Project Report

on

Wildfires Unveiled: Exploring the Impact on Air Quality and Water Resilience in Redding, California

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By

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Introduction

In Redding, California, where the natural splendor intertwines with the looming threat of wildfires, the community grapples with environmental resilience and escalating challenges. The recent surge in wildfires, though seemingly distant, casts a tangible shadow over the city, raising critical questions about its environmental repercussions, particularly on water quality.

As wildfires intensify across the North State, Redding and Shasta County face a unique convergence of challenges. The air, tainted by the scent of burning forests, bears the burden of particulate matter, altering the skies. Recent events, such as the Head Fire swelling to 4,000 acres and the Deep Fire expanding to 2,000 acres, underscore the gravity of the situation. The U.S. Forest Service reports unhealthy air quality in Shasta County, a consequence of numerous fires across the region.

Our exploration delves into the less-explored repercussions of wildfires on water quality, seeking to unravel the intricate relationship between wildfires, air quality, and Redding's lifeblood—its water supplies. The urgency of this study is underscored by recent events, with at least 30 fires ignited by dry thunderstorms, the Deep Fire affecting Trinity Lake, and a concerning shift in air quality from clear to moderate pollution levels.

This study's importance lies in its direct pertinence to the vitality and resilience of the Redding community. Understanding the potential future impacts of wildfires on water quality becomes crucial, even as the average distance of fires moves away. This exploration is motivated by the urgent necessity to comprehend the multi-faceted consequences of wildfires, particularly concerning water quality.

Wildfires, often viewed as airborne adversaries impacting air quality, transcend the atmospheric realm to influence Redding's water supplies. This analysis ventures into the predominantly unexplored territory of deciphering the aftermath of wildfires on water quality, rendering it both pertinent and groundbreaking.

The city confronts heightened risks due to its proximity to national forests, emphasizing the critical importance of preparedness for the aftermath of wildfires. The potential release of pollutants into water sources carries direct implications for public health, agriculture, and the ecosystem. Addressing this question transcends scientific exploration; it embodies a civic responsibility to safeguard the community's well-being.

This analysis surpasses conventional perceptions of wildfires and seeks to probe their subterranean implications. By investigating how the aftermath of fires resonates through water sources, influencing the quality of this essential resource, the study endeavors to enrich the discourse, indispensable for effective mitigation strategies and understanding resilience amid nature's challenges.

In summary, this analysis is not a mere academic pursuit; it is a response to a tangible problem faced by the community. It addresses unresolved research questions about the impact of wildfires on water quality, directly influencing the health, well-being, and resilience of Redding, California residents.

Background/Related Work

In the realm of wildfires and their impact on water quality, existing research provides valuable insights into related aspects. A notable contribution in this area is the 2019 US EPA's Wildland Fire Research: Water Supply and Ecosystem Protection report [1]. This comprehensive study delves into the intricate relationship between wildfires and water resources, emphasizing the need for a holistic understanding of the environmental consequences.

The report acknowledges the immediate effects of wildfires on air quality, recognizing the release of pollutants into the atmosphere. However, it also underscores the less-explored domain of sustained impacts on water quality. By investigating the potential release of contaminants into water bodies during and after wildfires, the report sheds light on the complex interplay between wildfires and aquatic ecosystems.

Additionally, insights from the article "Wildland Fires Could Be Putting Your Drinking Water at Risk" [2] provide a real-world perspective on the challenges posed by wildfires to drinking water safety. Decades of fire suppression and a changing climate have intensified wildfires, jeopardizing the supply of safe drinking water. The article emphasizes the need for proactive measures to address the evolving risks to public health and engineering systems.

The hypotheses, analysis, and system design of this study are deeply influenced by insights derived from existing research, particularly the US EPA's Wildland Fire Research report and the information presented in the article Wildland Fires Could Be Putting Your Drinking Water at Risk.

The US EPA's research serves as a foundational reference, guiding the formulation of hypotheses that aim to explore the impact of wildfires on water quality parameters such as specific conductance, pH levels, water temperature and turbidity. By acknowledging the immediate effects of wildfires on air quality and recognizing the release of smoke into the atmosphere, the study extends this understanding to the less-explored domain of sustained impacts on water quality.

The article, highlighting the risks posed to drinking water sources by wildfires, contributes valuable real-world examples and case studies [2]. The information about increased contamination, compromised distribution systems, and stressed water facilities informs the analysis framework, guiding the selection of relevant water quality parameters and emphasizing the importance of considering the resilience of water infrastructure.

Moreover, the article specifically addresses how wildfires can affect water temperature, pH levels, and turbidity [2]. This critical information plays a pivotal role in informing the analysis approach, directing attention to specific water quality parameters that are deemed vulnerable to the aftermath of wildfires. The insights derived from previous research also influence the system design, incorporating elements of predictive modeling, statistical analysis, and exploratory data visualization to address the specific context of Redding, California.

Hypotheses and Research Questions

Building upon insights from existing research, the analysis formulates specific hypotheses and research questions to address critical gaps and contribute to the evolving understanding of wildfires and water quality:

Hypothesis 1 : Examination of the Correlation Between Smoke Exposure and Changes in Water Quality Parameters

Building on the analysis of smoke estimates and water quality parameters, we hypothesize that the degree of smoke exposure, as estimated through burn area and distance from Redding, correlates with significant changes in water quality parameters. Specifically, we anticipate observing variations in water temperature, pH levels, specific conductance, and turbidity in relation to the intensity and proximity of wildfires.

Research Question 2: To what extent does smoke exposure, quantified by burn area and distance from Redding, correlate with changes in water quality parameters, including temperature, pH, specific conductance, and turbidity?

These specific hypotheses and research questions allow for a focused exploration of the impact of changing wildfire trends and smoke exposure on water quality parameters in the Redding, California region.

Hypothesis 2 : Changing Trends in Wildfire Frequency Near Redding

We hypothesize that the frequency or intensity of wildfires near Redding has increased over time, posing a growing threat to the region's environment and water quality.

Research Question 1: How has the frequency or intensity of wildfires near Redding changed over time, and what implications does this trend have on the region's environment and water quality?

Model Considerations and Dataset Selection

During the development of Course Project - Part 2, consideration was given to existing models that could be adapted or adopted to analyze the extended dataset. The most relevant models in the context of wildfires' impact on water quality are briefly covered below:

Extension Plan : Existing Models

1. The analysis builds upon the smoke impact model developed in Course Project - Part 1. This model served as the foundation for predicting smoke impacts based on various parameters. For Course Project - Part 2, the model was adapted to incorporate water quality parameters from the selected dataset. This adaptation aimed to create a more comprehensive model that considers the interplay between wildfires and water quality, offering a holistic understanding of the environmental consequences.

2. During the development of Course Project - Part 2, various models were considered for analyzing the extended dataset, with one notable model being the Soil and Water Assessment Tool (SWAT). The SWAT model is widely recognized for its ability to simulate the impact of land management practices, climate change, and disturbances such as wildfires on water quality. It considers complex interactions between land use, soil

properties, and hydrological processes, making it a comprehensive tool for understanding the transport of pollutants in river systems affected by wildfires [5].

3. While the SWAT model and other hydrological models offer sophisticated approaches to study the intricate dynamics between wildfires and water quality, the implementation of such models requires considerable time and a reliable dataset with detailed information on land use, soil properties, and hydrological characteristics. Unfortunately, due to constraints on both time and the availability of comprehensive datasets, a decision was made to adopt a correlation analysis approach. Correlation analysis, while less complex than hydrological models, provides valuable insights into the relationships between variables and served as a pragmatic choice given the limitations of the study. This approach allowed for a focused exploration of the existing data to identify potential correlations between wildfire-related factors and water quality parameters, contributing to the overall understanding of the research question.

Extension Plan : Dataset

The primary dataset utilized to expand upon the findings of Course Project - Part 1 is the "Water Quality Data" sourced from the California Open Data Portal [3]. This dataset encompasses a diverse range of parameters associated with water quality, rendering it an invaluable resource for delving into the potential repercussions of wildfires on Redding's water sources.

Rationale

The decision to opt for the "Water Quality Data" from the California Open Data Portal was underpinned by several key considerations:

1. **Comprehensive Water Quality Parameters:**
    - The dataset furnishes a comprehensive array of water quality parameters measured over time, including specific conductance, pH levels, and concentrations

of various substances. This richness in parameters offers a robust foundation for analyzing the potential impacts of wildfires on water quality in a nuanced manner.

2. **Relevance to Wildfire Impact:**

    - The parameters encompassed within the dataset hold high relevance to comprehending the impact of wildfires on water quality. The analysis, by closely examining these parameters in the context of wildfire occurrences, aspires to uncover discernible patterns and correlations that illuminate the enduring effects of wildfires on water quality.

    - The decision to focus on Shasta County within the broader California dataset is strategic. Shasta County's inclusion simplifies segregation, given that the dataset contains county information. This strategic focus acknowledges that not all rivers from across California may flow into Redding, and even if they do, the effects should be accurately captured by analyzing the water within the Redding region.

3. **Availability and Open Access:**

    - Sourced from the California Open Data Portal, the dataset aligns with the principles of open data. This not only ensures ease of accessibility but also upholds transparency and allows for the unrestricted use, modification, and sharing of the data. This commitment to open data principles contributes to the overall robustness and reliability of the analysis.

Methodology

- **Wildfire Data Extraction:**
    - **Overview:** Extracted wildfire data from the USGS Wildland Fire Dataset, including information about fire locations and attributes.
    - **Steps:**
        - Calculated distances of each fire from Redding, considering the largest ring.
        - Filtered data based on criteria such as distance (<1250 miles) and year (>1963).
        - Transformed and stored relevant attributes for further analysis.
    - **Reference:** Utilized code and methodologies inspired by David McDonald's work on extraction and geojson calculation.
    - **Finding:** Generated a processed subset of wildfire data for visualization and analysis.
    - **Why Chose This Methodology:**
        - **Objective:** The primary objective was to obtain a comprehensive dataset of wildfires in the United States, focusing on their attributes and geographical locations.
        - **Distance Calculation:** Calculating distances from Redding allowed for a spatial perspective, considering potential impacts on the local environment.
        - **Filter Criteria:** The filtering criteria, including distance and year, were chosen to ensure relevance and recency of data for the specific study area.
        - **Ethical Consideration:** By excluding data older than 1963, the study aimed to focus on more recent and potentially more accurate information, aligning with the ethical principle of using relevant data.

- **Human-Centered Considerations:**
  - Objective Alignment: The chosen methodology aligns with the broader goal of understanding the impact of wildfires on human environments, ensuring relevance to communities in and around Redding.
  - Ethical Handling: Excluding data older than 1963 reflects a commitment to using more recent and likely more accurate information, prioritizing ethical considerations related to data integrity and relevance.

- **Air Quality Index (AQI) Data Extraction:**
  - **Overview:** Extracted and processed AQI data from the AQS EPA website to understand the air quality trends near Redding.
  - **Steps:**
    - Retrieved daily data from 1963 to 2020 and converted it into yearly AQI.
    - Considered the worst 10 days per year for each pollutant to estimate yearly AQI. The intuition behind this is that usually for any day we take the maximum of all the pollutants according to the standard. We are then taking the worst 10 so that we can have a better estimation concerning our smoke impact since the smoke impact will just have the fire and distance parameters and make the estimate extreme. This might not match up if we just look at the rest of the year (when AQI is less). Thus to get an accurate estimation of the fire smoke estimation's effect on air quality we are taking the worst 10 days.
  - **Reference:** Incorporated code and logic from David McDonald's work and collaborated with Aaditya for data processing.
  - **Finding:** Produced a processed AQI dataset using pollutant and sensor data, focusing on the worst days for accurate estimation.
  - **Why Chose This Methodology:**

- **Data Source:** Utilizing the AQS EPA website ensured access to authoritative and standardized air quality data.
- **Temporal Consideration:** Converting daily data into yearly AQI allowed for a more aggregated and comprehensive analysis, capturing long-term trends.
- **Worst 10 Days Approach:** Focusing on the worst 10 days per year for each pollutant enhanced the study's accuracy, accounting for extreme scenarios typical of wildfire events.
- **Ethical Consideration:** The methodology adheres to ethical standards by considering worst-case scenarios, providing a more conservative estimate of air quality impacts.

- **Human-Centered Considerations:**

  Public Health Awareness: By focusing on extreme pollution events, the methodology contributes to raising public awareness about potential health impacts during wildfire events.

  Temporal Relevance: Converting daily data into yearly AQI ensures that the study captures trends relevant to the health and well-being of local residents over time.

- **Estimating Air Quality and Time Series Analysis:**
  - **Overview:** Leveraged data from previous notebooks to estimate fire smoke impacts, conducted time series analysis, and compared predictions with standard AQI data.
  - **Steps:**
    - Loaded JSON data generated from wildfire and AQI extraction notebooks.

- Estimated smoke impact for each fire, considering factors like distance and hectares burnt. We are taking the max distance i.e. 1250 miles for each fire to convert into a range of 0-1, where o being the farthest from Redding and 1 being the closest. We are using this distance to penalize the overall score. Another factor that might affect the fire is the Hectares burnt. For hectares burnt, we can see from the descriptive statistics that there is a huge difference between the mean and 50% of the distribution. To accommodate for these extreme ended values, we are using the value at 75% distribution which is 504.

  Smoke Estimate = (1 - Fire Instance's Distance From Redding/ 1250) * (504 - Acres Of Land Burnt / 504)

- Plotted graphs depicting wildfires by distance, area burned over time, and compared standard AQI with fire smoke estimates.

- **Finding:** Provided insights into estimated smoke trends, predicted future air quality, and evaluated model performance.
- **Why Chose This Methodology:**
  - **Integration of Data:** Leveraging data from previous notebooks ensures a holistic analysis, considering both wildfire impacts and AQI trends.
  - **Estimation Approach:** The smoke impact estimation, considering factors like distance and hectares burnt, aligns with the study's objective of understanding the potential consequences of wildfires on air quality.
  - **Graphical Representation:** Visualizing wildfires by distance and comparing standard AQI with fire smoke estimates facilitates clear communication of findings.

        - **Ethical Consideration:** Transparent representation of data and comparisons contributes to ethical reporting and dissemination of research outcomes.
    - **Human-Centered Considerations:**
        - Decision Support: The integration of data and transparent visualization techniques serves as a decision support tool, assisting local authorities and communities in planning for potential air quality challenges during wildfire seasons.
        - Communicative Visuals: Graphical representations cater to a broader audience, including policymakers and the general public, fostering understanding and informed decision-making.
- **Water Quality Analysis**
    - **Overview:** Utilizing the smoke estimate dataset and the wildfires dataset from the first step, this analysis aims to address the hypothesis regarding the correlation between wildfires and water quality in Redding, California.
    - **Steps:**
        - Downloaded the required water quality dataset from data.cnra.ca.gov to initiate the analysis.
        - Computed the smoke estimate for each fire as outlined in the third step of the methodology.
        - Generated maps illustrating the geographical distribution of wildfires and field results of water analysis to provide a visual overview.
        - Processed the water data, retaining essential information including sample_date, parameter, and fdr_result values.

- Plotted the distance of fires from Redding across years and introduced a trend line to reveal any discernible patterns.
- Constructed dual-axis plots for key water quality parameters (Water Temperature, pH, Turbidity, and Specific Conductance) against the calculated Smoke Estimate.

- **Findings:**
  - Produced graphical representations showcasing correlation and trend lines to interpret the results.
  - Concluded the hypothesis regarding the potential impact of wildfires on water quality by analyzing trends in both wildfires and water parameters.
- **Importance:** This step contributes to a holistic understanding of the interplay between wildfires, smoke estimates, and water quality. By visualizing trends and correlations, the analysis sheds light on potential connections between these factors in the Redding region.
- **Why Chose This Methodology:**
  - **Integration of Datasets:** Integrating smoke estimate and wildfire datasets allows for a comprehensive examination of potential correlations between wildfires and water quality.
  - **Geospatial Analysis:** Generating maps aids in visually understanding the geographical distribution of wildfires and water quality data.
  - **Parameter Analysis:** Analyzing key water quality parameters against smoke estimates provides a detailed exploration of potential relationships.
  - **Ethical Consideration:** The analysis contributes ethically by addressing the hypothesis transparently and interpreting results in a manner that respects the potential impact on water quality.

- **Human-Centered Considerations:**
  - Community Impact: Addressing the hypothesis about correlations between wildfires and water quality directly relates to the well-being of local communities, emphasizing the human impact.
  - Transparency: Clear graphical representations and findings ensure that the results are accessible to a wider audience, promoting transparency and understanding among community members.

Findings

1. Wildfire and Smoke Impact

- ### Histogram of Wildfire Occurrences by Distance

    - The histogram below visually presents the distribution of wildfires in relation to their distance from Redding, California. Binned into 50-mile increments, the chart's x-axis denotes the distance, while the y-axis illustrates the frequency of wildfires. With data spanning from 1963 to 2020, the chart highlights the variability in wildfire frequency at different distances from Redding. Some distances exhibit higher frequencies, suggesting potential hotspot regions. This visualization serves as a comprehensive overview of the spatial distribution of wildfires around Redding.

    - The analysis delved into the historical occurrence of wildfires within a 1,250-mile radius of Redding since 1963. Nearly 40,000 fires were recorded, with a significant concentration of almost 19,000 wildfires in California alone. A visual representation highlighted the geographic spread and frequency of wildfires in the region.

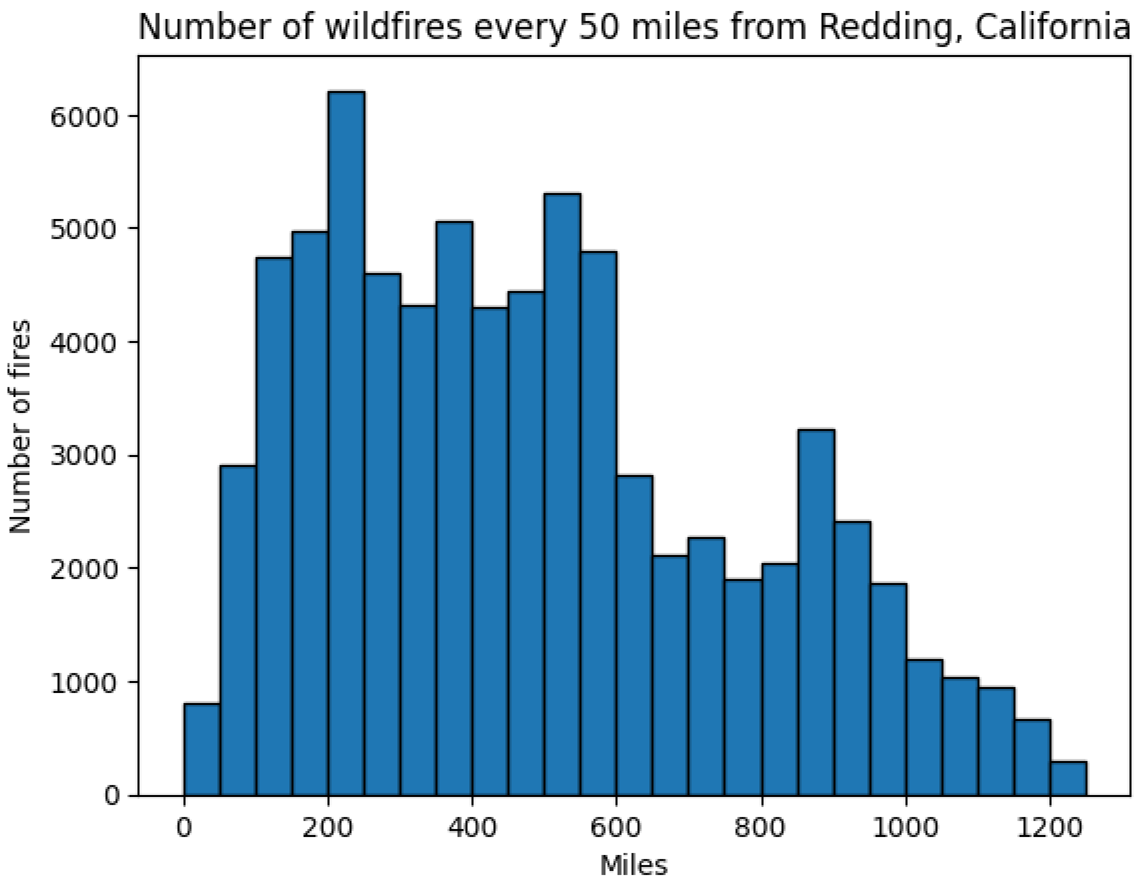

Figure 1: A graph of the number of wildfires every 50 miles from Redding, California.

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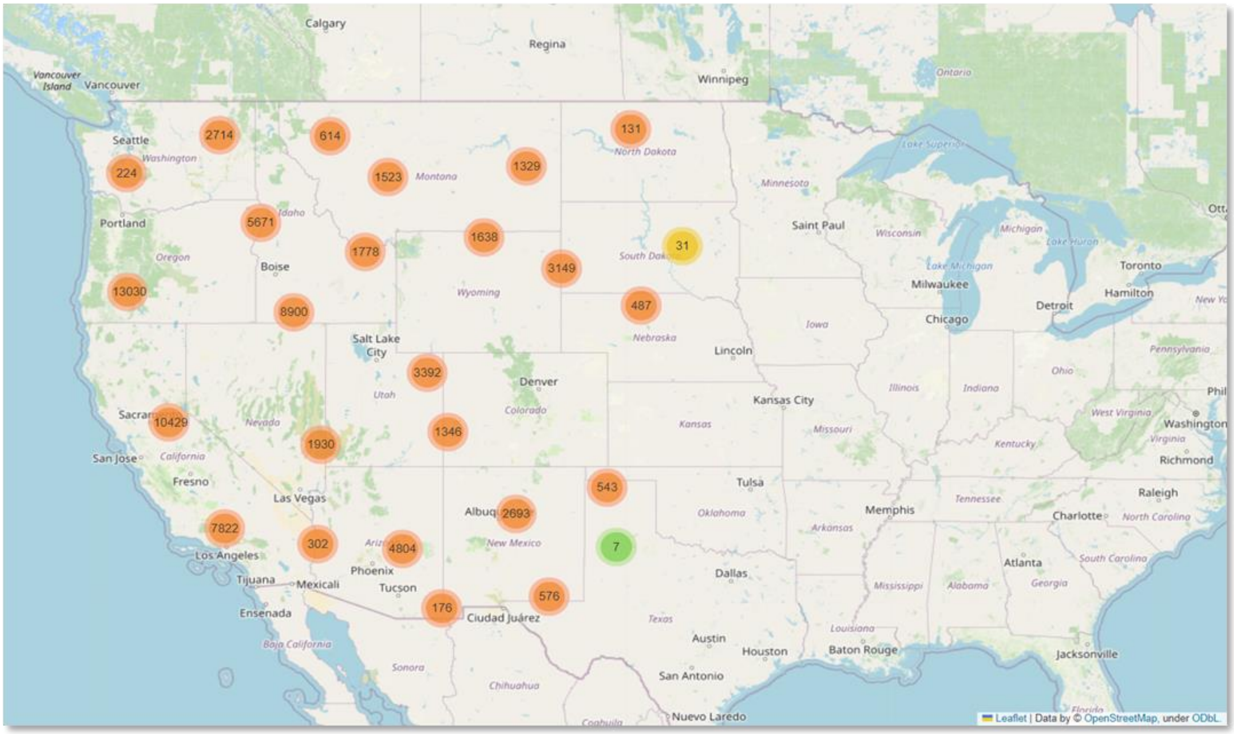

Figure 2: Location of wildfire near Redding (within 1250 miles)

- ## Time Series of Total Acres Burned Per Year

    - The time series graph below displays the total acres burned by wildfires annually in the vicinity of Redding from approximately 1963 to 2020. The x-axis represents time, while the y-axis denotes the area burned in millions of acres. Each point on the line graph corresponds to the total burned area in a specific year. Peaks and troughs in the graph indicate years with varying degrees of wildfire activity, allowing for the identification of trends or patterns. The visualization captures the fluctuating nature of wildfires over time, emphasizing notable years with substantial areas affected by fire.

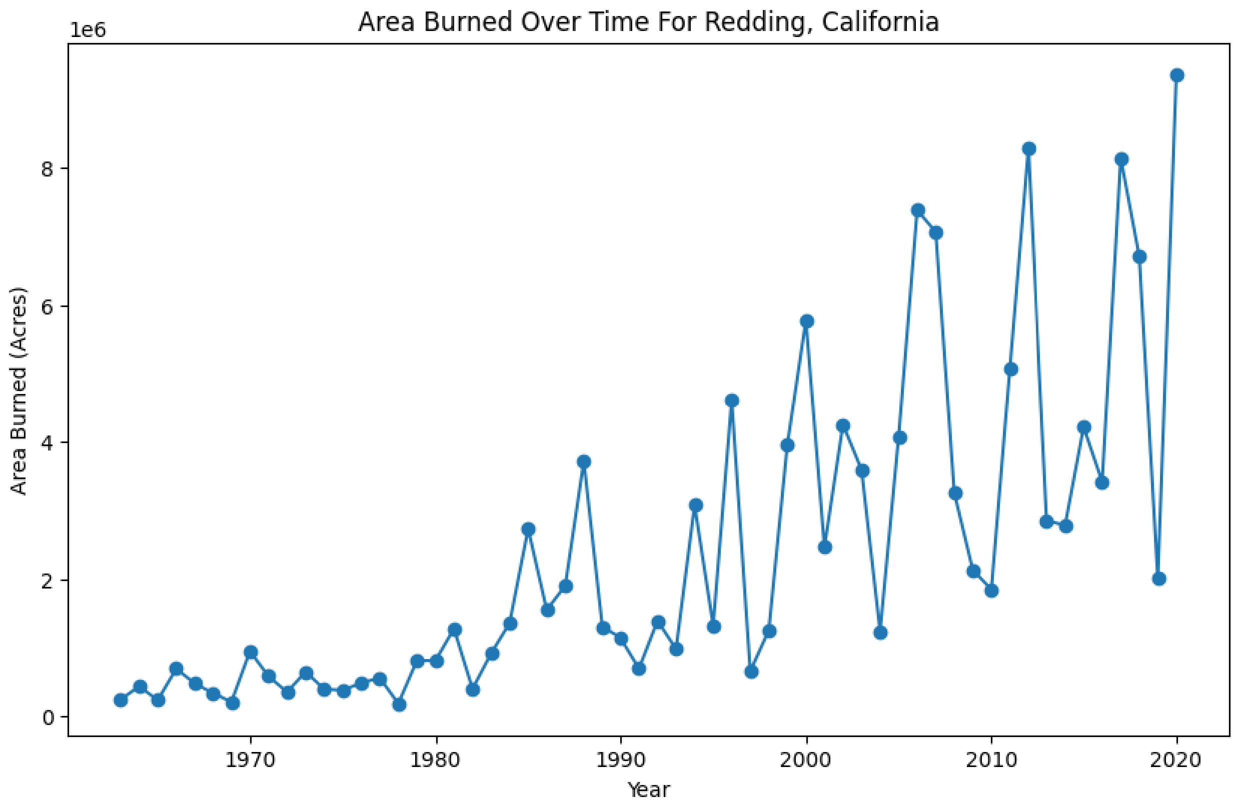

Figure 3 : Area burned over time for Redding, California

- ## Time Series of Estimated Smoke and Standard AQI

  - This graph juxtaposes the estimated smoke presence and the standard Air Quality Index (AQI) in Redding, California, spanning the years 1963 to 2023. The blue line represents "Estimated Smoke," while the orange line depicts "Standard AQI." Peaks and valleys in both lines signify periods of elevated smoke and AQI levels, respectively. Standard AQI data is derived from the AQS EPA API, incorporating various pollutants. The estimated smoke data, sourced from the USGS Wildfire Dataset, considers factors like fire proximity and burnt hectares. The visualization provides insights into the correlation between AQI and estimated smoke, offering a nuanced understanding of how wildfires impact air quality in the region.

- The estimation of smoke produced by these wildfires considered two key factors: burn area and distance from Redding. The smoke estimate showed a moderate correlation of approximately 44% with the standard Air Quality Index (AQI). This correlation indicates a significant but not absolute connection between the extent of wildfires and air quality, suggesting that other factors may also influence the AQI.
- Notably, the analysis revealed a positive trend over the years, indicating slight improvements in air quality, as seen in figure 5. This positive sign could be attributed to various factors, such as improved firefighting strategies, increased awareness, or changes in weather patterns.

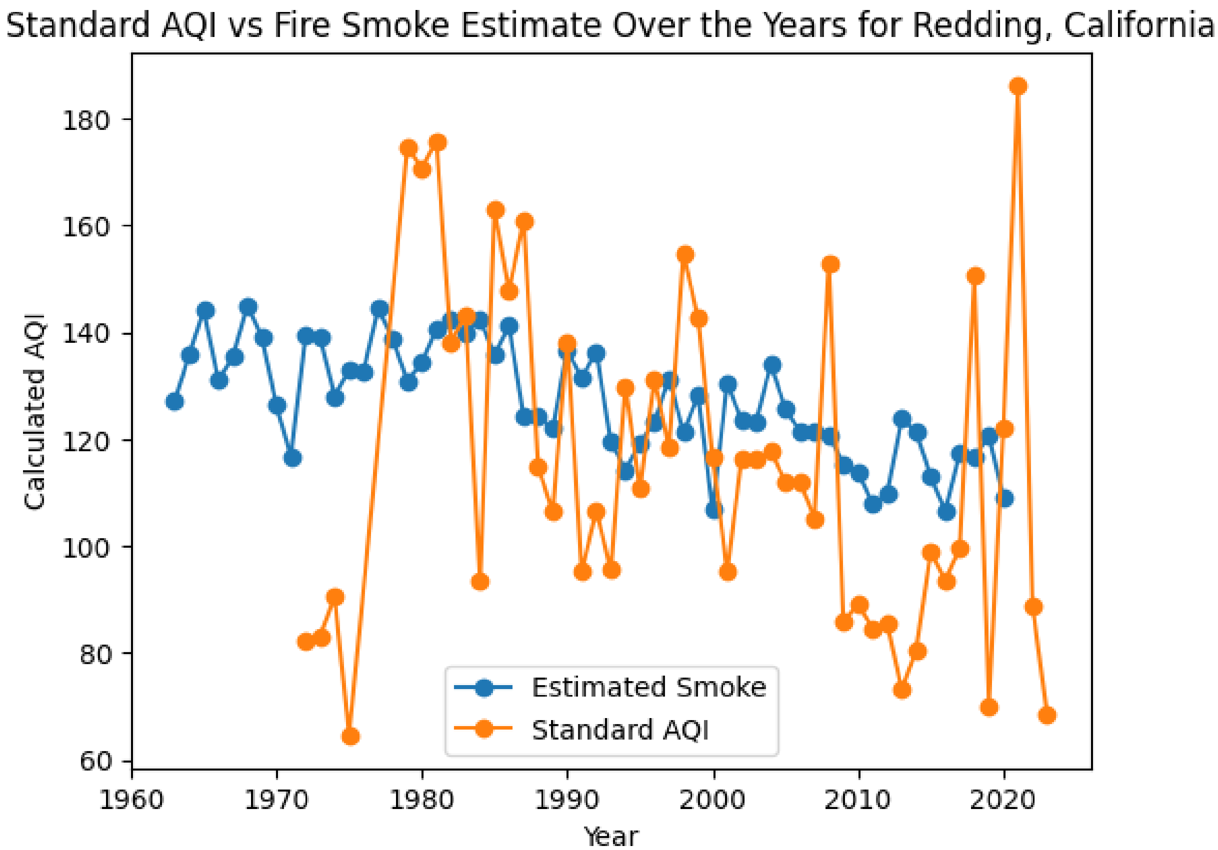

Figure 4 : Standard AQI vs Smoke Estimate

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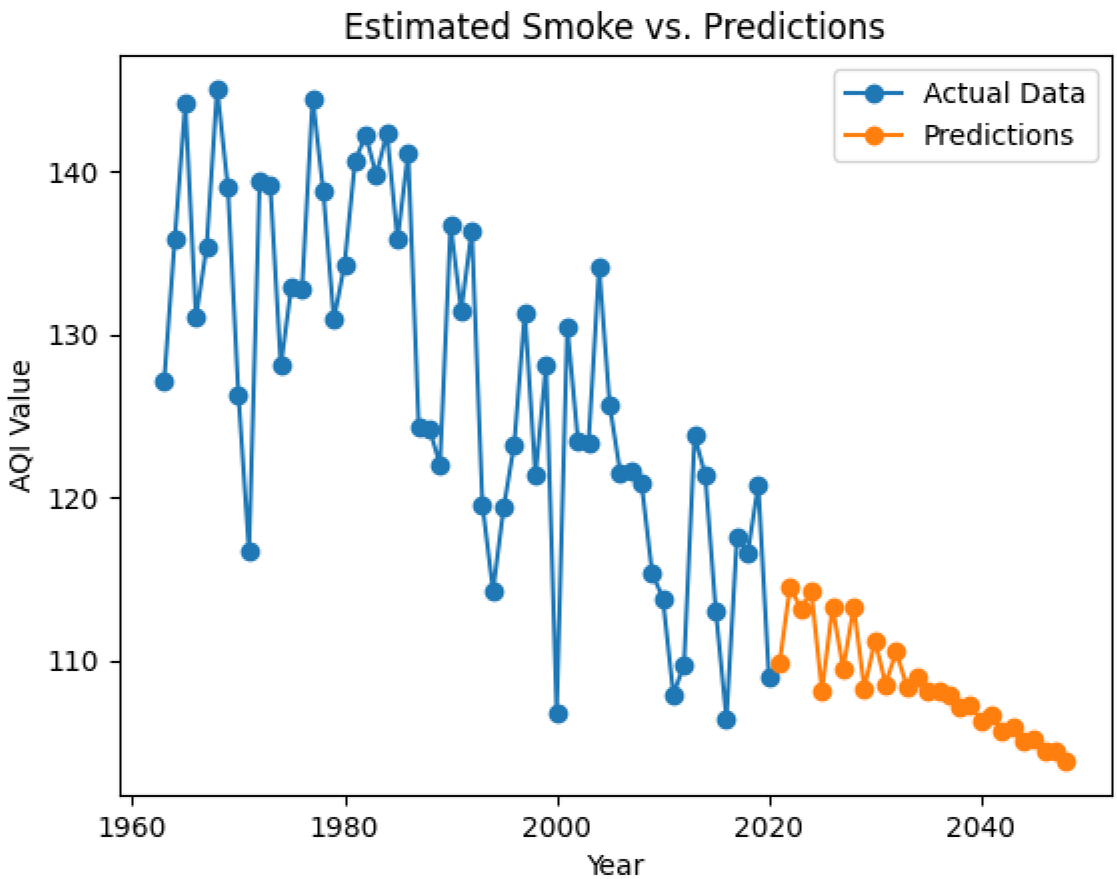

Figure 5 : Smoke Estimation using ARIMA

2. Hypothesis 1 : Examination of the Correlation Between Smoke Exposure and Changes in Water Quality Parameters

- Shasta, a prominent water source for Redding, was the focus of the water quality analysis. The decision to concentrate on Shasta was influenced by the exponential growth in the average distance of fires from Redding, increasing from 400 to 550 miles. Another reason is that water from far away might not even reach or be used in Redding. The analysis spanned almost nine decades, covering nearly 40,000 field results since 1936. Below map shows the point where the field results were conducted and the following parameters were collected.

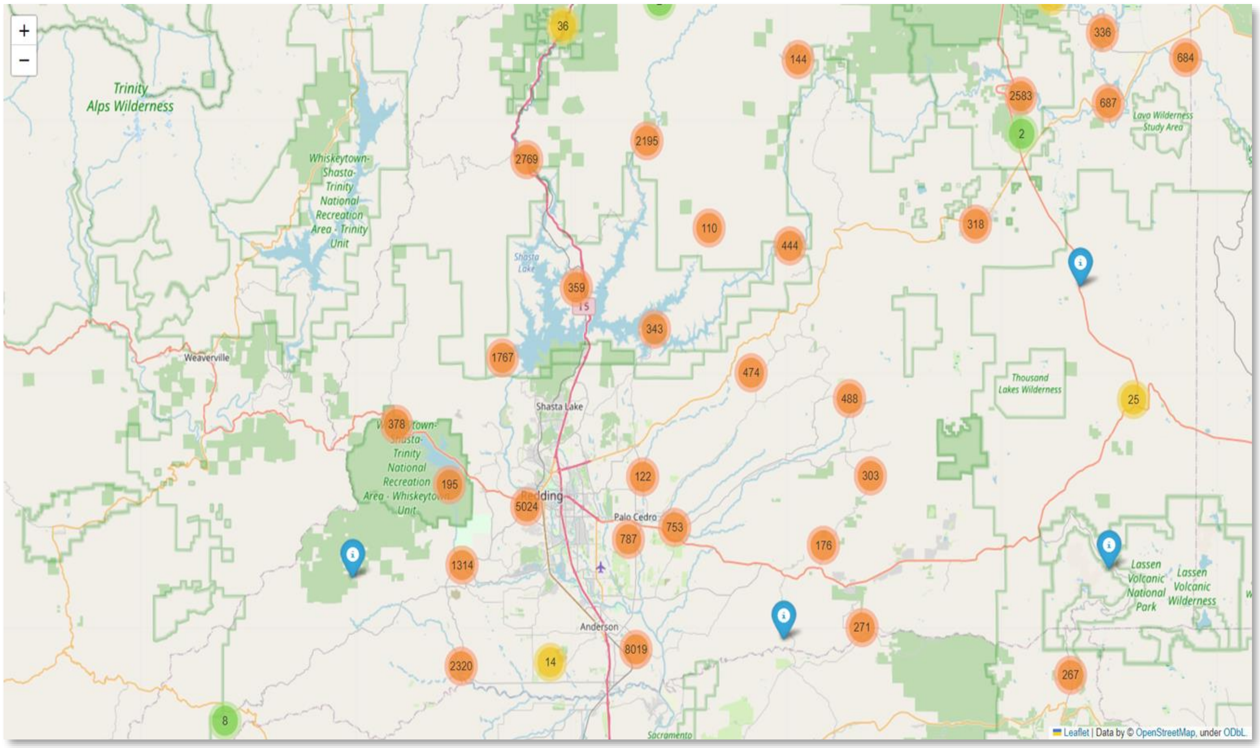

Figure 6 : Location of 40,000 Field Results in Shasta County from Water Quality Dataset

- Four crucial water quality parameters were scrutinized: Temperature, pH, Turbidity, and Specific Conductance. The objective was to understand the correlation between these parameters and the estimated smoke impact.

○ Temperature

The correlation between smoke estimate and water temperature suggests potential mechanisms by which wildfires influence this parameter. Wildfires release large amounts of heat energy, contributing to increased air temperatures in the surrounding areas. The elevated air temperatures, in turn, can influence water temperature through processes such as radiative heating and direct heat transfer. Additionally, the deposition of ash and particulate matter from wildfires can reduce the reflective properties of water surfaces, leading to greater absorption of sunlight and further elevating water temperatures. Therefore, the observed correlation underscores the complex interaction between wildfires, atmospheric conditions, and water temperature.

Figure 7 : Water Temperature vs Smoke Estimate

○ pH Levels

The negative correlation between smoke estimate and pH levels indicates a potential link between wildfires and changes in water acidity. Wildfires release various gases, including sulfur dioxide and nitrogen oxides, which can combine with atmospheric moisture to form acidic compounds. These compounds may be deposited into water bodies through rainfall or atmospheric deposition, leading to a decrease in pH levels. The acidity of water can also be influenced by the leaching of organic acids from burned vegetation. The observed correlation suggests that as the intensity and proximity of wildfires increase, the potential for acidification of water bodies also rises.

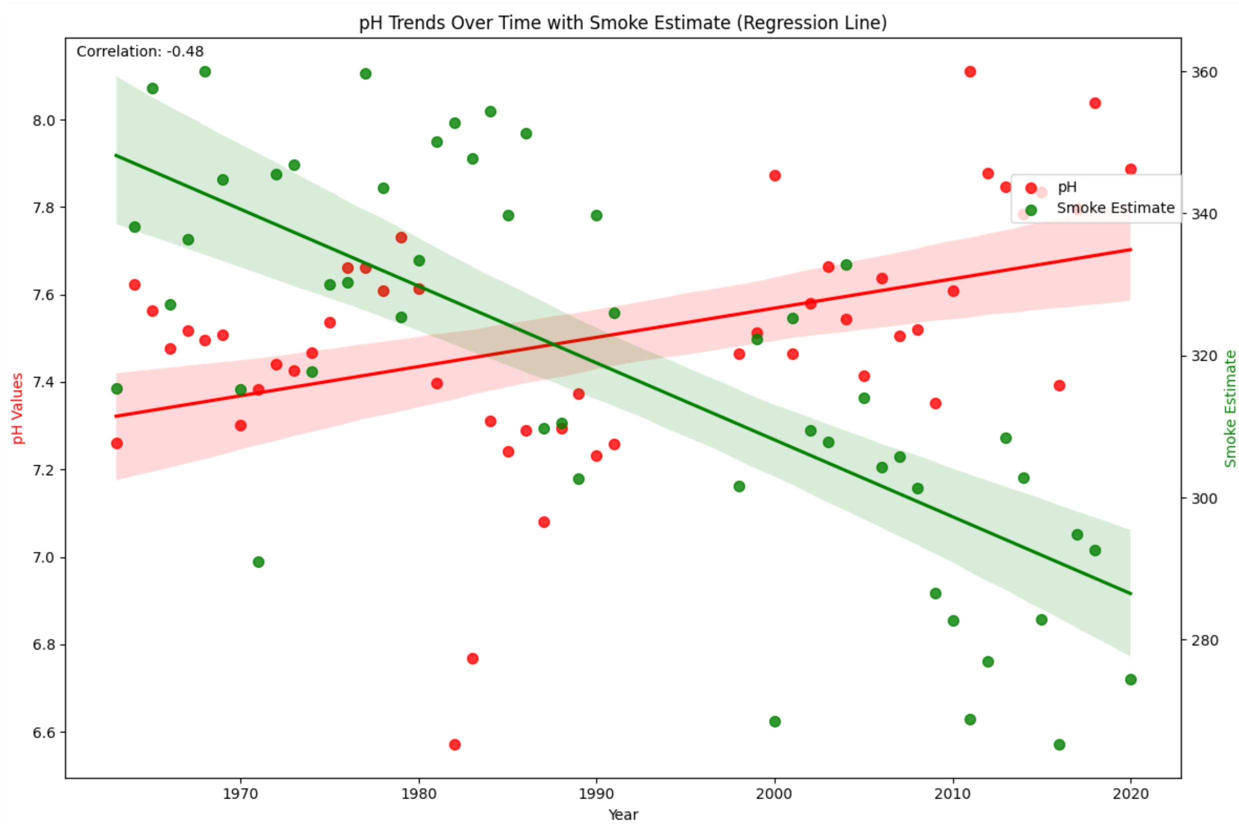

Figure 8 : pH vs Smoke Estimate

○ Specific Conductance

The moderate negative correlation with specific conductance implies potential alterations in water's electrical conductivity due to wildfires. Wildfires release ash and organic matter into the atmosphere, and when deposited into water bodies, these substances can impact the ion composition of the water. The presence of dissolved ions, such as salts and minerals, contributes to specific conductance. Increased smoke levels may lead to changes in the concentration and composition of these ions, resulting in a decrease in specific conductance. The correlation highlights the intricate connection between wildfire-induced deposition and changes in water chemistry.

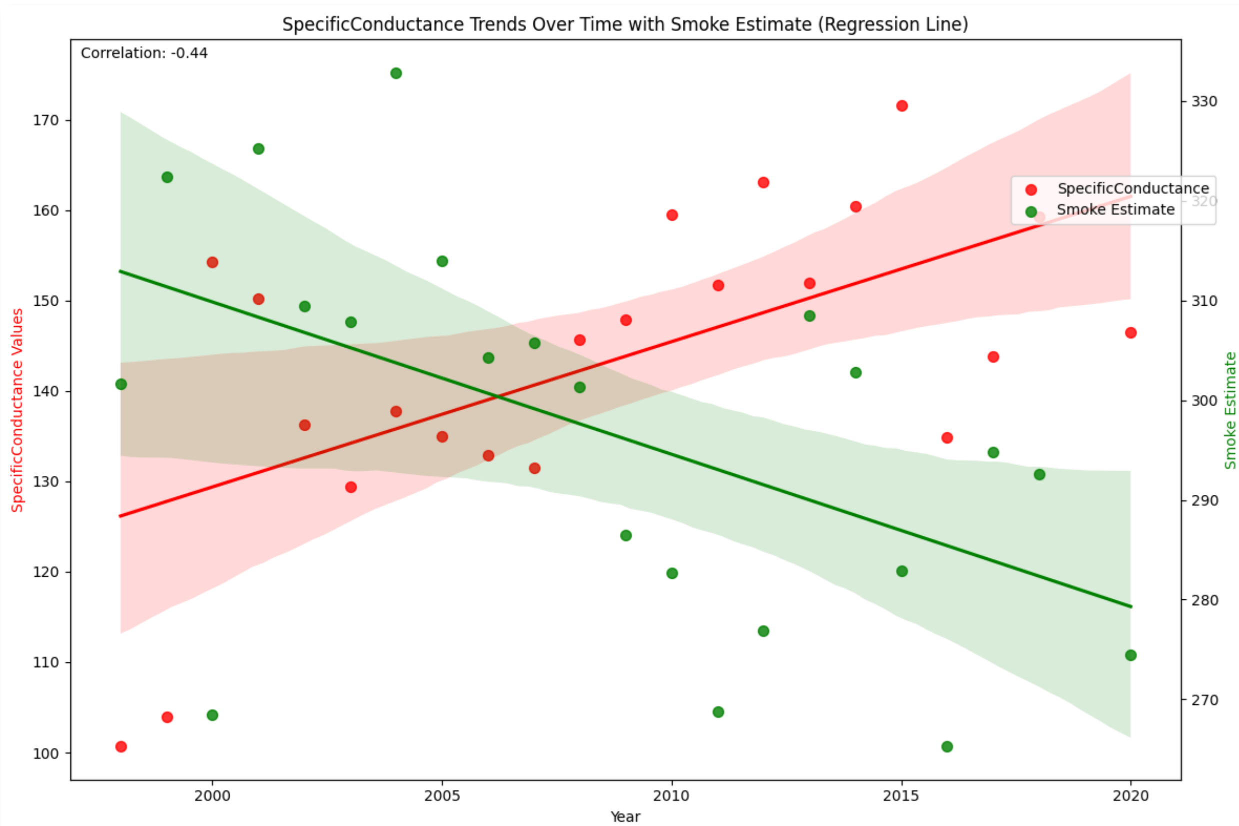

Figure 9 : Specific Conductance vs Smoke Estimate

○ Turbidity

The weak negative correlation between smoke estimate and turbidity suggests a relationship between increased smoke levels and reduced water clarity. Wildfires generate ash, soot, and particulate matter, which can be transported by winds and deposited into water bodies. The deposition of these particles may lead to increased turbidity by scattering light and reducing water transparency. Additionally, the combustion of vegetation during wildfires can release organic matter, contributing to suspended particles. Therefore, the observed correlation points to the potential influence of wildfire-induced deposition on water turbidity, emphasizing the need for monitoring and managing suspended solids in water.

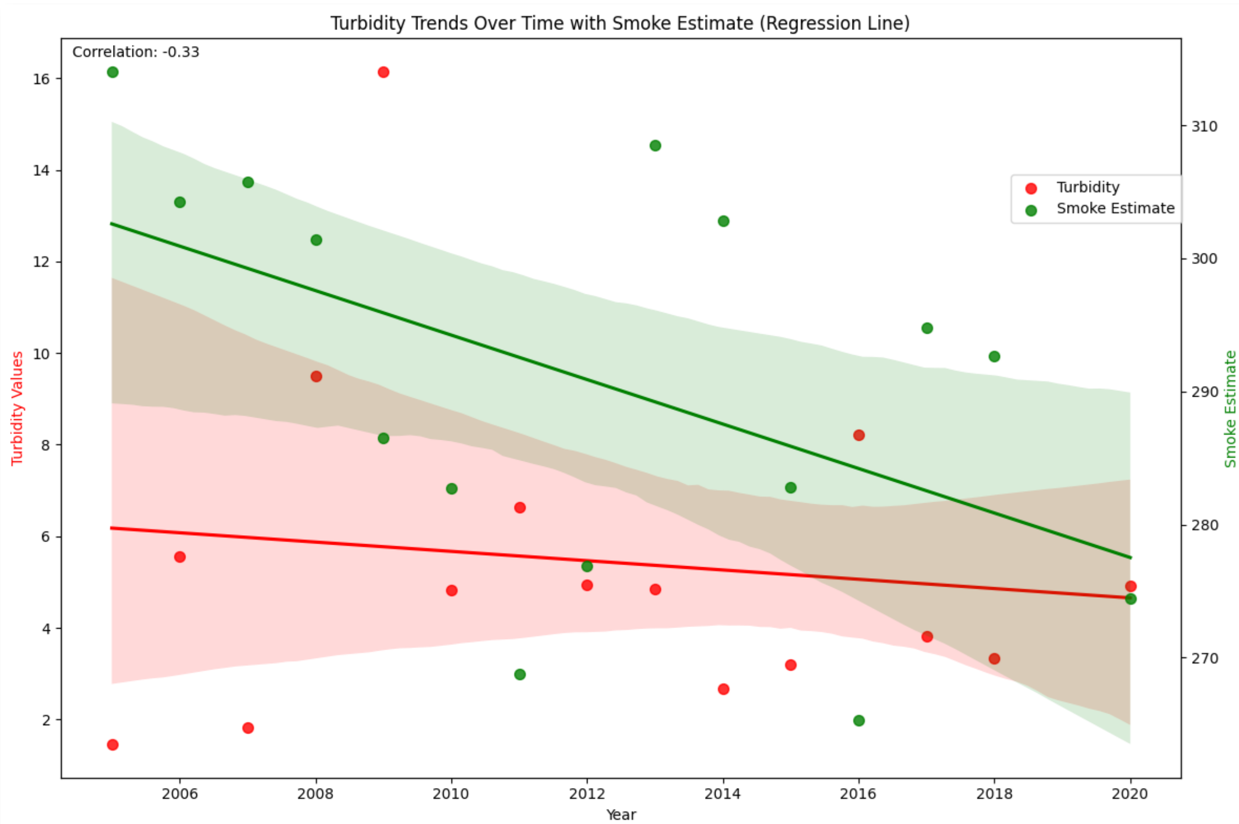

Figure 10 : Turbidity vs Smoke Estimate

3. Hypothesis 2 : Changing Trends in Wildfire Frequency Near Redding

- The graph depicting the historical trend of distance from Redding, California, reveals a continuous increase over the years, as evidenced by the ascending trend line. Notably, this upward trajectory has witnessed an acceleration in recent years. The findings distilled from the graph can be succinctly summarized: the distance from Redding has exhibited a consistent rise, and this upward trajectory is gaining momentum in recent periods. Projections based on the trend line suggest a continuation of this pattern into the future. Several contributing factors may underlie this trend, such as population growth in Redding and its environs, economic expansion attracting businesses to the region, and advancements in transportation infrastructure. The increasing distance bears potential implications, introducing challenges like heightened travel costs and traffic congestion, yet also offering opportunities, such as increased desirability and economic growth for Redding. Striking a balance between mitigating negative impacts and harnessing positive outcomes is crucial for prudent urban planning and community well-being.

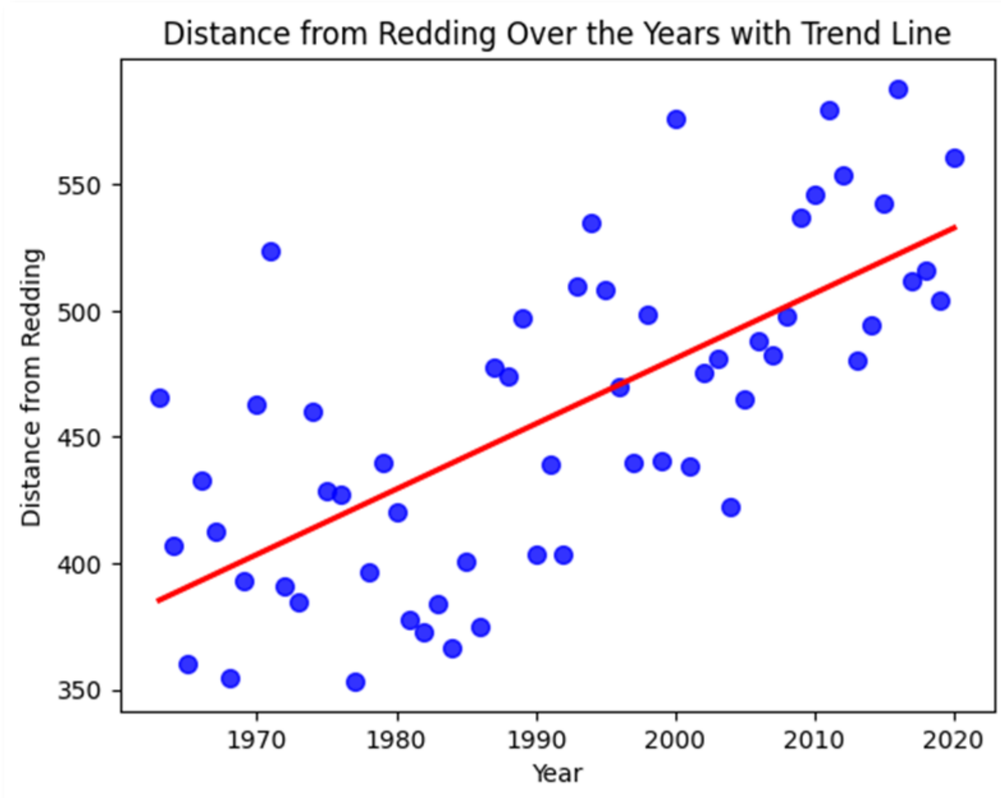

Figure 11 : Distance Trend for wildfires near Redding, California over the Years

Discussion/Implications

The findings of this analysis are crucial for understanding the intricate interconnections between wildfires, air quality, and water quality in Redding, California, given its unique geographical and climatic characteristics that make it susceptible to wildfire impacts. These correlations emphasize the need for proactive measures to address potential ramifications on both the environment and public health. For local authorities and decision-makers, understanding these correlations provides essential insights for informed decision-making and strategic planning, highlighting the urgency of developing comprehensive air and water quality management plans. From an environmental standpoint, recognizing these correlations is vital for safeguarding the region's ecosystems, necessitating efforts to preserve the ecological balance in the face of potential impacts on water bodies. Additionally, the public health implications underscore the importance of designing and implementing initiatives to raise awareness among residents and develop strategies for mitigating health risks during periods of increased wildfire activity, ensuring the well-being of the community.

Addressing the Findings

City Council and Decision-Makers

1. **Green Infrastructure: Natural Water Filtration and Pollution Impact Reduction**

   Prioritize developing and implementing projects integrating natural elements like wetlands, green roofs, and permeable pavements to enhance water filtration and reduce pollution impact. This resilient green infrastructure will contribute to overall ecological health.

2. **Real-time Monitoring: Early Warning Systems and Timely Response**

   Establish a robust system with early warning capabilities using advanced sensors and data analytics for continuous monitoring of air and water quality, especially during wildfire seasons. Investment in technology will empower prompt responses, emergency measures, and effective communication.

3. **Water Quality Management: Water Treatment and Nutrient Management**

   Focus on comprehensive management, incorporating advanced water treatment and nutrient strategies to address changes caused by wildfires. Collaborate with water treatment facilities to adapt processes, ensuring the integrity of Redding's water sources and safeguarding community health.

City Residents

1. **Water Conservation and Preservation**

   - Residents play a vital role; findings indicate potential risks, urging adoption of water conservation practices during increased wildfire activity for maintaining water clarity.

2. **Emergency Preparedness**

   - Prioritize emergency preparedness, ensuring access to clean water supplies during wildfire threats. The city should provide resources and guidance to residents on managing water in emergencies.

Concrete Planning and Monitoring

Urgent action is required from the city council, city manager/mayor, and residents. Concrete plans, addressing preventive and corrective measures, must be devised within the next twelve months. This timeline is essential to promptly implement strategies and safeguards in preparation for the upcoming wildfire seasons and potential environmental fluctuations. Continuous monitoring and adaptation are vital, with city officials urged to assess the effectiveness of implemented measures, adjust strategies as needed, and maintain regular communication with the public. This ensures ongoing engagement and collective efforts for environmental and public health safeguarding.

Human-Centered Data Science Reflection

The project, shaped by human-centered data science principles, prioritized understanding Redding's unique context. The analysis is tailored to address real-world concerns and provide actionable insights.

Understanding the Context

This project acknowledges the distinctive geographical and climatic features of Redding, California, recognizing the region's vulnerability to wildfires and the potential consequences for air and water quality.

Stakeholder-Centric Approach

The decisions were guided by a deep consideration of stakeholders, recognizing the pivotal role of Redding's local authorities, decision-makers, and residents. The correlations identified offer targeted solutions aligned with the needs of these key stakeholders.

Environmental Stewardship

With an environmental preservation lens, the recommendations emphasize green infrastructure and pollution reduction. This aligns with human-centered data science principles by contributing to the ecological balance and well-being of the region.

Public Health Integration

Findings from this project not only address environmental impacts but also prioritize public health. By promoting awareness and engagement in water conservation practices, we empower residents to actively participate in safeguarding their health.

City Council Recommendations

Our proposals for the city council are crafted to directly address community needs. The focus on technology for real-time monitoring aligns with leveraging advancements to benefit the community while emphasizing strategic actions for effective planning.

Resident Engagement

Engaging residents in water conservation practices and emergency preparedness aligns with human-centered principles. It ensures that the community plays an active role in implementing proposed measures, fostering a collective effort for environmental protection.

Timely Action and Adaptation

The urgency to formulate concrete plans within the next twelve months aligns with human-centered principles of timely action, while the emphasis on continuous monitoring and adaptation recognizes the dynamic nature of wildfires and underscores the need for ongoing assessment for effective strategies.

Limitations

- **Data Limitations:** The analysis heavily relies on the availability and accuracy of data. Incomplete or inaccurate data may introduce biases and impact the robustness of the findings. The dataset's temporal and spatial resolution may not capture nuanced variations in environmental parameters, limiting the precision of the analysis.
- **Modeling Assumptions:** The smoke estimate formula and ARIMA model make certain assumptions, such as linearity and stationarity, respectively. These assumptions may oversimplify real-world complexities, affecting the models' accuracy.
- **Regional Specificity:** The findings and recommendations are tailored to Redding, California, and may not be directly applicable to other regions with distinct environmental characteristics. Generalizing results should be approached with caution.
- **Predictive Nature:** The project relies on predictive modeling, and while valuable for identifying trends, it inherently involves uncertainties. Future events or changes not accounted for in the models may influence the actual outcomes.
- **Human-Centered Factors:** The success of proposed measures depends on community engagement, public awareness, and cooperation. Implementing strategies assumes a level of responsiveness that may vary among residents.
- **Resource and Time Constraints:** The project faced limitations in terms of time and resources. Comprehensive modeling, extensive data collection, or the exploration of alternative models were constrained by the project's scope and timeline.
- **External Variables:** External factors beyond the project's control, such as policy changes, socio-economic shifts, or unforeseen events, could influence the relevance and effectiveness of proposed interventions.
- **Dynamic Nature of Wildfires:** Wildfires are dynamic and influenced by various factors, including climate conditions. While the project considers historical data, the evolving nature of wildfires makes predicting future occurrences challenging.

- **Public Health Impacts:** While correlations between environmental factors are identified, the project doesn't delve deeply into the direct health impacts on individuals. A more comprehensive health analysis would require additional expertise and data.

- **Interdisciplinary Scope:** The project spans diverse domains, including environmental science, data science, and public health. Integrating insights from multiple disciplines introduces challenges in maintaining depth across all areas.

- **Incomplete Information:** Incomplete data may introduce uncertainties, impacting the accuracy of predictions and decision-making. Transparently communicating data gaps encourages a collaborative approach for community participation in data improvement initiatives.

- **Data Size Limitation:** During the project, intermediate data generated exceeded GitHub's size limits, preventing its upload alongside project files. While efforts were made for transparency, this limitation hinders complete replication. Interested parties can inquire about alternative means for accessing the intermediate data.

Conclusion

In conclusion, this project illuminates the complex relationships between wildfires, air quality, and water quality in Redding, California, emphasizing the region's vulnerability and the imperative for proactive measures to protect the environment and public health. The identified correlations provide crucial guidance for local authorities in decision-making and strategic planning.

The human-centered data science approach prioritized technical rigor, ethical considerations, and practical implications. Navigating challenges such as data quality issues, estimation formula assumptions, and statistical model limitations, the project-maintained transparency and focused on building community trust.

Recommendations for the city council include the development of green infrastructure, real-time monitoring systems, and comprehensive water quality management. These strategies aim to bolster the city's resilience against the intricate interplay of wildfires on its environment.

Despite its contributions, the project has limitations, including assumptions in estimation formulas, potential biases from data quality issues, and contextual specificity to Redding.

Stakeholders should approach conclusions with an awareness of these constraints and collaborate to address data gaps and enhance predictive models.

As Redding faces wildfire challenges, urgency lies in concrete planning and timely preventive measures. The proposed twelve-month timeline aligns with human-centered principles of swift action. Continuous monitoring, adaptation, and transparent communication ensure an informed and engaged community in the collective effort to safeguard the environment and public health.

In essence, this project acts as a steppingstone toward a more resilient and informed approach to mitigate wildfires' impacts on Redding, fostering a sustainable future for the city and its residents.

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https://www.sciencebase.gov/catalog/item/61aa537dd34eb622f699df81

[7] Air Quality System (AQS) API https://aqs.epa.gov/aqsweb/documents/data_api.html

Data Sources

[1] Water Quality Data: California Open Data Portal. Retrieved from https://data.ca.gov/dataset/water-quality-data/resource/b24d85ed-f88a-4d34-bdf1-812560c4b488

[2] Combined wildland fire datasets for the United States and certain territories, 1800s-Present (combined wildland fire polygons) https://www.sciencebase.gov/catalog/item/61aa537dd34eb622f699df81

[3] Air Quality System (AQS) API https://aqs.epa.gov/aqsweb/documents/data_api.html

Appendix : Data Description

Wildfires Dataset

Name	DType	Description
OBJECTID	Integer	Unique ID for the polygon and its attributes
USGS_Assigned_ID	Integer	Assigned ID for consistency in dataset exports
Assigned_Fire_Type	String	Type assigned to the fire, prioritized: Wildfire, Likely Wildfire, Prescribed Fire
Fire_Year	Integer	Calendar year of the fire occurrence
Fire_Polygon_Tier	Integer	Tier from which the fire polygon was generated
Fire_Attribute_Tiers	String	Fire tiers contributing attributes to the feature
GIS_Acres	Float	GIS-calculated acres of the fire polygon
GIS_Hectares	Float	GIS-calculated hectares of the fire polygon
Source_Datasets	String	Original datasets contributing to the polygon or attributes
Listed_Fire_Types	String	Fire types from merged dataset intersecting with the polygon
Listed_Fire_Names	String	Fire names from merged dataset intersecting with the polygon
Listed_Fire_Codes	String	Fire codes from merged dataset intersecting with the polygon
Listed_Fire_IDs	String	Fire IDs from merged dataset intersecting with the polygon
Listed_Fire_IRWIN_IDs	String	Fire IRWIN IDs from merged dataset intersecting with the polygon

Name	DType	Description
Listed_Fire_Dates	String	Fire dates from merged dataset intersecting with the polygon
Listed_Fire_Causes	String	Fire causes from merged dataset intersecting with the polygon
Listed_Fire_Cause_Class	String	Fire cause classes from merged dataset intersecting with the polygon
Listed_Rx_Reported_Acres	String	Prescribed fire reported acres intersecting with the polygon
Listed_Map_Digitize_Methods	String	Fire digitization methods from merged dataset intersecting with the polygon
Listed_Notes	String	Fire notes from merged dataset intersecting with the polygon
Processing_Notes	String	Indicates altered attribute data with rationale and count
Wildfire_Notice	String	Quality notice for wildfire data in the dataset
Prescribed_Burn_Notice	String	Quality notice for prescribed burn data in the dataset
Wildfire_and_Rx_Flag	String	Flag indicating attributes suggesting both wildfire and prescribed fire
Overlap_Within_1_or_2_Flag	String	Flag indicating overlap with a prior fire within 1 or 2 years
Circleness_Scale	Float	Measure of polygon's similarity to a circle
Circle_Flag	String	Flag for highly circular polygons (circle-ness >= 0.98)
Exclude_From_Summary_Rasters	String	Indicates exclusion of circular fires >1 acre from summary raster calculations

Name	DType	Description
Shape_Length	Float	Automatically calculated perimeter length in meters
Shape_Area	Float	Automatically calculated polygon area in square meters

Redding Wildfires Dataset (Intermediate Dataset)

Field	Type	Description
OBJECTID	Integer	Unique ID for the polygon and its attributes.
USGS_Assigned_ID	Integer	Assigned unique ID for consistency in dataset export.
Assigned_Fire_Type	String	Type assigned to the fire (e.g., Wildfire, Prescribed Fire).
Fire_Year	Integer	Calendar year when the fire occurred.
Fire_Polygon_Tier	Integer	Tier from which the fire polygon was generated.
Fire_Attribute_Tiers	String	Fire tiers contributing attributes to the feature.
GIS_Acres	Float	GIS-calculated acres of the fire polygon.
GIS_Hectares	Float	GIS-calculated hectares of the fire polygon.
Source_Datasets	String	Original datasets contributing to the polygon or attributes.
Listed_Fire_Types	String	Fire types from the merged dataset intersecting this polygon.
Listed_Fire_Names	String	Fire names from the merged dataset intersecting this polygon.
Listed_Fire_Codes	String	Fire codes from the merged dataset intersecting this polygon.

Field	Type	Description
Listed_Fire_IDs	String	Fire types from the IDs dataset intersecting this polygon.
Listed_Fire_IRWIN_IDs	String	Fire IRWIN IDs from the merged dataset intersecting this polygon.
Listed_Fire_Dates	String	Fire dates from the merged dataset intersecting this polygon.
Listed_Fire_Causes	String	Fire causes from the merged dataset intersecting this polygon.
Listed_Fire_Cause_Class	String	Fire cause classes from the merged dataset intersecting this polygon.
Listed_Rx_Reported_Acres	Null	Reported acres for prescribed fires in this polygon.
Listed_Map_Digitize_Methods	String	Fire digitization methods from the merged dataset intersecting this polygon.
Listed_Notes	String	Fire notes from the merged dataset intersecting this polygon.
Processing_Notes	String	Indicates altered attribute data and provides rationale.
Wildfire_Notice	String	Notice on the quality of wildfire data in this dataset.
Prescribed_Burn_Notice	String	Notice on the quality of prescribed burn data in this dataset.
Wildfire_and_Rx_Flag	Null	Flag indicating both wildfire and prescribed fire attributes.
Overlap_Within_1_or_2_Flag	Null	Flag identifying areas with >10% overlap of current fire within 1 or 2 years.
Circleness_Scale	Float	Measure of polygon similarity to a true circle.
Circle_Flag	Null	Flag for circle-like polygons (>=0.98).

Field	Type	Description
Exclude_From_Summary_Rasters	String	Indicates exclusion from summary raster calculations (Yes/No).
Shape_Length	Float	Automatically calculated perimeter length in meters.
Shape_Area	Float	Automatically calculated polygon area in square meters.
fire_lat	Float	Latitude of the fire location.
fire_lon	Float	Longitude of the fire location.
distance_from_redding	Float	Distance from the fire location to Redding, California.

Air Quality Index (Intermediate Dataset)

Field	Type	Description
Year	Integer	Year for which the AQI is calculated.
Calculated AQI	Float	For all the pollutants, we are taking worst 10 days and getting their average to be the calculated AQI for the year.

Water Quality Data

Name	Type	Description
station_id	Integer	Identification code for the station
station_name	String	Name of the station
station_number	String	Unique number assigned to the station

Name	Type	Description
full_station_name	String	Full name of the station
station_type	String	Type of station (e.g., Surface Water)
latitude	Float	Latitude coordinates of the station
longitude	Float	Longitude coordinates of the station
status	String	Status of the station (e.g., Public, Review Status Unknown)
county_name	String	Name of the county where the station is located
sample_code	String	Code assigned to the sample
sample_date	String	Date and time of the sample
sample_depth	Integer	Depth of the sample
sample_depth_units	String	Units used to measure the sample depth (e.g., Feet)
anl_data_type	String	Type of analytical data (e.g., EPA 360.2 (Field))
parameter	String	The parameter measured in the sample (e.g., DissolvedOxygen, pH, WaterTemperature)
fdr_result	Float	Result of the FDR analysis
fdr_text_result	String	Textual representation of the FDR result
fdr_date_result	String	Date of the FDR result
fdr_reporting_limit	Float	Reporting limit for the FDR result
uns_name	String	UNS (Unknown Sample) name

Name	Type	Description
mth_name	String	Method name (e.g., Std Method 2510-B (Field))
fdr_footnote	String	Footnote related to the FDR result