Wildfire Smoke Trends and the Air Quality Index

By: Anthony Barnack
September 2020

Laboratory and Environmental Assessment Division
7202 NE Evergreen Pkwy, Suite 150
Hillsboro, OR 97006
Phone: 503-693-5708
800-452-4011
Contact: Anthony Barnack

www.oregon.gov/DEQ

DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

State of Oregon
Department of Environmental Quality

This report prepared by:

Oregon Department of Environmental Quality
700 NE Multnomah Street, Suite 600
Portland, OR 97232
1-800-452-4011
www.oregon.gov/deq

Contact:
Anthony Barnack
503-693-5708

Table of Contents

Glossary

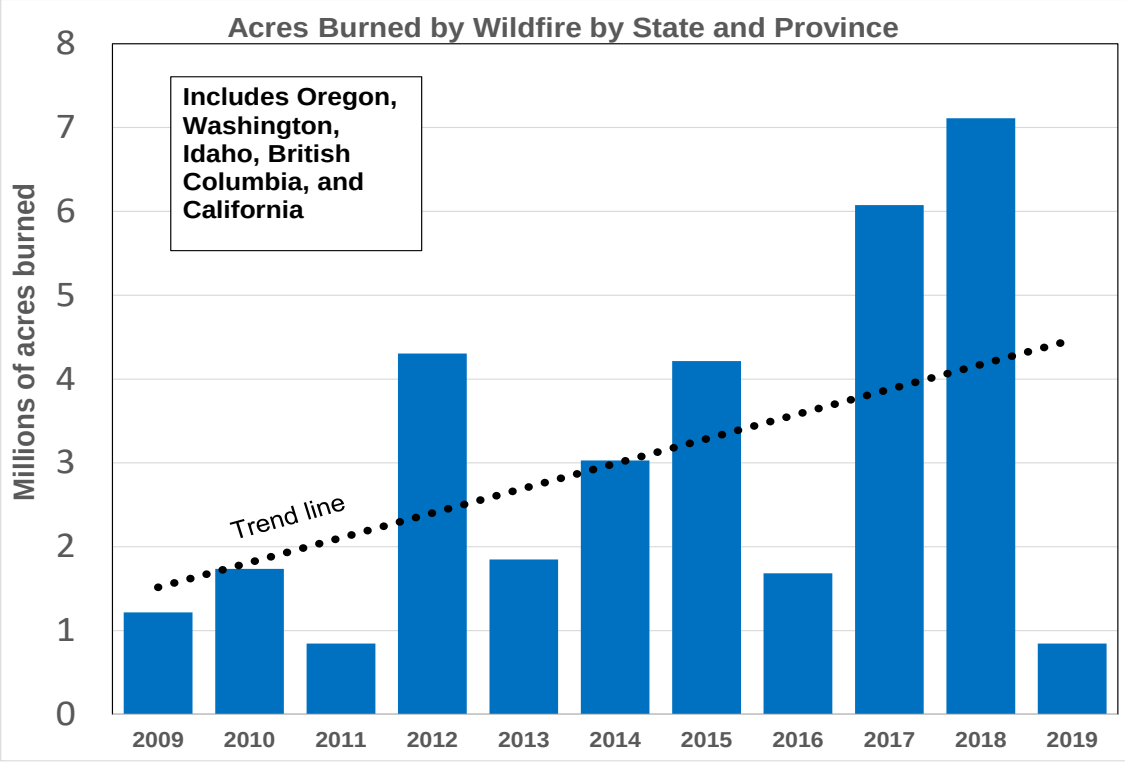
AQI – Air Quality Index, EPA Air Quality health scale.
PM2.5 – Particulate matter 2.5 microns in diameter or smaller
PM10 - Particulate matter 10 microns in diameter or smaller
≥USG – Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy, and Hazardous AQI

Executive Summary

Large wildfires have been increasing across the western United States in the last decade and are expected to become more frequent, according to the National Interagency Fire Center. Across Oregon, smoke from fires is causing Air Quality Index values that are **unhealthy for sensitive groups or worse, or ≥USG**, for short. For example, until 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 2019, Portland had three out of five years with wildfire smoke impacts causing air quality to be ≥USG. In 2018, Klamath Falls and Medford had five weeks where air quality was ≥USG. This was the most days with wildfire smoke impact since monitoring began in the 1980s. Bend had three weeks of air quality that was ≥USG in 2017 and one week in 2018. Before 2017, Bend had not had over three days of ≥USG in any year. If these trends continue, Oregon should expect to see an increase in ≥USG during a given summer and more summers with impacts. In other words, summers with little or no wildfire smoke, like 2016 and 2019, will be much less commonplace.

1. 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 the increasing wildfire trends over the last decade for areas in the western United States and Canada where smoke impacts Oregon. The fire season is longer and fires are larger than in the past.



Data provided by the National Interagency Fire Center and Washington DOE

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

2. Scope of This Report

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

3. Wildfire Smoke Impacts

Oregon's wildfire season used to start in late July and run 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.

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.

4. Air Quality Index

PM2.5 is a criteria pollutant that is easily measured and has well established National Ambient Air Quality Standards. The U.S. EPA created the color-coded Air Quality Index, or AQI, which is used to convert pollutant concentrations into more useful 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 considered the drivers of associated health risks. In the summer, the ozone AQI in urban areas is usually higher than the PM2.5 unless there is wildfire smoke.

5. Calculating AQI Trends

The AQI is useful for calculating wildfire trends because it includes health risk in its value. These AQI trends are calculated using PM2.5 measurements because PM2.5 has the highest AQI levels of any of the pollutants during wildfire smoke intrusions.

DEQ and the Lane Regional Air Protection Agency measure PM2.5 using Federal Reference Method filter samplers. Air passes through a filter for 24 hours starting at midnight and samples are collected daily or every three or six days depending on the location. The filter samplers are colocated 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.

PM2.5 estimate calculations

To calculate the AQI, the PM2.5 filter data is used when available. When there is no filter data, the nephelometer derived PM2.5 estimates are used. Most days and locations do not have filter data so the PM2.5 estimates consist of over half of the values.

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 changed very little, but a small change can be significant if the PM2.5 estimate is near an AQI break point.*

AQI calculations

The AQI was also updated using the most recent AQI breakpoints. The AQI breakpoints changed when EPA updated the PM2.5 standards. In order to compare apples to apples, 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), May 2016.** 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 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.

6. Trends

DEQ compiled the wildfire AQI trends for "Unhealthy for Sensitive Groups," "Unhealthy," "Very Unhealthy" or "Hazardous." 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 Sept. 30 were selected. July 4 was removed from the trends because of fireworks. DEQ

evaluated summertime AQI trends up to 2019 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 divided into blocks of five year totals. For example, the sum of ≥ USG from 1985 to 1989, from 1990 to 1994, etc.

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 and in Table 2. The graphs for the remaining cities are shown in the appendix.

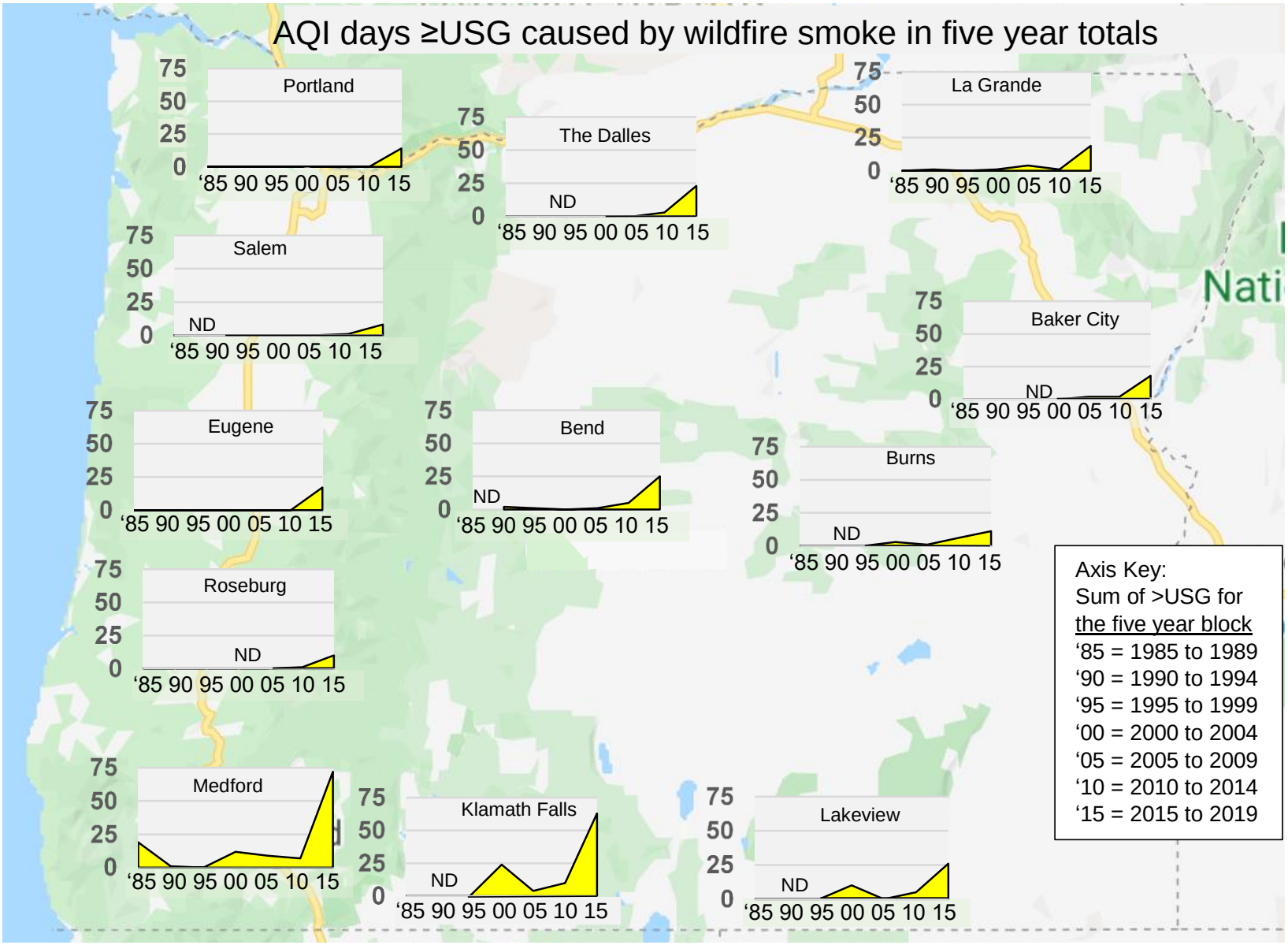


Figure 2. Map of wildfire AQI trends across Oregon.

The charts' vertical axis are the number of days per year that have an AQI of ≥USG (Unhealthy for Sensitive Groups or worse). ND = No data collected for these years. The charts' horizontal axis are the five year total of the <USG for each block. The increments are shown in the key on the graph.

7. Discussion

Wildfire smoke impacts are increasing across the state. There are more ≥USG days per year and more years with at least one ≥USG. The most significant impacts from fires are in Southern Oregon. Eastern Oregon also experiences more ≥USG than in the past. Portland did not experience smoke impacts at all from 1985 until 2015, and then three out of the next five years had smoke impacts.

Based on the AQI, associated health impact levels are also increasing. There are more "unhealthy," "very unhealthy" and "hazardous" days than in the past.

- Between 1987 and 2014, Bend had five unhealthy days. Between 2015 to 2019, Bend has had 13 unhealthy days. In 2017, Bend had three "very unhealthy" days for the first time since monitoring started in 1987.
- Klamath Falls had 22 "unhealthy" days before 2015 and had 35 "unhealthy" days between 2015 and 2019. Klamath Falls had two "very unhealthy" days before 2015 and four between 2015 and 2019.
- Medford had 18 "unhealthy" days between 1985 and 2014 and had 41 between 2015 and 2019. Medford had nine "very unhealthy" days between 1985 and 2014, mostly in 1987. From 2015 to 2019, Medford had 10. Medford had one "hazardous" day in 1987 and did not have another one until 2017.
- Portland had no "unhealthy" days between 1985 and 2014 and had five from 2015 to 2019.

Table 2. Number of USG or worse days from Wildfire Smoke Impacts.

	Bend					Klamath Falls					Medford						Portland			
	USG	Unhealthy	Very Unhealthy	Sum	% Data Completeness	USG	Unhealthy	Very Unhealthy	Sum	% Data Completeness	USG	Unhealthy	Very Unhealthy	Hazardous	Sum	% Data Completeness	USG	Unhealthy	Sum	% Data Completeness
1985	-	-	-	-	-	-	-	-	-	-						93%				98%
1986	-	-	-	-	-	-	-	-	-	-						99%				50%
1987	-	-	-	-	-	-	-	-	-	-	3	8	7	1	19	99%				100%
1988	-	-	-	-	-	-	-	-	-	-						99%				95%
1989					-	-	-	-	-	93%						100%				98%
1990		2		2	95%					100%						97%				98%
1991					98%					-						97%				100%
1992					100%	-	-	-	-	-		1			1	100%				99%
1993					90%	-	-	-	-	-						97%				97%
1994					97%	-	-	-	-	-						97%				100%
1995					98%	-	-	-	-	-						97%				97%
1996		1		1	84%					-						89%				60%
1997					97%	-	-	-	-	-						93%				70%
1998					100%	-	-	-	-	-						97%				98%
1999					97%					80%						88%				100%
2000					100%					100%						100%				98%
2001					100%					100%						100%				100%
2002					94%	9	13	2	24	100%	8	4			12	100%				100%
2003					100%					100%	1					100%				100%
2004					100%					100%						98%				100%
2005					100%					100%						100%				97%
2006					98%					98%						100%				98%
2007					100%					99%						100%				99%
2008					100%	1			1	100%	7				7	100%				98%
2009	1			1	91%	1	2		3	98%	1	1			2	96%				100%
2010					99%					97%						100%				100%
2011					99%					100%						98%				100%
2012	2	2		4	99%	1	3		4	100%						100%				100%
2013					100%	1	4		5	98%	1	4	2		7	98%				99%
2014	1			1	100%	1			1	100%						100%				100%
2015	1	1		2	100%	7	2		9	100%	6	7			13	100%		2	2	100%
2016					99%					100%						100%				100%
2017	4	8	3	15	94%	7	8	1	16	100%	6	9	4	1	20	100%	4	2	6	98%
2018	4	4		8	100%	10	25	3	38	99%	8	22	3		33	100%	5	1	6	100%
2019					94%					100%	3	3			6	100%				100%

a. Errata: Earlier data released for Portland showed one unhealthy for sensitive groups day in 1985 and one in 1990 but these were subsequently changed to zero because they were determined to be from field burning.

b. Data does not include July 4 Fireworks.

c. "-" = no data collected

d. Federal Reference Method data and correlated nephelometer light scattering data used

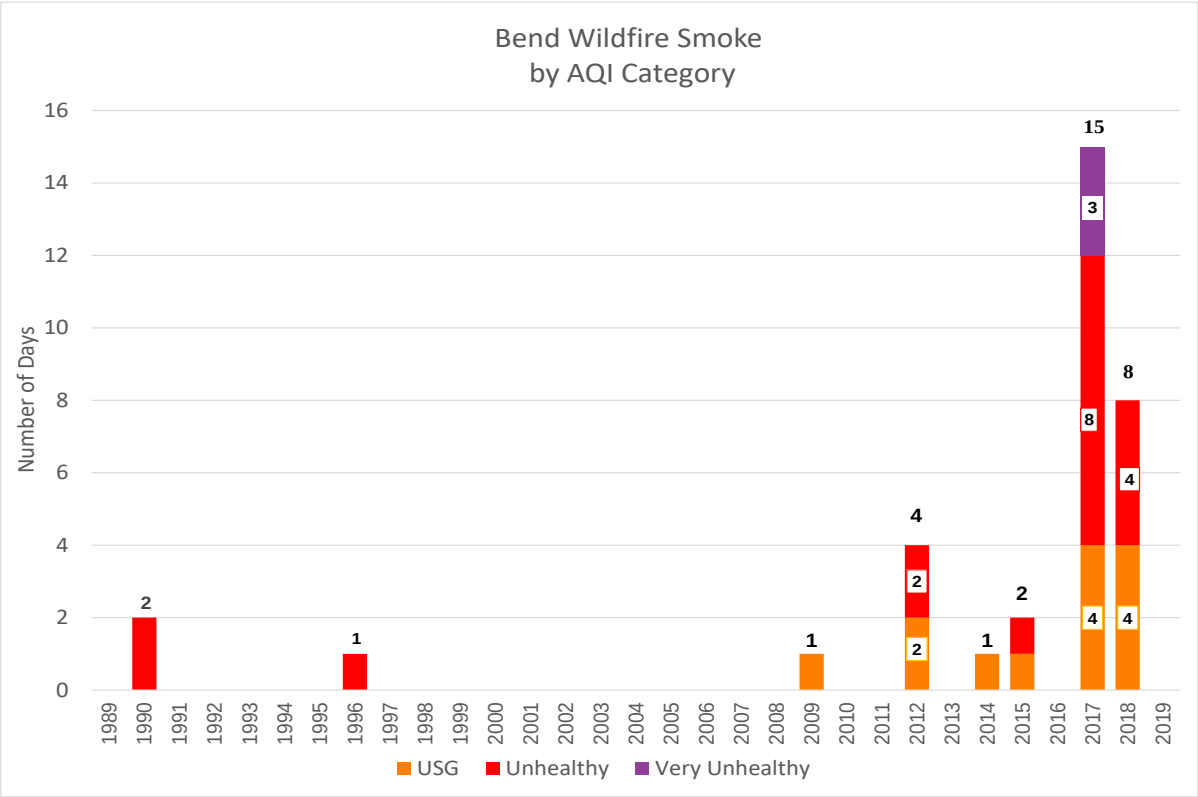


Figure 3. Bend ≥ USG AQI wildfire smoke trends.

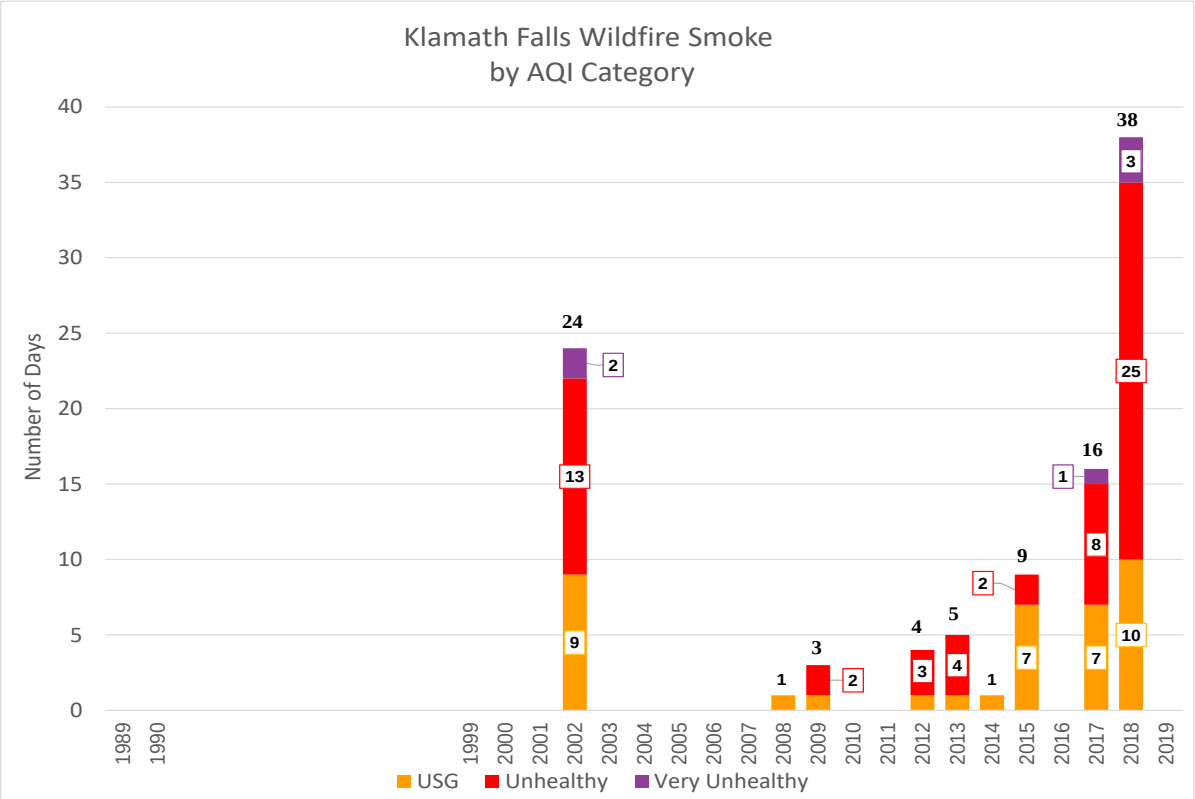


Figure 4. Klamath Falls ≥ USG AQI wildfire smoke trends.
Notes: No data was collected during the summer from 1991 through 1995, 1997, and 1998.

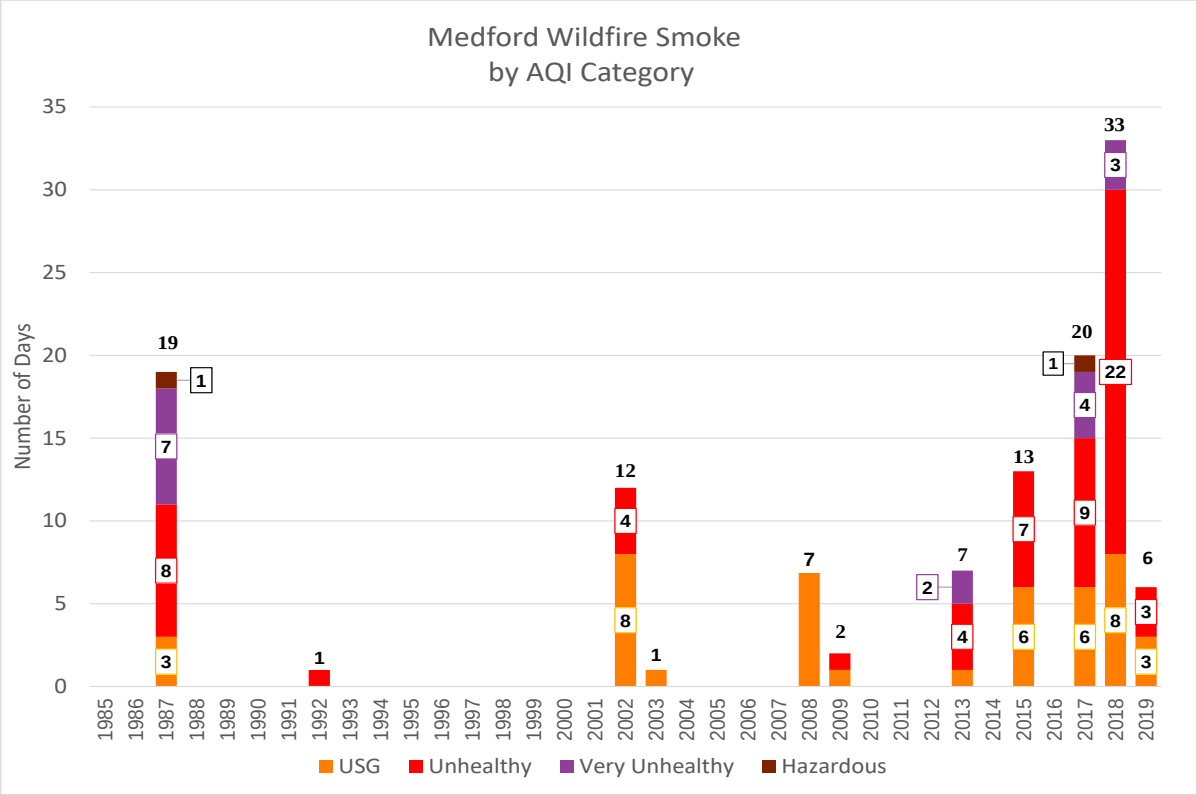


Figure 5. Medford ≥ USG AQI wildfire smoke trends.

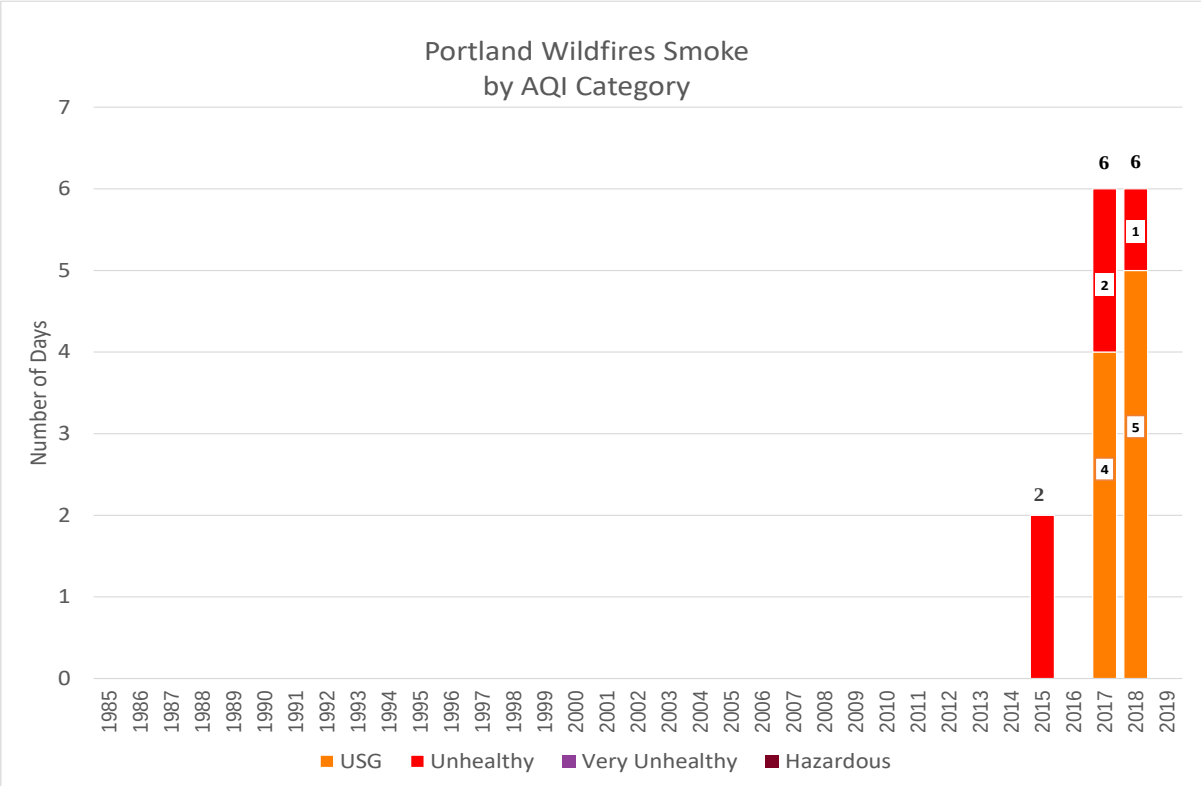


Figure 6. Portland ≥ USG AQI wildfire smoke trends.

Note: Not included: There were four USG days in Portland in mid to late September, two in 1985, one in 1987, and one in 1990. These were likely from field burning and are not shown here.

8. Conclusion

This report is intended to show the AQI trends from wildfire smoke impacts. The data shows that AQI categories from wildfire smoke have been increasing starting around 2012 and there have been much more frequent days at a more "unhealthy" level. If these trends continue, Oregon should expect to see an increasing number of ≥USG during the summer, and not just in Southern Oregon but also across the state.

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 smart phone app.

During wildfire season, you can also track air quality on the Oregon Smoke Blog.

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

Alternative Formats

DEQ can provide documents in an alternate format or in a language other than English upon request. Call DEQ at 800-452-4011 or email deqinfo@deq.state.or.us.

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.

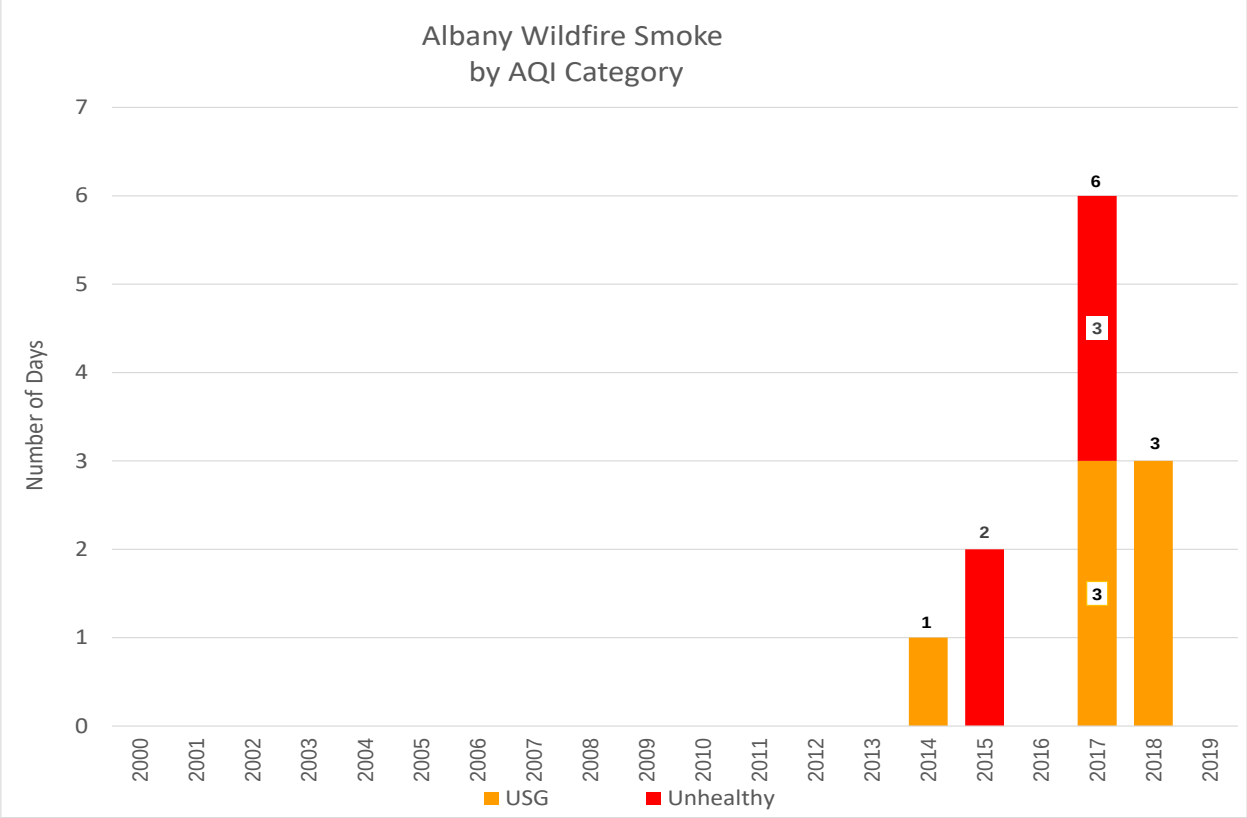


Figure 7. Albany wildfire ≥ USG AQI wildfire smoke trends.

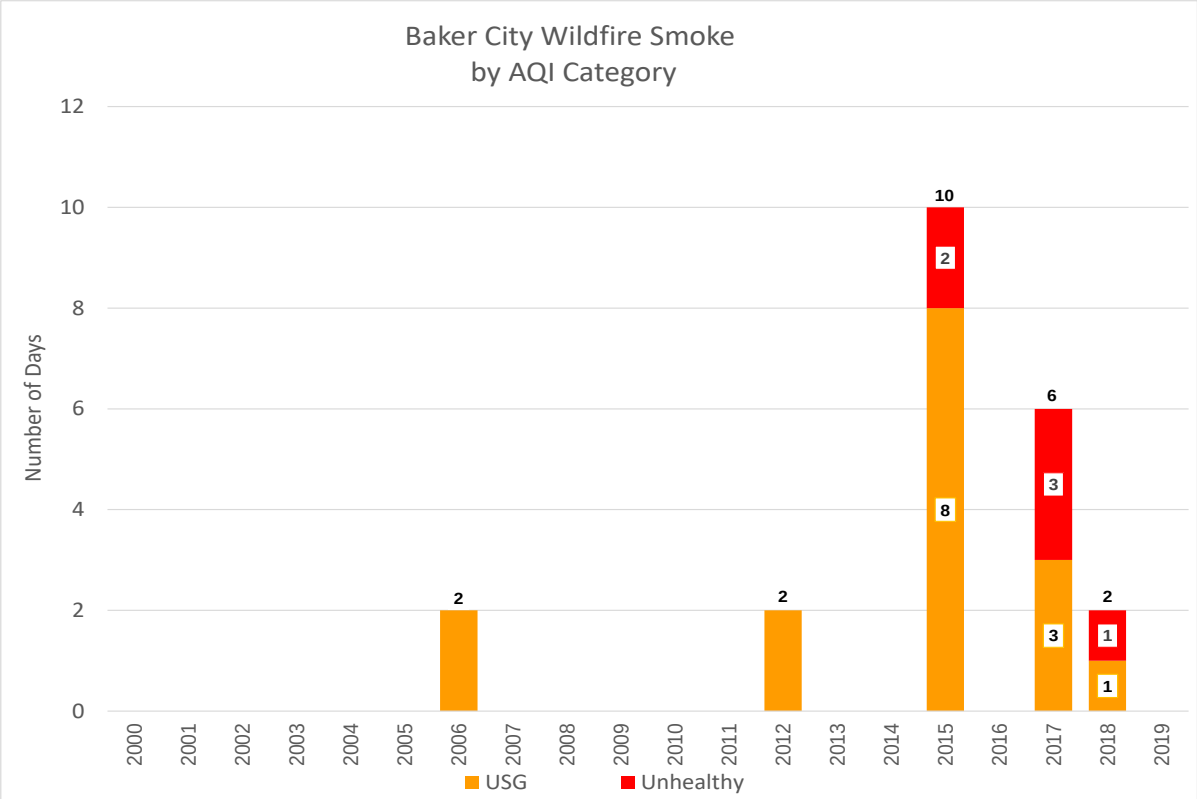


Figure 8. Baker City wildfire ≥ USG AQI wildfire smoke trends.

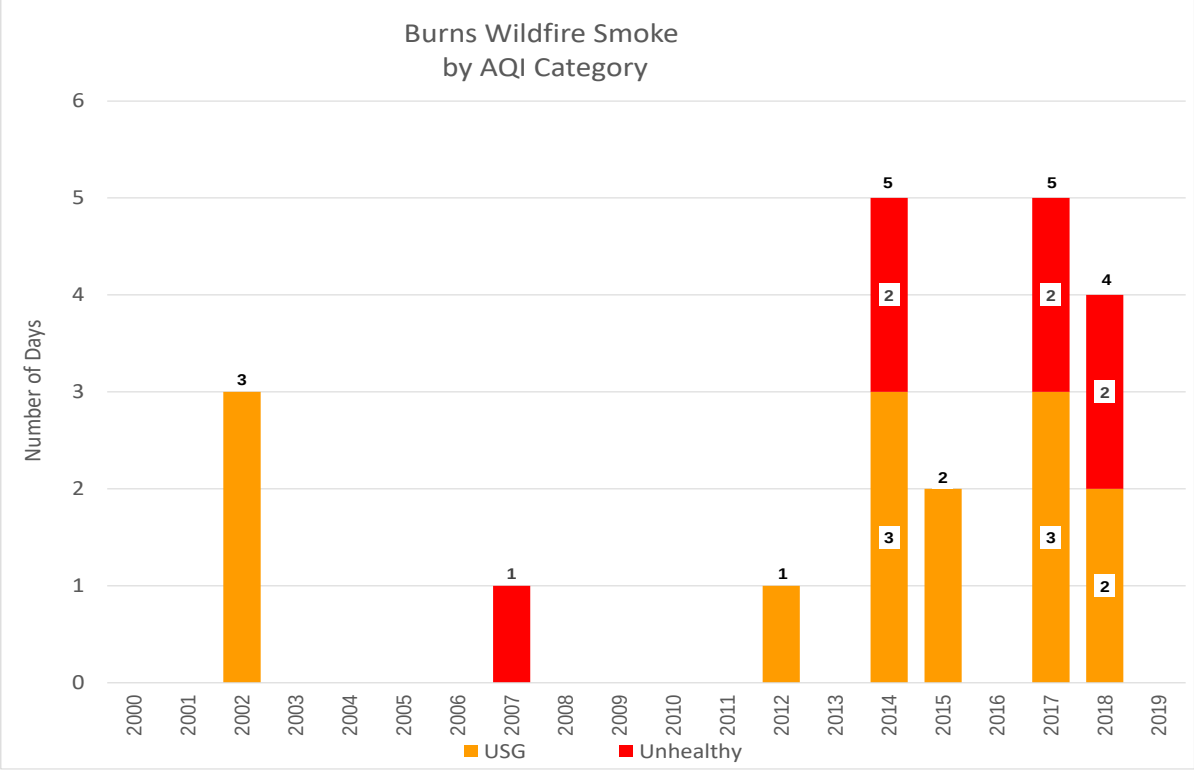


Figure 9. Burns wildfire ≥ USG AQI wildfire smoke trends.

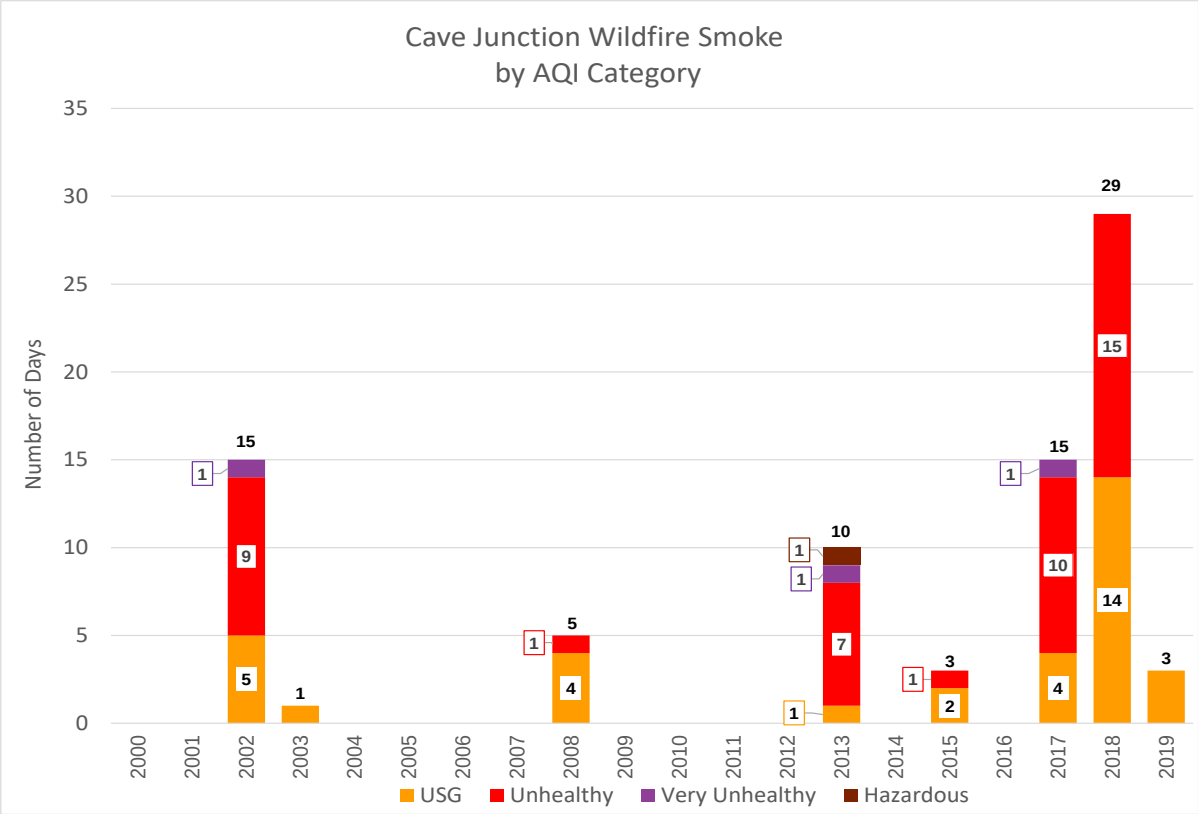


Figure 10. Cave Junction wildfire ≥ USG AQI wildfire smoke trends.

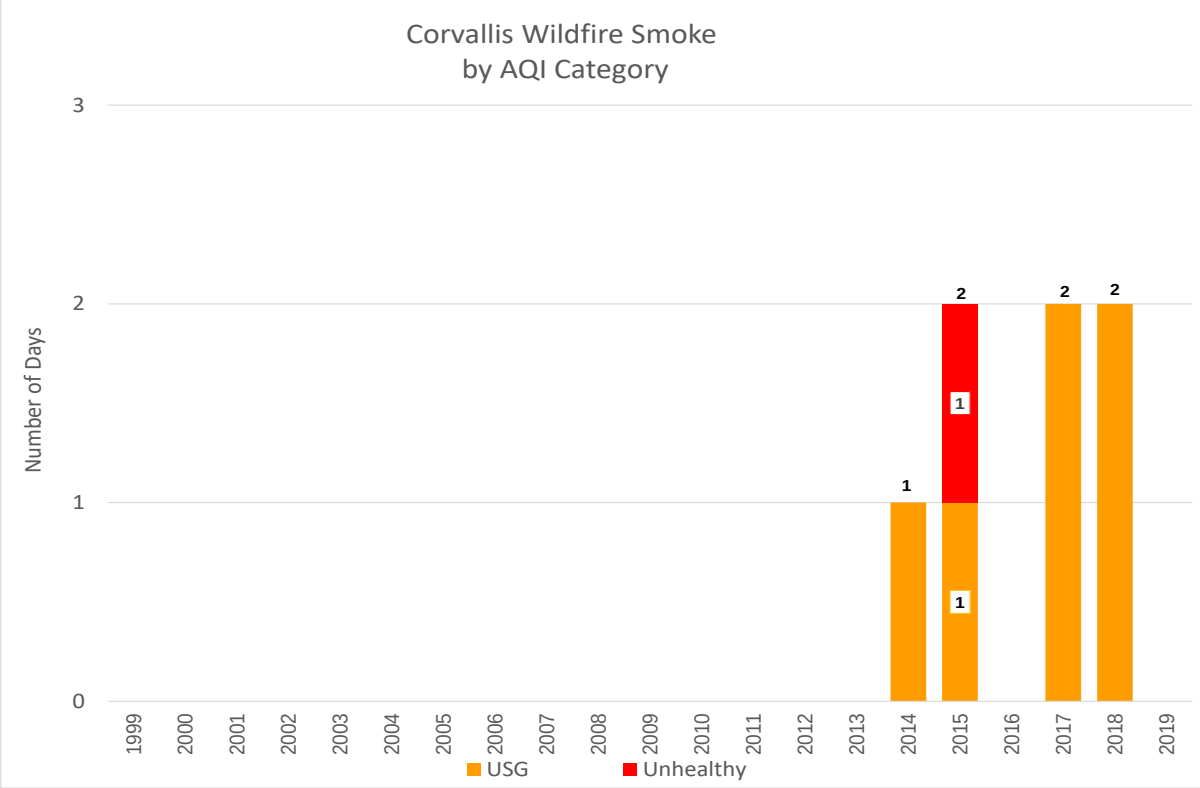


Figure 11. Corvallis wildfire ≥ USG AQI wildfire smoke trends.

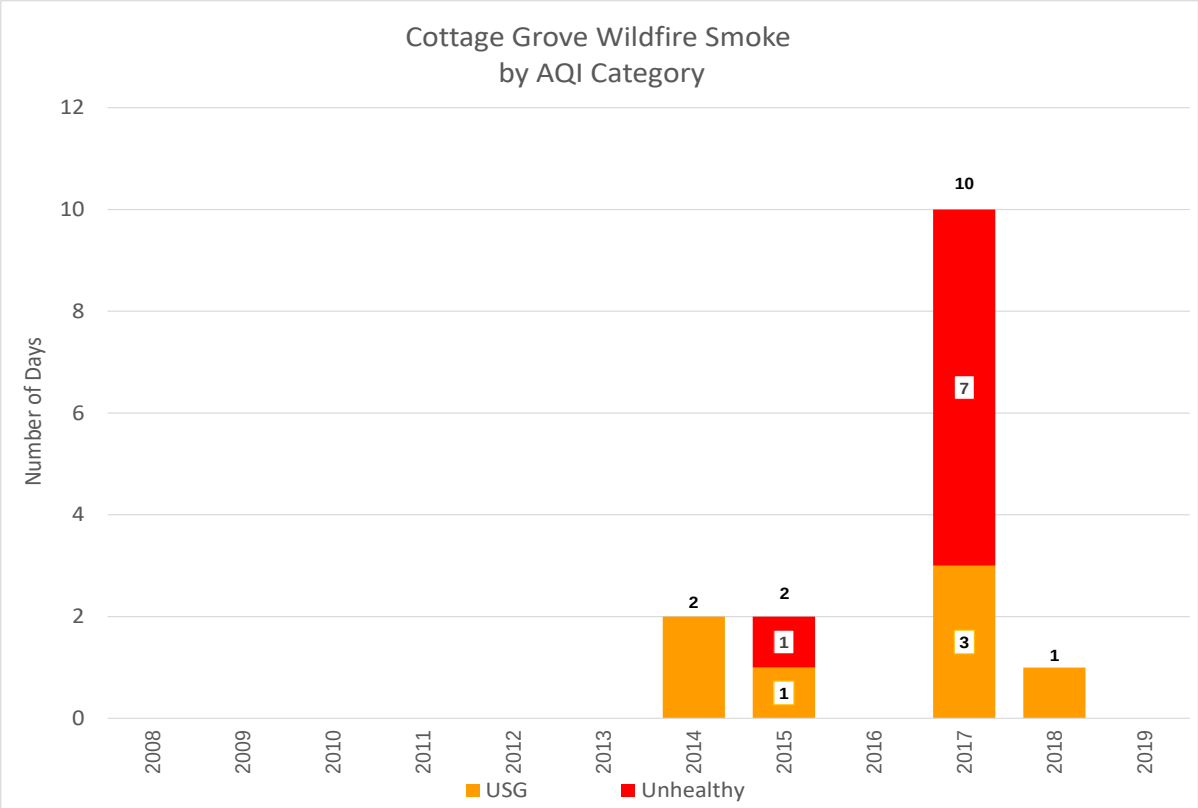


Figure 12. Cottage Grove wildfire ≥ USG AQI wildfire smoke trends.

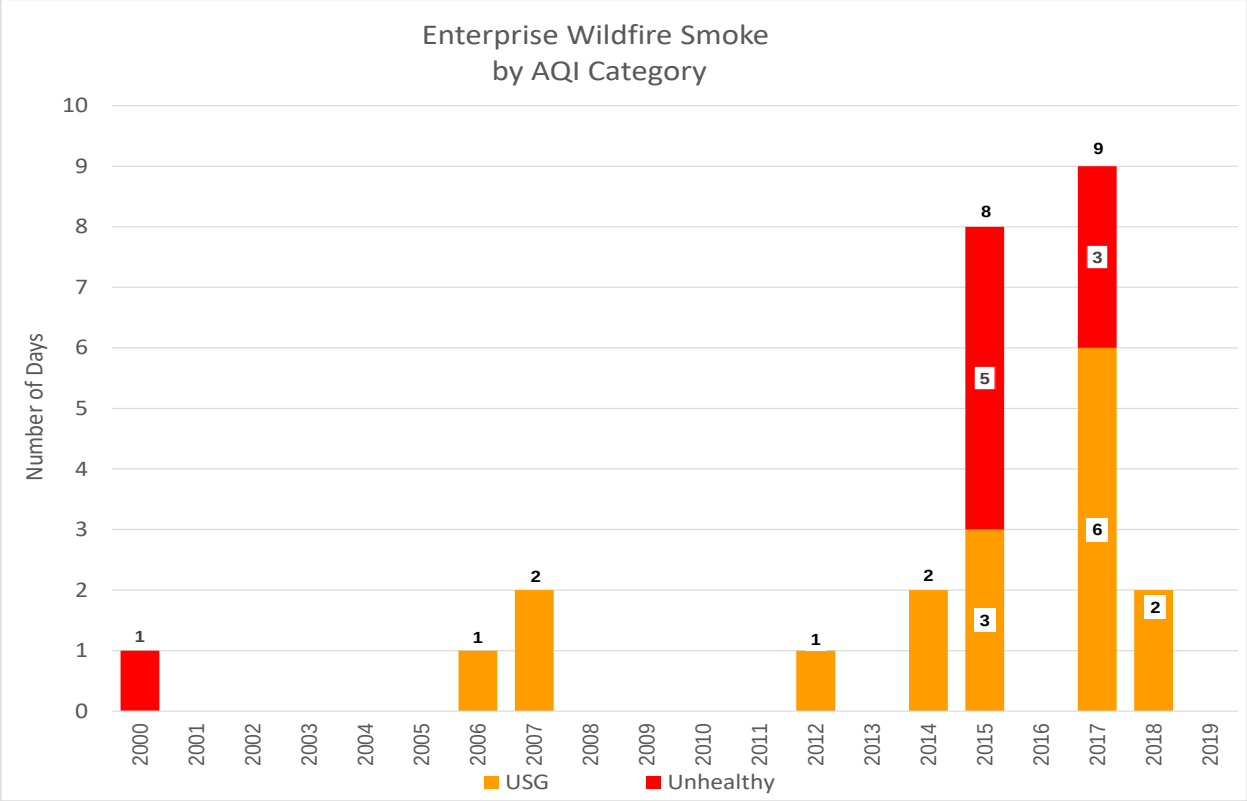


Figure 13. Enterprise wildfire ≥ USG AQI wildfire smoke trends.

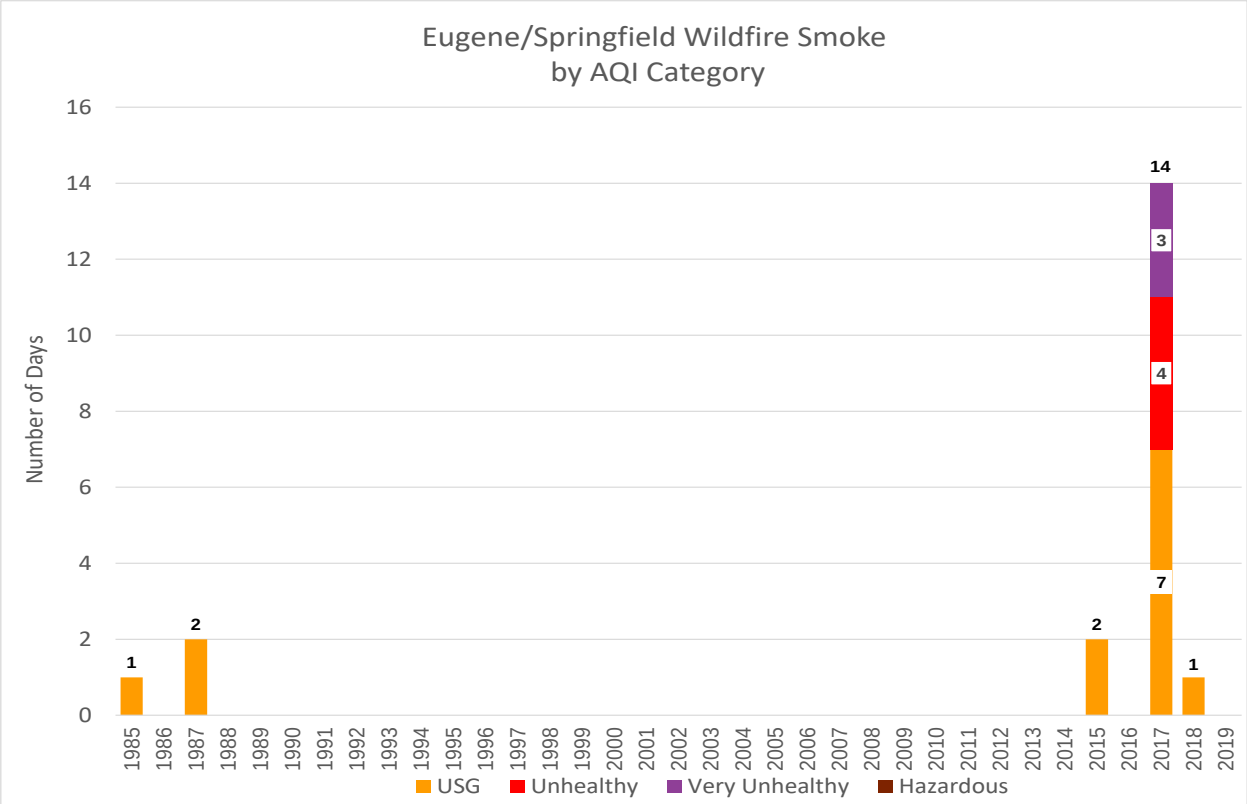


Figure 14. Eugene/Springfield wildfire ≥ USG AQI wildfire smoke trends.

1985 and 1987 was likely field burning.

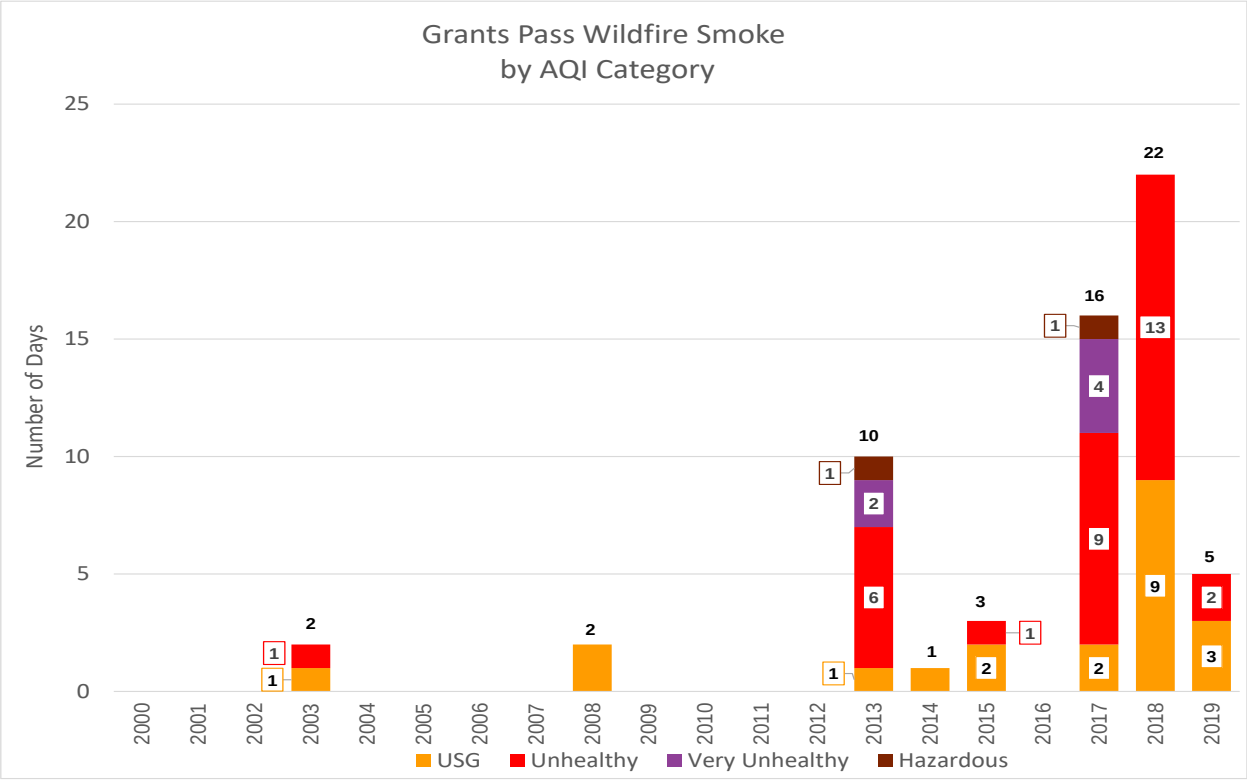


Figure 15. Grants Pass wildfire ≥ USG AQI wildfire smoke trends.

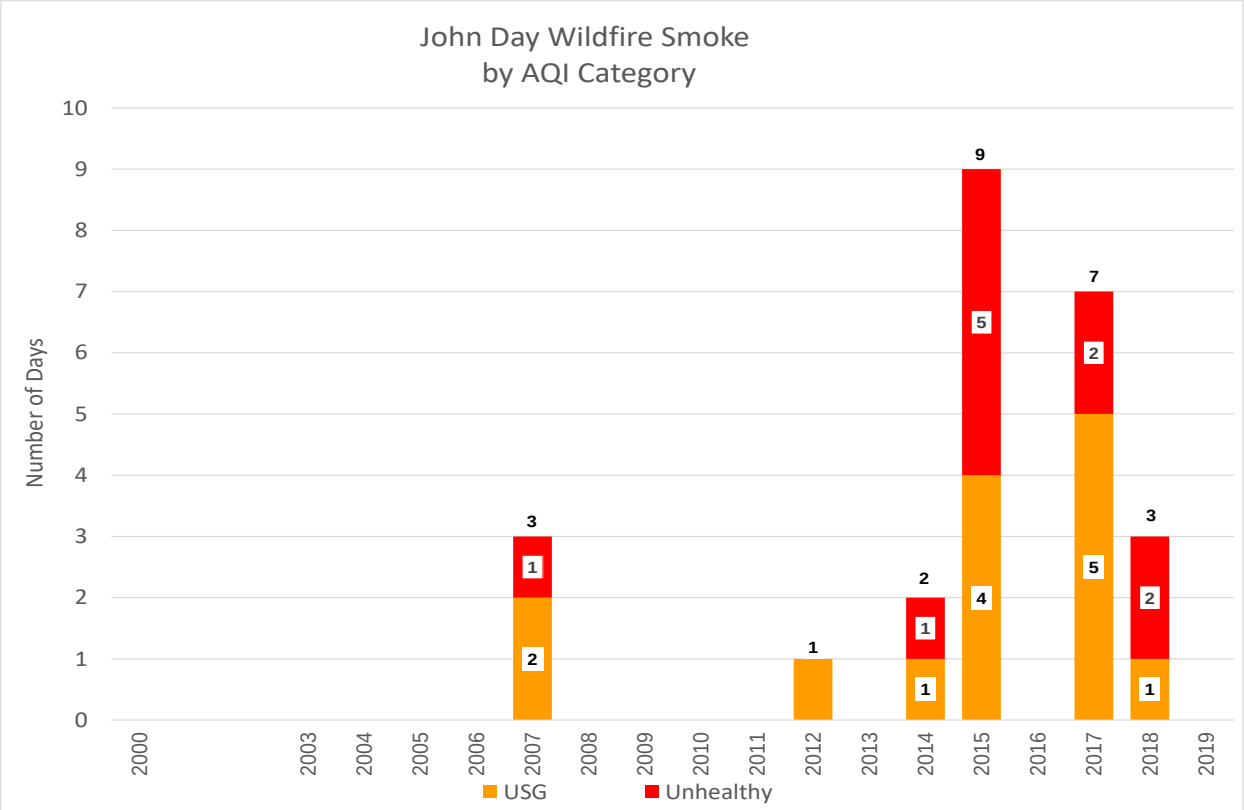


Figure 16. John Day wildfire ≥ USG AQI wildfire smoke trends.

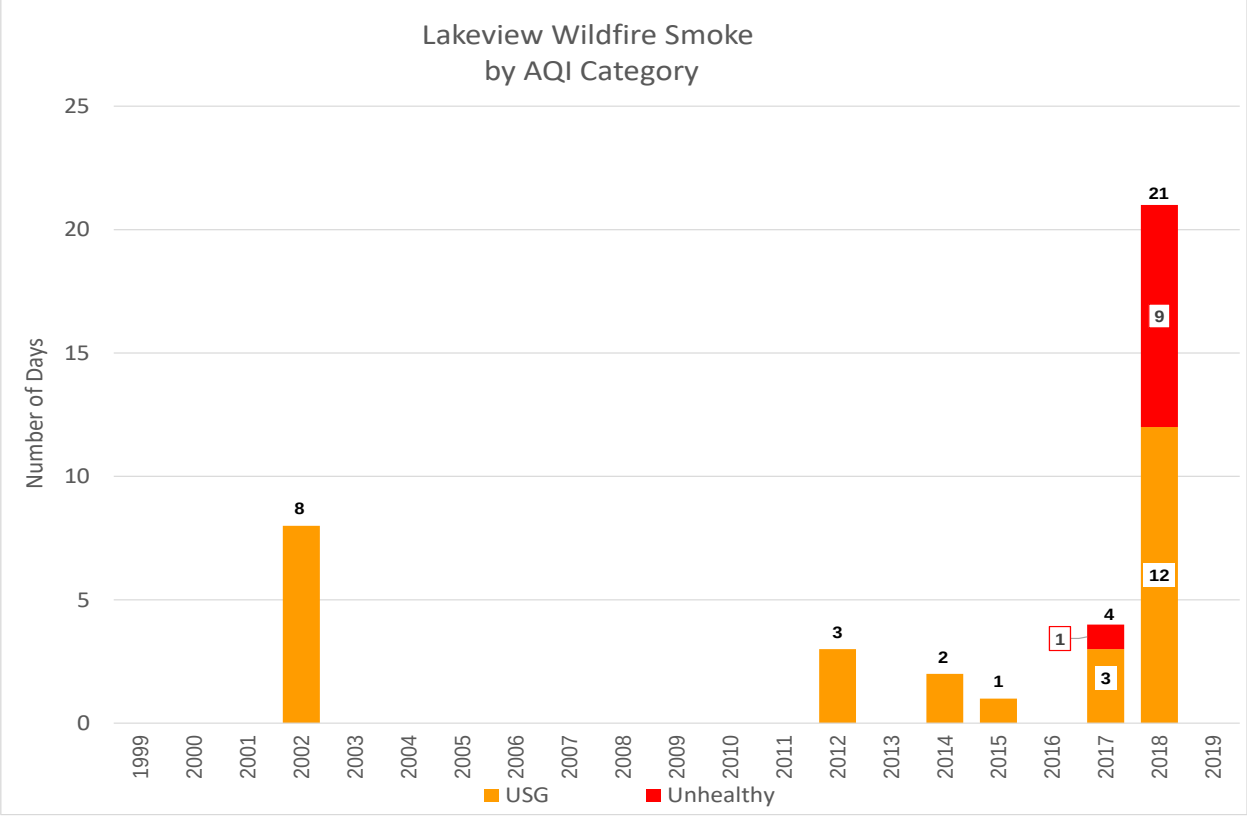


Figure 17. Lakeview wildfire ≥ USG AQI wildfire smoke trends.

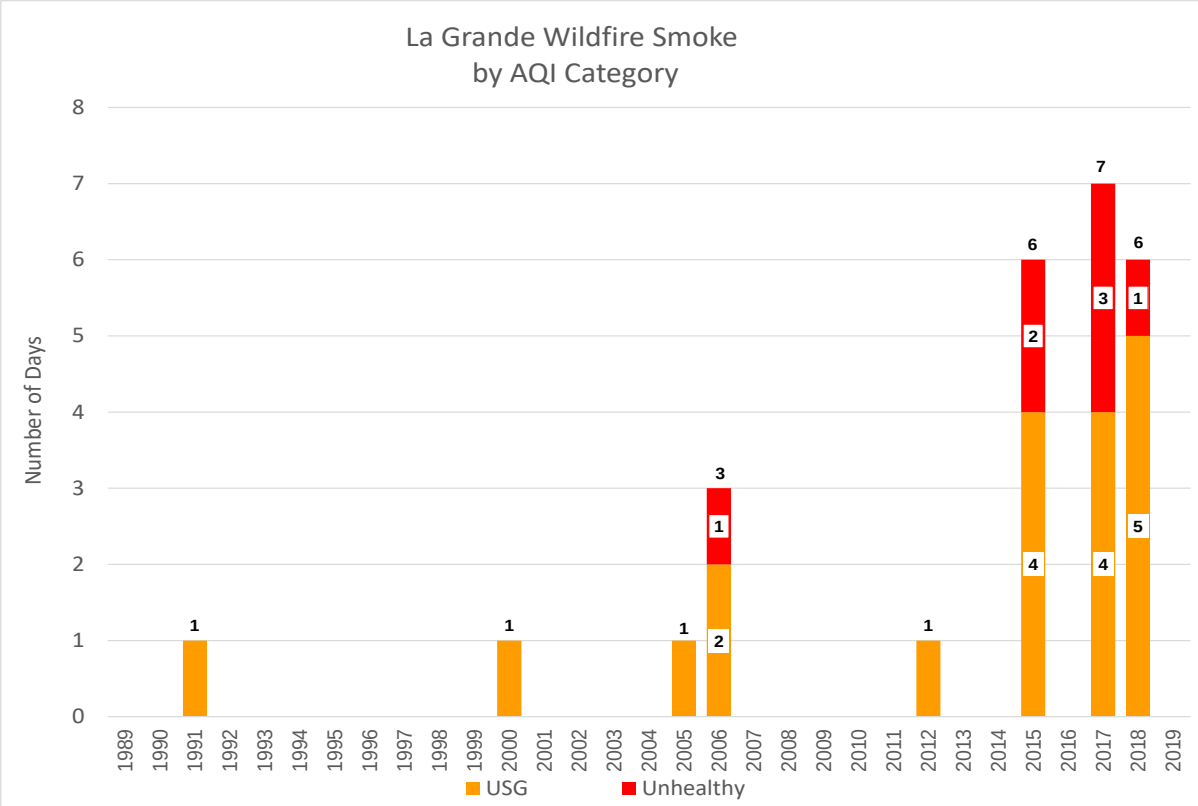


Figure 18. La Grande wildfire ≥ USG AQI wildfire smoke trends.

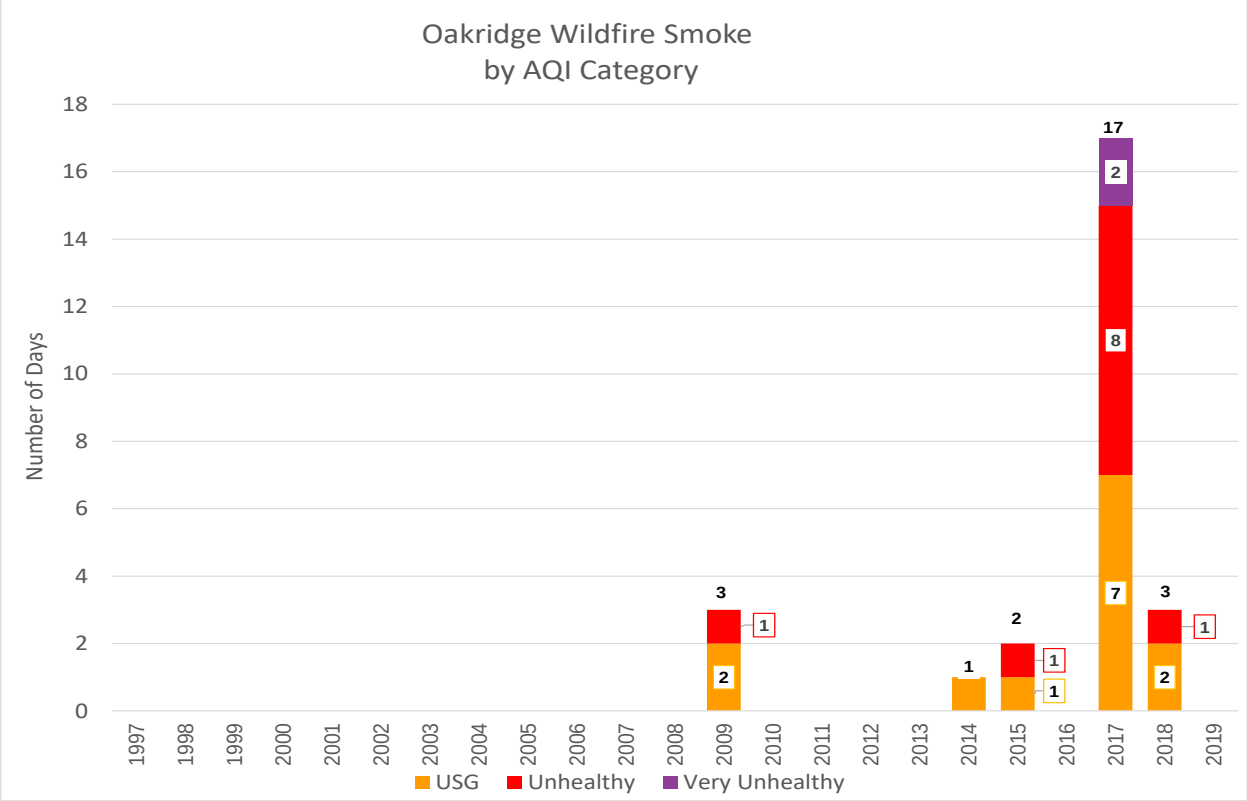


Figure 19. Oakridge wildfire ≥ USG AQI wildfire smoke trends.

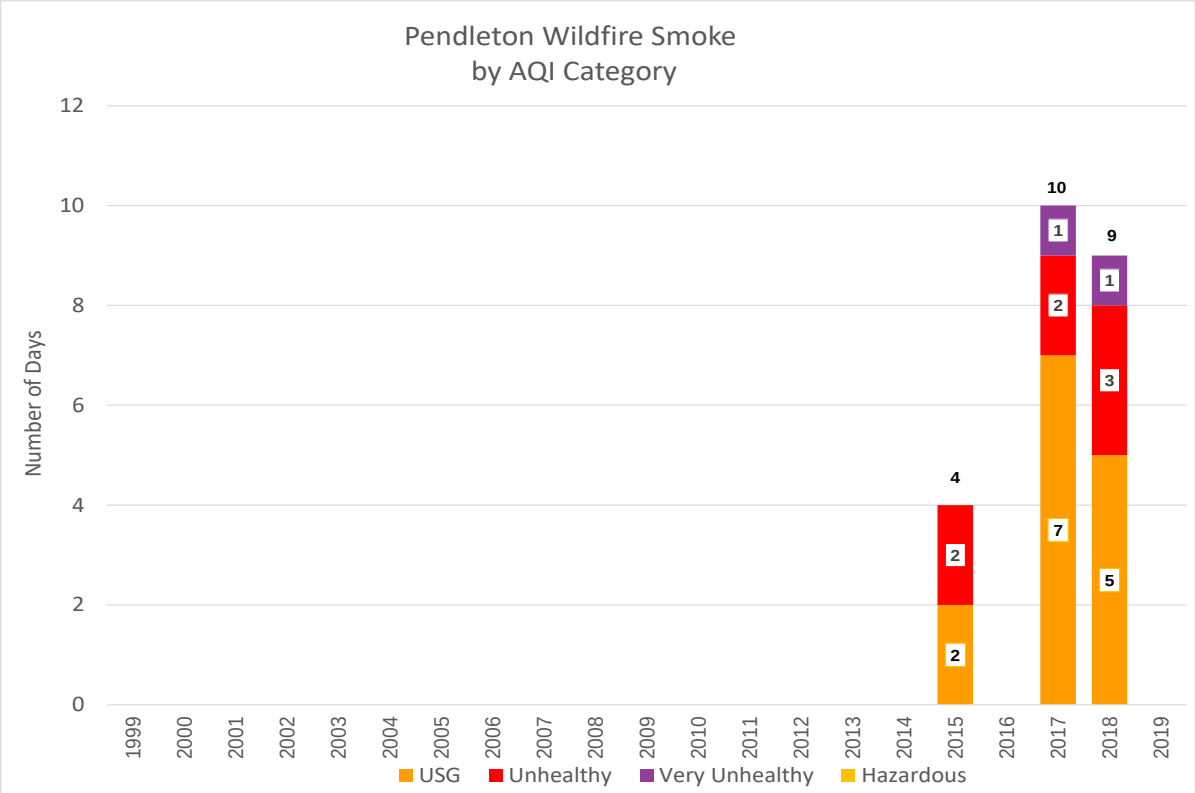


Figure 20. Pendleton wildfire ≥ USG AQI wildfire smoke trends.

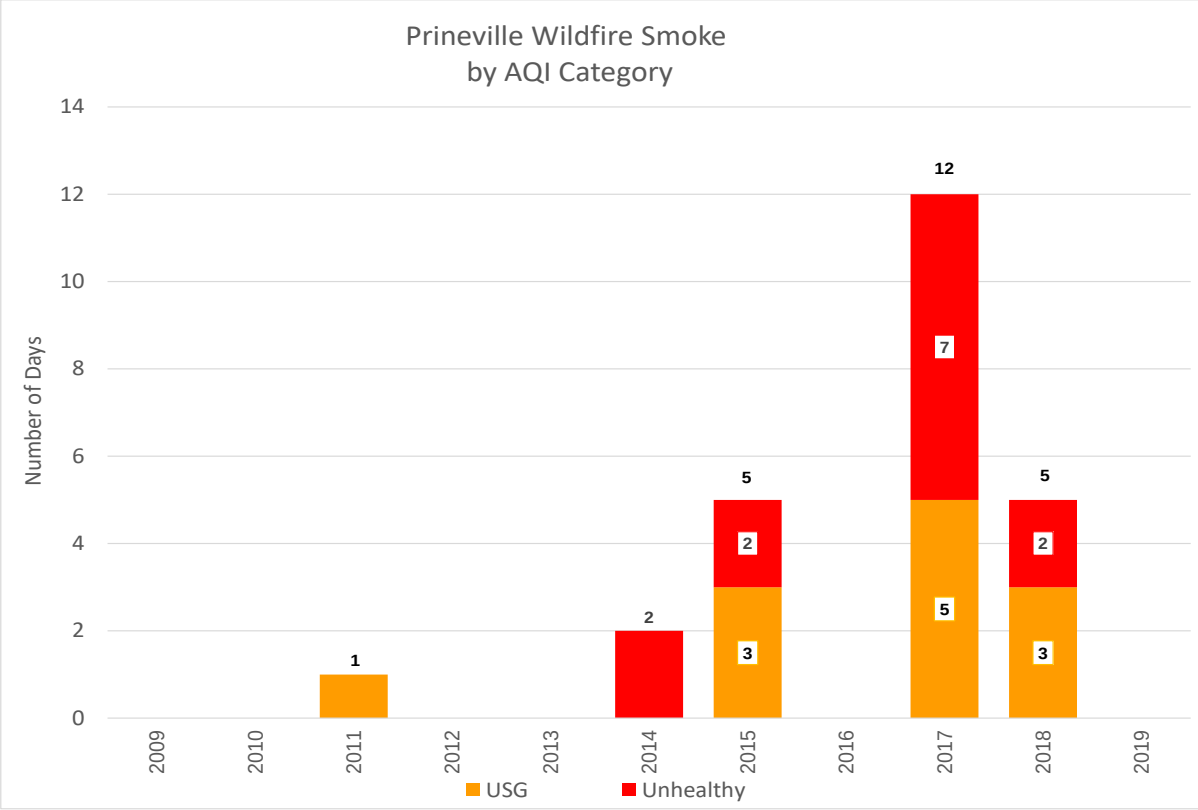


Figure 21. Prineville wildfire ≥ USG AQI wildfire smoke trends.

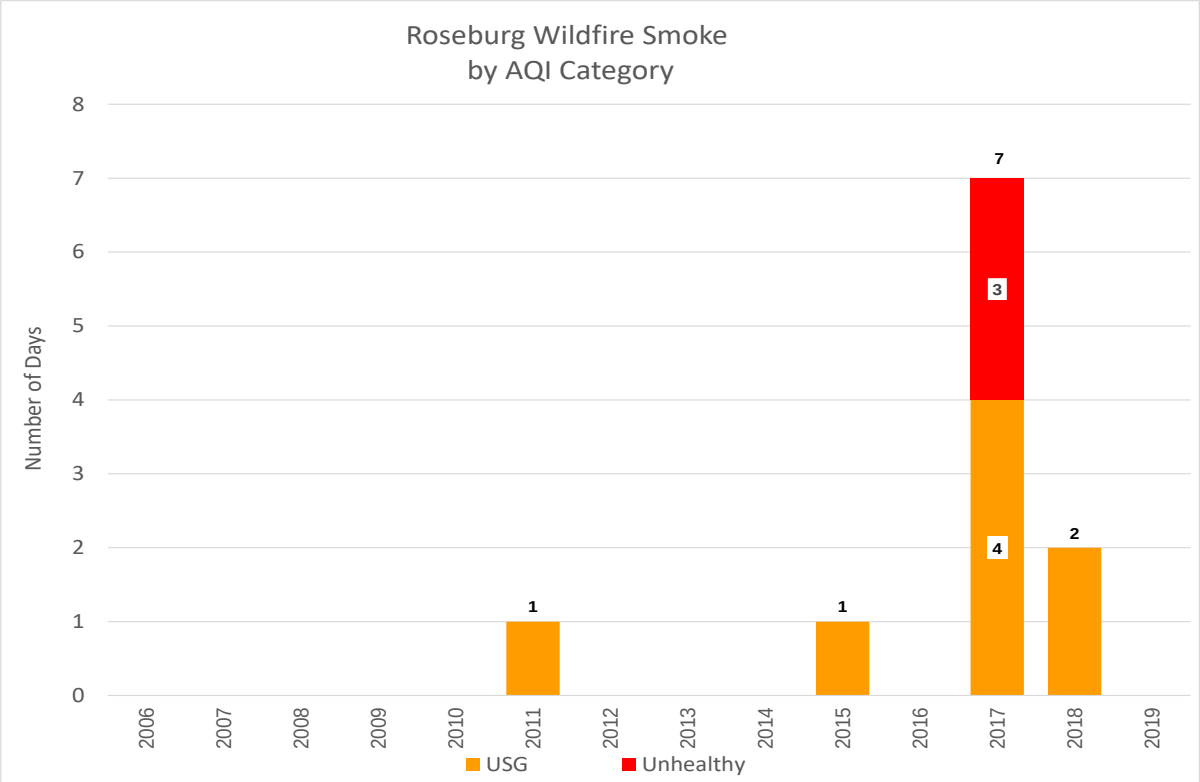


Figure 22. Roseburg wildfire ≥ USG AQI wildfire smoke trends.

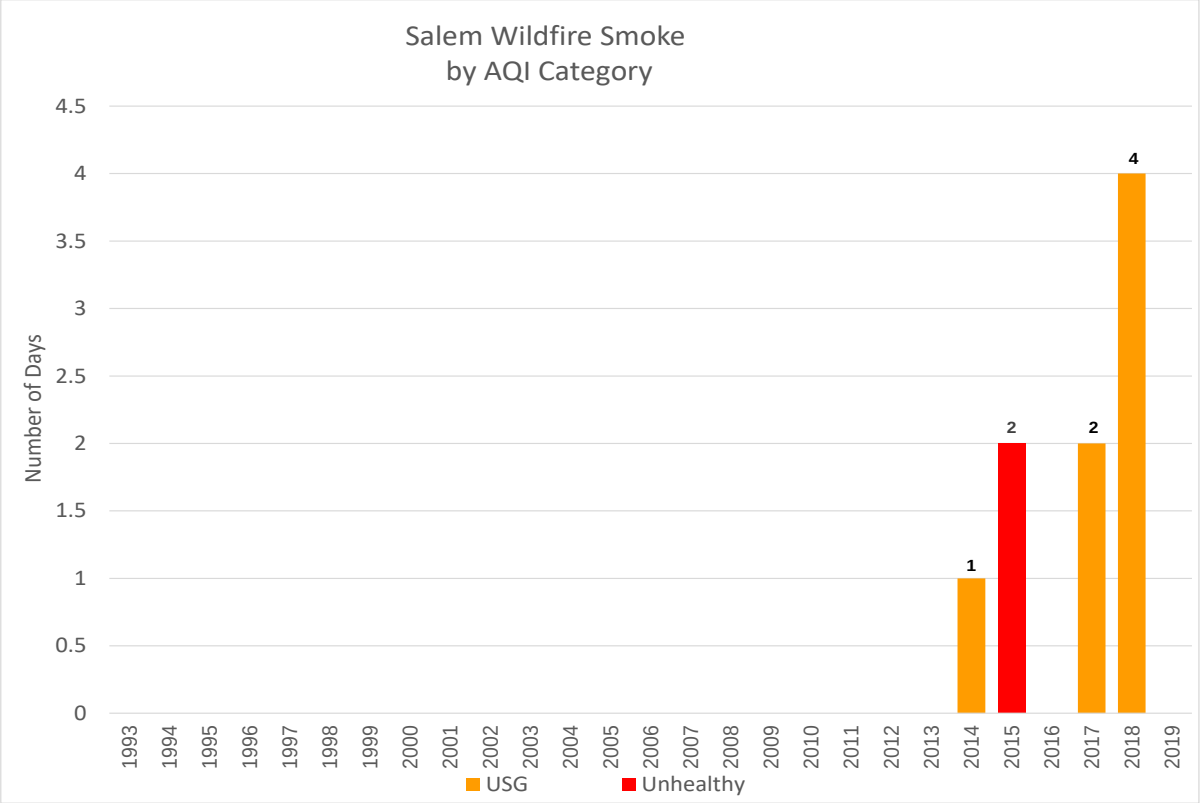


Figure 23. Salem wildfire ≥ USG AQI wildfire smoke trends.

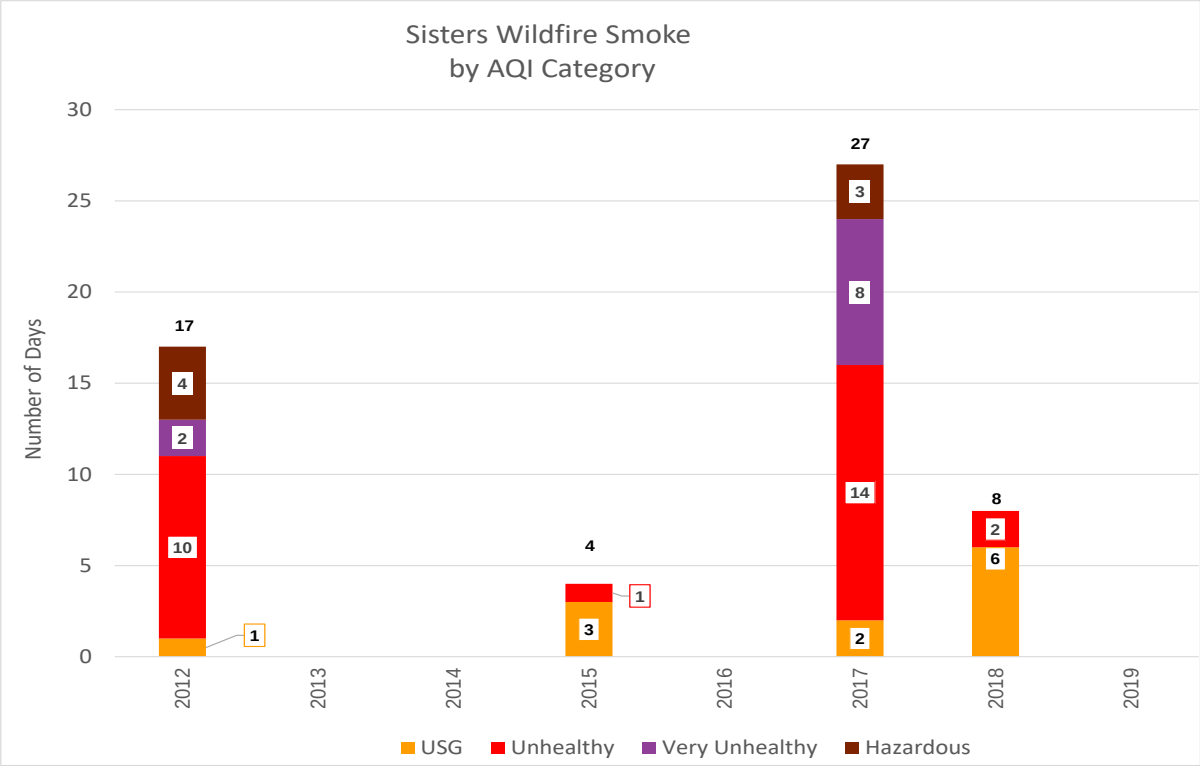


Figure 24. Sisters wildfire ≥ USG AQI wildfire smoke trends.

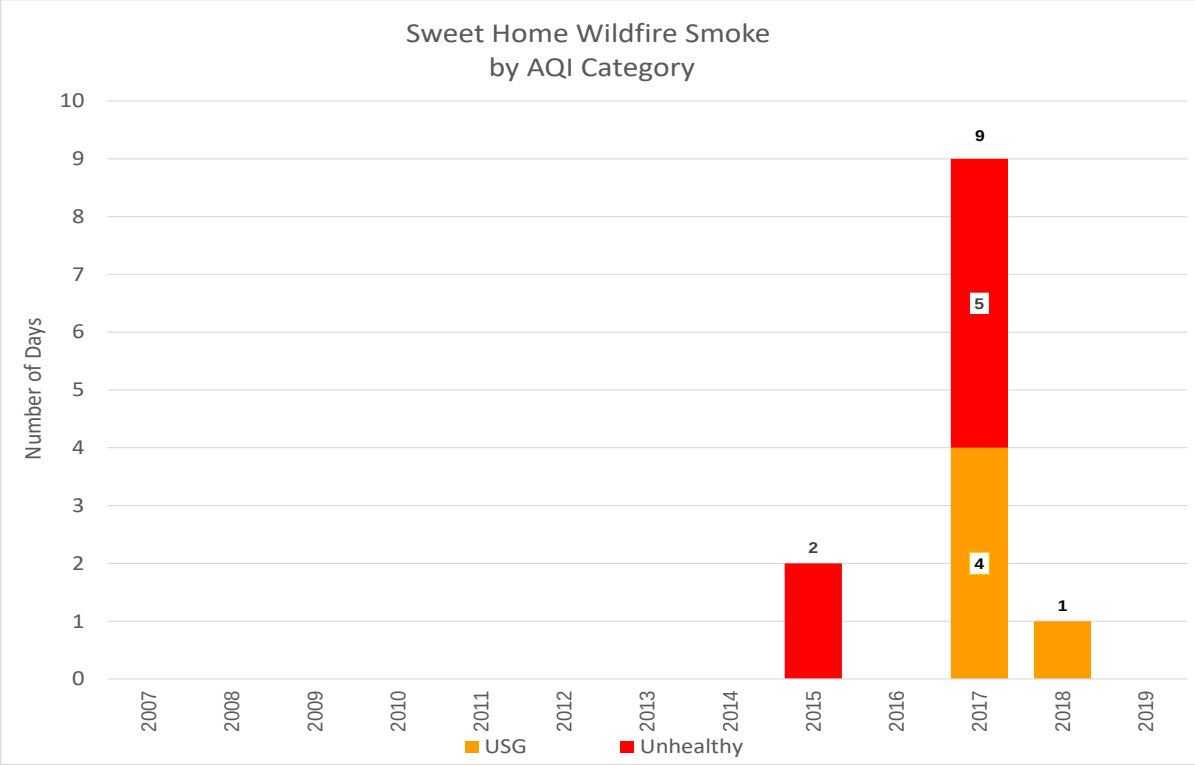


Figure 25. Sweet Home wildfire ≥ USG AQI wildfire smoke trends.

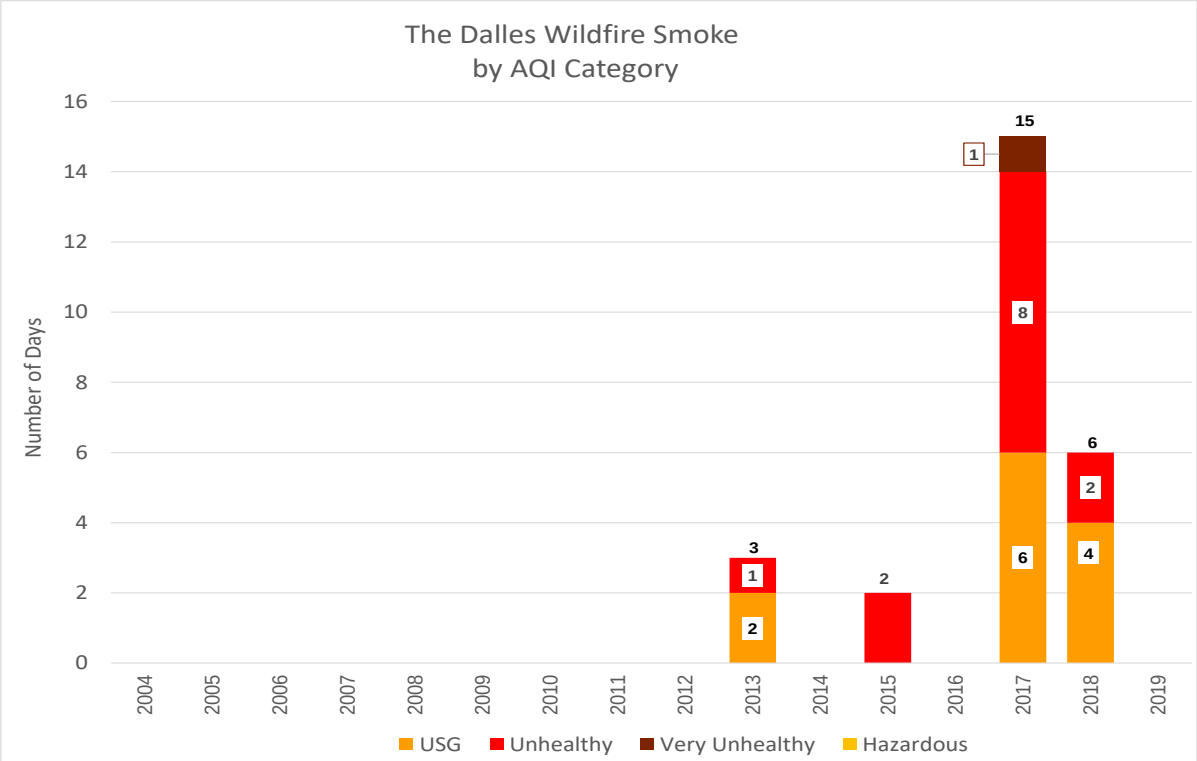


Figure 26. The Dalles wildfire ≥ USG AQI wildfire smoke trends.