

# **The Effects of Outdated Wildfire Suppression in California**

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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## **Introduction:**

As the inevitable urbanization of humanity continues ever onwards, society must now face the consequences of the ignorance and haste of our development. Without a doubt the 20th and 21st centuries introduced technological marvels that vastly improved the quality of life for humans globally. However, these advancements were possible because of numerous fossil fuels that appear to have permanently marred the planet and the protective atmosphere surrounding it. For most people, the effects of global warming can occupy a place of willing blindness as they go about their daily lives blissfully unaware of the world changing around them. This behavior has been quite easy to continue for the past few decades, but for several regions of the world an ever growing problem has forced society to reexamine our relationship with the environments we live in: wildfires.

The 2019-2021 global wildfire seasons continued a trend of record setting catastrophes as numerous portions of the world were set ablaze. The western United States experienced one of the worst seasons to date as mass scale wildfires, such as the Dixie Fire in California, spanned larger regions than ever previously recorded (California DoF, 2021). Australia's 2019 bushfire season devastated the continent's ecosystem with nearly 3 billion animals killed or displaced after approximately 18.6 million hectares of land were burned (Collins, 2021). Recent research has indicated that these events are becoming increasingly common and dangerous as the United States has measured a 400% increase in average affected land area over the past decade (Donovan, 2017). As the climate crisis continues, society must learn to adapt to survive in a more fire prone environment. In addition to increased awareness of fire safety, new technologies must be developed to combat and control these devastating natural disasters.

Due to the massively increasing scale of wildfires over the last century, traditional firefighting techniques are proving to be insufficient at suppressing the spread of these catastrophes. With the advent of large scale aircraft the concept of aerial firefighting became a commonplace practice. The aircraft most commonly used are fixed wing cargo or passenger aircraft retrofitted to fulfill their mission with either internal or external water tanks and dropping mechanisms. These aircraft were never intended to be used as aerial firefighters and as such were not designed to be optimal in this role. As such, these aircraft are deficient in their ability to effectively respond to the growing threat of these wildfires. To properly address these problems new aircraft need to be designed with the intent of an optimized performance for the dangerous conditions of an aerial firefighting mission.

Every year the American Institute of Aeronautics and Astronautics (AIAA) sponsors a design competition for students to face real world problems that are currently being faced by engineers in the field. Competing in this competition is the goal of MAE 4650 supervised by Dr. Jesse Quinlan. This year the AIAA based their competition on developing firefighting aircraft to replace the current designs being used by U.S. federal and state governments. All the competitors must fulfill specific requirements stated in the request for proposal (RFP) to act as a proper replacement for the current aircraft. These requirements were determined based on the shortcomings of the current aircraft in usage today.

## **Modern Documentation and Wildfire Reconstruction Efforts**

In the same way firefighting efforts still utilize antiquated equipment, natural disasters are still assessed using outdated metrics. As these natural catastrophes become increasingly common, the methods used to report the damage need to encompass a wider range of factors to properly estimate the severity of each event. While wildfires in the US occur across many states including Colorado, Oregon, and Washington, the severity of the damage can be seen most clearly in California. With approximately 12% of the US population and 15% of the US GDP, any size of fire close to population centers can drastically disrupt both the economy and the community. Due to these factors, California was chosen as the primary case study in analyzing current wildfire documentation and public policy responses.

### *Housing and Employment*

The most immediate issue faced within communities affected by wildfires is the loss of shelter and the consequences that follow. Survivors who were interviewed after wildfires nearly always cited the stress and uncertainty that comes with a loss of their homes. The instantaneous loss of housing security leaves numerous people with no other option but than to move between various places such as hotels, rentals, and shelters (Rosenthal, 2021). Frequent movement has a heavy financial and emotional toll on these survivors and has been linked to exacerbating medical issues from either pre-existing conditions or issues created from the fire itself. The ripple effects of so many individuals being displaced has consequences on the entire housing market in surrounding communities as people try to find suitable living conditions. In addition to the housing situation, the destruction of many businesses and employers in the surrounding area leaves several survivors without any kind of employment. This in turn makes paying rent more

difficult as several people no longer have any form of income coming in. These effects compound with one another leaving families that were already struggling financially in an incredibly difficult position to recover following the disaster.

### *Medical Care*

Perhaps one of the most disheartening effects of these natural disasters is the onset of PTSD in numerous survivors. Research has shown that the high stress immediately following the incident often leads to grief and anxiety later on and ultimately symptoms of PTSD closer to a year and a half later (Rosenthal, 2021). This increased stress has been correlated with an uptick in several kinds of abuse throughout the community as studies have shown drug usage and domestic violence rates increase over the next two years in the communities that have been affected by these wildfires. These issues also often go undiagnosed and untreated during this period as a large number of people developing these problems had no prior history of mental illness. Additionally, destruction of local pharmacies and hospitals put a burden on the whole community as treatment times were greatly increased (Rosenthal,2021).

### *Economic Impacts*

Research done on the economic impacts of California's 2018 forest fires found a surprisingly serious effect on multiple market sectors. This research discovered that beyond the typical calculated capital losses for the state there existed far larger costs due to healthcare expenses and indirect losses. The service industry suffered the heaviest losses with nearly 45.1% of the state's industry suffering some kind of loss and a total of 44.4 billion in overall losses. Nearly half of this cost was due to healthcare for employees following the forest fire season as

workers across the state dealt with health problems from the poor air quality and pollutants from the fire (Wang,2020). However, this trend was not true for every market sector. For example the market industry suffered the second highest total quantity of losses with the majority of the costs being tied to indirect capital losses. These indirect losses were the result of the California supply chain being affected for various products. This caused ripple effects throughout the entire manufacturing sector causing losses approaching 22.3 billion dollars (Wang,2020).

### *Wildlife Losses*

In the recent Australian bushfire season of 2019, modern technology allowed for some of the first research into short-term post-burn devastation forest fires have on the biodiversity of the affected regions. This resulted in some of the first wide-scale metrics immediately following a burn regarding how these natural catastrophes leave a lasting impact on the environment by way of disrupting the ecosystem. Additionally, a large portion of the land burned in these fires was protected habitat that these creatures would no longer be able to immediately return to (Collins,2021). These wide scale reporting efforts have shown that each wildfire season can have long lasting effects into the biodiversity and health of the ecosystem for several subsequent years that previously has not been reported.

In regards to California, a recent more focused study analyzed how deteriorating air quality following the 2020 wildfire season led to a sharp increase in avian related deaths. The research looked to find the relationship between multiple ecological covariates and the resulting reported bird deaths from August to September. The final model identified that the highest correlation in avian deaths was tied to the increased quantities of carbon monoxide and nitrogen dioxide surrounding wildfires. Similar research was conducted during South Africa's 2020

wildfire season that showed that approximately 61% of species sampled surrounding a major burn suffered from pulmonary edema (Donovan, 2017). While these studies focused on specific species during these seasons, it can be expected that similar effects were experienced by other members of these ecological systems.

### **Potential Policy and Reporting Improvements**

Using the above information, both state and federal governments globally need to account for the actual impacts of these disasters. A more holistic view of the aftermath of wildfires should hopefully spur a more appropriate response to the severity of wildfire prevention efforts. This holistic approach needs to replace the current piecemeal efforts of separate organizations individually monitoring separate portions of the aftermath and focus on a communication and sharing of findings to alleviate the overall stress placed on the community.

#### *Fire Monitor Systems*

Rather than waiting for the cascade effect of wildfires displacing massive numbers of citizens from a community, local governments need a more robust system for monitoring fire risk in urban areas during burn periods. Networks of fire cameras should be installed throughout the rapidly expanding urban areas surrounding Southern California to allow for an increase in data collection regarding the initial stages of a burn. Existing fire camera systems cover a relatively small portion of the recurring burn regions and lack proper automation, yet the ALERT system utilized during the Kindescade Fire provided crucial information to first responders and allowed

for the first large scale evacuation without casualties in California's history. Current research using machine learning algorithms trained to monitor wildfire detections across a fire camera network reported an accuracy metric of 99.67% during preliminary testings (Govil,2020). integration of automated fire camera systems into the growing infrastructure, response times could be drastically reduced by these automated systems.

### *Improved Reconstruction Programs*

Even with improved monitoring systems, the escalation of wildfire risk will inevitably result in runaway fires that will destroy residential areas. With an ever expanding housing market in California pushing housing areas deeper into wildfire prevalent areas, policies need to be put in place to account for the increased poverty gap exacerbated by these natural disasters. Research by the National Bureau of Economic Research has indicated that following a major wildfire the high spike of out-migration by the higher class members of the community and an in-migration of surrounding poor citizens looking to move into cheaper, high risk areas can lead to a poverty rate increase as much as 1% per disaster (NBER, 2017). This effect was also observed to result in even larger migration swings in developing regions which would encompass the majority of expanding communities in the Southern California region. As such, policy makers should develop more efficient reconstruction programs that will work to prevent unwanted migration, both outwards and inwards, in these communities. The US federal government has programs in place to help families with up to 100% mortgage insurance for complete reconstruction costs in these communities through FHA Article 203(h), but only within presidentially declared disaster areas. With the increase in scale of long-term fires, federal declarations often will not occur quick enough to help affected communities. For example, the 2021 Dixie fire became the largest



single fire in California history on August 6th, but was not declared a federal disaster area until August 24th (Governor's Office of California, 2021). Delays like this often occur because of political contention along both party and federal/state disputes and leave citizens to become destitute in the interim. This model for aid relief needs to be reformed so that economic funds can be freely distributed quicker so that the previously discussed cascading effects of these disasters cannot escalate further. A potential solution would be allowing existing agencies such as the Federal Emergency Management Agency, FEMA, the ability to provide support without waiting for state governor requests and allowing federal aid to be distributed without presidential approval.

#### *Development of Reliable Disaster Housing*

As discussed previously, the housing market immediately following major wildfires becomes increasingly volatile and overpriced due to an influx of displaced families. The current relief method is to provide funding to families displaced by natural disasters, but this practice forces relief aid to be manipulated by a shortage in the housing market creating inefficiencies throughout the system. Rather than relying on the surrounding rental market for housing relief, federal or state governments could potentially develop rapidly deployable housing for the homeless. This concept was previously attempted during hurricane Katrina through the deployment of FEMA trailers. However, these trailers were poorly designed and were not intended for the longer duration reconstruction took. This led to several of the occupants developing long term medical problems from formaldehyde inhalation and other health concerns from the construction of these units. Despite this, the trailers were still integral in solving the homelessness crisis in the rural regions hit by Katrina and an improved upon model of quickly

deployable housing could improve recovery rates of afflicted regions. One of the most promising replacements to the niche of FEMA trailers is the concept of modular and prefab housing for survivors. A Washington based company called Pallet designed a prefabricated housing unit to help the homelessness crisis for less than 5,000 dollars that can be setup as quickly as one hour (Ligety, 2021). With as many as 100,000 people left without homes in a matter of days, being able to quickly deploy cheap housing solutions such as these could act as a buffer as more long term solutions can be implemented through reconstruction efforts. As effective as these prefabricated homes are, another potential solution involves the implementation of modular housing that can be quickly constructed and later built upon as long-term reconstruction housing. This model was tested in Texas during hurricane Dolly as the company RAPIDO was able to distribute 20 “housing cores” immediately following the disaster. These housing units are fully livable immediately upon being installed, but can later have future affordable implementations such as additional bedrooms installed when further funding is provided by relief programs (Barr, 2021). These houses will then remain as long-term housing ensuring housing stability for the displaced families. This model allows for families to remain together and quickly return to their communities shortly after the disaster and allows for faster reconstruction.



Figure: RAPIDO Modular Housing Units Post-Relief

### *Regulatory Oversight of Electrical Infrastructure*

While there are numerous discussions of individual citizen fire safety, the unfortunate reality facing California currently is that the vast majority of the most destructive fires in the past decade have been the result of irresponsible business practices placing priority on profits over the safety of the state. Pacific Gas and Electric Company, PG&E, is one of six electric companies that has developed and overseen the California electrical infrastructure, and has been charged criminal negligence due to the destruction its faulty safety practices have caused. According to Federal Judge William Alsup, PG&E is responsible for wildfires covering nearly 1.5 million acres and the deaths of 113 Californians over the past decade (Cuevas, 2022). This comes following a court case in 2010 where the company was placed on probation for a gas explosion killing 8 people. PG&E's decision to build an electrical infrastructure of predominantly overhead electrical wires throughout some of the most flammable regions of the state rather than spending the additional money to dig underground lines has led to the initial catalyst for several of the state's largest wildfires mostly due to tree contacts with these lines. Despite all these charges, PG&E only plans to bury around 9% of its existing overhead lines and will be charging its

customers an additional \$15,000 dollars over the next decade to cover these costs and maintain profit margins (Melo, 2020). Due to the distinction of legal ramifications faced by corporations in the United States, PG&E has managed to claim bankruptcy and avoided paying the appropriate settlements to the victims of these natural disasters and continues to maintain a monopoly over the electrical industry for over 5.2 million people (California Energy Commission, 2022). While policies and new technology can be implemented to alleviate the increasing catastrophic effects of wildfires, unless California's electrical companies like PG&E change their business practices, relief efforts will always struggle to keep up with climate change in an increasingly flammable world.

### **Conclusion:**

Destructive forest fires have become an inevitable part of the annual cycle in the United States and increasing climate change is only accelerating the need to properly respond to these natural disasters. With such a wide range of people being affected by these natural disasters, the usage of outdated equipment is simply insufficient to protect the lives and the economy of these citizens. Our proposed design allows for a more efficient usage of resources and time to combat the spread and damage of these events. The incorporation of new era firefighting aircraft will be vital to the continued survival of wildfire hotspots as an ever growing population learns to adapt with an increasingly volatile climate.

Despite the immense damage already recorded by wildfires, the current measurement processes are antiquated in properly assessing the long term impacts of these natural disasters. Modern disaster reporting is limited by a lack of communication between collection sources and a failure to properly track the downstream long term effects on the displaced populations created

by wildfires. These errors allow for faulty systems to continue to exist despite failing to address the relief concerns of the poor citizens impacted by these natural disasters.

Though the future looks bleak as climate change continues to accelerate and force a growing population into a more haphazardous environment, technological advancements and intelligent policy decisions can help to aid and mitigate the damage caused by these disasters. Better monitoring systems can help keep these communities safe longer by improving response times for conventional firefighting efforts and reduce the runaway effect that leads to catastrophic flames. While having appropriate aerial firefighting technology can help reduce the impact of the large scale disasters, affordable housing solutions can prevent the cascading effects throughout surrounding areas and help for quicker recovery times for these communities. Even with all of these solutions and advancements, the ultimate fate of California and the rest of the western United States will have to rely on both federal and state policymakers prioritizing the safety of their constituents over profit margins and power struggles.

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