Global Climate Change, Oregon Wildfires, and Portland Air Quality

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Oregon Wildfires and Air Quality

On September 9th and 10th, a windstorm roared through the Pacific Northwest. After an extremely dry summer, this created a "once in a generation" wildfire event in Oregon, with over one million acres burning and multiple lives being lost. In Portland, we avoided the worst of the consequences. We were not forced to evacuate, and we did not lose our homes and neighborhoods to the flames.

One of the main effects for Portlanders was air quality in the "Hazardous" range for over a week, sometimes rising to levels above the EPA scale. While this had impacts on everyone in Portland, the impacts were not felt equally. For those experiencing homelessness, those with essential jobs, and those without an air sealed home or the resources to buy an air filter, the effects were much more severe.

Figure 1: Twitter posts connecting the smoke in Portland, OR to climate change

Many in Portland connected the hazardous air quality to climate change (Figure 2). Climate change increases the area burned by wildfires, therefore also increasing smoke (7). According the Oregon Department of Forestry, the number or acres burned by wildfires has been increasing in recent years (figure 2).

But is climate change causing a perceptible change in Portland's air quality?

Liu et al. investigated this question using a chemical transport model. With this model, they looked at the wildfire smoke risk of different counties in the Western United States in 2009 and in 2051 to see how climate change might increase or decrease this risk. They found that Clackamas, Washington and Multnomah counties all had a risk of 4 (with 5 being the highest) in 2009. By 2051, their model showed Clackamas and Washington increased to the highest risk level, while Multnomah remained at the level 4 risk. (4)

Using Portland temperature and air quality data, I investigated these predictions by seeing how air quality is changing in Portland, and whether these can be connected to our changing climate.

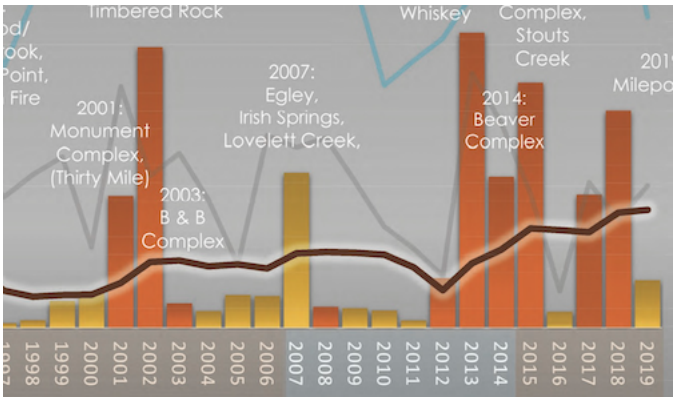

Figure 2: Graph by the Oregon Forestry Department. The orange and yellow bars show the total area burned that year. The black trend line shows that the number of acres burned has been increasing from 1999-2019. The grah has been zoomed in on the portion from 1999 to 2019 because that is where I will be focusing my analysis.

Portland is Getting Hotter

Daily temperature data collected at the Portland International Airport was obtained from the NOAA database. From this data, monthly means were calculated and graphed. I hypothesized that there would be an increase in daily maximum temperature over the four months looked at: June, July, August, and September. To test this, I looked at whether the null hypothesis, that there is no increase in temperature, could be rejected using a 95% confidence interval.

As you can see from Figure 3, all four months show an increase in temperature. Additionally, for all four months, the null hypothesis is rejected and the increase in temperature is found to be significant.

Notably, in August, one of the main fire season months, this trend is particularly strong, with an extremely small p-value ($p = 8.038 \times 10^{-6}$). August also had an adjusted R-squared value of about .2, meaning that 20% of the variation in the data can be explained by simply looking at the year. This is very high for climate data which, as shown in Figure 1, tends to vary greatly by year, suggesting that climate change is having a large effect in August in particular. In addition, the August trendline had the largest slop, with temperature increasing by 0.037 degrees per year. While this may seem small, it corresponds to a two degree increase over fifty years, which will have a significant effect on a variety of climatic and ecological systems.

It is important to note, however, that this data is for Portland only, not for all of Oregon. Temperature changes may be slightly different in other parts of the state, where wildfires occur. This data does show, however, that regardless of smoke, climate change in influencing Portland by increasing temperatures.

Air Quality is Not Getting Worse (But it's Not Getting Better)

I obtained air quality data from the EPA, which compiled daily air quality measurements for a variety of pollutants from a variety of different locations around Portland.

The EPA monitors and measures air quality under the Clean Air Act of 1970. It then ranks each pollutant on a scale known as the Air Quality Index (AQI) which ranges from 0-500, where higher values represent greater pollution and health risk. The EPA uses the AQI to measure the concentrations of five main pollutants: particulate matter, ground-level ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide. (1)

Smoke from fires contains many different chemicals, but this analysis will focus on one of the most dangerous components, PM 2.5, or particulate matter with a diameter of 2.5 micrometers and smaller. These particles are particularly dangerous because, due to their small size, they can travel deep in the lungs (1). Focusing on PM 2.5, however, also limited the length of this analysis, as PM 2.5 data was only available starting in 1999.

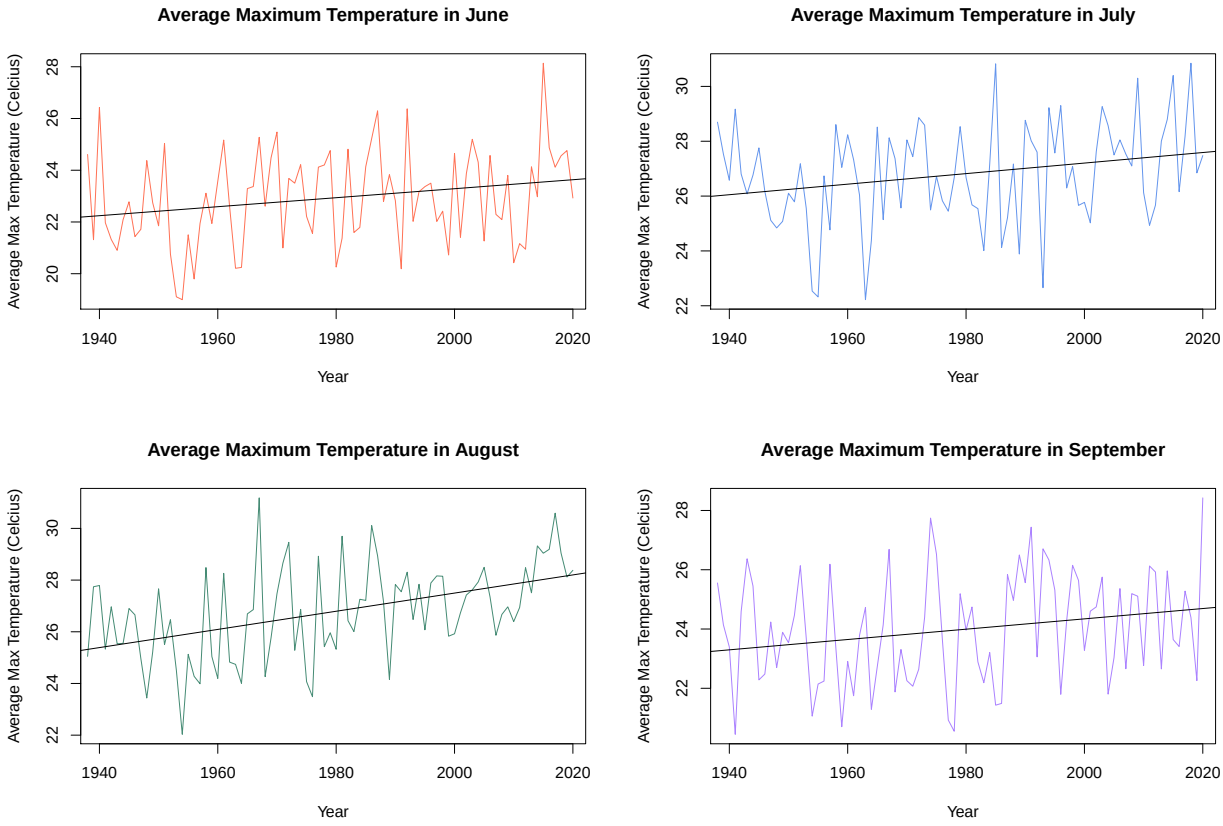

Figure 3: Graphs of average daily max temperature in June, July, August, and September. All four months showed a significant trend. For June, $p = 0.03627 < 0.05$ and Adjusted R-squared = 0.04132. For July, $p = 0.0223 < 0.05$ and the Adjusted R-squared = 0.0512. For August, $p = 0.000008038 < 0.05$ and the Adjusted R-squared = 0.2096. For September, $p = 0.03693 < 0.05$ and Adjusted R-squared = 0.04095.

The data from the EPA provided a daily PM 2.5 value, which I used to create and graph monthly averages.

Like with temperature, I hypothesized that air quality decreased over time (causing increasing AQI values and a positive trend in the graph). To test this, I tested the null hypothesis, that there was no increasing or decreasing trend. A 95% confidence interval was used for this analysis as well.

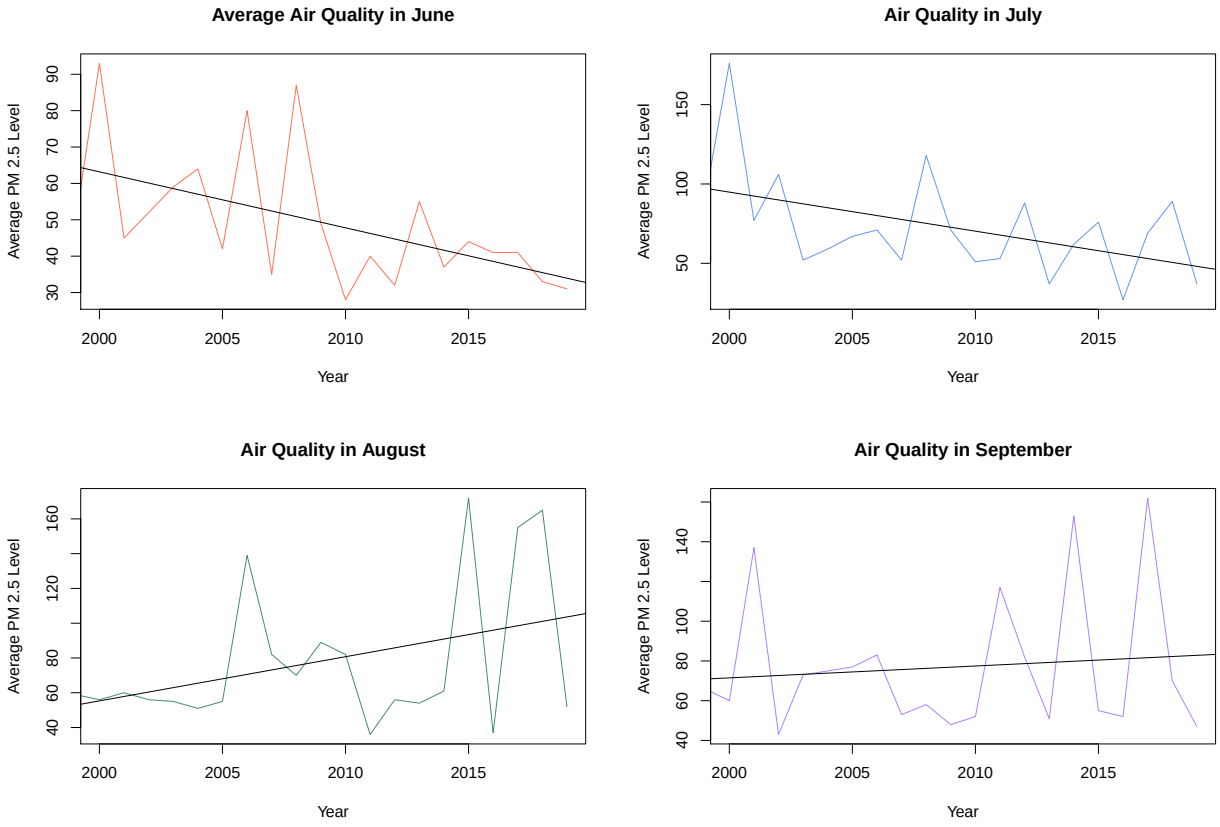

Figure 4: Graphs of average daily PM 2.5 AQI value for June, July, August, and September. For June, p = 0.01491 < 0.05, Adjusted R-squared = 0.2357, and slope = -1.539. For July p = 0.03258 < 0.05, Adjusted R-squared = 0.1775, and slope = -2.461. For August, p = 0.09299 > 0.05, Adjusted R-squared = 0.09619, and slope = 2.542. For September, p = 0.651 > 0.05, Adjusted R-squared = -0.04105, and slope = 0.5974.

Figure 4 shows the average AQI PM 2.5 reading for Portland from 1999 to 2019. For the months of June and July, both my hypothesis and the null hypothesis were rejected. Instead, both months showed a significant decreasing trend in AQI. Additionally, both had very high Adjusted R-squared values of 0.24 and 0.18 respectively, meaning that 24% and 18% of the variation in the data can be explained by time alone. This suggests that, for June and July, there is a strong correlation between time and decreasing AQI values (improving air quality).

In August and September, this trend was not maintained. Instead, both graphs showed an increase in the average AQI value over time. This increase, however, was not found to be significant within a 95% confidence interval. If we lower to a 90% confidence interval, however, the increasing trend in August is found to be significant (p = 0.09299 > 0.10).

This data seems to imply that forest fires and climate change are not having a perceptible impact on air quality, but that may not be the full story. According to the EPA/National Park Service Visibility Program (known as IMPROVE), PM 2.5 AQI values have been improving throughout the US due to EPA regulations after the Clean Air Act of 1970 (7). Many other sources besides wildfire pollute PM 2.5, such as construction sites,

fields, smokestacks, and reactions between other pollutants in the atmosphere (1). Regulations and decreases in these forms of pollution have contributed to a general decrease in PM 2.5 AQI and an improvement in air quality. Increases in forest fire smoke, however, may be one reason that in August and September (biggest fire months), PM 2.5 AQI is not decreasing.

It is difficult to prove that this lack of improvement in PM 2.5 concentrations is due to forest fires. O'Dell et al. investigated this question. Looking at the Western United States, they combined PM 2.5 measurments with satellite smoke data to try and determine which days and locations were "smoke influenced." When excluding these smoke days, there was a significant decrease in PM 2.5 values, suggesting that increases in air pollution from wildfires is cancelling out decreases in pollution from other sources. (7)

Consequences of Increased Smoke

Figure 5: Smoke due to wildfires in Portland, OR on September 12, 2020. Source: https://www.koin.com/news/wildfires/trash-collection-delayed-by-hazardous-air-quality-in-portland-metro/

The connection between wildfire smoke and climate change provides a lot of potential. When it was passed, the Clean Air Act received bipartisan support, and the fight for clean air has consistently managed to bring together a broad coalition of public health activists, social justice activists, and climate activists (2). Connecting climate change to decreased air quality could provide an opportunity to unite these activists around climate change.

Public Health

A variety of studies have investigated the health impacts of exposure to wildfire smoke. Lui et al. reviewed 61 studies investigating the relationship between wildfire smoke and health. They reported that 90% of the studies found a significant association between wildfire smoke and an increased risk of respiratory morbidity (5). Another study by Jones et al. found that smoke-related health costs rose 1256% in Oregon from 2005 to 2015, and that wildfire smoke related health costs in the Western US totaled $165 million per year (3).

Social Justice

Poor air quality from wildfires is also a climate justice issue. For example, people experiencing homelessness experience a greater exposure to wildfire smoke. According to the US Interagency Council on Homelessness, about 15,876 people experience homelessness on any given day in Oregon and about 4,015 of those people are in Multnomah county (8). After adjusting for population, Portland has one of the highest rates of homelessness in the country, due to a lack of affordable housing and mental health resources (8). Poor air quality will undoubtedly affect these individuals more, as they often do not have a safe indoor space where they can escape the poor air quality for long periods of time.

Additionally, those in the essential workforce may be required to go outside and work in the dangerous air quality. People with low incomes may not have the resources to afford air filters or to air seal their home to keep out the smoke.

Studies have also found that the health effects of poor air quality disproportionately affect minority groups. These disparities are caused by the systematic racism that pervades all levels of US society. One study by Liu et al. looking at individuals over 65 years of age found that a higher fraction of Blacks were exposed to more than one smoke wave. They also found that Blacks had a 21.7% increased rate of respiratory admissions to hospitals, compared to a 6.9% increase for whites. (6)

What can we do?

With an election coming up, you may be tired of the advice to vote, but I am going to go give it anyway. Vote! Vote for candidates on the local, regional, and national level that believe in climate change and will make it a priority to solve this problem.

Beyond that, this issue provides the opportunity to unite a variety of activists to fight for clean air by limiting carbon dioxide emissions, just like in the 1960s and 70s. In social media posts about the fires and climate change, focus also on the climate justice and health implications of the smoke to highlight how this is an interdisciplinary issue.

Lastly, lawyers and activists can use this issue to press the EPA to regulate carbon dioxide emissions. While the Supreme Court has previously given the EPA the right to regulate carbon dioxide emissions, that right is not absolute and carbon dioxide is still not heavily regulated. And as the court becomes more conservative and possibly less reliant on precedent, the EPA may no longer have the right to regulate carbon dioxide.

Connecting rising carbon dioxide levels to worsening levels of PM 2.5 could provide a solution. On the EPA's website, it states that its "national and regional rules to reduce emissions of pollutants that form PM" will help reduce PM levels. The EPA is already regulating other pollutants that cause an increase in particulate matter in order to decrease particulate matter and they could and should do the same with carbon dioxide.

Citations

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