Final Report

**Introduction:**

In this report I seek to understand the correlation between Death Valley attendance and smoke estimates/AQI in Pahrump, NV. For this project we were encouraged to “help inform the city council, city manager/mayor, and city residents about the potential future impacts of smoke on their community” (SOURCE) through the lens of a human centered data science question. I chose to examine Death Valley attendance due to the impact tourism likely has on the economic viability of Pahrump.

From Pahrump’s Wikipedia page, it would appear that the town’s economic activity centers on two wineries and two legal brothels (*Pahrump, Nevada*). While it may have been possible to infer potential impacts on Pahrump’s industries from data linking smoke and winery production generally, I wanted to study economic activity more directly. A search for Pahrump on TripAdvisor revealed multiple tours to nearby Death Valley National Park (The 15 best things to do in Pahrump - 2023 (with photos)). In addition, when one plots a course from Las Vegas to Death Valley on Google Maps, one of the two primary routes goes directly through town. From this data I conclude that tourists originating in Las Vegas likely drive through town, filling up their cars, buying snacks, and gathering provisions for the park. Each of these actions provides direct economic benefit to the town. This hypothesis is bolstered by the approximately 20% of adults in Pahrump who work in “Accommodation and Food Services”, or “Arts, Entertainment, and Recreation Industries”, well above the total national average of 9%. It is distinctly possible that the proximity of Death Valley drives additional employment in these sectors (Economy in Pahrump, NV). Beyond tourism, Pahrump locals may also be employed to work in the National Park or to maintain outside infrastructure (e.g., road crews, firefighters).

Identifying a correlation between smoke estimates/AQI and Death Valley attendance would allow citizens of Pahrump to diversity their industries or challenge their government to do more about fire prevention in the event that smoke/poor air quality should increase.

**Background/Related Work:**

Some research has already been conducted on the impact of wildfire smoke on National Part attendance. Clark et. al found in modeling black carbon (an element of wildfire smoke) and recreational visitation to 32 US National Parks that “The results of these models are mixed, but overall show little to no effect of ambient smoke on visitation to the 32 parks tested, even when allowing for critical thresholds at the extreme upper ranges of smoke exposure. This indicates that wildfire smoke does not greatly alter park attendance” (Clark et al., 2023). Gellman et al. executed a similar analysis of wildfire smoke and federal campgrounds in the US between 2008 and 2017 and found “[…] fire and smoke affect 400,000 and 1 million visitor-days per year, respectively […but] the magnitude of the smoke effect is small […] suggesting that smoke fails to deter most visitors to public lands” (Gellman et al., 2022).

These findings run contrary to expectations, though it is important to remember that correlation does not imply causation. While wildfire smoke may be burdensome to National Park visitors, it is possible that significant investments of time and money could make them reluctant to change or cancel plans.

For my analysis I will examine the correlation between Death Valley attendance and smoke estimates/AQI estimates in Pahrump, NV. Despite earlier research, I would hypothesize a negative correlation between smoke estimates/AQI and park attendance. Given many park visitors likely originate in the Las Vegas area, they could easily avoid the hassle of driving to the park and have many alternate entertainment options available. The impact of smoke on local visitors (e.g., those who live in and around the park) is less clear and will be addressed in the “Limitations” section of this paper.

There has also been significant prior work to quantify smoke from wildland fires which I use in my smoke estimate calculations. My estimates leverage the USGS Wildland Fire Data (Welty and Jeffries, 2021), which includes fields such as type of fire, acres burned, distance to town, recency of other fires in the same area, and year of fire recording.

A basic smoke estimate includes the acres burned multiplied by . I assume that the acreage burned is proportion to the amount of smoke, and that smoke diffuses in air with an inverse-squared relationship similar to light. However, I also believe other factors such as type of burn, recency of burn, and data accuracy impact how much smoke is created.

Per David Frisbey's 2008 thesis "A comparison of smoke emissions from prescribed burns and wildfires", "The results suggest that the smoke impacts of a wildfire may not be any greater than a prescribed burn when compared using the methodology. This research demonstrates how a combination of the fuel load and the size of the burn may be more significant in controlling downwind concentration of PM10 than the atmospheric conditions. Even when there is a planned burn under prescribed meteorological conditions there can be significant impacts if the size of the burn and fuel loading are not also considered" (Frisbey, David, 2008). Examining “Forest Service Professionals Prepare for a Prescribed Burn” (Avitt, 2023), we can see that forestry services do take fuel moisture, forest stand characteristics, historical data, terrain, and elevation into account when creating a prescribed burn. Given David's findings, and assuming the Forest Service correctly accounts for the fuel variables to create less intense blazes, I multiply my basic smoke estimate for prescribed burns by 0.50.

I also assume that fires in areas burnt within the last 2 years should produce much less smoke than otherwise calculated. The idea of a differential burn is supported by “Burn out: Frequent fires are changing Western landscapes” (Pontecorvo, 2020). For the areas of a fire burned within the past 2 years, I multiply the basic smoke estimate by 0.20.

Finally, the USGS wildland fire metadata note that "Areas burned prior to 1984 in this dataset represent only a fraction of what actually burned. While areas burned on or after 1984 are much more accurate and complete, errors still can and do occur." Given the underestimation of acres burned, I multiply the smoke estimates for fires prior to 1984 by 1.5.

There are limitations with this smoke estimate, including no variable for fuel composition, weather, terrain, etc. which will be discussed in more detail in the “Limitations” section of this report.

AQI data is sourced directly from the EPA’s API, the code for which can be found in my “epa\_comparison” script (Ekrolen).

Death Valley attendance data is sourced from National Park annual attendance records. While the land was officially declared a National Park October 31st, 1994, the National Parks Service has kept attendance records for the site since 1933. The data consists of year of park visitation and annual total number of recreation visits. Per the National Park Service’s Visitor Use Statistics Page, a “Recreation Visit” is “The entry of a person onto lands or waters administered by the NPS except as defined above for non-reportable and non-recreation visits [e.g., entry into the park by NPS employees or contractors, commuter or through traffic, guides, government personnel with business in the park]. Funeral parties at National Cemeteries, school groups, etc. are reportable as ‘recreation’ use since their use is for the purpose for which the park was established. Visits originating on surface vehicles (trains, boats, other) and aircraft may be counted if they stop and disembark passengers on NPS administrated territory. The applicable rule is that one entrance per individual per day is countable” (U.S. Department of the Interior, 2023). Per the National Parks Service Disclaimer page, “Copyright law does not protect “any work of the U.S. Government” where “a work prepared by an officer or employee of the U.S. Government as part of that person's official duties” (See, 17 U.S.C. §§ 101, 105). Thus, material created by the NPS and presented on this website, unless otherwise indicated, is generally considered in the public domain. It may be distributed or copied as permitted by applicable law” (U.S. Department of the Interior, 2020).

**Methodology:**

To map the correlations between smoke, AQI, and Death Valley attendance I will use a linear regression model with both the independent variable (smoke or AQI estimate) and dependent variable (Death Valley attendance) normalized. I will normalize both measurements to ensure they are on the same scale for visual analysis. I have chosen linear regression not only for its simplicity, but also for its Pearsons correlation coefficient which describes how much variability in the dependent variable is attributable to the independent variable. Additionally, I calculate a p-value for the coefficient which indicates its statistical significance.

I believe there are limited ethical concerns in using this data and modeling it in the above manner. It is possible that park attendance estimates do not accurately reflect all visitors and may leave out portions of the population (e.g., those who carpool may be more challenging to count) and fire data may be more accurate for areas with more resources (e.g., areas who could afford to send fire scouts, areas near fires, or areas with land/resources/items “worth monitoring”).

There are certainly ethical implications in how conclusions are interpreted. First, linear regression assumes 5 conditions (linearity, homoscedastic, normal distribution of errors, no/limited covariates, and no autocorrelation) to be a valid modeling technique. If these conditions are not met, I cannot assume the conclusions of correlation are valid. Additionally, it would be wrong to conflate correlation with causation. Even if I should find a strong correlation between smoke and park attendance, I could not say conclusively that smoke is what deterred visitors. Finally, I cannot state in totality how much of Pahrump’s economy would be harmed by smoke because of the correlation issue described above, and because Death Valley-related business is likely only a fraction of total town income.

**Findings:**

1. Findings

What did you find? Use words and figures, don’t just point to code.

1. Discussion/Implications

Why are your findings important or interesting; What should the city council, city manager/mayor, and city residents do to address your findings? How long do they have to make a concrete plan?

This section should include a thoughtful reflection that describes the specific ways that human centered data science principles informed your decision-making in this project.

1. Limitations

This is a required section for your report. There are often many, many limitations for any study. If you honestly tried to list them all, this might end up being the longest section. You should prioritize and list the ones that are most likely to have a significant impact on your results. Specific license issues could be a limitation, depending on what data sources you used. Flaws in the data, data cleaning techniques, potential assumptions and/or how you handled missing values could be a limitation. Statistical techniques often have specific assumptions and preconditions; if you’re not certain all of the data meets those requirements - this is a good place to make that clear.

Should have just done attendance during fire season, but couldn’t split by month

Composition of fuel certainly impacts the amount of smoke generated per acre burned. Given we are not currently bringing in additional vegetation information, we will assume a linear relationship between acres burned and smoke produced.

Many factors impact smoke dispersion (direction of terrain, wind, other atmospheric conditions), but we will focus on distance to town as our primary variable. We will assume that smoke disperses like light (1/distance^2 relationship), see Nasa.gov for more details.

The impact of smoke on local visitors (e.g., those who live in and around the park) is less clear and will be addressed in the “Limitations” section of this paper.

1. Conclusion

Restate your research questions/hypotheses and summarize your findings. Explain to the reader how this study informs their understanding of human centered data science.

**References:**

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U.S. Department of the Interior. (2020, March 2). *Disclaimer (U.S. National Park Service)*. National Parks Service. https://www.nps.gov/aboutus/disclaimer.htm

U.S. Department of the Interior. (2023, March 24). *NPS visitor use statistics definitions*. National Parks Service. https://www.nps.gov/subjects/socialscience/nps-visitor-use-statistics-definitions.htm

Welty, J.L., and Jeffries, M.I.. (2021), *Combined wildland fire datasets for the United States and certain territories, 1800s-Present: U.S. Geological Survey data release*, https://doi.org/10.5066/P9ZXGFY3.

Wikimedia Foundation. (2023, November 10). *Pahrump, Nevada*. Wikipedia. https://en.wikipedia.org/wiki/Pahrump%2C\_Nevada#Economy

**Data Sources:**

AQS API URL root: https://aqs.epa.gov/data/api

U.S. Department of the Interior. (n.d.). *Stats report viewer*. Annual Park Recreation Visitation (1904 - Last Calendar Year). https://irma.nps.gov/Stats/SSRSReports/Park%20Specific%20Reports/Annual%20Park%20Recreation%20Visitation%20(1904%20-%20Last%20Calendar%20Year)?Park=DEVA

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