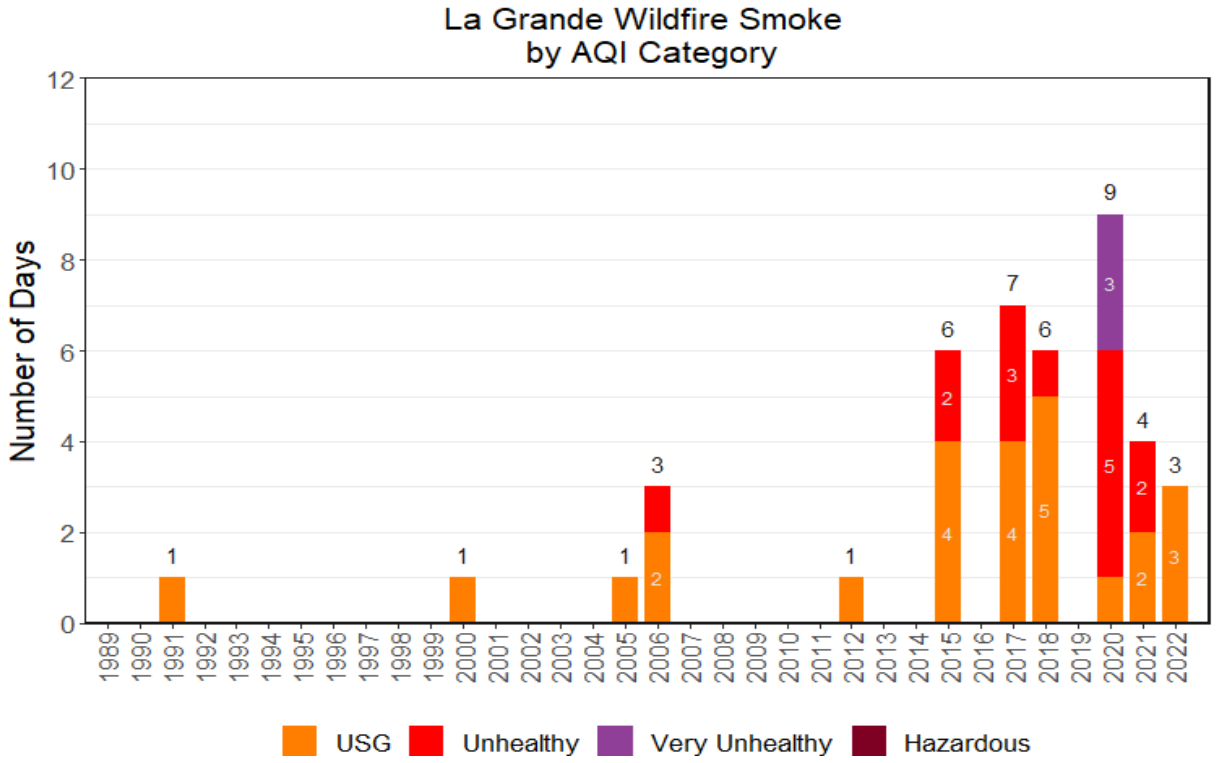

Figure 18. La Grande wildfire ≥ USG AQI wildfire smoke trends.

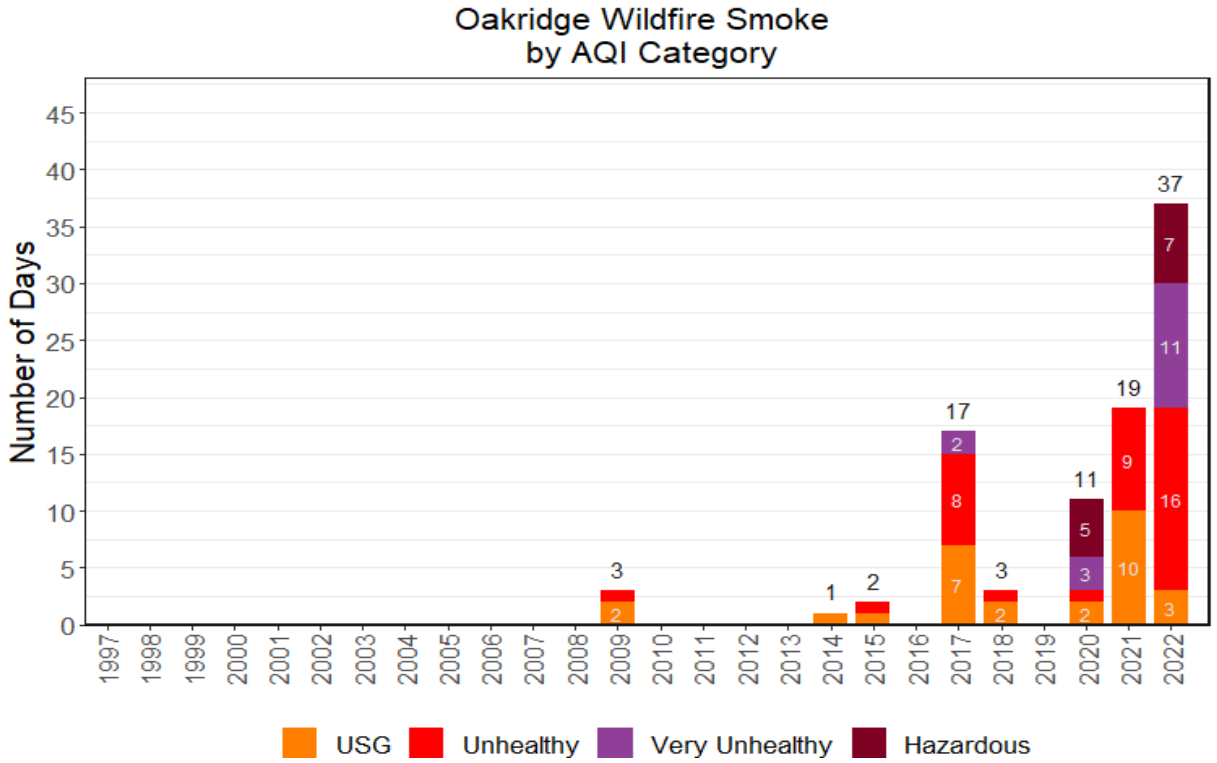

Figure 19. Oakridge wildfire ≥ USG AQI wildfire smoke trends.

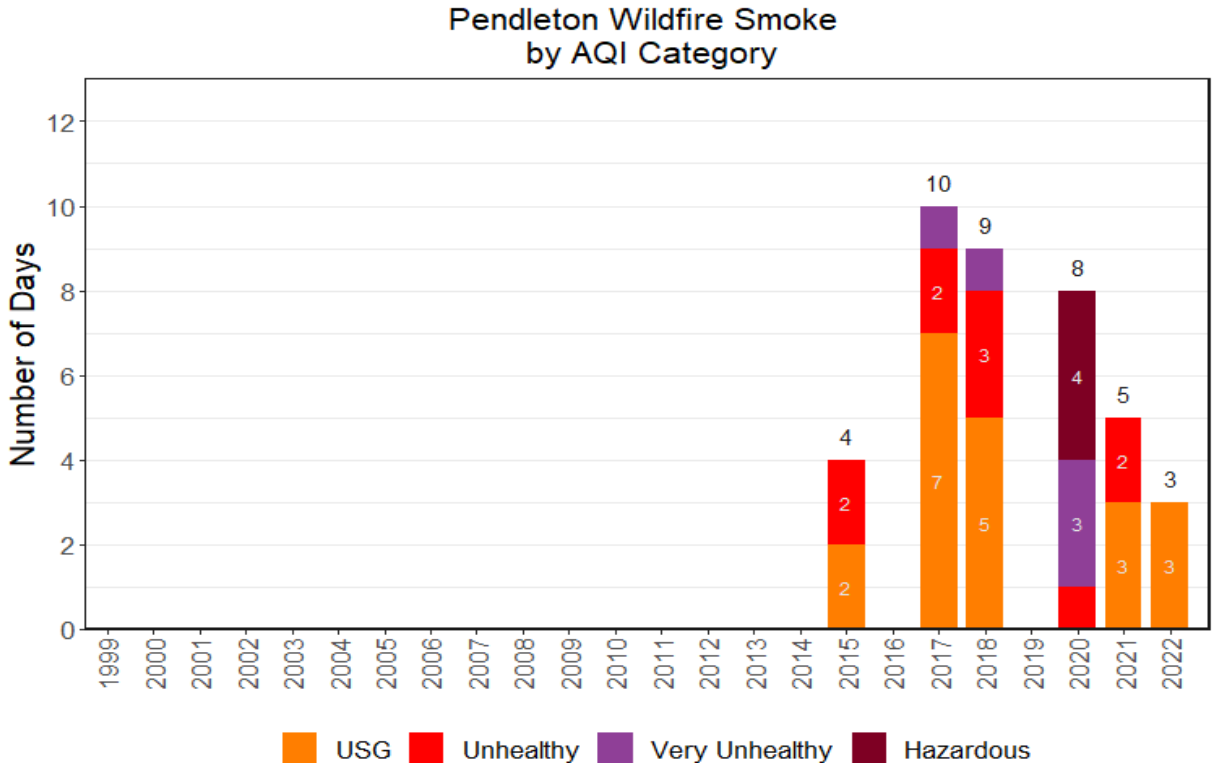

Figure 20. Pendleton wildfire ≥ USG AQI wildfire smoke trends.

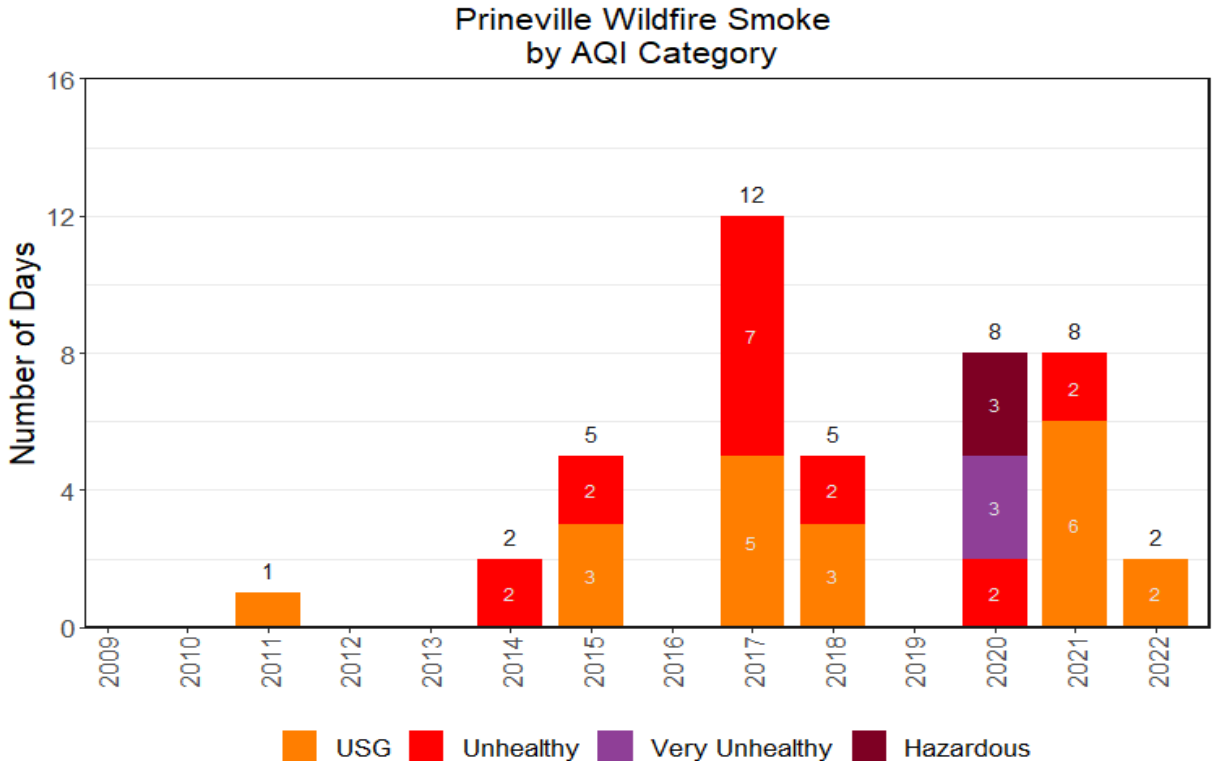

Figure 21. Prineville wildfire ≥ USG AQI wildfire smoke trends.

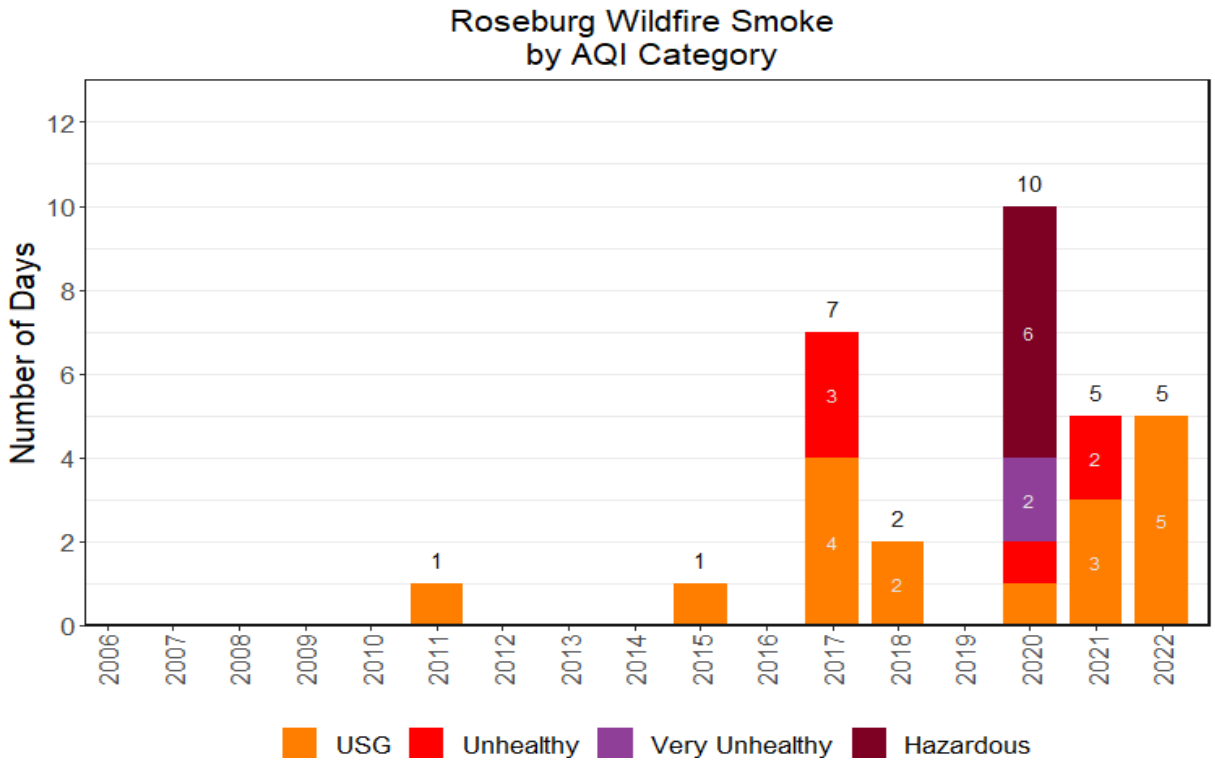

Figure 22. Roseburg wildfire ≥ USG AQI wildfire smoke trends.

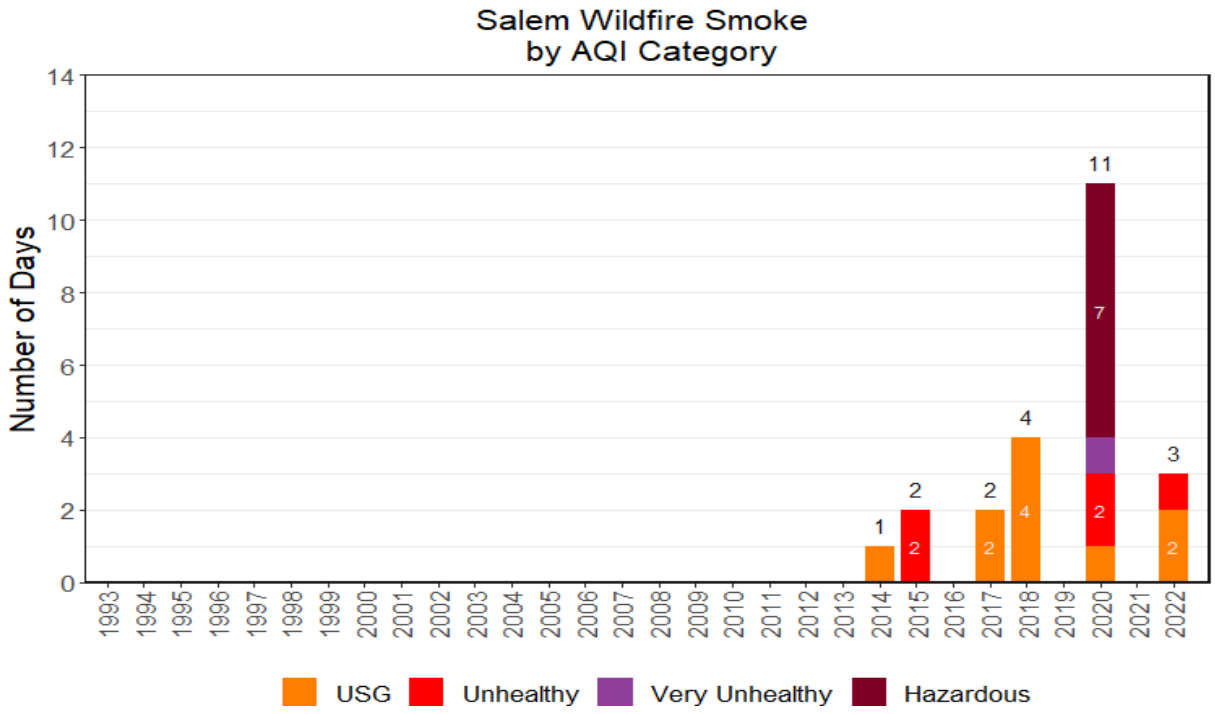

Figure 23. Salem wildfire ≥ USG AQI wildfire smoke trends.

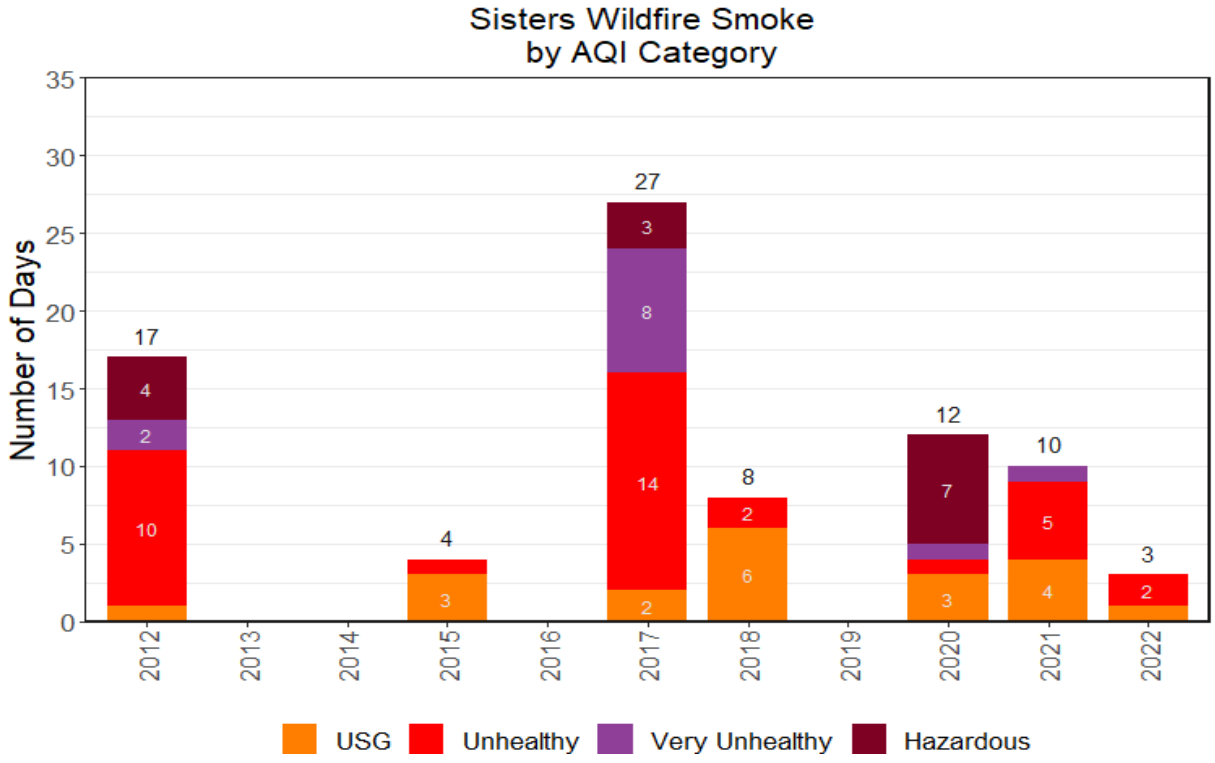

Figure 24. Sisters wildfire ≥ USG AQI wildfire smoke trends.

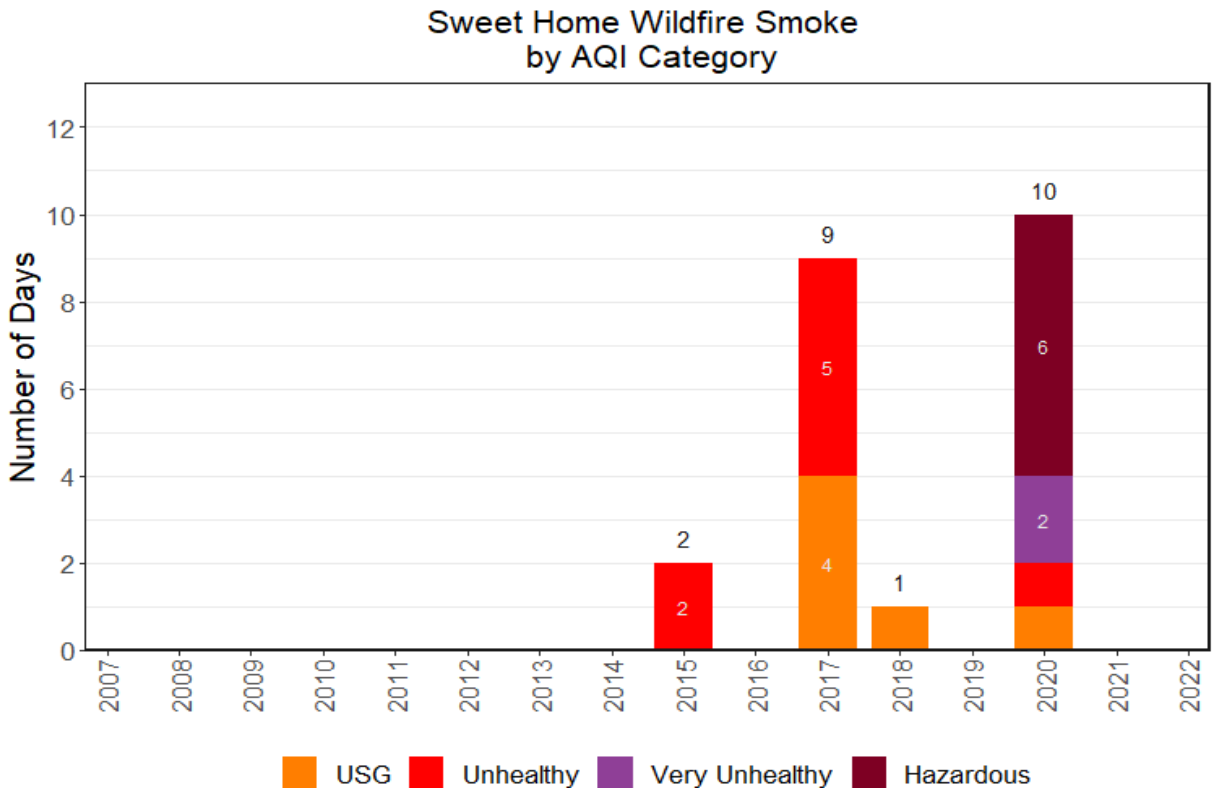

Figure 25. Sweet Home wildfire ≥ USG AQI wildfire smoke trends.

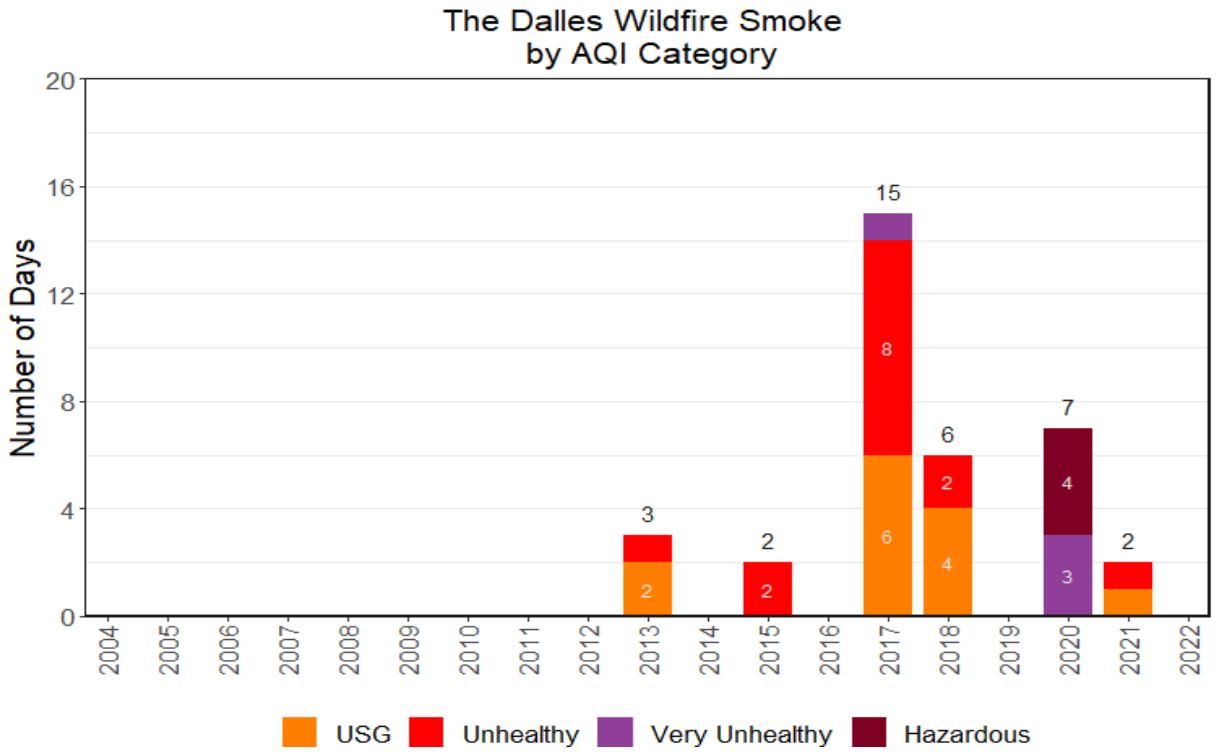

Figure 26. The Dalles wildfire ≥ USG AQI wildfire smoke trends.