The Economic Impact of Wildfires: A Comprehensive Research Study

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The Economic Impact of Wildfires: A Comprehensive Research Study

Chippagiri Vishnu, Pareekshith US Katti

Abstract

While wildfires are crucial for maintaining forest health, their potential for destruction has intensified due to climate change and increasing temperatures. This research delves into the growing economic repercussions of wildfires, drawing from various research papers, published data, and exploratory analyses of forest fire datasets. The study reveals a significant rise in suppression spending per hectare, soaring from $800 in 2012 to a peak of $1400 in 2021. Projections anticipate a 5-year rolling average of $1161 and $1337 for 2030. Correspondingly, annual suppression costs have surged, reaching peaks of $4.390 billion (additive) and $5.125 billion (multiplicative) for 2030. Analyzing building destruction and restoration costs during 2000-2013, we found that 31% of the 13,035 destroyed buildings were restored, primarily in California. Damages, destruction, and restoration expenses exhibited upward trajectories. Under both building damage and complete destruction scenarios, the cost of building damage was $51.3 million in 2007. The most financially impactful destruction year was 2007, with costs totaling $562.7 million, while the highest restoration expense occurred in 2003, amounting to $297.11 million. Turning to human losses, including fatalities, injuries, and medical assistance, we observed peaks of 104 deaths in 2018, 194 injuries in 2022, and 650,000 medical assistance cases in 2007. Costs were quantified, with peak expenses of $1 billion (2018) for human life, $113.9 million (2022) for injuries, and $497.1 million (2007) for medical aid. The cumulative cost of human losses reached $1.3 billion in 2018, averaging $150 million annually. This study underscores the escalating economic impact of wildfires and stresses the immediate necessity for effective policies and proactive measures to mitigate their severe consequences. Our findings offer essential insights for policymakers, forest managers, and communities, guiding collaborative endeavors aimed at addressing the mounting challenges posed by wildfires in the forthcoming years.

Introduction

Wildfires are a vital part of forests, they play an important role in the overall health of the forest ecosystem. Wildfires are needed to remove dead organic material, increase fertility, and help in the reproduction of various plant species. But climate change and rising temperatures have made wildfires extremely destructive making it difficult to control them. Wildfires have become a catalyst for major environmental disasters and have caused huge economic losses in the affected region due to a decrease in rainfall, humidity, and an increase in temperatures (Daoping Wang et al., 2020). It has also led to adverse health conditions, including respiratory and cardiovascular disease, as well as exceptional health costs due to wildfire smoke (Fay H. Johnston et al., 2020). The effects of wildfire smoke on human health and the economic impact of wildfires have been widely discussed. In the past ten years, Spain and Portugal have accounted for approximately half of Europe's major wildfires, resulting in an average annual destruction of approximately 90,000ha of forest land (Hoinka et al., 2009). Unlike hurricanes and tornadoes, which typically last for several hours or a few days, wildfires can burn for an extended period of time, and controlled fire can cross containment lines or spread embers thousands of miles away to create new wildfires. Wildfires can have a significant effect on the overall carbon footprint of a region, as they can cause smoke to remain in the air until the rains come. This can lead to increased recovery costs and revenue loss due to non-operation, as well as damage to tourism facilities, accommodations, and infrastructure. In some cases, tourism activities that depend on forests may not be able to recover completely from the effects of a wildfire. This can have a long-term and damaging economic impact, as it can lead to a decrease in the revenue of tourism-related industries during the disaster, as well as a continued decrease in tourist demand and expenditure (Slocum et al., 2022).

Literature Review

The economic repercussions of wildfires have been on the rise as climate change has increased the frequency and intensity of wildfires around the globe. As a result, wildfires in the western United States have become increasingly hazardous, resulting in economic losses, property damage, and an increase in health-related illness and expenditure. The economic impact of wildfires in California alone for the year 2018 totalled $148.5 billion of which $88.6 billion (59%) in indirect losses, $27.7 billion (19%) in capital losses and $32.2 billion (22%) in health costs, all of which is roughly equivalent to 1.5% of California's GDP (Daoping Wang et al., 2020). In a similar study conducted in 2008, the economic implications of the changes in the labor market, the amount of suppression expenditure, and qualitative interviews were examined in the context of the economic impact of the Trinity County communities in California. 13 largest wildfires that happened in the summer of 2008 burnt a total area of 241050 acres and resulted in expenditures of over $150 million dollars in suppression spending. The authors also pointed out that the economic effects of wildfires on communities vary by sectors, and ultimately concluded that while wildfires will lead to the displacement of some economic activity, suppression efforts can lead to an increase in economic activity, provided that suppression efforts leverage local community resources (Emily Jane Davis et al., 2013).

Large fires like that of 2003 Old, Grand Prix and Padua wildfire complex in California was a 12500 acre blaze which was responsible for the evacuation of 100,000 residents, a total of 787 total losses and 3860 partial losses to property. Suppression cost amounted to $61 million, Rehabilitation costs of $534 million, indirect costs of $681 million including expenditures by the 13 largest insurance companies in the state and staggering total cost of $1.2 billion (Dunn et al., 2003).

In addition to the direct economic losses, the loss of tourist/visitor expenditure also has an economic impact. The authors conducted a study on five national parks in the state of Utah. The study covered a period from May 1993 through December 2015. The researchers found that Arches National Park had a loss of $ 780,000 (average) in visitor spending. Similar findings were made for all national parks, resulting in a loss of $ 2.89 million (average) during a typical fire year. Tax revenue was also negatively impacted, with the state and local governments projected to experience a decrease of $0.36 (average) in tax revenue (Man-Keun Kim et al., 2019).

A study was conducted on 2 major wildfires in Montana and New Mexico namely Canyon Ferry Complex Fire and Cerro Grande Fire respectively. The Canyon Ferry Complex Fire in Montana that started in July 2000 was due to two fires Cave Gulch and the Bucksnort burning on either side of Canyon Ferry lake in Helena National Forest. The fire burnt 43,944 acres of land and destroyed 6 homes. The suppression cost amounted to $9.5 million. As the fire burnt predominantly in Helena National Forest, there was a 10% decrease in recreational visits. The authors estimated the total cost including all direct, rehabilitation, indirect, and additional costs for the Canyon Ferry fire complex exceeded $18 million. The Cerro Grande Fire in New Mexico was a prescribed fire but broke fire lines due to high winds on May 4, 2000 which led to the burning of 42,873 acres, destroyed 260 homes and an estimated 18,000 people had to be evacuated from nearby communities, and also causing substantial destruction to the utility infrastructure. The suppression cost amounted to $33.5 million. As the fire caused extensive damages to the Los Alamos National Laboratory, repair costs totaled to $138 million and an additional $203 million to replace damaged equipment and facilities. The authors estimated a cost including all direct, rehabilitation, indirect, and additional costs for the Cerro Grande fire exceeded $970 million (Morton et al., 2003).

In another study of the Missionary Ridge Fire that burnt in Colorado in the summer of 2002, the fire was responsible for burning 70,000 acres, destruction of 57 homes and 27 additional structures causing evacuation of more than a thousand people in the affected region. The suppression costs for the fire amounted to $37 million. The authors estimated a total cost including direct, indirect, rehabilitation and additional costs of $152 million. Rodeo-Chediski Fire in Arizona burnt 4,62,614 acres of land of which 59% was in Fort Apache Indian Reservation, 38% inside National forest and the rest 2% in private land. The Fire was responsible for destruction of 490 structures and 30,000 people had to be evacuated from the affected communities. Suppression cost for the fire was estimated between $43 million and $50 million. Total direct costs amounted to $122.5 million, Rehabilitation costs of $139 million, and a total estimated cost of $308 million (Mitchell et al., 2007).

A further study published in 2014 provides an in-depth analysis of the effects of wildfire on employment growth in the western United States. This study examined the prevalence of wildfires in the region between 2004 and 2008, during which 346 wildfires were reported in the region, resulting in an associated cost of $2,400,000,000. The authors stated that economic activity quantified in terms of employment differs by industry and population size. Less populated regions/counties (below 250,000 inhabitants) are more susceptible to the adverse effects of wildfire than metropolitan areas/counties with a larger population. The conclusion of the study was that the effects vary between sectors. In the case of small population counties, the employment growth of leisure and hospitality, tourism, and recreational-oriented businesses decreases while the employment growth of natural resources, mining, and federal employment increases, which is likely due to the implementation of suppression measures. In large population counties, leisure and hospitality employment increased while federal employment decreased, indicating that the impacts of wildfires on complex and diverse economies are not uniform. However, any increase in employment was considered to be temporary, and it is important to emphasize that the positive employment growth developed into a negative decrease in local employment for a two-year period following the wildfire. (Cassandra et al., 2014).

A study was conducted to analyze the wildfire suppression contracts associated with 135 major wildfires that occurred in different types of counties, such as those with unincorporated economies, government-controlled counties, service-oriented counties, and counties with specialized industries such as mining, manufacturing or agriculture. The results of the study revealed a significant increase in the local capture of suppression contracts in counties with a larger number of vendors involved in federal non-fire related contracting. In addition, the study found that counties with a more diversified economy were more likely to receive suppression contracting opportunities than counties with a more specialized economy. The number of major wildfire suppression events rose from 19 occurrences in 2004 to 35 occurrences in 2008. The study found that the total cost of wildfire suppression for a sample of 135 major wildfires was USD 1.23 billion, with approximately 38% (USD 469 million) of total suppression costs attributed to private sector subcontractors. The authors found that local capture, a measure of the percentage of contracted expenses allocated to vendors in a county affected by a fire, was 13% on average. However, the rate of local capture varied significantly from fire to fire, ranging from zero to 63%, and in less than a tenth of counties, there was no local capture at all. The authors concluded that economic diversification combined with wildfire suppression contracting is a complex combination (Max Nielsen-Pincus et al., 2018).

A new study has revealed that insurance providers and homeowners alike are concerned about the increasing frequency of catastrophic wildfires in the United States, particularly in the western states. Media reports have highlighted insurance cancellations and cancellations due to wildfire risks, particularly in California, while neglecting the wildfire risks faced by policyholders with lower incomes. These lower-income homeowners face the challenge of investing in expensive fire protection measures, and the authors have conducted a study to determine that high wildfire risks are correlated with lower income and higher insurability risks. The authors further analyzed the prevalence of vulnerable dwellings in counties with elevated wildfire hazards and elevated poverty rates, as well as the potential impact of highly-concentrated insurance markets on lower-income households in states with elevated wildfire hazards but elevated poverty rates. The authors identified 14 states with highest wildfire risks namely, Arizona, California, Colorado, Florida, Idaho, Montana, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington, and Wyoming. The emphasis is placed on the geographic location of homeowners in states with a high risk of wildfires, taking into account both wildfire exposure and socioeconomic vulnerability. The authors point out that the majority of regions with high wildfire risk and socio-economic vulnerability are located outside of California. Despite this, California has been a leader in the implementation of moratoria for insurance cancellations and nonrenewals caused by wildfire risks, as well as providing subsidies to homeowners to protect their property. The Safer from wildfires program taken up by the state of California, is seen by the authors as the most well resourced program for wildfire prevention and protection and also programs like Firewise USA is seen as important for community based wildfire management. The authors urged the implementation of a concerted effort to combat the devastating wildfires across the United States by bringing together the various stakeholders who are impacted by wildfires, including federal and state governments, as well as local and tribal entities, as well as businesses, non-profit organizations, homeowners' associations, neighborhoods and individual homeowners. (Matthew et al., 2022).

In a 2013 study, it was revealed that the demographic trends of the United States have been affected by wildfire management issues, a decrease in population and housing concentration, population growth due to amenities in some non-metropolitan counties, and inter-regional population movements to the west and southeast, all of which have a lasting and significant impact on wildland–urban interface areas. The authors point out that wildfire management has been rendered more challenging due to the development of the Wildland-Urban Interface (WUI). An example of this is the wildfires in Southern California in 2007, which resulted in the destruction of 3,079 structures and suppression costs of $300 million; similarly, Montana has experienced wildfire issues, with 39% of the protected areas being located within the WUI and thus incurring higher suppression costs, which were 46% greater than those incurred in non-WUI wildfires in the state of Montana. (Roger B. Hammer et al., 2009).

In a further study conducted in 2013, the socio-economic impact of wildfires and the duration of vegetation recovery in the region were examined. The duration of vegetation recovery was based on a variety of variables, including vegetation structure, reproduction strategy, availability of water, soil degradation, fire frequency, and fire intensity. The authors identified three primary areas of wildfire damage, namely the effects on property, the effects on people, and the effects on ecosystem services. The most significant loss of ecosystem services was attributed to the carbon sequestration function of biomass, amounting to 4,054,907 TEUR (TEUR = 1000). This was followed by the loss of recreational opportunities provided by forests, amounting to 853,325 TEUR. Finally, the damage to productive functions of forests resulted in a loss of 622,739 EUR. The authors further noted that the short-term loss of recreational functions contributed approximately 2% to the total estimated damages. (María Victoria Román et al., 2013).

The economic impact of wildfires on tourism is twofold. First, during the initial stages of the disaster, tourism-related industries experience a direct decrease in revenue due to a decrease in visitation and cancellations. Second, in the aftermath of the disaster, there is a long-term effect on tourism demand and spending, as prospective travelers may be reluctant to travel to the affected regions due to a fear of limited amenities and attractions, resulting in a prolonged decline in tourism activities.

Wildfires have had a significant impact on the tourism industry in Kelowna, BC, Canada, which is home to the renowned Kettle Valley Railway National Heritage Site. This fire season saw 26,000 people evacuate their homes, as well as the destruction of 238 private homes, all of which had an impact on regional tourism infrastructure. Furthermore, the authors noted that the small businesses and accommodation sector were particularly vulnerable to the effects of the wildfire.The authors also provided an estimation of the duration of the adverse effects on various industries, with the food and beverage sector recovering three months following the wildfire, the accommodation sector recovering five months and the entertainment sector recovering ten months respectively, while the average duration was reported to be six months (Perry W. Hystad et al., 2008).

A comparable study was conducted on the impact of wildfire on local tourism-related businesses in the tourism sector of Portugal, which accounts for 10% of the country's GDP. Utilizing burned area data from 278 municipalities spanning the 2000 to 2016 period, the authors found a significant negative effect on the influx of domestic and incoming tourists. The authors further provided projections for the years 2030 and 2050, estimating that the economic impact of the affected region by 2030 is estimated to be between EUR 17.03 million and EUR 24 million for domestic tourists, and between EUR 18.26 million and EUR 34.08 million for incoming tourists. This cost is projected to increase fourfold by 2050. The authors presented projections of the number of municipalities that will be impacted, as well as projections of the burnt area for 2030 and 2050. They also discussed the psychological consequences of frequent wildfires, which will lead to a decrease in tourism, which in turn will have a negative impact on the local economy and businesses. (Otrachshenko et al., 2021).

In Portugal, the tourism season coincides with the wildfire season. The peak of the tourism season is during the summer months, when temperatures are at their highest and relative humidity levels are at their lowest, however, this coincides with the peak of the wildfire season, placing a strain on both the local population and tourists. The authors pointed out that wildfires in portugal never exceeded 1,50,000 ha of total burnt area but in 2000's portugal witnessed large wildfires such as the 2003 wildfire responsible for burning a total area of 4,71,750 ha and the 2017 wildfire burnt 5,39,921 ha. The authors brought in a different perspective on how wildfires affect the tourism-accommodation sector. On an average one hectare of burnt area reduces overnight stays in at least 3 units and each hectare of burned area in a municipality reduces overnight stays by 0.7 units. Burnt area is positively correlated to the number of stays after three months. This is explained by the authors as due to postponed bookings and reservations or a decrease in prices that might have occurred post wildfire (João Cerejeira et al., 2022).

Another paper examined the effects of wildfires and the accompanying smoke on nature-based recreational tourism in Southern Oregon. It proposes an accommodation-focused approach to tourism in Josephine County and Jackson County from the point of view of Airbnb hosts in the area. The authors have noted that visitors who visit during a fire-smoked season have negative experiences while enjoying outdoor activities. Furthermore, they have concluded that smoke is the primary cause of tourist cancellation, and that poor air quality reduces visitor satisfaction, making outdoor activities more hazardous and thus reducing return visits. (Slocum et al., 2022).

Each year, wildfires consume thousands of hectares of woodland during the summer months. The Mediterranean Basin is particularly prone to such destructive fires. The authors observed that areas that have been scorched by wildfires are more likely to experience them again. The cycle of destruction continues, making it increasingly difficult to restore and maintain these fragile ecosystems. Wildfires can have a considerable impact on the overall carbon footprint of a region. In addition to ecological damage, wildfires can also cause significant damage to tourism facilities, accommodation, and infrastructure. This can lead to increased costs for recovery efforts, as well as significant revenue losses due to the cessation of operations. Furthermore, wildfires can have a particularly detrimental effect on tourism activities that depend on forests for their livelihoods. In some instances, forestry-dependent tourism activities may never fully return to their pre-wildfire condition, resulting in a lasting negative impact on the tourism sector. The authors draw attention to two distinct events, one of which is the Saittas fire incident in Cyprus on 29 June 2007, which affected the Troodos mountain area, located approximately 55 km from the capital Nicosia. This fire spread to the surrounding villages, causing damage to both private and public forests, covering an area of 12 square kilometers. The other is the summer 2007 fires in Greece, which caused the death of 87 people, the destruction of over 150 villages, the destruction of housing and infrastructure, and the destruction of over 1,500 dwellings and the homes of more than 3,000 people. The estimated economic damages from the 2007 fires in Greece totaled to approximately 3.5 billion euros, while the cost of fire-fighting operations reached around 600 million euros. The conclusion of the study was that the effects of wildfires on the tourism industry can have a lasting impact on the local economies. This can lead to a decrease in tourism-related activities, a decrease in social activities, and a decrease in the number of people visiting rural areas, all of which may necessitate a substantial effort to rebuild and revive the regions affected. (Boustras et al., 2013).

A study was conducted to assess the effects of wildfire on tourism in Florida, taking into account the tourist perception and responses to wildfires. Data was collected from

771 non-resident overnight leisure travelers, categorizing them into three groups: Conscious Travelers, Caution Travelers and Courageous Travelers, all of whom demonstrated varying levels of risk perception. The survey included a variety of questions related to topics such as risk perceptions of wildfires, attitudes towards wildfires, travel use patterns and other travel behavior. In the 3 segments of travelers, Conscious Travelers represented 42% and showed willingness to travel while being cautious about wildfire situations and assessed the wildfire conditions and risks beforehand. 45.5% of Conscious Travelers were open to changing there travels plans due to road closures, 45.3% for health issues due to arising smoke and ash, 45.3% due to presence of smoke from current fire in the destination region, 54.5% due to multiple fires occurring in the state but not in their vacation region and 46.2% were willing to change plans for prescribed controlled fires in their vacation region. Cautious Travelers represented 25% of the segment and placed strong emphasis on safety and risk avoidance. When encountered with even the smell of burned wood in the air Cautious Travelers took significant action, with 46.2% opting to cancel their trip, 47.4% changing their destination, and 40.7% modifying their activities. The presence of multiple fires occurring in the state but not in their vacation region led to the highest cancellation rate (53.8%) and destination changes (78.3%) among Cautious Travelers. Similarly, when faced with prescribed controlled fires in their vacation region, they were likely to cancel their trip (62.1%) and opt for a different destination (35.7%). Courageous Travelers representing 33% of the segment were open to travel regardless of wildfires. Courageous Travelers were less inclined to alter their travel behaviors due to particular wildfire situations. The authors also suggested that the segmentation approach utilized in this study offers valuable insights for Destination Management Organizations, enabling them to craft targeted marketing messages tailored to each segment during crisis situations (Brijesh at al., 2013).

Wildfires are one of the primary threats to the environment, however, the trail of smoke they produce is another major environmental concern. Not only does this smoke pose a risk to human health, but it also affects air quality and can exacerbate respiratory conditions. With the increasing frequency and intensity of wildfires, it is essential to address the secondary effects of smoke emissions in order to protect human health and the natural environment.

This study provided a comprehensive overview of the megafires that occurred in Australia between 2019 and 2020. The fires burned for a period of six months and caused the destruction of an estimated 8 million hectares of mainly eucalyptus forest. The 2019-2020 fire season was a major global anomaly, as the smoke related health costs amounted to AU$ 1.95 billion which is over nine times the median annual wildfire-associated costs for the previous 19 years (AU$211 million). This health cost was mainly due to an estimated 429 premature deaths, 3,230 hospital admissions for cardiovascular and respiratory disorders, and 1,523 emergency attendances for asthma. Wildfire smoke is a complex and dynamic combination of particulate matter, nitrogen dioxide and a variety of gaseous compounds, such as carbon monoxide, VOCs and polycyclic aromatic hydrocarbons, which can cause severe air pollution in affected regions for weeks to months. Furthermore, PM 2.5 has been demonstrated to be a major contributor to cardiovascular and respiratory health issues. Wildfire smoke can affect not only the region of origin, but also transnational air quality, with the 2019-2020 megafires having a significant impact on air quality in New Zealand. (Fay H. Johnston et al., 2020).

A similar paper where the authors estimate 5200 to 8500 respiratory hospital admissions per year from 2008 to 2012 due to exposure to wildfire smoke. Estimated 1500 to 2500 PM 2.5 related deaths caused by wildfire smoke over a five-year period. Highest number of PM 2.5 related deaths and hospital admissions happened in the year 2008 when PM 2.5 concentration was the greatest among all the years considered. The combined economic value of short-term PM 2.5 related premature deaths and hospital admissions was estimated by the authors to be between $11 billion to $20 billion per year. The combined economic value of long-term PM 2.5 related premature deaths and hospital admissions was estimated by the authors to be between $76 billion to $130 billion per year (Neal Fann et al., 2018).

A study analyzed the relationship between air quality and tourism demand in specific destinations, for this authors analyzed monthly data spanning from January 2008 to December 2015 for five European countries namely Austria, Cyprus, Great Britain, Italy, and Switzerland. In Austria and Italy, the growth of tourism appears to have a negative impact on air quality. In contrast, in Cyprus and the United Kingdom, the already poorer air quality of a destination can result in a decrease in tourist demand. Over time, pollution has a negative effect on tourism in Cyprus, with higher pollution levels resulting in a drop in tourist demand. In the United Kingdom, tourism has a significant negative impact on PM10, suggesting a link between tourism activity and air pollution. In the case of Italy, the increase in tourism demand is strongly linked to an increase in particulate matter (PM10) levels, particularly over a period of five months or more. In the case of Austria, the surge in tourism has a considerable and detrimental effect on the air quality, leading to an increase in PM10 levels (M. Robaina et al., 2020).

Each year, in the northern region of Thailand, the presence of small particles in the air becomes a major issue, largely due to wildfires and the burning of agricultural-weed. A study investigated the impact of small particles on tourism-related small and medium-sized enterprises (SMEs) in the Chiang Mai region of Thailand. The research was conducted by collecting data from 286 entrepreneurs active in the tourism-related SME sector. Every year, the city of Chiang Mai experiences an excessive amount of SPM, which exceeds the normal atmospheric air quality levels, particularly during the months of January to April. Small particulate matter (SPM) has a wide range of negative impacts on health, the environment, and the economic sector. The tourism industry is particularly affected and the decreased visibility of SPM has resulted in travel disruption and cancellation. The authors reviewed five businesses and found that three of them, namely Accommodation, Travel Agencies, and Souvenir Businesses, were affected by the issue. The results of the study suggest that the most significant impact of small particulate matter is on tourism-related industries, with a particular focus on the reduction of tourists and customers in tourism-related industries (Srinamphon et al., 2022).

Wildfires in the Western United States are becoming increasingly severe and frequent, and are increasingly difficult to forecast due to the wide range of ecological diversity and the variability of vegetation, soil, hydrological and topographical elements that affect fire regimes in the region. The authors noted that the fire data available is mainly from the past decade and a half, as climate and human activities have undergone rapid changes during this time. The authors conducted a study to reconstruct the burning levels of sedimentary charcoal over the past 3,000 years in the western United States. They found that burning increased during periods of high temperatures and drought, and decreased during periods of cooler, less drought-prone conditions. Furthermore, they noted that human activity following the late 1800s had a significant effect on biomass burning. Taking into account future projections of an increase in temperature and increased drought, the authors caution that fire regimes in the future will be more extreme than those observed over the last 3,000 years. The authors concluded that a comprehensive comprehension of historical, archaeological, and charcoal records is necessary for future responses to climate-induced wildfires.(Marlon et al., 2012).

The report by the National Fire Protection Association from the year 2007 to 2011 estimated that the US local fire departments responded to an average 22,600 fires per year. Federal and state wildfire fighting agencies reported that from the year 2008 to 2012 the average lightning-caused wildfire burned nine times more than the average of human-caused wildfires. Lightning-caused wildfires on an average burnt 3.6 million acres which is 55% of the total 6.5 million acres that got burnt due to wildfires in the same period from 2008 to 2012 (Marty, 2013).

The authors in this report considered all types of fires including structure fires, vehicle fires and outside fires. The authors stated that in 2021 alone the local fire departments responded to over 1.35 Million fires in the US and these fires resulted in an estimated loss of $15.9 Million, majority of which were structure fires.Loss of human life was more in the same year of 2021, as it accounted for 3800 civilian deaths and an enormous 14,700 people injured. The authors stated that fires in the Colorado wildland/urban interface (WUI) caused $648 billion in direct property damage and this was part of the category called outside and other fires. The authors approximated that in 2021 49% of all reported fires were categorized as other and outside fires. The authors estimated 658,500 outside and other fires which were responsible for the death of 110 civilians, 600 injuries and an economic loss of $363 Million. The direct property damages totaled up to $156 Million. (Shelby et al., 2022).

The authors give a comprehensive report including the total cost of fires in the United States from 1980 to 2014. The total cost of fire includes both the net expenditures on fire protection and also net losses due to wildfires. The authors state that for the year 2014 the total cost of fire was estimated at $328.5 Billion which is equivalent to 1.9% of GDP of the USA. Of the $328.5 Billion, $273.1 billion was the cost of expenditure and the rest $57.4 billions in losses.The authors apart from expenditures and losses they have also provided yearly Value of Statistical Life (VSL) and yearly Value of Statistical Injury (VSI). The authors in the report give a comprehensive explanation for calculating VSI using VSL. For calculating VSI the scores has been differentiated into six levels in MAIS scale classification and it is as follows: minor (0.003), moderate(0.047), serious (0.105), severe (0.266), critical (0.593) and lastly unsurvivable (1.000). The authors used the moderate class for calculating VSI from VSL. The authors have provided VSL and VSI from the year 1980 to 2014 including $ values adjusted to 2014. The authors have also provided comprehensive guides and formulas to calculate expenditure cost for protection, donations to fire departments, fire insurance expenditure, direct loss which includes human losses and lastly indirect loss (Zhuang et al., 2017).

Methodology

Suppression Costs Due To Wildfires:

Suppression cost data was sourced from the National Interagency Fire center (Suppression Costs | National Interagency Fire Center, n.d.). The data included records of all fires from 1985 to 2022, the total acres burnt, and the corresponding suppression spending by the Forest Service and DOI Agencies in U.S. dollars. The suppression cost for one hectare of burnt area was calculated from 1985 to 2022. The cost has fluctuated between the years but the overall trend seems to be increasing (Fig 1). Fig 1 shows that the highest suppression cost per hectare was $800 until 2012. Subsequently, after 2012, suppression costs have exceeded $800 in a majority of cases and reached a peak of $1400 in 2021.

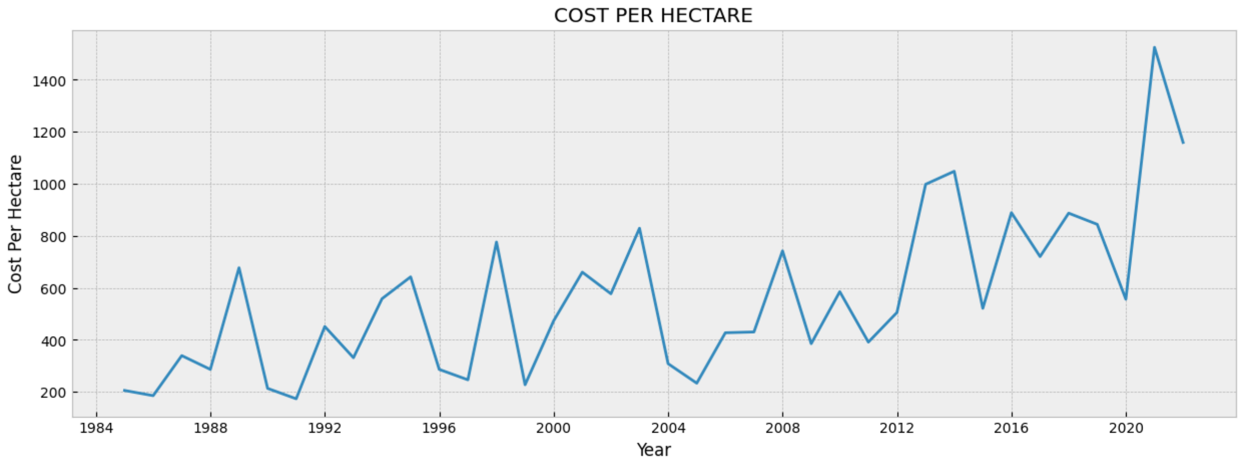

Fig 1: Overall Trend Of Cost Per Hectare

In order to obtain a more clear representation of the trend, a 5-year rolling average of the same data was calculated to smooth out the curve. (Fig 2). The same pattern can be observed in Fig 2, where the cost per hectare increases at a relatively stable rate until 2012, but then increases at a faster rate after 2012, with a more pronounced increase after 2020.

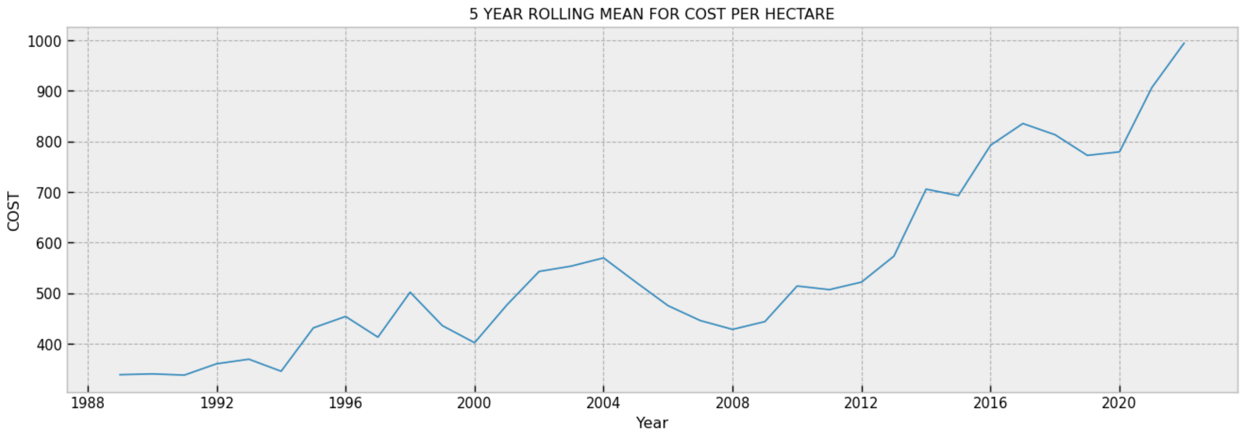

Fig 2: Five Year Rolling Mean Of Cost Per Hectare

Utilizing the calculated 5-year rolling average, an estimate of suppression cost was projected for one hectare of burned area over the period of 2023-2030. For forecasting, an exponential smoothing model with trend (degree 2) was employed. We used two trends models for forecasting namely additive (Fig 3) and multiplicative (Fig 4). The additive trend forecast estimates a cost of $1161 per hectare in 2030, while the multiplicative trend forecast estimates a cost of $1337 per hectare in 2030. Since the forecast was done using a 5 year rolling mean, fluctuations are expected in actual data.

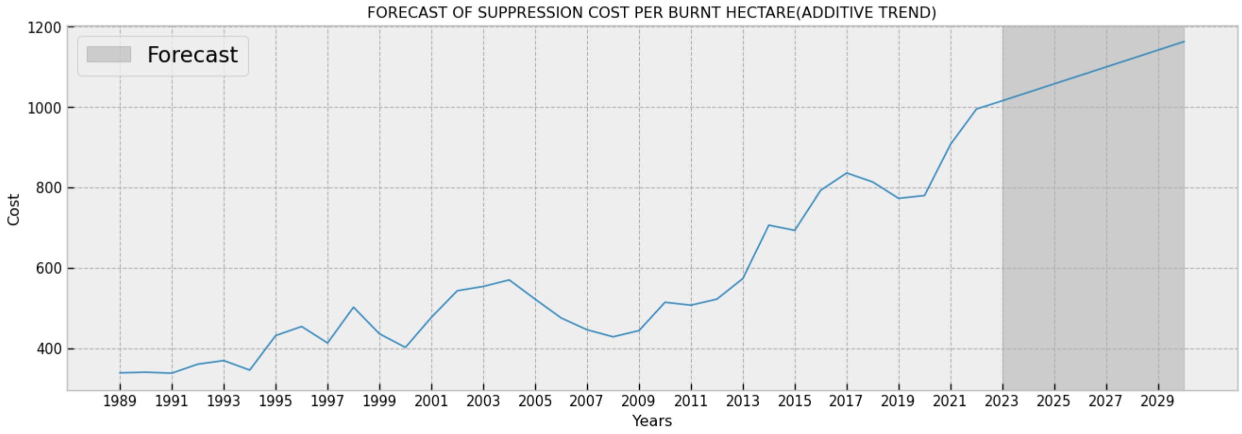

Fig 3: Cost Per Hectare with Additive Trend

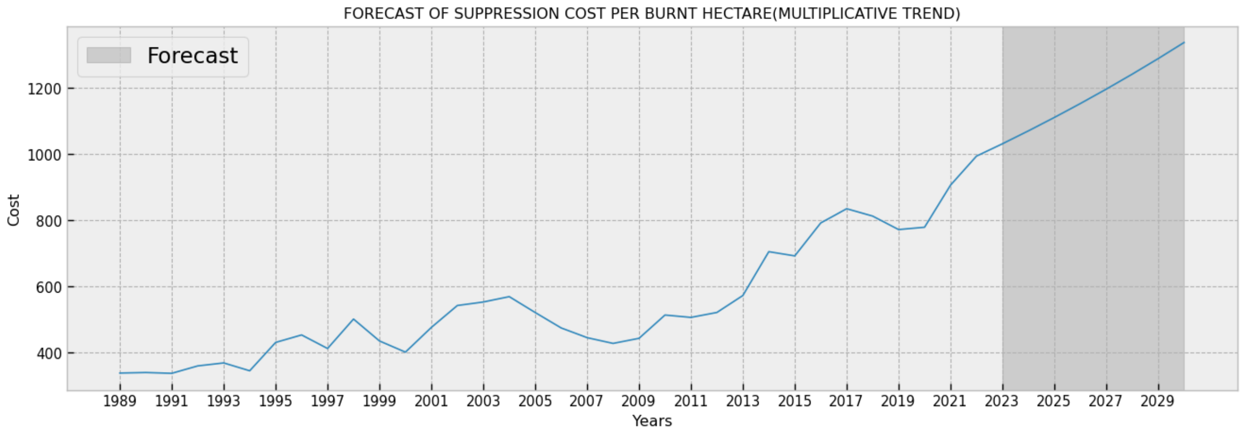

Fig 4: Cost Per Hectare with Multiplicative Trend

Similarly, Total suppression costs for all the fires from 1985 to 2022 was obtained from the same data. The Total suppression cost as depicted in Fig 5 indicates that the total cost remained below the $2 Billion threshold until 2012, however, the suppression cost increased after 2012 and increased significantly after 2020. To analyse the trend, the 5 year rolling average of the same was calculated (Fig 6) and a similar trend was observed, indicating that the cost increased significantly every five years after 2000.

Fig 5: Total Suppression Cost from 1985 to 2022

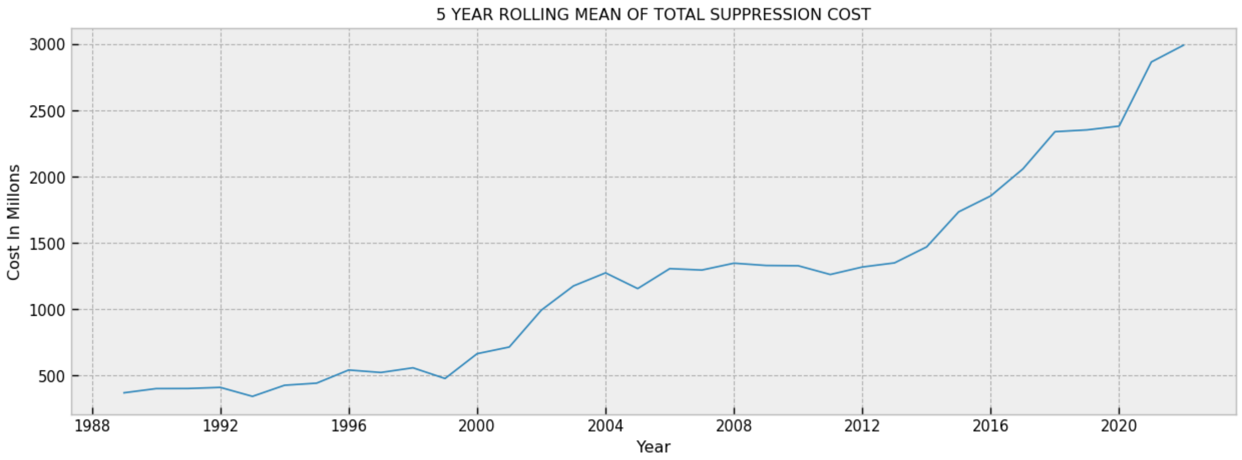

Fig 6: Five Year Rolling Mean Of Total Suppression Cost

Utilizing the 5 year rolling mean of total suppression cost we forecasted an estimation of total suppression cost from 2023 to 2030. As stated above we used the Exponential Smoothing Model with Trend (Degree 2). Fig 7 and Fig 8 show additive forecasting and multiplicative forecasting respectively. The additive trend forecast estimated a total suppression cost of $4.390 Billion for the year 2030 and the multiplicative trend forecast estimated a total suppression cost of $5.125 Billion for the year 2030.

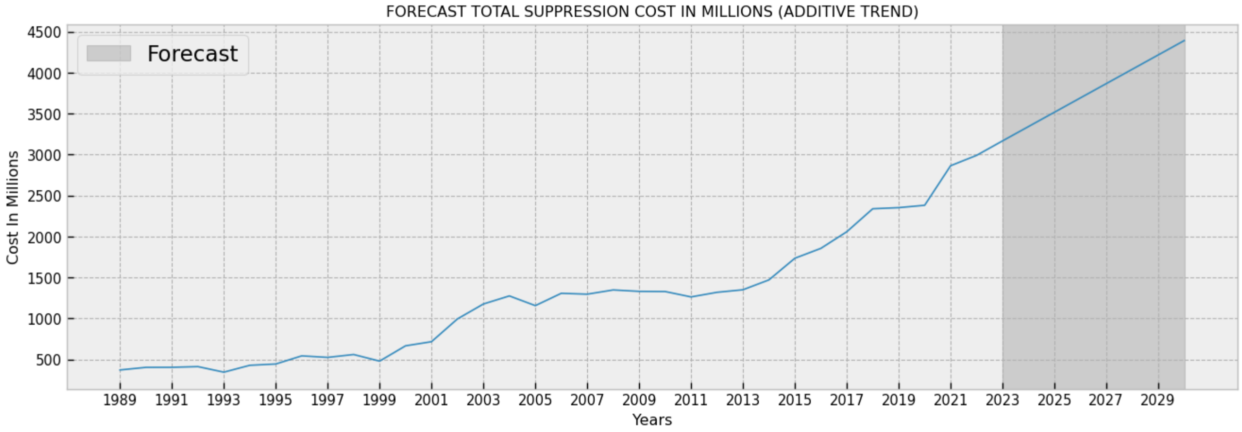

Fig 7: Total Suppression Cost with Additive Trend

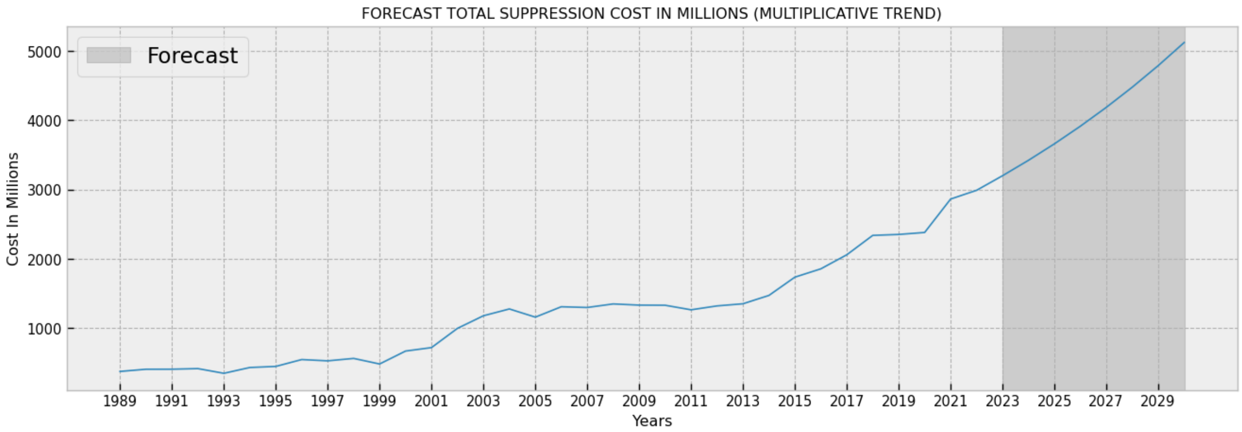

Fig 8: Total Suppression Cost with Multiplicative Trend

Effect on Buildings due to Wildfires :

The number of buildings damaged or destroyed by wildfires was evaluated using data collected from the US Department of Agriculture's Research Data Archive (Kramer et al., 2023). The data comprised all records of structural damage/loss of structures caused by wildfires between 2000 and 2013 for nearly all states in the United States. Each building within the wildfire perimeter is assigned a geometry, and the data assigns a destruction code to each building, with UH indicating Unimpacted Buildings, BH indicating Burned Buildings, RH indicating Rebuilt Buildings, and NH indicating New Buildings. In this research study we have considered BH and RH separately and then estimated the cost for both BH and RH and finally calculated the total cost. The data was aggregated yearly and the total number of buildings that got destroyed due to wildfires and restored after the wildfire from the year 2000 to 2013 was calculated. Fig 9 contains the total number of buildings burnt per year. Total number of buildings destroyed/damaged for the year 2000 to 2013 was 13035.

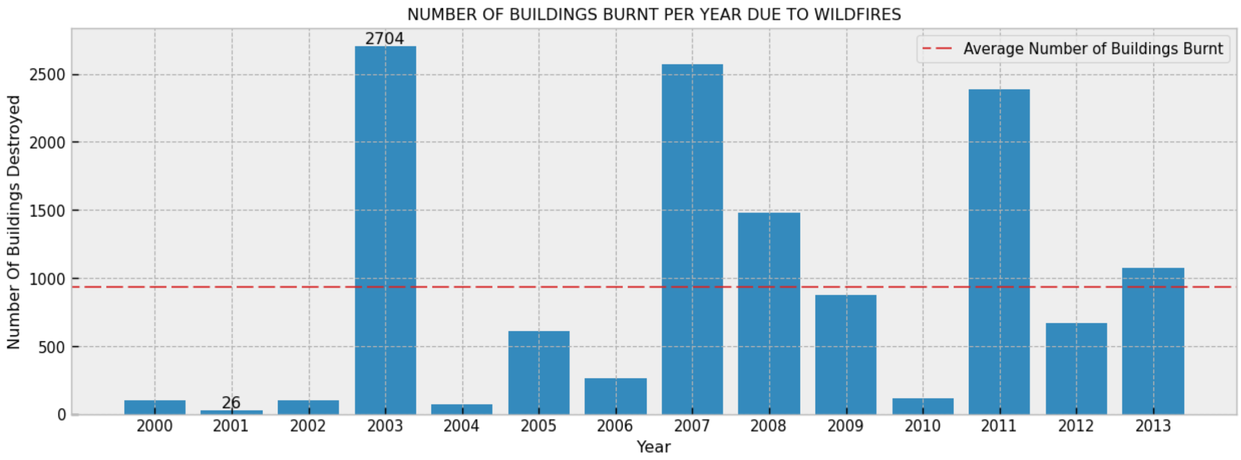

Fig 9: Total Number of Buildings Destroyed due to Wildfires.

As seen from the above Fig 9, the years 2003, 2007 and 2011 have sharp peaks. In order to gain a comprehensive understanding of the damage caused by wildfires, we examined which states were most impacted by wildfires and consequently incurred property damage. As a result, we plotted all point-geometry of each building destroyed/damaged by wildfires in Fig 10.

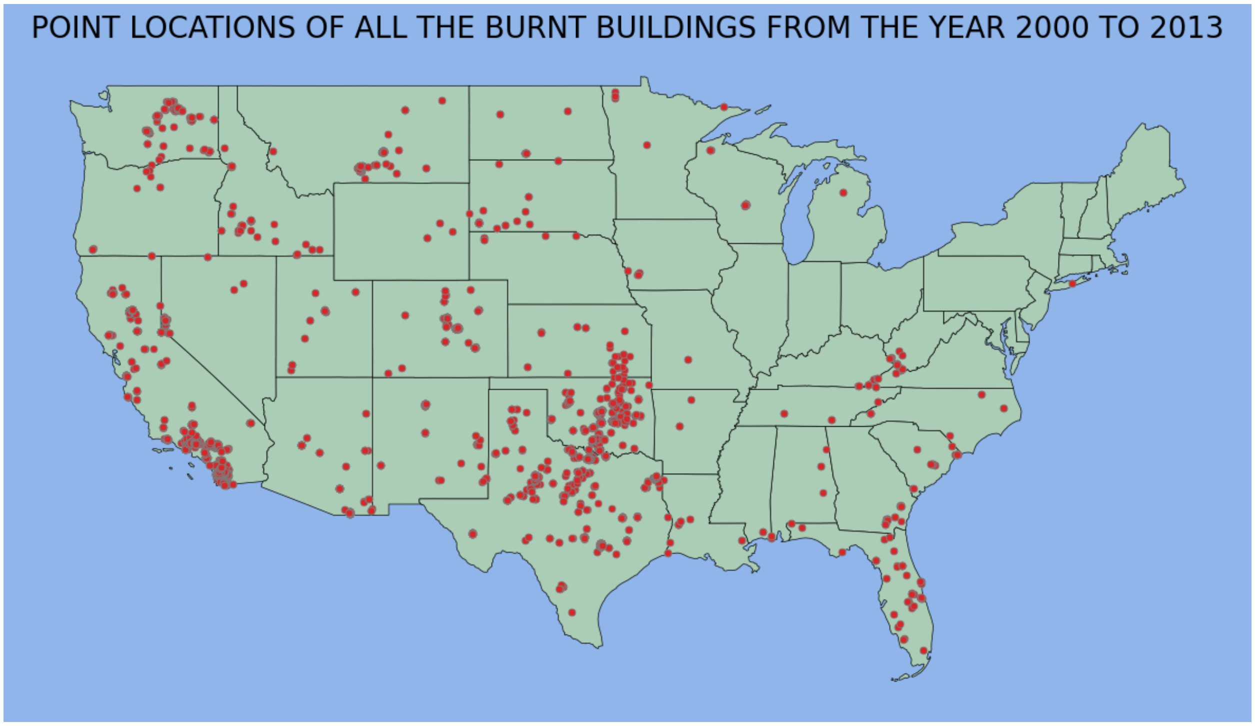

Fig 10 : Buildings Burnt due to Wildfires

In addition, the top 7 most impacted states were identified and the number of reported buildings burnt per state was calculated as outlined in Fig 11 below. California (6621) had the highest number of buildings burnt by a huge margin followed by Texas (2491), Colorado (949), Oklahoma (910), Arizona (524), Washington (371) and Montana (228).

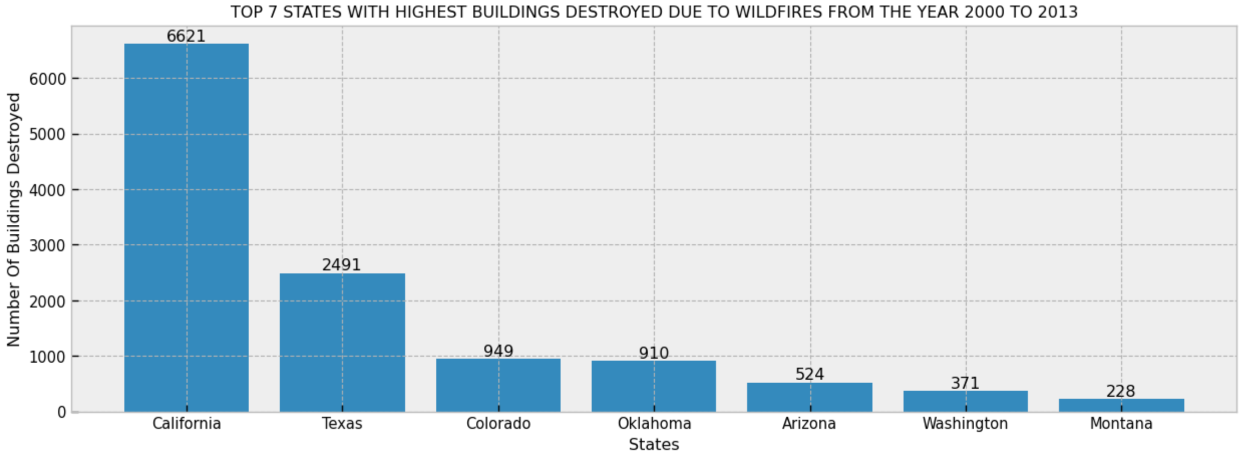

Fig 11: Top 7 States with Highest Buildings Burnt

Fig 12 shows the point geometries of all the buildings destroyed/damaged due to wildfire in the above mentioned states.

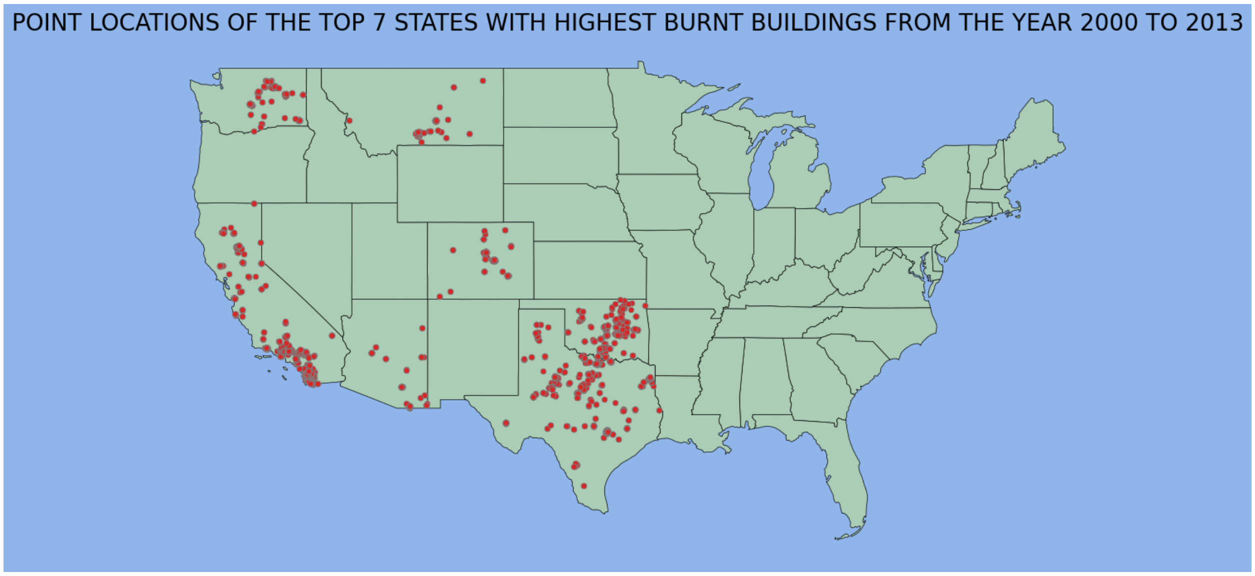

Fig 12 : Top 7 States With Highest Buildings Burnt

Similar to the above analysis carried out on BH that is Buildings Destroyed/Damaged due to wildfires, we also analysed RH that is buildings that were restored after the wildfire. Fig 13 shows the number of all the buildings restored per year.

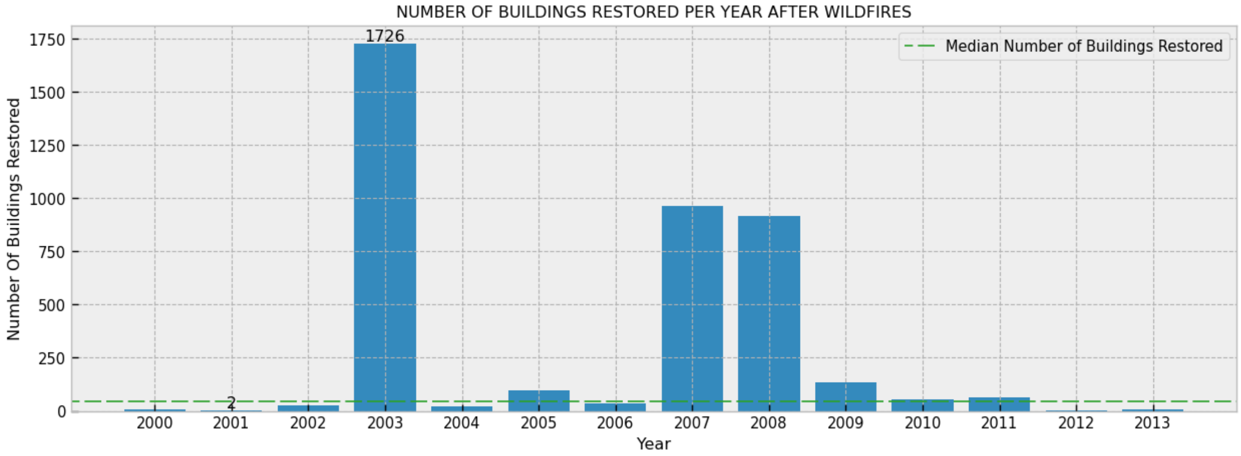

Fig 13: Total Number of Buildings Restored after Wildfires.

Total number of buildings restored from the year 2000 to 2013 was 4064 and as seen from the above Fig 13, the year 2003 has a noticeable sharp peak, and when compared with Fig 9, it shows even though there are sharp peaks around the year 2007 and 2011 they do not correspond to similar peaks in Fig 13 showing the unwillingness to restore buildings damaged after a wildfire and this maybe due to the cost involved with restoration efforts. In order to gain more insights on all the buildings restored and also to understand which states had restored the most buildings we plotted the below Fig 14, which gives all the point-geometry of each building restored after wildfires.

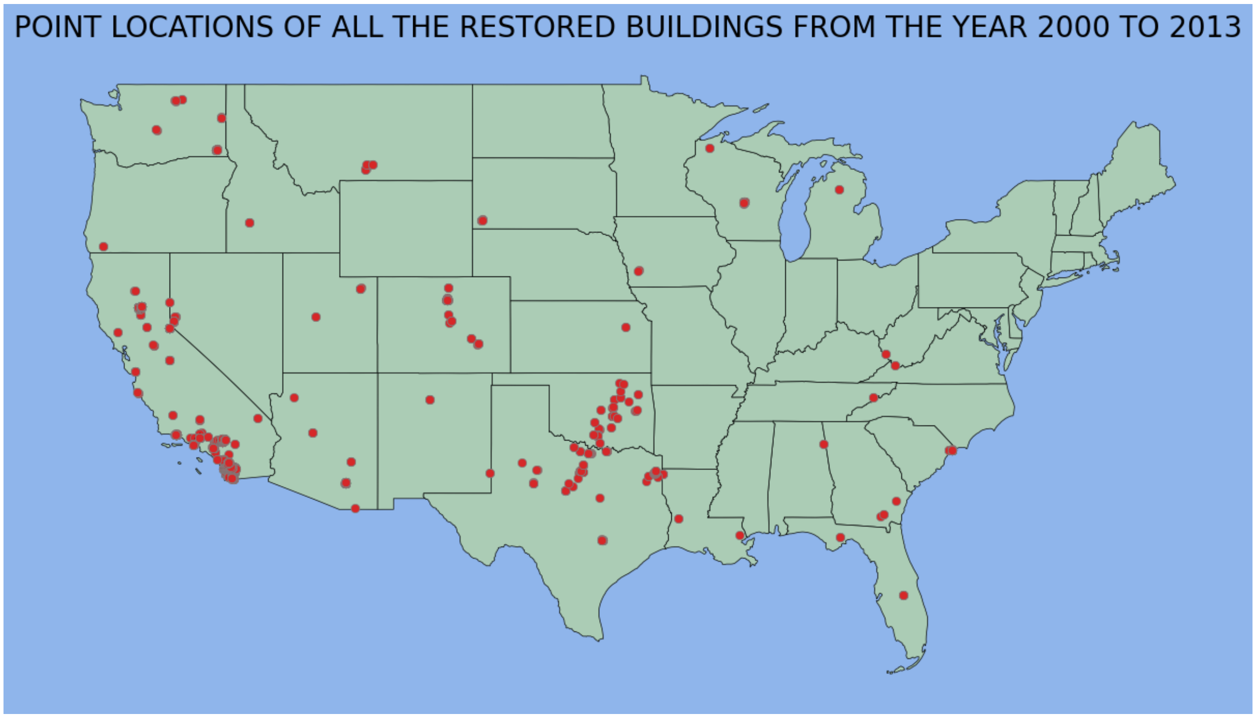

Fig 14: Buildings Restored after Wildfires

The top 7 most impacted states were identified and the number of reported buildings restored per state was calculated as outlined in Fig 15 below. California (3556) had the highest number of buildings destroyed by a huge margin followed by Texas (100), Colorado (77), Arizona (73), Oklahoma (51), South Carolina (50) and Washington (44).

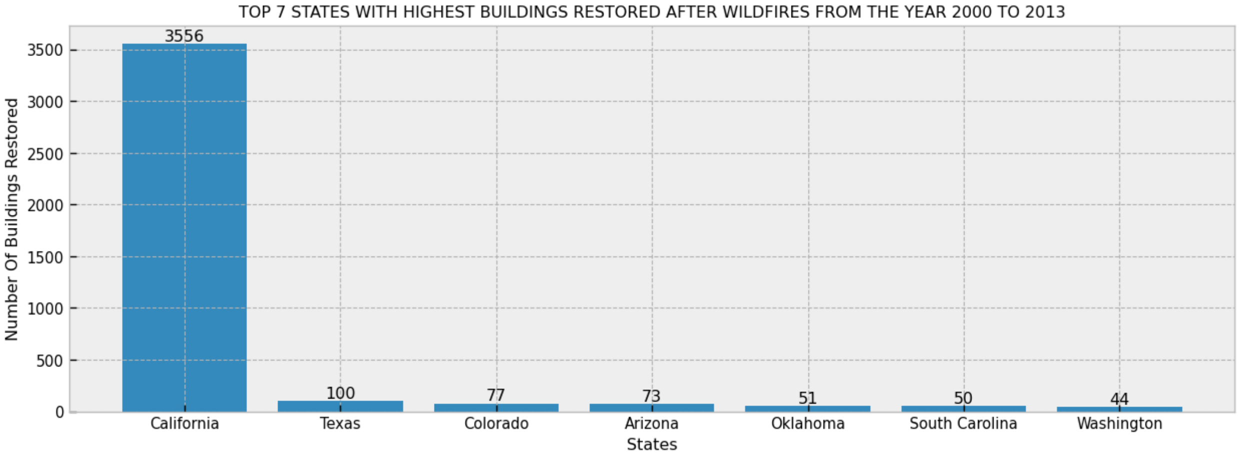

Fig 15: Top 7 States with Highest Buildings Restored

Fig 16 shows the point geometries of all the buildings in the above mentioned states.

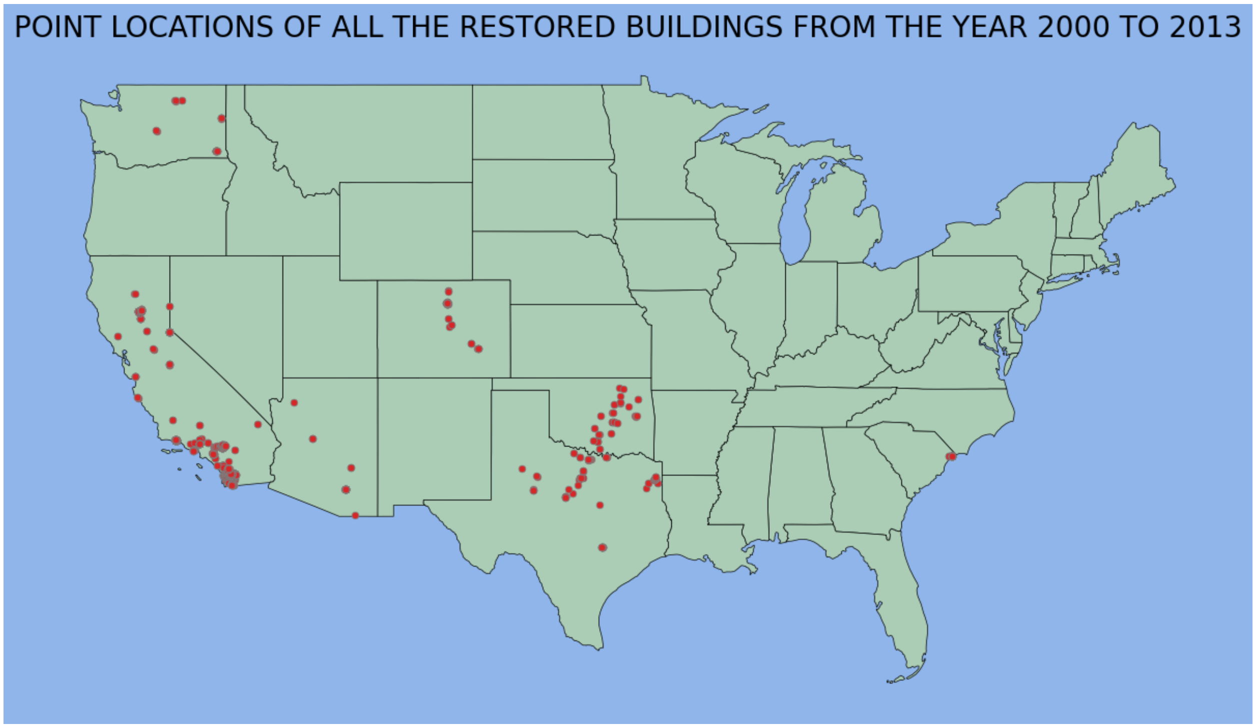

Fig 16: Top 7 States With Highest Buildings Restored

Two scenarios were taken into consideration for buildings that were affected by the fire. In the first scenario, buildings categorized as BH were solely damaged by the fire. The second scenario involved the complete destruction of all buildings falling under category BH.

We sourced the average cost of structural damage data for buildings from 1980 to 2021 from the National Fire Protection Association (NFPA) report - Fire Loss in the United States, expressed in U.S. dollars (Shelby et al., 2022).

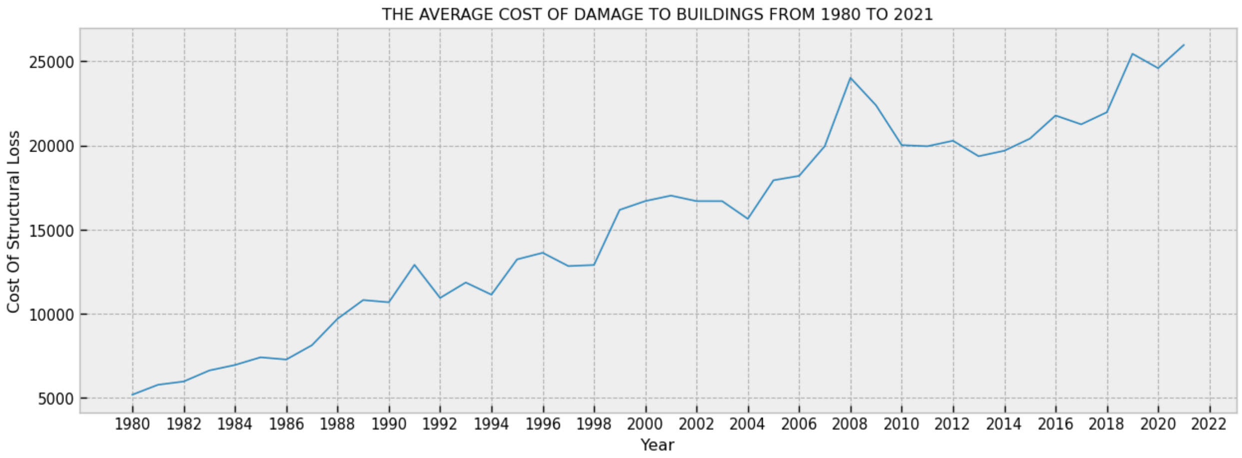

Fig 17: Average Cost for a Damaged Building

Fig 17 illustrates the average cost of damaged buildings over the period 1980-2021. The average cost has increased significantly, with a notable increase in 2008, which may be attributed to the financial crisis. To comprehend the linearity of Fig 17, we have calculated the 5-year rolling average. Fig 18 illustrates the 5-year average cost per damaged building.

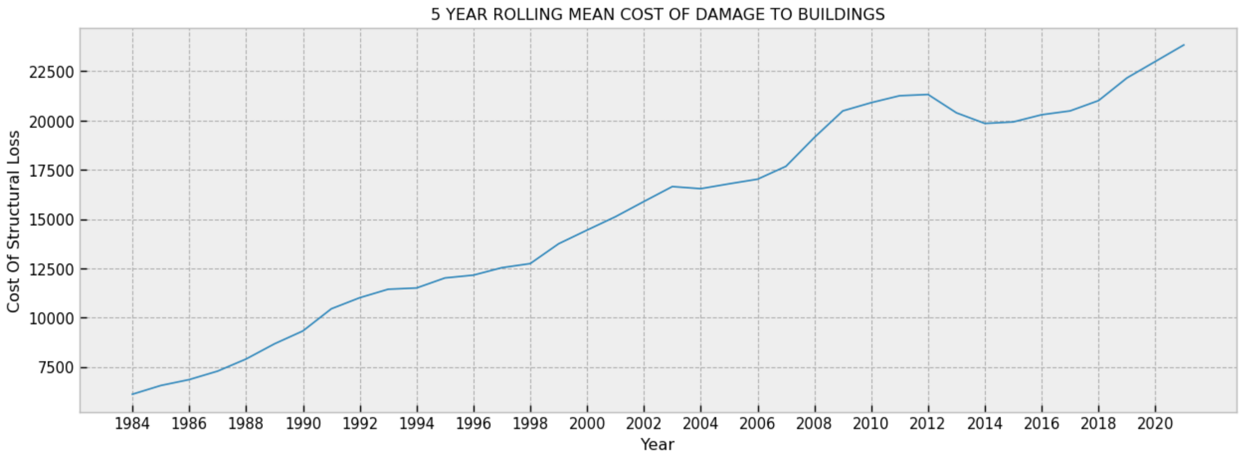

Fig 18: Five Year Rolling Mean Cost for a Damaged Building

The cost per damaged building increases in Fig 18, and the growth rate between 2008 and 2012 is higher than the previous years. However, the cost decreases immediately for a few years, and then increases at the same rate as the subsequent years. Utilizing the five-year rolling average, we projected an estimate of the cost per building damaged over the period 2022-2030 using the exponential smoothing model with trend (degree 2). The additive trend forecast predicted that the cost of buildings damaged due to fires in 2030 would amount to $31400, while the multiplicative trends forecast predicted the cost of damages to buildings due to fire would amount to $33000 in 2030. Fig 19 and Fig 20 illustrate the additive and multiplicative trend forecasting respectively.

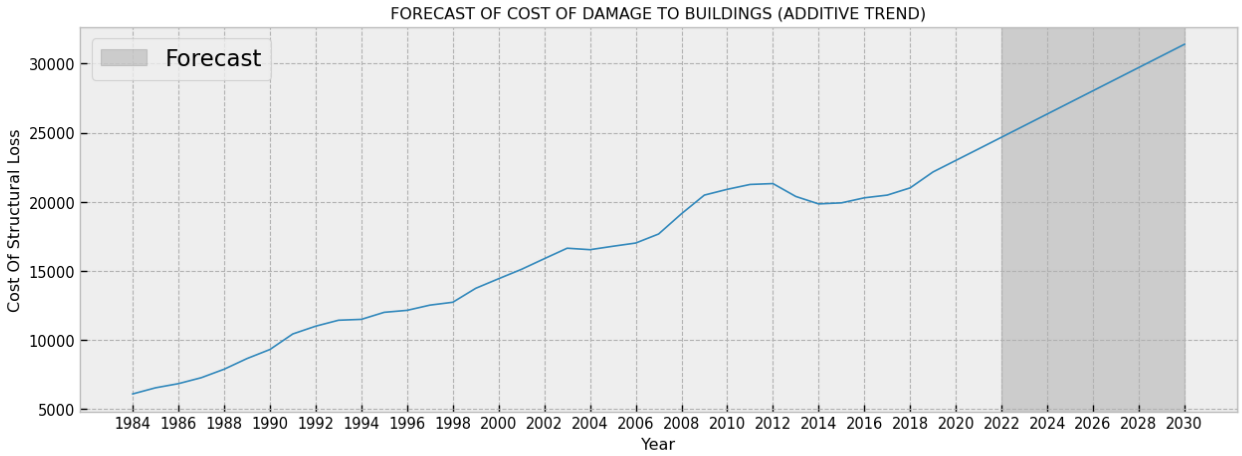

Fig 19: Cost of Damaged Building with Additive Trend

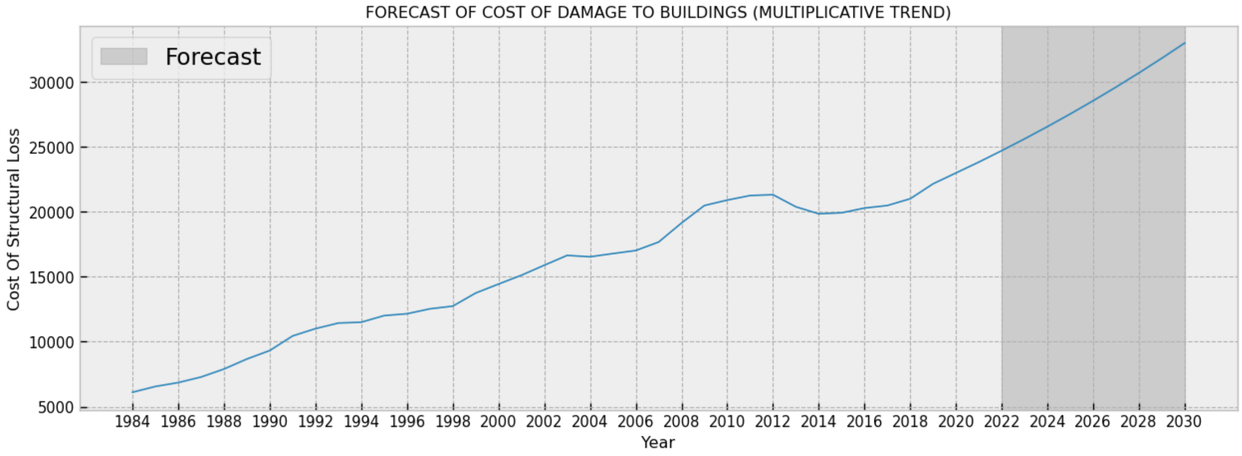

Fig 20: Cost of Damaged Building with Multiplicative Trend

Fig 19 and Fig 20 demonstrate that the difference in estimated cost for 2030 is lower than $2000, indicating that the outcomes obtained from additive and multiplicative trends are comparable. From the above, the total annual cost of damaged buildings over the period 2000 to 2013 can be calculated in Fig 21.

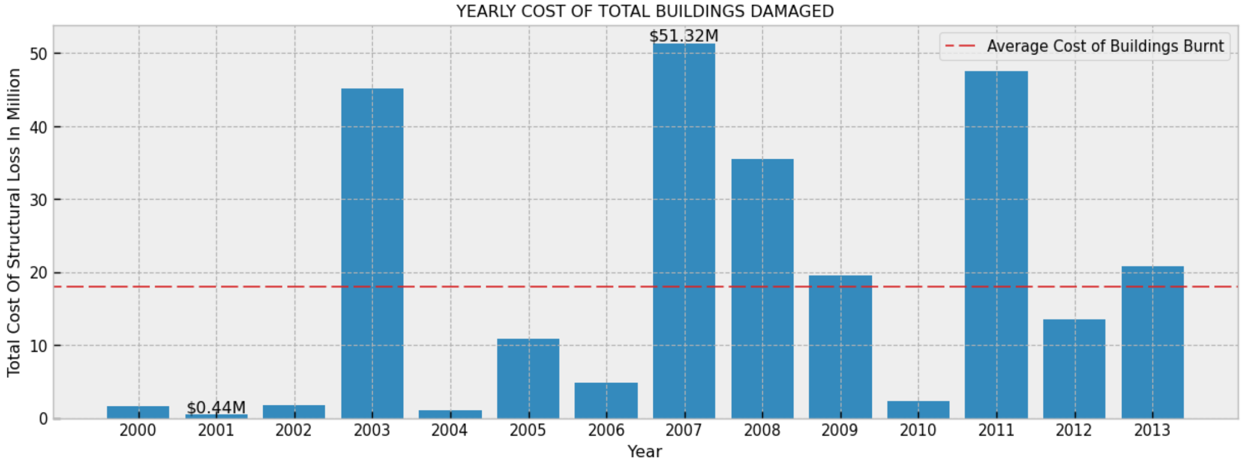

Fig 21: Yearly Cost of Damaged Buildings.

In Fig. 21, we observe significant fluctuations in the costs associated with buildings damaged by wildfires during the years 2003, 2007, and 2011, coinciding with the total count of buildings that were damaged/destroyed, as evident in Fig. 9. The data reveals that the highest recorded cost for building damages occurred in 2007, reaching $51.3 million, whereas the lowest cost was observed in 2001 at $440,000. Over the period spanning from 2000 to 2013, the average cost for the loss of buildings was $18.3 million. In addition, we derived the five-year average costs for rebuilding buildings following wildfire incidents. The years 2000 to 2004 yielded an average cost of $9.99 million, followed by $24.41 million for the period of 2005 to 2009, and $21.05 million for the years 2010 to 2013.

In the second scenario, where all the buildings within category BH were assumed to be destroyed, we calculated the associated cost using the total cost required for the construction of a building. Notably, this cost estimation was based on the average cost associated with constructing a typical single-family American household. The relevant data regarding the construction cost of houses was sourced from Economics & Housing Policy, provided by the National Association of Home Builders (E. Lynch, 2023). Fig 22 illustrates the average building costs per year within the period spanning 1998 to 2019. It is evident from the graph that there was a reduction in construction costs during the year 2011, which was subsequently followed by a significant upward trend until 2017. In order to gain a clearer insight into these trends, we generated a graphical representation depicting the 5-year rolling mean of construction costs, as displayed in Fig 23.

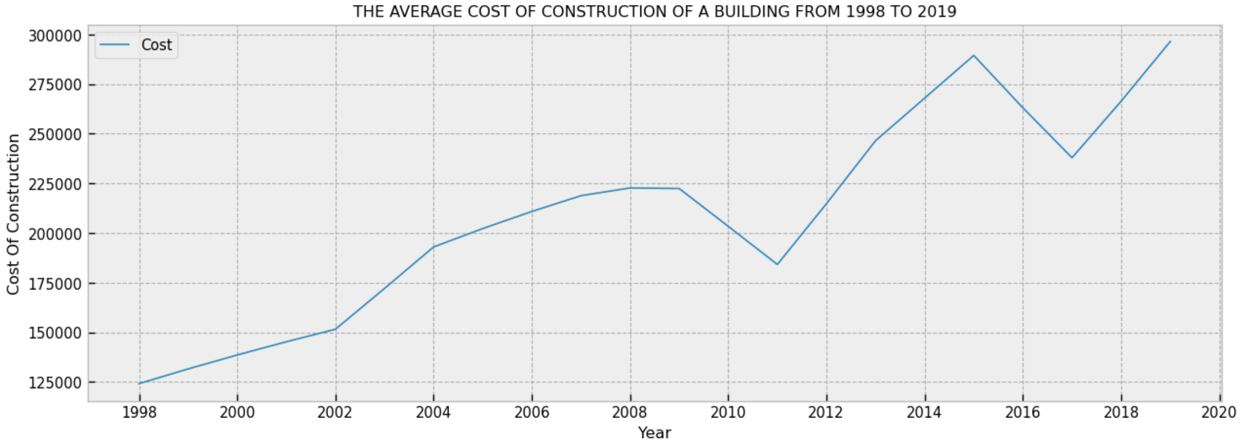

Fig 22: Average Construction Cost

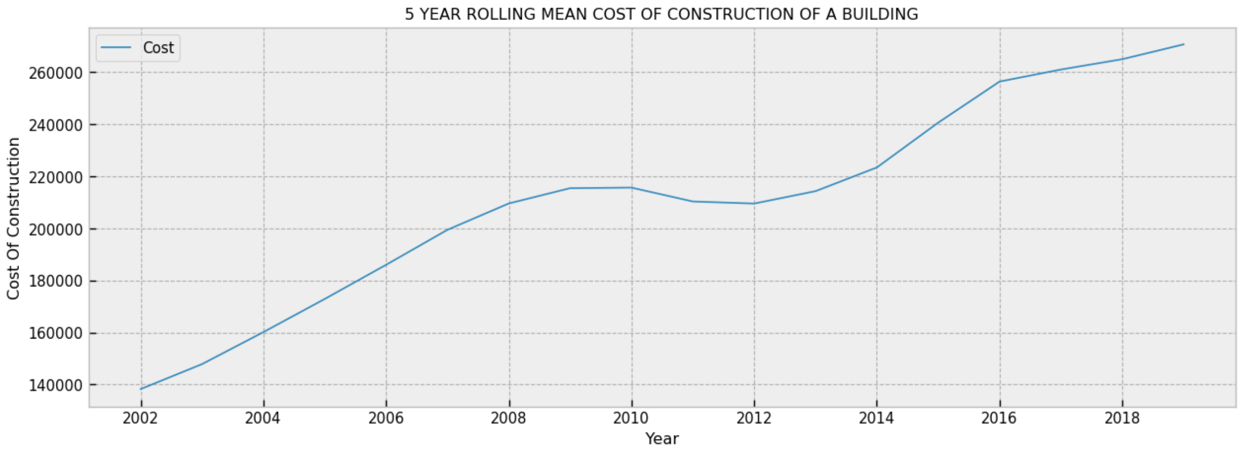

Fig 23: Five Year Rolling Mean of Construction Cost

By employing the five-year rolling mean of construction costs, we projected estimated construction expenses for buildings from 2020 to 2030. The Exponential Smoothing Model with Trend (Degree 2) was utilized for this purpose. This forecasting procedure resulted in two distinct predictions: one utilizing additive forecasting and the other utilizing multiplicative forecasting, as demonstrated in Fig 24 and 25 respectively. Utilizing the additive trend forecasting approach, the estimation for construction costs in the year 2030 amounted to $333,005.7. In contrast, the multiplicative trend forecasting method indicated a projected total construction cost of $341,621.6 for the year 2030. It is noteworthy that both forecasting trends produced similar cost predictions for the scenario involving building destruction.

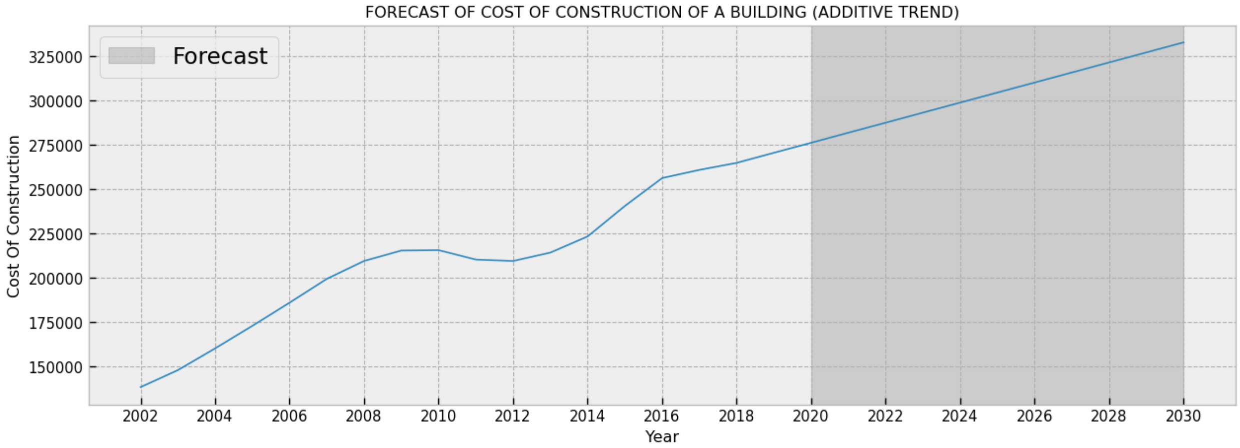

Fig 24: Construction Cost with AdditiveTrend

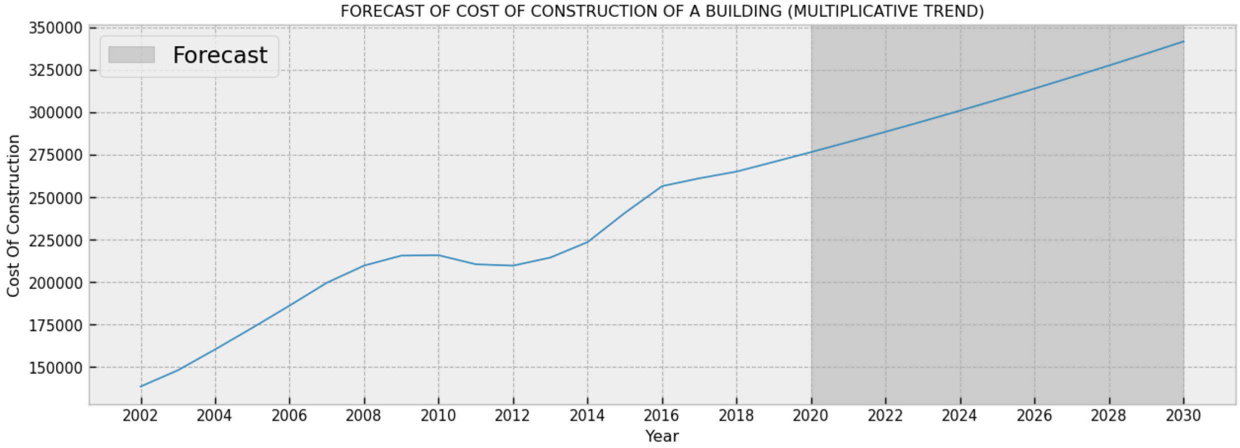

Fig 25:Construction Cost with Multiplicative Trend

Utilizing both the construction cost per building and the annual count of buildings destroyed, we computed the total cost of destroyed buildings, as depicted in Fig 26. The data illustrates that the highest recorded cost for building destruction was in 2007, reaching $562.7 million, while the lowest cost was observed in 2001 at $3.78 million. Across the period from 2000 to 2013, the average cost for building losses amounted to $189.09 million. Furthermore, we calculated the five-year average costs for buildings destroyed due to wildfire incidents. The years spanning 2000 to 2004 yielded an average cost of $102.24 million, followed by $252.95 million for the period from 2005 to 2009, and $217.80 million for the years 2010 to 2013. Similarly, by employing the construction cost of a building, we determined the number of buildings that were rebuilt subsequent to being destroyed by fires. This information is illustrated in Fig 27. Notably, the highest recorded reconstruction cost was in the year 2003 at $297.11 million, while the lowest cost was observed in 2001 at $290,000. On average, the cost for rebuilding these structures amounted to $57.49 million. Moreover, we calculated the five-year average costs for rebuilding buildings that were destroyed following wildfire incidents. The years spanning 2000 to 2004 yielded an average cost of $61.28 million, followed by $94.59 million for the period from 2005 to 2009, and $6.36 million for the years 2010 to 2013.

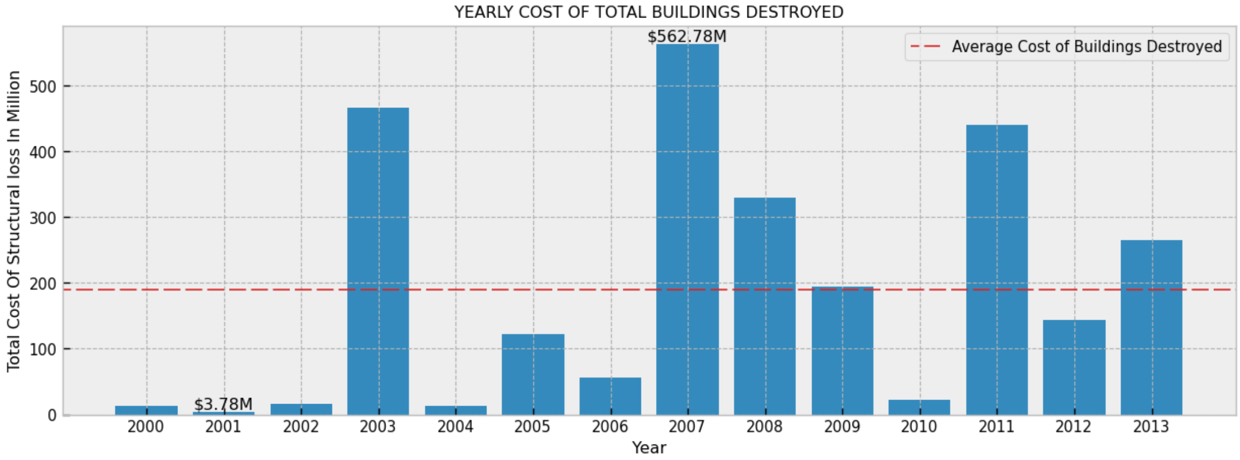

Fig 26: Total Cost of Buildings Destroyed

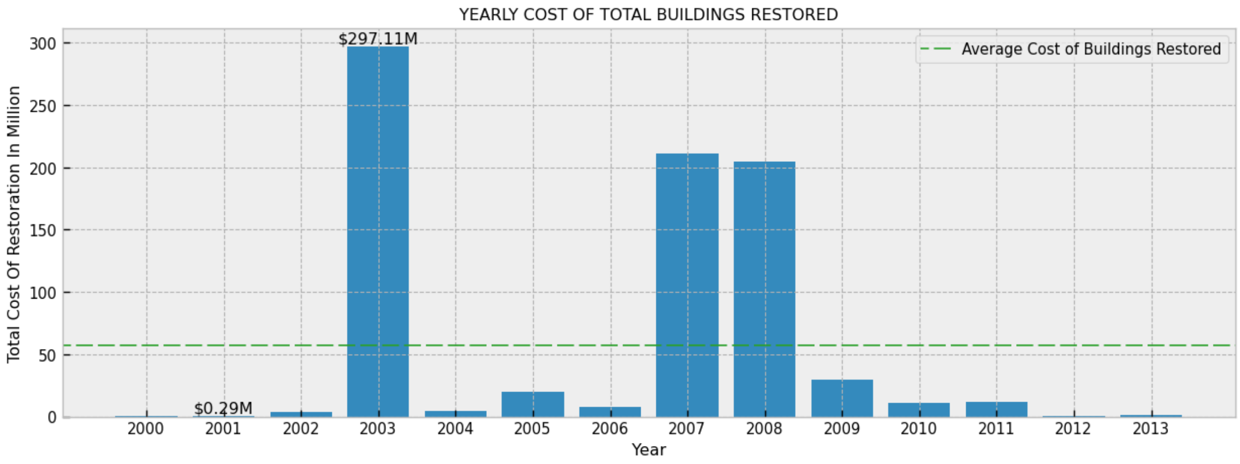

Fig 27:Total Cost of Buildings Restored

Considering the total cost of both scenarios for category BH, along with restoration costs, the resulting outcomes are as follows, visually depicted in Figs 28 and 29. Fig 28 illustrates the aggregate cost of damaged buildings and the overall restoration expenses. The highest cost was recorded in 2003 at $342.23 million, while the lowest cost was in 2001 at $730,000. The average cost across all years amounted to $75.79 million. In Fig 29, the total cost of destroyed buildings and the associated restoration costs are presented. The peak cost occurred in 2007, totaling $773.71 million, whereas the lowest cost was observed in 2001 at $4.07 million. The average cost over the entire period equaled $246.58 million.

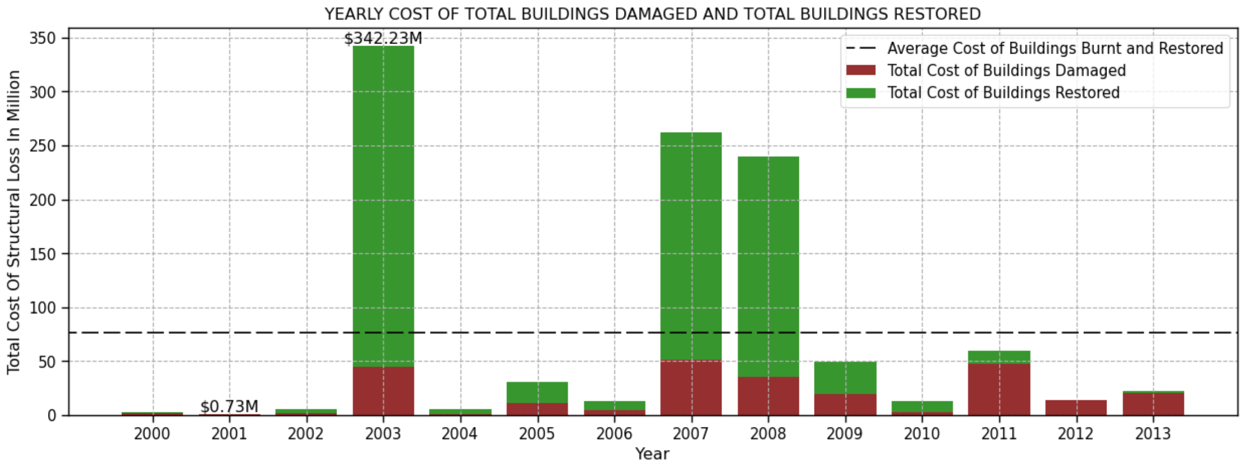

Fig 28: Total Cost of Damaged Buildings and Total Cost of Buildings Restored

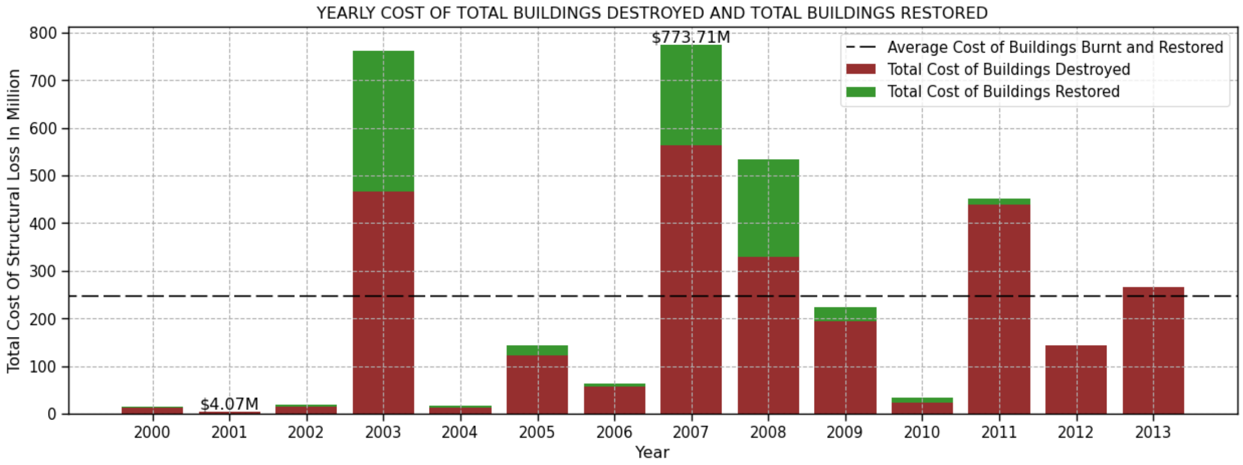

Fig 29: Total Cost of Destroyed Buildings and Total Cost of Buildings Restored

Human-Related Losses:

In this section, we focus on the direct impact of wildfires on human beings. Our analysis involves estimating the costs associated with loss of life, injuries, and the subsequent emergency medical assistance required. To obtain the necessary data, we relied on information from ourworldindata.org (Hannah Ritchie et al., 2022), the source data covers a wide range of natural disasters, including Droughts, Earthquakes, Floods, and Wildfires, on a global scale. This dataset includes the effects of these disasters on human populations. Specifically, we've examined metrics such as the number of deaths resulting from wildfires in the United States, as presented in Fig. 30, the number of injuries attributed to wildfires in the US, as depicted in Fig. 31, and the count of individuals affected by wildfires in the US, as illustrated in Fig. 32. Our analysis specifically focuses on wildfires occurring in the United States between the years 1991 and 2022. As depicted in Fig. 30, the most substantial number of deaths due to wildfires in the US was recently recorded in 2018, with 104 fatalities, and the average number of deaths stands at 11. Turning to Fig. 31, we find that the highest number of injuries due to wildfires in the US also occurred quite recently, reaching a peak of 194 in the year 2022, with an average of 40 injuries. Similarly, in Fig. 32, we observe the highest number of people affected by wildfires in 2007, impacting 650,000 individuals. The median number of people affected is 528.

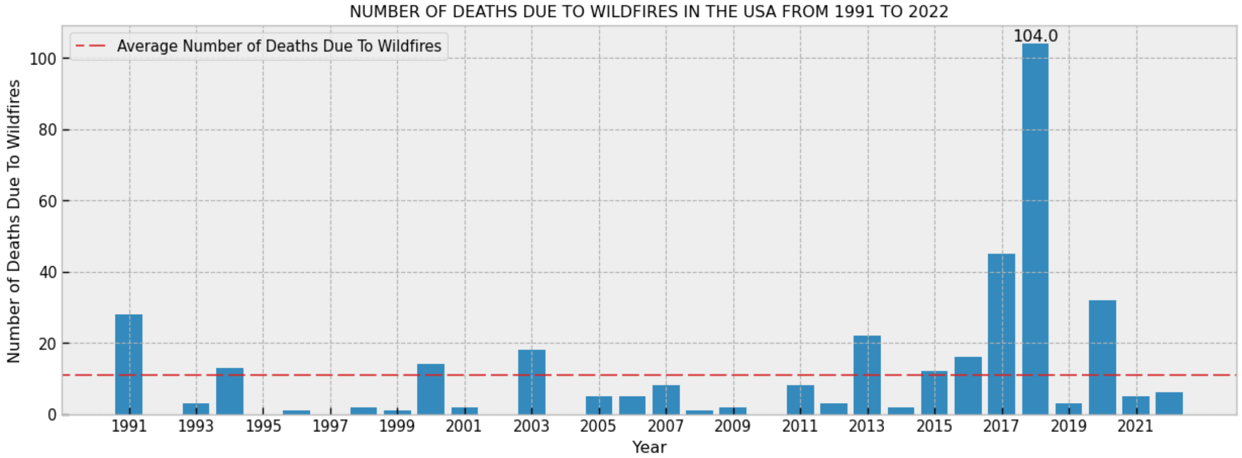

Fig 30: Number of Deaths Due To Wildfires

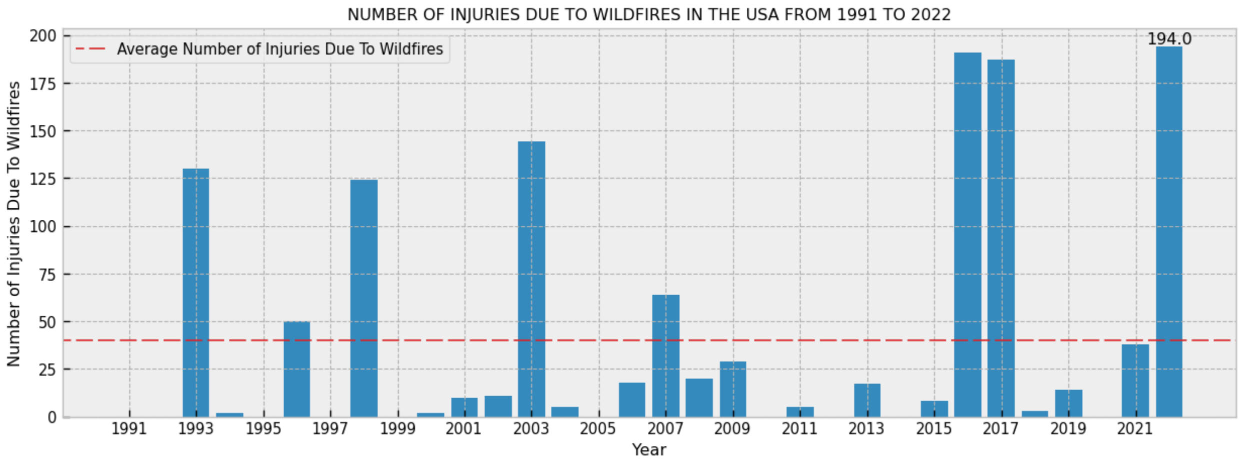

Fig 31: Number of Injuries Due To Wildfires

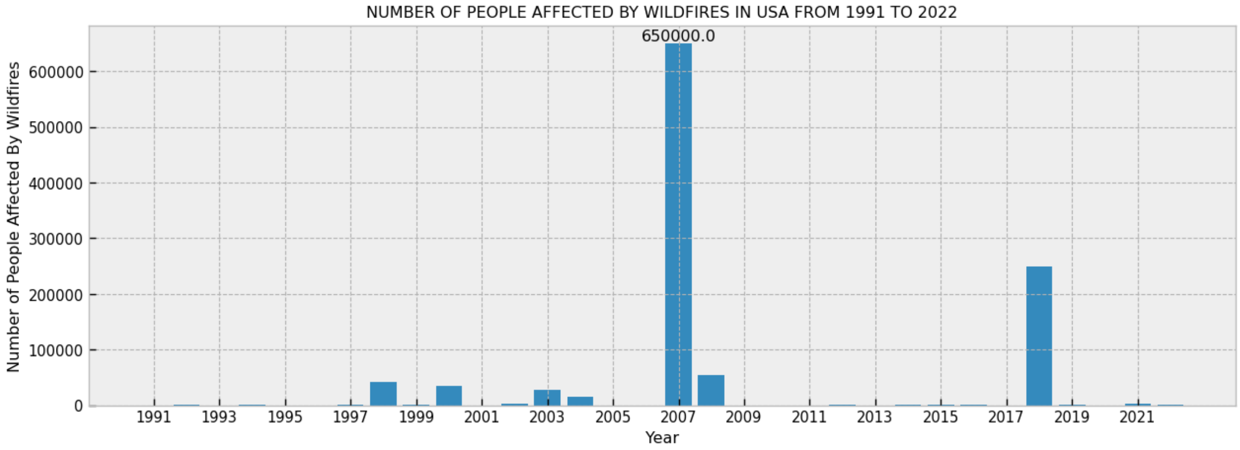

Fig 32: Number of People Affected By Wildfires

We employed a method considering the number of deaths resulting from wildfires, combined with the Value of Statistical Life (VSL) for the respective years, to estimate the costs associated with human fatalities, as illustrated in Fig. 33. Similarly, we calculated the costs of human injuries for each year, as shown in Fig. 34, by using the Value of Statistical Injury (VSI) calculated from the number of injuries and a moderate conversion rate, treating all injuries as moderate. To provide further details, the VSL for the years 2012 to 2022 was obtained from a study by Timothy et al. (2023). For the period spanning 1991 to 2011, we calculated the VSL using data from studies conducted by Zhuang et al. (2017) and Shelby et al. (2022). When calculating the VSI for the corresponding years, we utilized a conversion factor of 0.047 based on the methodology from Zhuang et al. (2017). This approach assumes that all injuries incurred are of moderate severity. The resulting figures, Fig. 33 and Fig. 34, offer insight into the estimated costs attributed to human fatalities and injuries, providing a comprehensive understanding of the economic impact of these aspects within the context of wildfires.

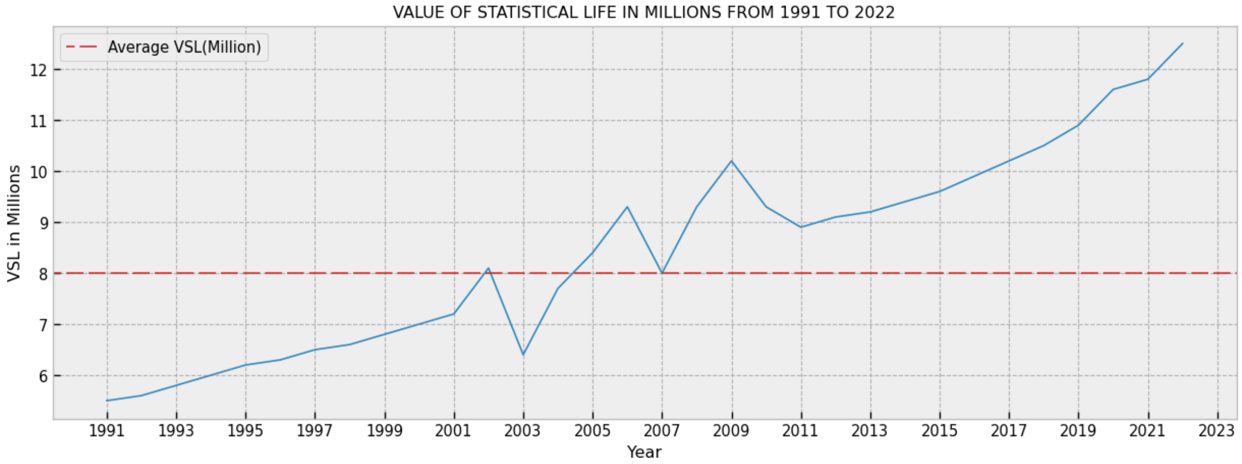

Fig 33: VSL Per Year

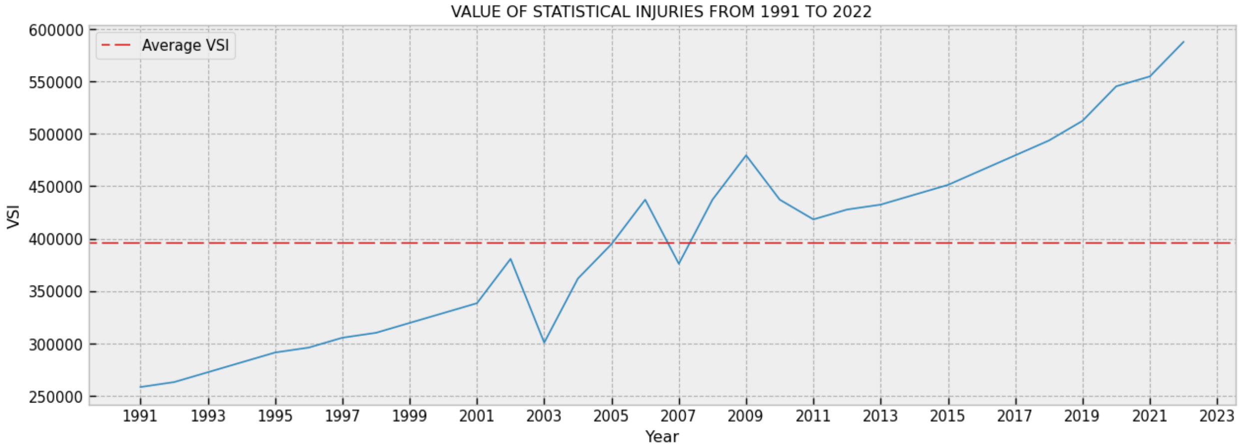

Fig 34: VSI Per Year

We calculated the costs of deaths and injuries due to wildfires for each year by multiplying the respective counts with the Value of Statistical Life (VSL) and Value of Statistical Injury (VSI) measures. Fig. 35 illustrates the total cost attributed to all deaths resulting from wildfires each year. Notably, the year 2018 stands out with the highest cost, amounting to $1 billion, while the average annual cost across the entire period is $105.2 million.

We further examined the average costs over specific 5-year periods, revealing the following figures: from 1991 to 1995, the average cost was $49.9 million; from 1996 to 2000, it was $24.9 million; from 2001 to 2005, it was $34.3 million; from 2006 to 2010, it was $28.0 million; from 2011 to 2015, it was $87.0 million; and from 2016 to 2020, it reached a substantial $422.7 million. These calculated averages provide valuable insights into the financial impact of wildfires on human lives, helping to understand the varying costs over different time spans and their implications on public safety and disaster management

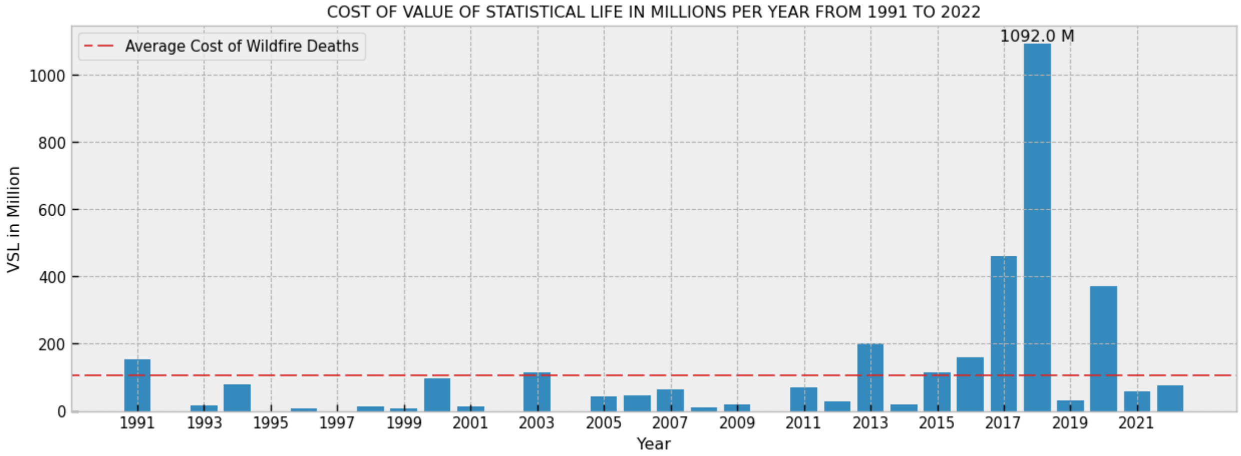

Fig 35: Total Cost of VSL Per Year

Similar observations were made for VSI and Fig 36 gives the cost of all the injuries that happened due to wildfires for every year. The highest cost was incurred in the year 2022 which was $113.9 and the average cost was $16.6 Million. We calculated the average cost for 5 year periods which are as follows, from 1991 to 1995 it was $7.2 Million, from 1996 to 2000 it was $10.8 Million, from 2001-2005 it was $ 10.5 Million, from 2006 to 2010 it was $10.9 Million, from 2011 to 2015 it was $2.6 Million, from 2016 to 2020 it was $37.4 Million.

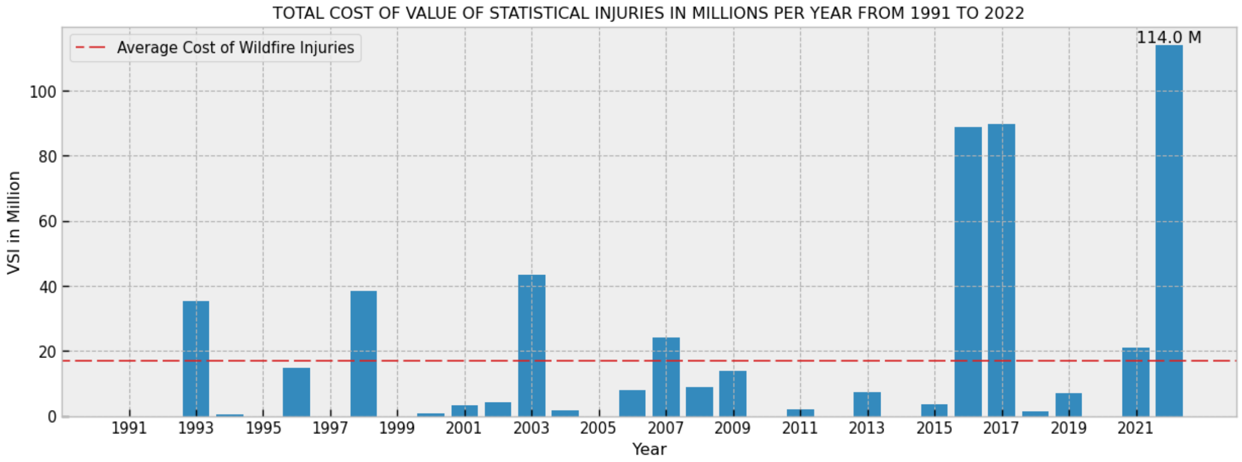

Fig 36: Total Cost of VSI Per Year

In addition to our previous analyses, we made conservative estimates for Emergency Medical Services (EMS) by utilizing the number of people affected by wildfires and incorporating EMS values. We refer to this as a conservative estimate because EMS costs can vary significantly based on regional differences, insurance coverage, and other factors. For our estimation, we collected EMS values from various web sources and news articles, including references such as (Chicago Tribune, 1985), (The Oklahoman, 2000), and (Talk to Mira, 2023). Where necessary, we interpolated missing data points to ensure a comprehensive representation. Fig. 37 provides a visualization of the trends in the cost of EMS per year. This analysis contributes an essential perspective to the overall economic impact assessment, recognizing the potential variability in EMS costs and the importance of factoring in local factors and circumstances. The conservative nature of our estimate underscores the significance of these services in wildfire incidents while acknowledging the complexities involved in accurately quantifying their costs.

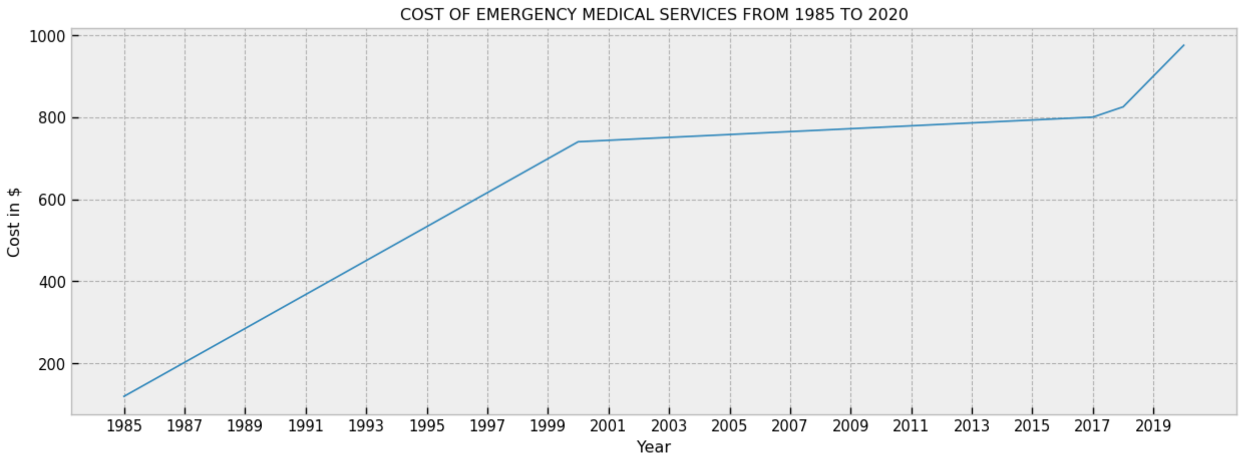

Fig 37: Cost of EMS Per Year

Fig. 38 provides a comprehensive view of the total cost of Emergency Medical Services (EMS) for all individuals affected by wildfires. Notably, this data exhibits some anomalies, with the highest recorded cost reaching $497.1 million. The average cost across the entire period, however, is $28.0 million. Further analysis includes the calculation of average costs over distinct 5-year periods, revealing the following results: from 1991 to 1995, the average cost was $0.2 million; from 1996 to 2000, it was $10.9 million; from 2001 to 2005, it was $6.9 million; from 2006 to 2010, it spiked to $107.9 million; from 2011 to 2015, it decreased to $0.5 million; and from 2016 to 2020, it reached $41.5 million. These calculated averages provide a valuable perspective on the varying costs of Emergency Medical Services, emphasizing the significance of time intervals and their implications for understanding the financial impact on public health and disaster response. The anomalies highlight the importance of considering the context and underlying factors when interpreting the cost trends in EMS.

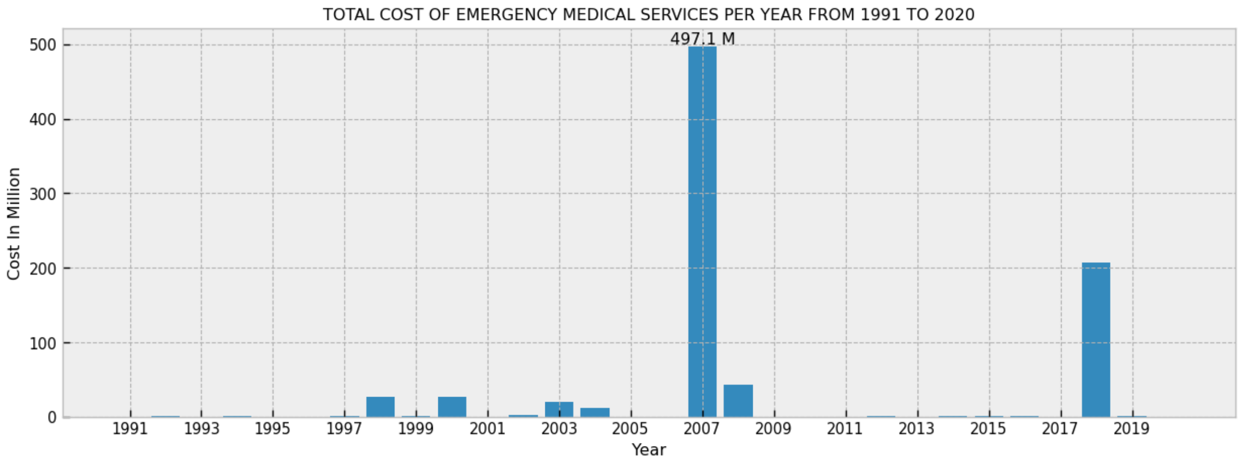

Fig 38: Total Cost of EMS Per Year

The total cost of human losses was determined by aggregating all three parameters mentioned above: the total cost of deaths, the total cost of injuries, and the total cost of Emergency Medical Services (EMS). Fig. 39 provides a comprehensive visualization of this cumulative cost. As evident from the figure, the highest cost was incurred in the year 2018, amounting to a staggering $1.3 billion, representing the combined impact of human-related losses due to wildfires. The average cost across the entire period is approximately $150 million.

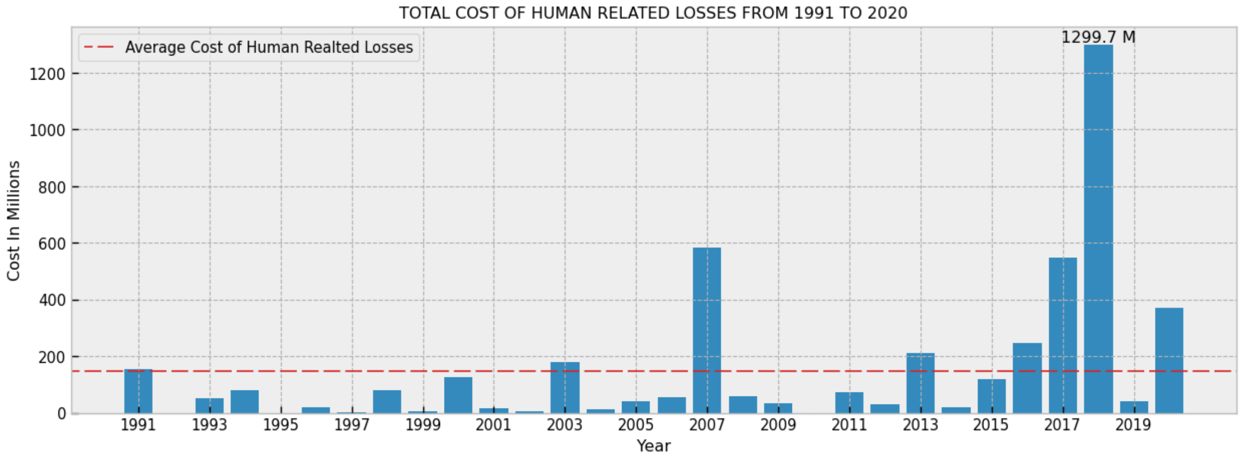

Fig 39: Total Cost of Human Related Losses

Further analysis encompasses the calculation of average costs over distinct 5-year periods, yielding the following results: from 1991 to 1995, the average cost was $57.3 million; from 1996 to 2000, it was $46.5 million; from 2001 to 2005, it was $51.7 million; from 2006 to 2010, it escalated to $146.8 million; from 2011 to 2015, it decreased to $90.1 million; and from 2016 to 2020, it reached a substantial $501.6 million. The significant cost incurred solely for human-related losses underscores the devastating and far-reaching economic consequences of wildfires, emphasizing the urgent need for effective wildfire management, prevention, and disaster response measures.

Fig 40 presents a graphical representation of the mean and median expenses associated with the aforementioned categories investigated in this study. Specifically, the mean suppression loss is recorded at $1.282 billion, while the median suppression loss stands at $979.97 million. Furthermore, for scenario two of building losses, the mean loss attributed to buildings is calculated to be $246.58 million, with the median buildings loss amounting to $143.47 million. Additionally, human-related losses exhibit an average value of $149 million, with a corresponding median of $53.6 million.

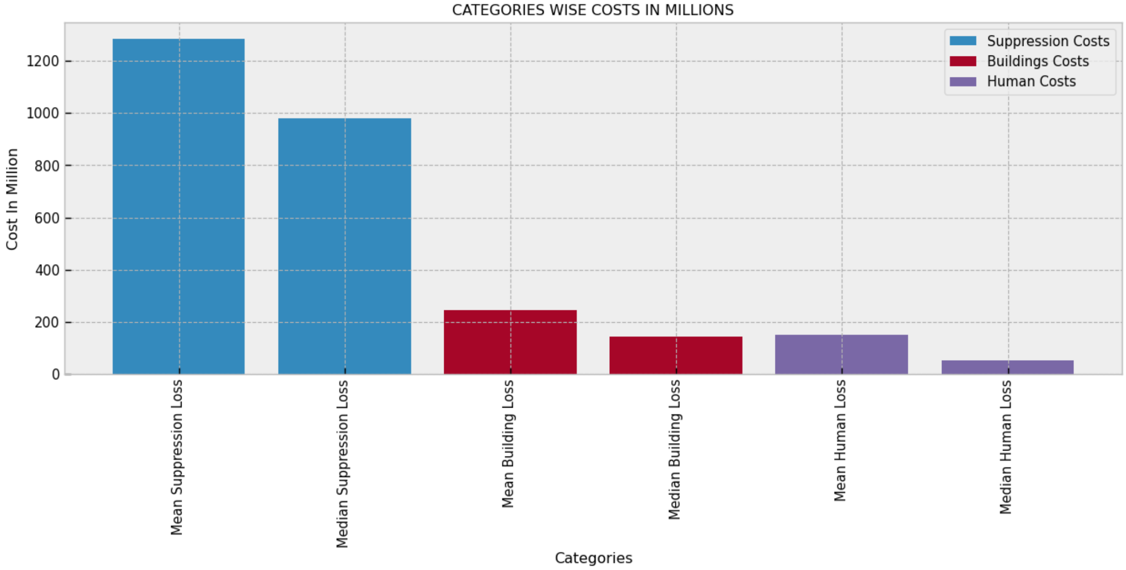

Fig 40: Category Wise Cost Comparison of all the Mentioned Losses

Conclusion

The research introduces a comprehensive methodology aimed at comprehending the influence of wildfire seasons on local economies in the USA. It investigates how communities prone to wildfires manage the resulting economic, psychological, and environmental challenges. The study sheds light on approximated costs and losses attributed to wildfires, and further delves into forecasting trends in economic expenditures and losses. Divided into three core sections—suppression spending, economic losses due to building destruction, and human losses—the research offers a detailed analysis of the multifaceted aspects associated with wildfires' impact on the economy.

The research analyzed the cost of suppression spending from 1985 to 2022, focusing on two aspects: suppression spending per hectare and total annual suppression spending. The highest cost per hectare was $800 until 2012, but it sharply increased to a peak of $1400 in 2021. This indicates a significant rise in spending after 2012. Using all collected data, the study projected the trend of suppression spending per hectare until 2030. For 2030, the estimated costs were $1161 (additive trend) and $1337 (multiplicative trend) based on 5-year rolling means. Regarding total annual suppression costs for all fires, costs were consistently below $2 billion until 2012. However, costs surged thereafter, with a more pronounced increase after 2020. Notably, a distinct pattern emerged where total costs tended to sharply rise every 5 years, particularly evident from 2000 onwards. Utilizing the provided observations, we extrapolated the trend's trajectory up to the year 2030. This projection yielded estimated figures of $4.390 billion (additive trend) and $5.125 billion (multiplicative trend) for the year 2030.

The subsequent section of the research aimed to calculate the financial implications resulting from the destruction of buildings, coupled with the subsequent costs incurred during their restoration. To accomplish this objective, data spanning the years 2000 to 2013 were gathered, encompassing both the count of buildings destroyed and the count of buildings restored. The findings of the study revealed a cumulative total of 13,035 buildings being lost to wildfires, with a significant surge of 2,704 buildings being affected in 2003 alone. Notably, the states most impacted in terms of building losses were documented, with California leading at 6,621, followed by Texas at 2,491, and Colorado at 949. Comparable observations were made regarding reconstructed buildings. A total of 4,064 buildings were revitalized following wildfire incidents, constituting only 31% of the demolished structures. Parallel to the prior findings, the year 2003 exhibited the highest number of building restorations, totaling 1,726. The states at the forefront of post-wildfire building reconstruction were also noted, with California contributing 3,556, followed by Texas at 100, and Colorado at 77. This emphasizes the remarkable statistic that over 85% of all building restorations took place in California. Utilizing the aforementioned data, we proceeded to estimate the costs linked to both the destruction and the subsequent restoration of buildings. This involved utilizing data ranging from 1980 to 2021, capturing the average cost of damage incurred by buildings due to fires. Specifically, between 2008 and 2012, a substantial cost escalation was observed. This trend was extrapolated in the forecast from 2022 to 2030, resulting in a projected additive trend of $31,400 and a multiplicative trend of $33,000 for the year 2030. The range of building damage costs was quite variable, with the highest expense occurring in 2007 at $51.3 million and the lowest being recorded in 2001 at $440,000. Similarly, utilizing data spanning from 1998 to 2019, which accounts for the average cost of constructing a building, we noted a noticeable increase in costs post-2011, which persisted until 2015. This upward trend in construction costs was extrapolated in the forecast from 2020 to 2030, resulting in an estimated additive trend forecast of $333,005.7 and an estimated multiplicative trend forecast of $341,621.6 for the year 2030. Based on these observations, the highest recorded cost for building destruction occurred in 2007, totaling $562.7 million, while the lowest cost was observed in 2001 at $3.78 million. The highest recorded cost for building restoration was observed in the year 2003 at $297.11 million, and the lowest cost was recorded in the year 2001 at $290,000.

The concluding segment of the research centered on observing and documenting the financial ramifications of human losses attributable to wildfires. This encompassed not only the loss of life but also injuries sustained and the necessity for emergency medical assistance. The examination of these aspects yielded insightful findings: The most tragic toll in terms of fatalities transpired in 2018, accounting for a total of 104 lives lost due to wildfires. Similarly, the highest number of injuries occurred recently in 2022, amounting to 194 cases. Further, the most substantial requirement for emergency medical assistance was recorded in 2007, reaching a staggering figure of 650,000 instances. The data for Value of Statistical Life (VSL) was collected, from which corresponding Value of Statistical Injury (VSI) values were calculated. Additionally, the cost per instance of emergency medical assistance was estimated. Leveraging the provided figures, the total loss attributed to human life was computed. Notably, the highest loss in terms of monetary value was $1 billion in 2018, with an average annual cost of $105.2 million. The expenses associated with injuries reached their zenith at $113.9 million in 2022, with an average of $16.6 million. The highest cost attributed to Emergency Medical Services (EMS) was observed in 2007, tallying at $497.1 million. The summation of these costs—comprising human life, injuries, and EMS—revealed the comprehensive extent of human losses due to wildfires. The peak total loss was recorded at $1.3 billion in 2018, with an annual average of $150 million.

This analysis emphasizes the critical necessity for collaborative endeavors involving policymakers, forest management agencies, and local communities, all guided by well-defined and strategic policies. By taking into account the intricate interplay of economic, ecological, and human elements, we can systematically implement measures to mitigate the escalating and adverse repercussions of wildfires. This cooperative approach provides a pragmatic strategy not only for addressing the immediate repercussions of wildfires but also for cultivating sustained resilience. This resilience serves to safeguard our environment, economy, and the overall well-being of our communities in the long term.

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