

California Wildfires: Analyzing Environmental, Health, And Regional Impacts With Air Quality Correlations

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Abstract - Wildfire activity has become one of the most sensational and urgent issues in the United States after the Tornadoes event. Overviewing the chronological data of the past 24 years, it has been observed that wildfires have increased in severity, frequency and intensity, posing serious detrimental impacts on the health of humankind, and ecological disturbance. This research analyzes wildfire occurrence data across California from 2000 to 2023 using Geographic Information Systems (GIS) to identify patterns of wildfire activity, mapping affected areas focused on land and forest. It also highlights the correlation between wildfires and PM2.5 & ozone pollutants to measure the Air Quality Index (AQI).

Keywords: Wildfire, California Wildfires, Air Quality Index (AQI), PM2.5, Ozone Levels, Seasonal Wildfire, Forest and Land Area Burned, Environmental Health Risks, Climatic Influence.

1. INTRODUCTION

The USA has experienced multiple disaster events including tornadoes, hurricanes, earthquakes, and wildfires. Among these, wildfires are considered the deadliest in U.S modern history. Wildfires have impacted multiple states, primarily in western and southern regions. Analyzing the history, it appears that wildfires destroyed millions of acres across at least 25 states, with most significant damage occurring in California, Texas, Oregon. Studies shows that over the past two decades, California has witnessed an alarming rise in wildfire frequency and intensity, driven by a combination of climate change, prolonged droughts, rising temperatures, and human encroachment into fire-prone areas (Keeley & Syphard, 2018; Radeloff et al., 2018). According to the California Department of Forestry and Fire Protection (CAL FIRE, 2023), California alone is responsible for 26% of all wildfire incidents in the U.S, which makes the state more vulnerable and challenging for wildfire management.

Wildfires intensity and severity is not just an environmental issue, it has become a health significance. The pollutants such as PM2.5, ozone, carbon monoxide emitted from the wildfire showcased the major contribution to air pollution. Reid et al., 2016; Liu et al., 2017 research says that these pollutants have caused detrimental health issues, especially to children, elderly, and the individuals with prior respiratory problems. 2020, also named as year of wildfire, has escalated the levels of PM2.5 concentrations reaching up to 38 times of the set daily atmospheric levels, resulting in hazardous Air Quality Index (AQI) levels in cities like San Francisco, San Bernardino, and Los Angeles (Jaffe et al., 2020). Long-term exposure to these pollutants has been linked to an increase in emergency hospital visits, respiratory diseases, cardiovascular problems, and even premature mortality (Di et al., 2017; Rappold et al., 2021).

Apart from air quality, the impact of wildfire on the ecology is immense and far-reaching. Millions of acres of forestland and wildlife have been destroyed due to rapid expansion of fire-prone areas, accounting for 16.5% of California's forested areas and 34.3% of its total land area burned in recent decades (CAL FIRE, 2023; Westerling, 2018). It has been analyzed that wildfires reduce carbon storage, accelerate soil erosion, and harm local ecosystems, threatening biodiversity and intensifying the long-term consequences of climate change (Brey & Fischer, 2021). Additionally, the interaction between wildfire emissions and atmospheric conditions exacerbates climate feedback loops, further increasing the likelihood of extreme fire events in the future (McClure & Jaffe, 2018). Climate plays a crucial role in wildfire behavior. California's Mediterranean climate, characterized by hot, dry summers and mild, wet winters, favor wildfire ignition and spread (Keeley & Syphard, 2018).

This study aims to provide a broad analysis of wildfire trends and patterns in California, focusing on the relationship between wildfire occurrences and air quality. By mapping wildfire-affected areas and analyzing PM_{2.5} and ozone concentrations, this research will offer critical insights into the trends and patterns of wildfire (seasonally and yearly), areas affected by wildfire in terms of forest and land, how wildfire smoke affects air pollution across various cities of California.

2. LITERATURE REVIEW

California possesses a long and well-documented history of wildfires, dating back to the 1860s. Historical records shows that significant wildfire events in the early 20th century, counting for the catastrophic fires of 1929, were closely correlated with prolonged exposure of drought. A universally accepted tool to measure the drought intensity, Palmer Drought Severity Index (PDSI) highlights the strong connections between dry spells and increased wildfire activity (Cook et al., 2004). The 1929 fire season, ignited by arid climate and dry vegetation, provides the example of the way climatic conditions favor wildfire acts.

Over the last decades, both the frequency and intensity of wildfires in California have escalated dramatically. According to the California Department of Forestry and Fire Protection, in 2020 a new grim benchmark was set, over 4,2 million acres burned. In the recorded history of California, this is the largest area burned in a single area. As stated by Westerling, 2018 stated that the results of wildfire activity are due to the rising temperatures, prolonged drought, and increased human development in fire hazard zones.

During a wildfire, large amounts of fine particulate matter (PM_{2.5}) and ozone-forming pollutants, sized 2.5 microns or smaller, are released into the atmosphere, posing serious health hazards. Due to their small size, these particles can easily penetrate the lungs and enter the bloodstream. As a result, wildfires are considered major contributors to the deterioration of the air quality index. According to Jaffe et al., 2020, during the 2020 wildfire season, direct PM_{2.5} emissions in California raised up to 38 times the daily norm, showing wildfires' severe air quality damage. Furthermore, the daily 8 hours averages of ground level ozone increased by up to 10 parts per billion (ppb), worsening respiratory health, especially among the vulnerable populations. PM_{2.5} concentrations have worsened the air quality index by 10 times, in various parts of California and Western border of the US, highlighting the significant impact of wildfire smoke (Liu et al., 2017).

The research conducted by Reid et al. (2016) analyzed the correlation between PM_{2.5} exposure and the frequency of hospitalizations due to respiratory and cardiovascular diseases, as well as increased premature mortality. It stated that health consequences are closely linked with wildfire induced air pollution. Modification and improvement in air quality monitoring have been observed, low-cost sensor networks, such as PurpleAir, which provided more clear and detailed information into smoke exposure and its impacts on health. Data from these sensors revealed a wildfire-related mortality is 16% higher than what was predicted by traditional monitoring methods, emphasizing the importance of accessible, real-time air quality data (Rappold et al., 2021). Furthermore, the surge in wildfire emissions poses a significant challenge to decades of progress in air pollution control measures. The frequent and immense gas emitted by wildfire threatens to undergo the progress to reduce the industrial and vehicle pollution (McClure & Jaffe, 2018).

Taking everything in consideration, it has been concluded that exacerbating events of wildfires has caused a serious threat to air quality as well as human health. This literature summarized the need for comprehensive wildfire management strategies and effective air quality monitoring systems to mitigate the far-reaching impacts of wildfire smoke. Future research should focus on merging climate adaptation strategies with pollution control measures to safeguard environmental and human health.

3. OBJECTIVES

- Analyzing the trends and patterns of wildfire activity in the United States over the last 24 years.

- To compare historical occurrence and seasonal variations of wildfire across the USA and California.
- Mapping out the significant wildfire-affected areas, focusing on land and forest across California.
- To analyze the correlation between wildfire occurrences and changes in Air Quality Index (AQI) specifically Ozone and PM 2.5 concentrations in affected regions.
- To assess the extent of forest and land area burned in California.

4. METHODOLOGY

This research used a structured approach which combined existing literature, data collection, and geospatial analysis to examine the relationship between California wildfires and their impact on air quality. Initially literature review is conducted to explore existing studies, scientific articles, and reports on wildfire trends, air pollution, and public health implications. The initial step gives an overview and guidelines for research by identifying knowledge gaps and developing the clear research objectives. The research objectives are focused on understanding the spatial and temporal distribution of wildfires in California, determining the seasonal patterns of fire activity, and correlating wildfire severity with air pollution levels, particularly PM2.5 and ozone. Defining these objectives ensures that the study remains targeted and relevant.

Next, the data collection process involves collecting relevant geospatial and environmental data from authoritative agencies and sources. Geographic boundary data is obtained from the Census Tiger/Line Shapefiles, which provide detailed geographic features for spatial analysis. Wildfire-related data like incidence occurrences, affected areas, and severity is extracted from US Data.Gov and the California Department of Forestry and Fire Protection (CAL FIRE). Air quality data, including particulate matter (PM2.5) and ozone concentrations, is gathered from the U.S. Environmental Protection Agency (EPA) to determine pollution trends during wildfire events. The main part of this research involves geospatial analysis, where Geographic Information Systems (GIS) techniques are used to process and understand the collected data. The analysis starts by combining wildfire data with geographic boundaries, creating a detailed spatial map of fire activity across California. Attribute selection allows filtering specific criteria, such as the year of occurrence or fire size, for targeted investigations. Intersection operations identify areas where wildfires overlap with populated regions or protected lands, while dissolve and erase functions simplify data by merging regions or excluding irrelevant features. These spatial tools facilitate the visualization of wildfire patterns and their correlation with pollution levels.

Finally, the results of this analysis provide insights into the most wildfire-affected states, the seasonal distribution and recurrence of wildfires in California, and the relationship between wildfire severity and air quality degradation. Metrics such as PM2.5 concentration spikes and ozone increases during significant fire events are examined. The study concludes with a summary of findings, emphasizing the implications for public health and environmental management. This methodology offers a systematic approach to understanding and addressing the growing threat of wildfires and their impact on air quality in California and beyond.

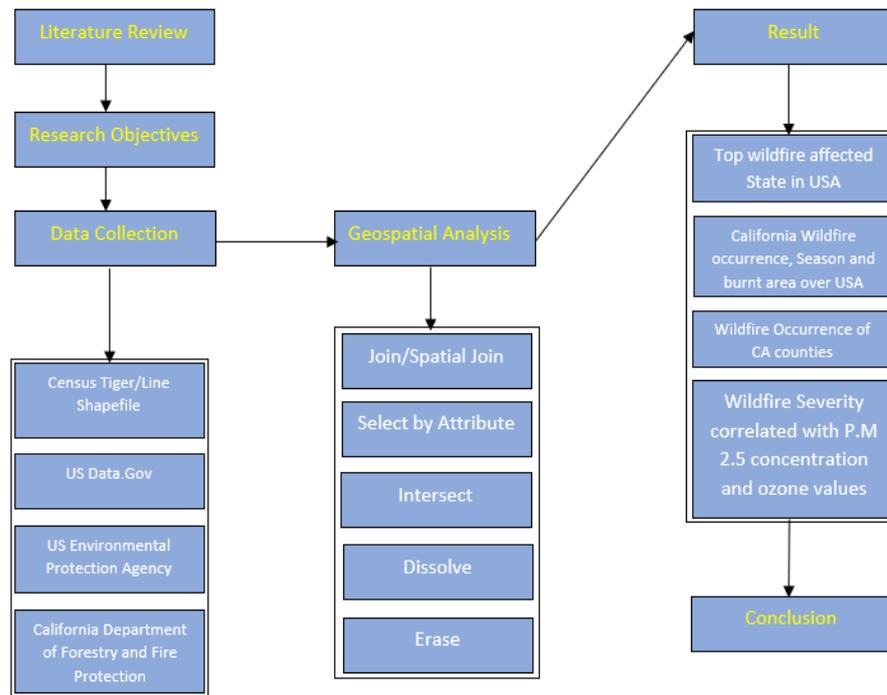


Figure 1. Research Methodological Framework of Wildfire Analysis

5. RATIONALE OF THE RESEARCH

The rationale for focusing on the study area is to understand the significant impacts of the California wildfires in the Air Quality Index (AQI), since CA has experienced the fierce intensity and severity of wildfires over the period of time. From the year 2000 to 2023, the state recorded 7,817 wildfire incidents, out of which the 2018 Campfire, mentioned as the most destructive and deadliest wildfire in California's history. It has been stated that 2018 wildfires have caused over 18,000 infrastructures, and 85 human casualties, and worsen the air quality across the state CAL FIRE, 2019 National Interagency Fire Center, 2019). This event has dragged the attention to study the correlation of wildfire with the air quality and its impacts on humankind. To support the study, a statewide wildfire map gives the visualization, which represents California in deep red, symbolizing extreme wildfire activity, while neighboring states like Oregon, Idaho, and Washington show relatively lower, but still significant, fire frequencies. In contrast, central and eastern states demonstrate much lower occurrences, as indicated by lighter color shades. These regional disparities highlight California as a critical area for wildfire impact studies (CAL FIRE, 2023; National Interagency Fire Center, 2023).

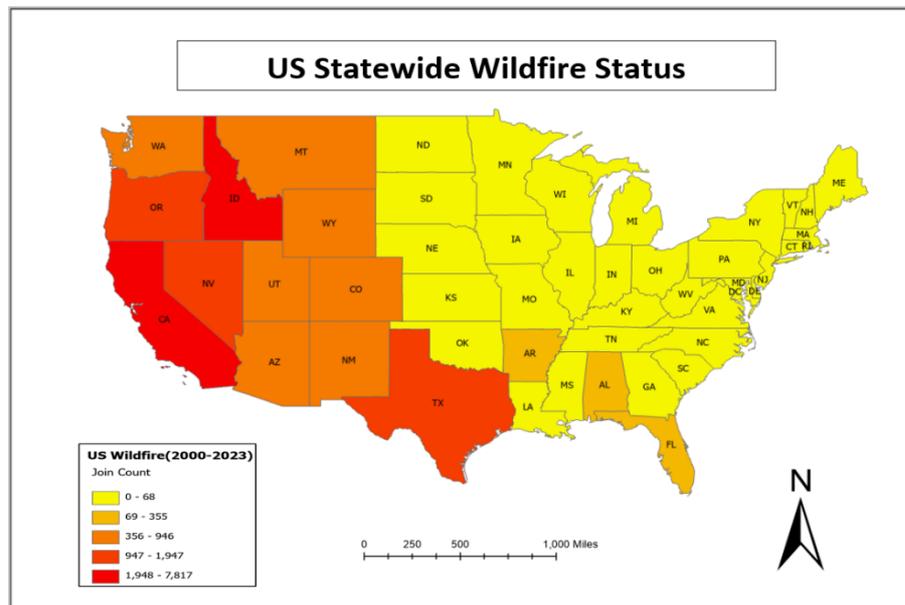


Figure 2. Wildfire Frequency and Geographic Distribution in the US (2000–2023) (Source: Prepared by Author 1st, 2024)

Climatic factors and human activities have been considered as the major push factor for the California wildfires. Prolonged drought, dry vegetations, and powerful Santa Ana Winds, make the conditions favorable to ampule the wildfire incident on an intense level (Keeley & Syphard, 2018). Furthermore, advancement and urbanization in wildland-urban regions (WUI) areas escalates fire risk and increases the potential for human and economic losses (Radeloff et al., 2018). As per the U.S EPA, 2022 reports, the increased frequency of wildfires is directly proportional for declining air quality, as major pollutant sources like PM 2.5 and ozone are contributed by wildfires. For instance, in 2020, California wildfires caused PM2.5 emissions to spike up to 38 times the daily average, dramatically exceeding air quality standards (Brey & Fischer, 2021).

The frequent incidence of wildfire has shown adverse impact on air quality, despite the years of advancement and mitigation policies of pollution prevention and public health. Climate change has driven the prevalence of wildfires, and the state has become the best study area to analysis the correlation of wildfires in air quality. This research helps to examine the wildfire incidents, interaction with different types of land (both forest area, and other landscapes), their correlation with the major pollutant.

6. ANALYSIS

6.1 Wildfire Trends and Distribution in California (2000–2023)

Data was obtained by using the geoprocessing tool “Dissolve”. The “Dissolve” tool was applied to the attribute table of wildfire incidents in both the USA and California, which aggregate the multiple incidents data in one single incidents data. After that, the given data has been extracted in excel sheet, with the help of pivot table, the study examined wildfire occurrence per year in both the USA and California between the year 2000 to 2023. The bar graph depicts the wildfire occurrence, year-to-year fluctuations in wildfire occurrences across the U.S. (blue bars) and California (red bars). The analysis clearly shows that the year 2017, 2020 has the most severe wildfire seasons, with 1392, and 970 respectively for the USA and 608, 505 for California simultaneously, worsening the situation by extreme heatwaves and severe drought, increasing the risks of fires across the state. This drew attention to how climate change can act as the catalyst to worsen the wildfires' events, causing adverse impact on air quality and human health. Likewise, the years 2009 and 2014 show significantly lower wildfire activity in California, indicating the wildfire activity can be influenced by changing environmental and meteorological conditions. In addition, the pie-chart further

illustrates the proportional contribution of California’s wildfires to the national total. California accounted for 26% of all wildfire events recorded in the United States between 2000 and 2023, reaffirming its status as the most wildfire-prone state in the nation.

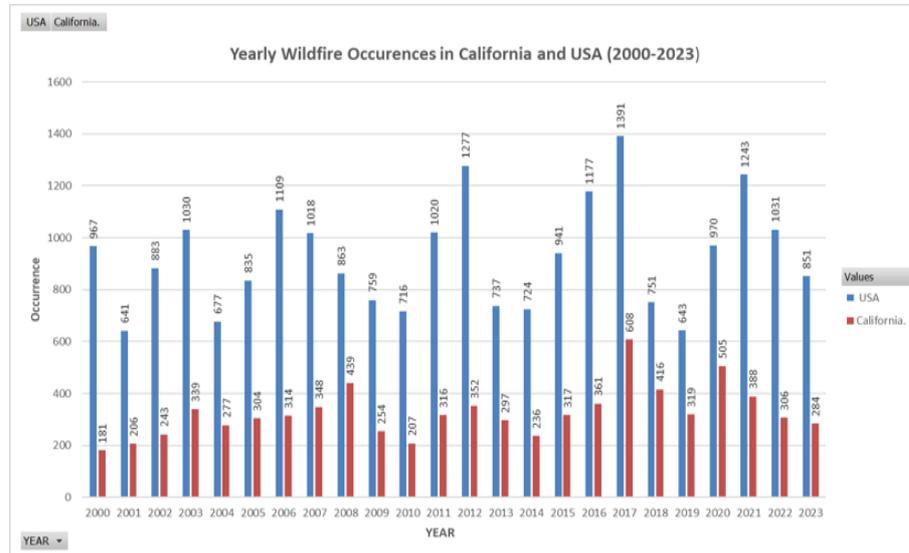


Figure 3. Annual Wildfire Trends in California vs. USA (2000–2023) (Source: Prepared by Author 1st, 2024)

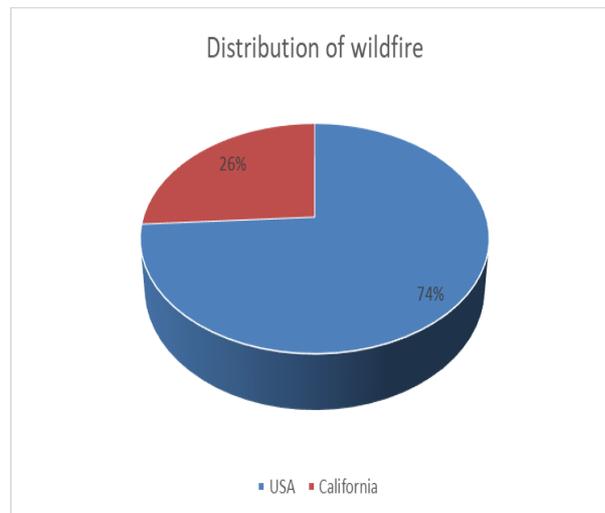


Figure 4. Percentage Distribution of Wildfires in the USA and California (Source: Prepared by Author 1st, 2024)

6.2 Wildfire Burned Area Trends

The analysis aimed to identify the total area affected by wildfires in California and the entire USA over the time frame of 24 years. The graph shows the comparison between the wildfire burned areas and examines how California contributes a large share to the nation's fire damage. It has been observed that in 2020, over 6.9 million acres burned nationwide, and California alone saw about 4.18 million acres affected. Similarly, years like 2007, 2017, and 2021 also show California’s significant role and contribution in major wildfires.

On the right, the pie chart illustrates the distribution analysis, showing that California represents about 25% of the total wildfire-burned area in the USA, with the remaining 75% distributed across

other states. This piece of study highlights California's is highly prone to wildfire due to its vegetation, climate, and geography.

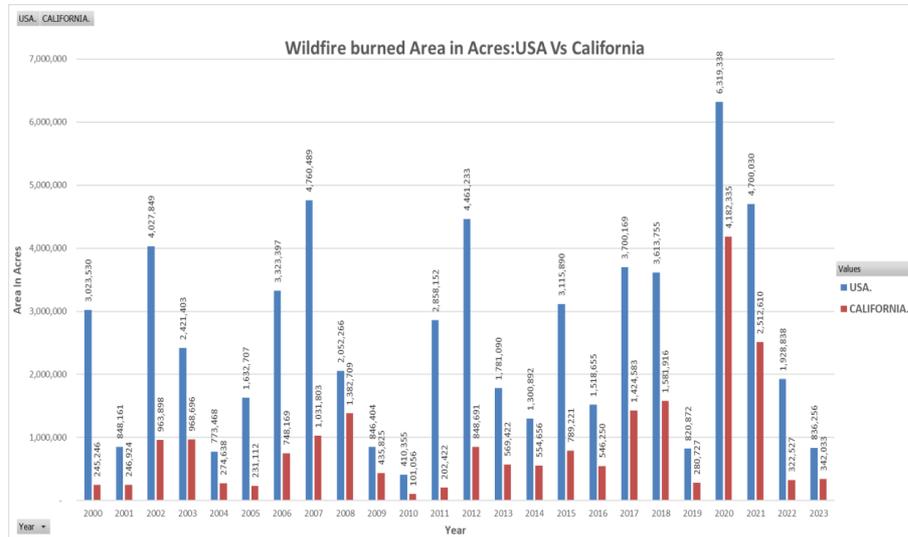


Figure 5. Trends in Wildfire Burned Areas in the USA and California (2000–2023) (Source: Prepared by Author 1st, 2024)

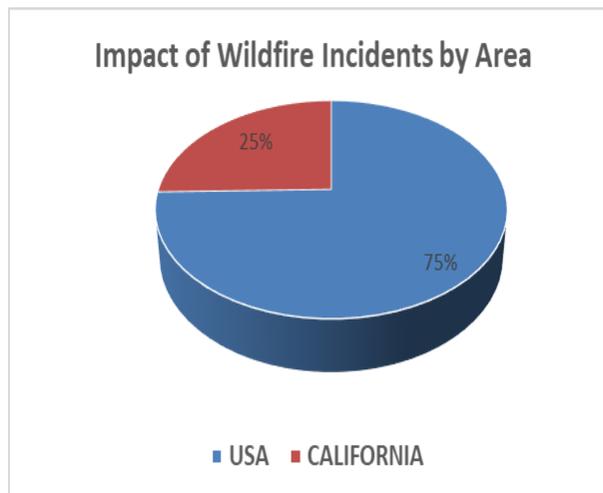


Figure 6. Percentage Share of Wildfire Impact in the USA and California (Source: Prepared by Author 1st, 2024)

6.3 Wildfire Trends and Seasonal Analysis

The analysis highlights the monthly wildfire occurrences in the United States and California, showing clear seasonal patterns. It has been observed that wildfire activity escalates in summer months, with July (4,324 incidents) and August (4,085 incidents) being the month with the most wildfires with respect to the USA. Compared to California, with a similar record, July (1,595 incidents) and August (1,347 incidents) witnessed the highest wildfire occurrences in the state. In both regions, months like January (2,828 incidents in the US and 515 in California) and December (270 incidents in the US and 187 in California) wildfires events lower the prevalence which falls in winter months. This demonstrates a strong correlation between wildfire activity and seasonal climatic conditions.

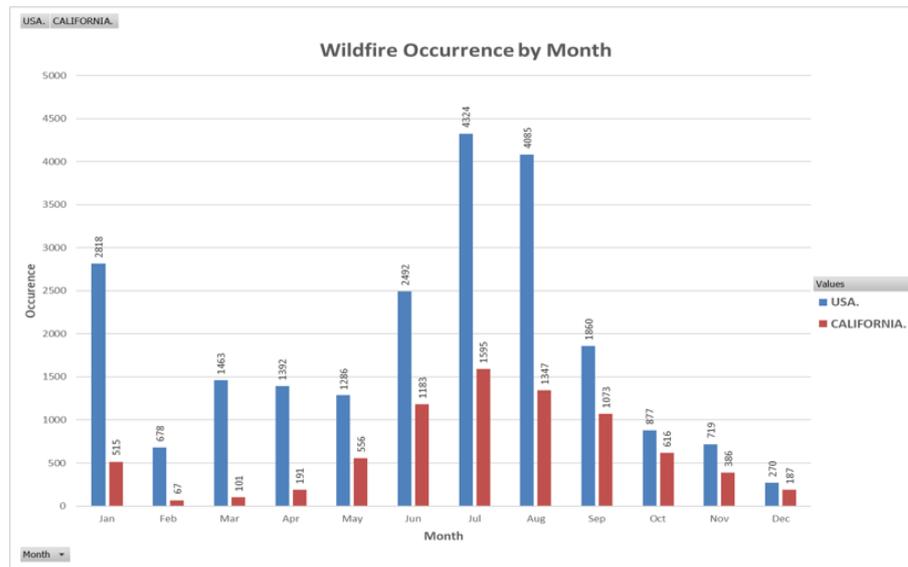


Figure 7. Monthly Wildfire Trends in the USA and California (Source: Prepared by Author 1st, 2024)

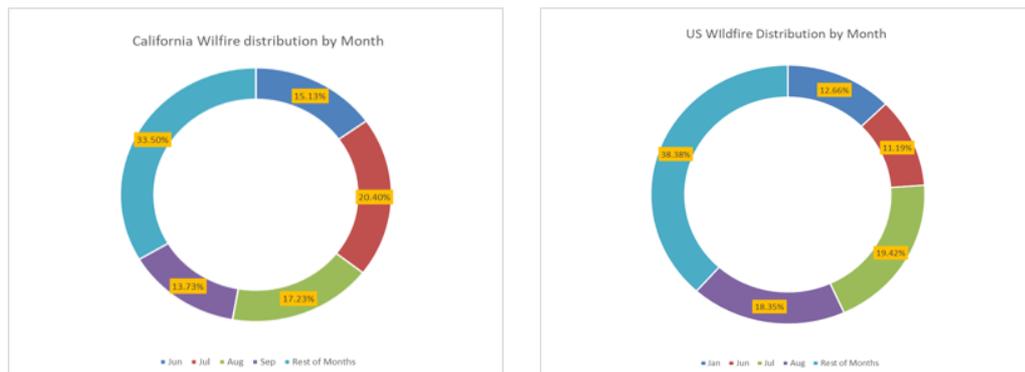


Figure 8. Understanding Peak Wildfire Months in California and the USA (Source: Prepared by Author 1st, 2024)

The given figure provides a clear view of season pattern wildfires of both the USA and California. It represents months like July and August (summer months) as an active month accounting for 38.38% and 33.50% of all wildfires per annum for the USA and California respectively. In addition, months like June and September also contribute 18.5% and 12.66% respectively for the USA, whereas California together account for 37.63% of all wildfires in the state, followed by July (20.40%) and August (17.23%) showing significant activity. On the other hand, months like January and February show lower wildfire prevalence. This analysis provides useful information on how higher temperature, warmer months, lower humidity, and dried vegetation fueled the ignition of the wildfire and extinguished its intensity and severity.

6.4 Wildfire Impact on California Forests

The map illustrates geographical distribution of wildfires and how it impacts different forms of land. The different landforms have been categorized by using colors for burned areas (red), active fire zones (orange), and national forest coverage (green). The given map clearly showed that northern and central regions of California have been heavily affected by wildfires, where dense forests are prevalent. Since these areas are rich in vegetation, they have enough fuel to flare up wildfires resulting in making the areas prone to wildfire and the damage they caused. On the contrary, Southern California also shows signs of wildfire activity, though the impact is less

extensive compared to the north. Overall, the map implies that areas with dense vegetation are more susceptible to wildfires occurrence because such areas provide fuel for fires activity and can easily spread.

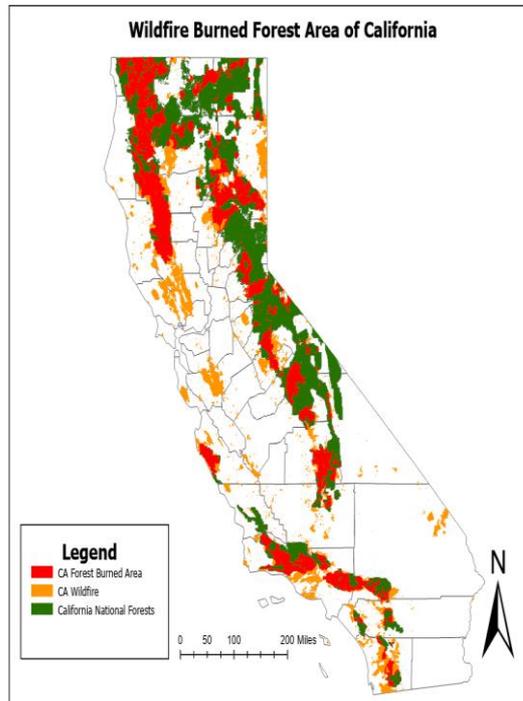


Figure 9. Mapping California's Wildfire-Affected Forest Regions (Source: Prepared by Author 1st, 2024)

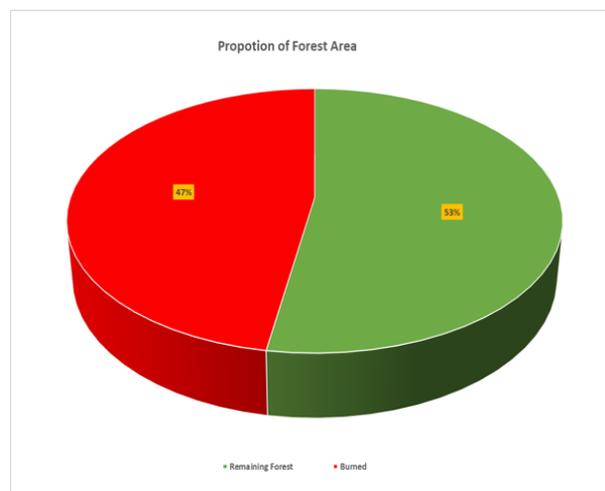


Figure 10. Proportion of Burned and Remaining Forest Area (Source: Prepared by Author 1st, 2024)

The provided pie chart demonstrated that 47% of California's forests have been destroyed by wildfires, while 53% remain unburned. This almost equal distribution emphasizes how severely wildfires affect the state's forest. This analysis shows the importance of mitigating measures like wildfire prevention, effective and prompt fire management, and additional well-equipped resources for firefighting and forest recovery. Reducing the future risk by protecting the remaining forest should be a top priority.

6.5 Wildfire Impact on California Land Area

The visuals show the distribution of wildfire in California, revealing the spatial and proportional land- burned areas. Colors help to distinguish different landforms, red color denotes the burned areas, which are particularly prevalent in northern and central California. Due to their dense vegetation and climatic conditions, these regions are highly susceptible for wildfires as it covers national forests (green). Compared to the north and central California, southern California seems less prone to wildfires, but some of the activities are prevalent. This evaluation highlights the significance of the focused measures of forest areas, as these regions are disproportionately affected by wildfires.

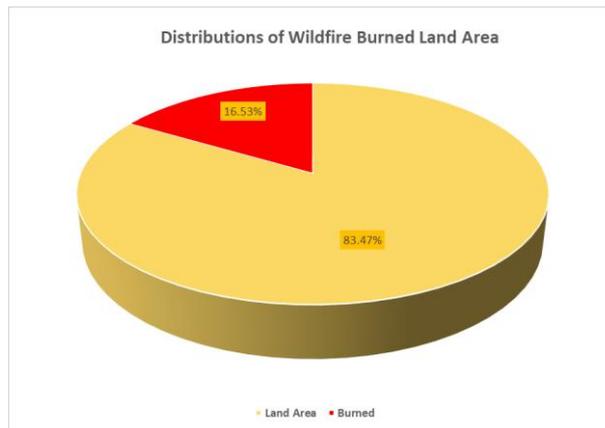


Figure 11. Proportion of Burned and Remaining Forest Area (Source: Prepared by Author 1st, 2024)

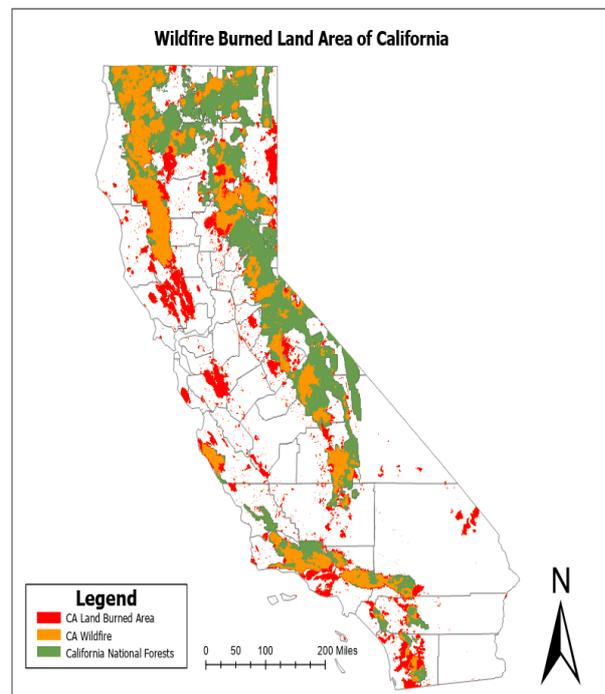


Figure 12. Mapping California's Wildfire-Affected Non-Forest/ Land Regions (Source: Prepared by Author 1st, 2024)

The pie chart provides a clear outline of wildfire encroachments in California, presenting that 16.53% of the state's total land area has been burned, while 83.4% remain untouched. Comparing the percentile the fraction of burned areas accounts for the smaller portion, but the widespread nature

of these fires alarm for effective and prompt land management and fire control measures especially environmentally sensitive areas. This data highlights the importance of taking proactive steps, such as controlled burns, improved firefighting efforts, and land restoration, to reduce future wildfire risks and safeguard vulnerable ecosystems. Protecting these areas is crucial for the environment and communities alike. This finding emphasized to lessen the future wildfire risks by focusing on protective measures, strengthening the community resilience, and land restoration.

6.6 Wildfire Impact on Forest and Land Areas

The piece of analysis shows how wildfires in California have affected forested and non-forested areas differently. Data reveals that 65.66% are total forest land, stressing how vulnerable forests are to wildfires due to their vegetation and ecological composition. Conversely, 34.34% of the burned land is non-forested, revealing that wildfires not only impact forests but also spread and affect other forms of land type. This finding says that the forests play a significant role in wildfire dynamics, due to their high combustibility, forest areas become more vulnerable and prone to wildfire. It provides vital information for focused strategies to reduce dangers through managed fires and enhancement to forest health. At the same time, fire encroachment in non-forested areas highlights the importance of addressing mitigation measures in all types of terrain. Overall, analysis urges for wildfires mitigation approaches and smart land-use planning to lessen the wildfire vulnerability and saves the forest and landscapes for future use.

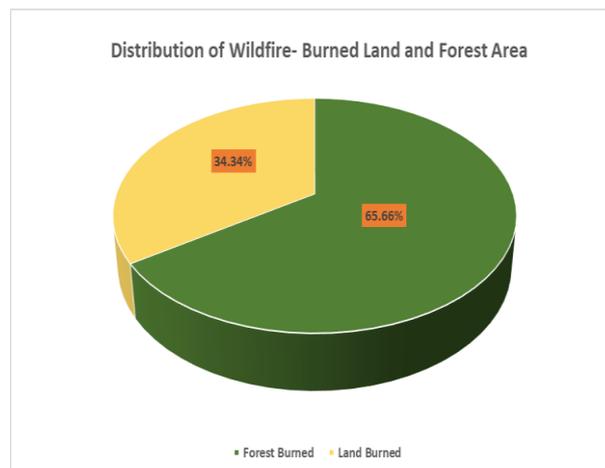


Figure 13. Proportion of Wildfire Impact: Forest Burned vs Non- Forest/Land Burned (Source: Prepared by Author 1st, 2024)

6.7 California Counties Affected by Wildfire

California has been characterized for its prolonged dry summers and wet winters. Its Mediterranean climate plays a significant role in igniting the wildfire. Numerous studies and observations have witnessed that long term droughts reduce soil moisture and dry up vegetation, leaving plenty of fuel for wildfires. 60 mph hot, dry Santa Ana winds in California mostly prevalent in Southern California, and dense forest, San Diablo winds, and terrain topography in northern California worsen these circumstances. As a result, causing a dangerous situation, makes it difficult to manage flames since it can easily spread across wide regions.

To obtain this data geoprocessing tools “Dissolve”, “Select by attributes”, and “Spatial Joining” were implemented. With the help of the “Dissolve” tool all the California’s counties wide wildfire incidents were aggregated. Then with the aggregated data, spatial joining was performed with the California Counties layer. This part of the analysis shows Northern California counties such as Siskiyou, Plumas, and Trinity, as well as Southern California areas including Los Angeles, Riverside, Kern, San Bernardino and San Diego are at high risk of wildfires due to its dense vegetation, topography, and climatic condition. On the other hand, counties like Napa, lake, Monterey, and San Luis Obispo show moderate severity. The finding reveals that northern and southern California are more prone to wildfire as compared to the central region. Although the

central regions are less prone to wildfires, they still need to be addressed with targeted strategies such as better forest management, controlled burns, and community preparedness. These combined factors highlight the critical impact of California's climatic and geographical conditions on its wildfire patterns.

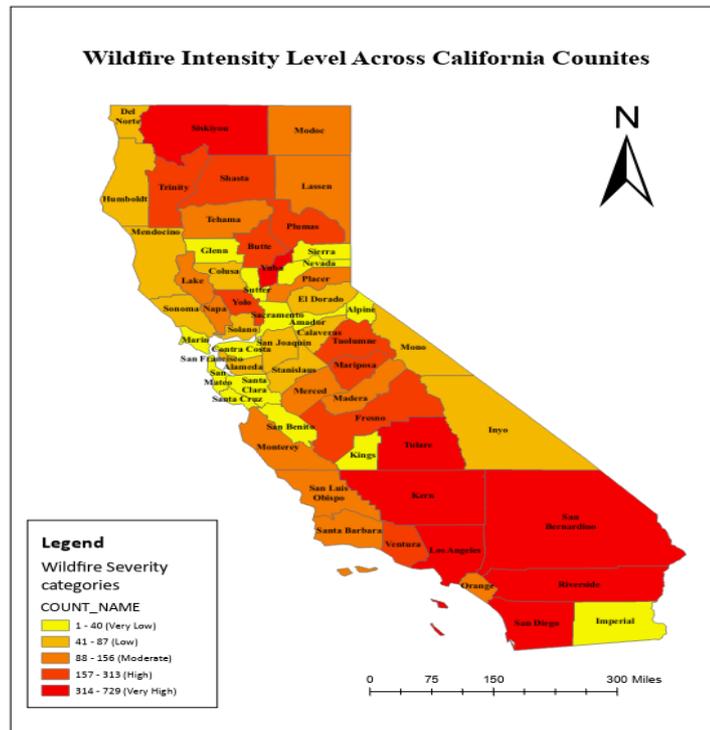


Figure 14. Wildfire Intensity Levels Across California Counties (Source: Prepared by Author 2nd, 2024)

6.8 Correlation between Air Quality Index (AQI) and wildfires

PM 2.5 is the fine particulate with a diameter of 2.5 micron or smaller. The size of particulates is so small that it can easily penetrate into the lungs through air, and enter the bloodstream, causing a detrimental issue to human health. To assess the air quality impact by wildfire, pollutants like PM 2.5, and ozone precursors (VOCs and NOx) have been considered because they have major impacts on the environment and human health and are greatly impacted by emissions from wildfires. And to identify the correlation, per year Air Quality index data was extracted from the Environmental Protection Agency (EPA).

6.8.1 Analyzing the impact of wildfire events and PM2.5 emissions

This section of analysis shows the correlation between the wildfires and Air Quality Index (AQI) pollutant PM2.5. The findings indicate that areas such as Kern, San Diego, Orange, and Los Angeles experience hazardous and very unhealthy air quality. Regions like Kern and Los Angeles County due to their basin topography acts as “bowl”, which traps the pollutants and restricts dispersing resulting in impact on the air quality. In addition to the geographical constraints, human activities, and urbanization also fuels deteriorating air quality in these regions. Furthermore, counties like Trinity, Pulmas, Butte, and Del Norte of northern California have unhealthy air quality. The combination of mountainous topography, San Diablo wind, and dense vegetation fuel to wildfire activity, as well as the farming activities added significant contribution to worsen the air quality in these zones. Although central California has fewer wildfire activities, the regions encountered hazardous air quality index. San Francisco, Santa Clara, Alameda, San Mateo these are few counties that have been exposed to hazardous air. Wildfires smoke from Sierra Nevada or Southern California

can be easily transported across the states, significantly increasing PM 2.5. The combined effects of seasonal and meteorological factors, and human activities like crop burning, diesel powered farm equipment, and fertilizers, and vehicle emissions have escalated the issue. This observation highlights the urgent need of mitigation practices that target both the urban population and wildfire management.

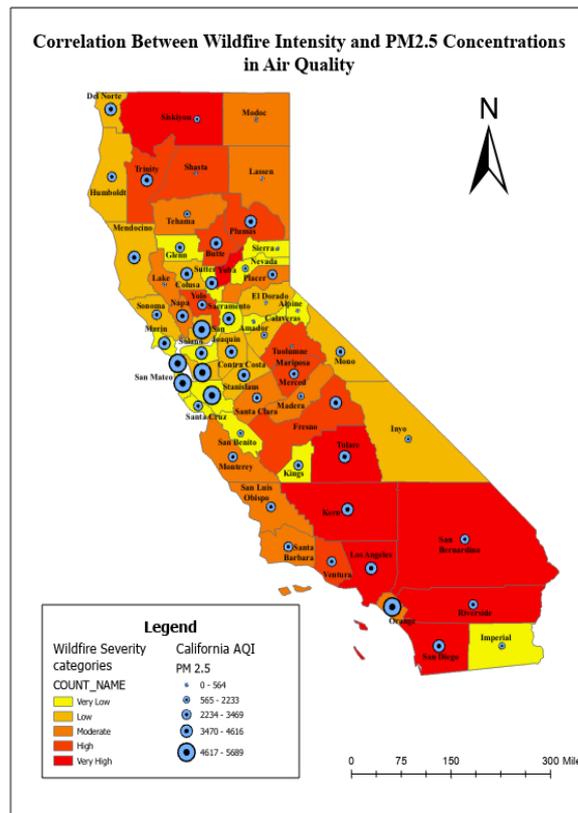


Figure 15. Correlation between Wildfire Intensity and PM2.5 Levels in California (Source: Prepared by Author 2nd, 2024)

6.8.2 Analyzing the impact of wildfire events and ozone precursors emissions

This portion of analysis examines the regions that have been exposed to ozone pollutants and their relationship with wildfire events in California. The map illustrates that northern California is highly experienced with ozone pollution, while the southern part has less encountered. Counties such as Shasta, Lake, Nevada, Alpine, Amador, and Tuolumne from northern California, along with San Benito County of central California were on the radar of hazardous ozone pollution. Even though these counties were not as industrialized and urbanized like southern California. Due to their geographical features, stagnation of air, pollutants transported from urban areas, wildfire emissions, and local anthropogenic activities (farming, vehicles, and industry) promote ozone formation by releasing the volatile organic compounds (VOCs) and nitrogen oxides (NOx) to the atmosphere. By visualizing the map, it reveals that areas with moderate wildfires occurrence are susceptible to serious air quality problems. Addressing the ozone pollutants in these zones required an integrated approach to make safer and resilient communities.

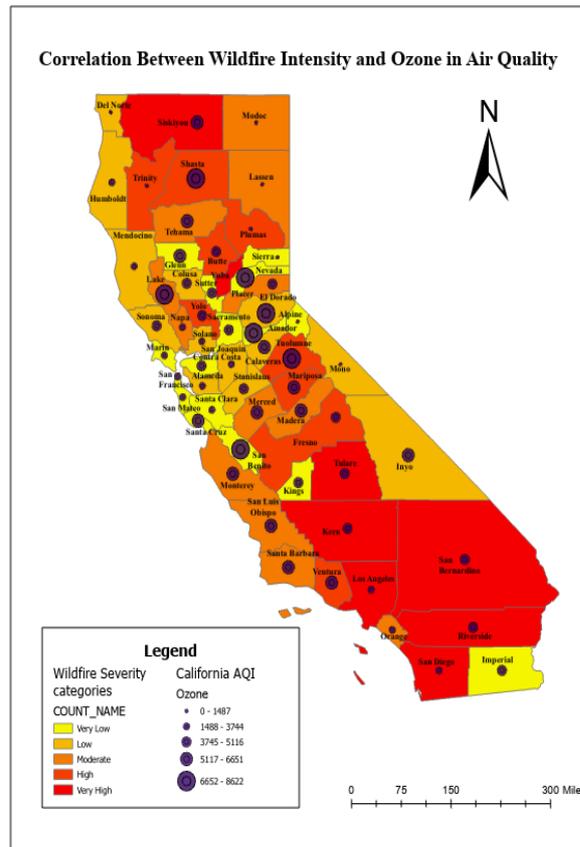


Figure 16. Correlation Between Wildfire Intensity and Ozone in California (Source: Prepared by Author 2nd, 2024)

7. CONCLUSION

This paper shows an analysis of California wildfires with the use of spatial tools and historical data from 2002 to 2023. The findings identify location and months of wildfire activity. The examination also provides comprehensive study on the areas in terms of land and forest affected by the wildfire over the decades. Furthermore, the observation highlights the emission of PM 2.5 and ozone pollutants in the different counties of California showing the intensity and severity of gas emitted by wildfire across different locations.

California's wildfire crisis has intensified over the past two decades, while analyzing the wildfire data of the USA, California accounts for 26% of wildfire incidents. Factors such as hot temperature, Santa Ana winds, and the Mediterranean climate are responsible for increasing the intensity, frequency, and severity of wildfires. The study illustrates that most fire occurrence years 2020, 2017, and 2007 have seen massive destruction, with 2020 alone witnessing 4.18 million acres burned in California—the largest single-year burned area in state history. Fire suppression efforts, while essential, have led to the buildup of dry vegetation, increasing the risk of severe fires in the future. The seasonal nature of wildfires, particularly in June, July, and August, further amplifies fire hazards, making proactive forest management crucial.

Moreover, the analysis indicates the environmental consequences of wildfires in California are severe, with 16.5% of the state's forested areas and 34.3% of total land affected over the past two decades. It reveals that forest regions in Northern and Central California are particularly vulnerable due to dense vegetation that fuels intense fires. The analysis on distribution of wildfire-burned land and forest area, it accounts 65.66% of burned areas are forests, highlighting the need

for sustainable land management practices, including controlled burns and vegetation thinning, to mitigate fire risks and promote forest resilience.

Along with the ecological impacts, wildfires have devastating air quality, with PM_{2.5} pollution emerging as the most critical concern. Fine particulate matter released from wildfires worsen respiratory illnesses, increasing the risk of cardiovascular diseases, and mortality risks, particularly among vulnerable groups such as children and the elderly. The study also shows the correlation between wildfire and air quality index, finding southern California cities like Los Angeles, Riverside, and San Bernardino experience the worst air quality degradation due to wildfire smoke, urban pollution sources, and high population density. Although Northern California sees significant fire activity, lower industrial and vehicular emissions contribute to faster air quality recovery. Neither the state boundary nor the regulations will restrict the wildfire spread so it can travel across a mile, worsening air pollution far beyond the immediate fire zones. Due to its adverse effects on long-range atmospheric transport, PM_{2.5} remains the key air quality indicator for assessing wildfire impacts, with organizations like the EPA and WHO emphasizing its monitoring to protect public health.

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