Disasters
and
Urban Planning

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1 Introduction

1.1 The Camp Fire

The Camp Fire, a forest fire event that ravaged the state of California, was the deadliest and most expensive natural disaster of the world, in 2018. It was the most destructive wildfire in the history of California.

The fire started on November 8, 2018, in Northern California's Butte County, and began to spread at an alarming rate. It was ignited by a faulty power line on Camp Creek Road, its place of origin from which it is named. An urban firestorm began forming in the foothill town of Paradise, after exhibiting extreme fire spread, fireline intensity, and spotting behaviors through the rural community of Concow (KQED, 2018).

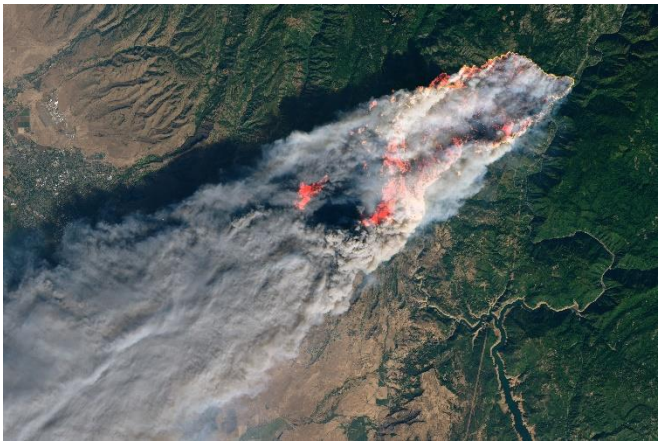


Figure 1 Figure 1 The Camp Fire Fireline Spread.

Credit: NASA (Joshua Stevens)

The total coverage of the fire was 153,336 acres, and it is reported to have destroyed 18,804 structures, with most of the infrastructural damage caused in the first few hours. The impact of the event on life was significant, with a death toll of 85, and with civilian injuries amounting to 12. One person was believed to still be missing, as of November 7, 2019 (Damon, 2019). By January 2019, the total damage was estimated to be about $16.5 billion.
It was the deadliest wildfire in the United States since the Cloquet Fire in 191, which prompted a response from Multiple US state and federal agencies who deployed their resources to combat this destructive event, with it being declared a disaster by the President of the United States.

1.2 The Town of Paradise

Situated in Butte County, California (USA), Paradise is a town in the Sierra Nevada foothills above the northeastern part of Sacramento Valley. The town had a population of 26,218, according to the 2010 Census. The wildfire destroyed most of Paradise, and much of the nearby communities of Magalia, Butte Creek Canyon, and Concow. The town lost almost 90 percent of its population due to the devastating wildfire, with the majority of the residents not returning to the town. Predominantly a mining and tourist town situated in a wildfire-prone area, Paradise is a small town with limited capacity for combatting disasters.
Shortly after the fire erupted, the Butte County Sheriff's Office ordered the evacuation of the eastern quarter of the town, and the remaining portions an hour later. However, many residents did not receive an evacuation warning, while others *chose* not to leave because the warnings did not convey a sense of urgency with regards to the situation. Other locations outside of town were also issued evacuation orders or warnings, and emergency shelters were established.

Figure 2 The Camp Fire and The Town of Paradise

2 The Two Primary Hazards

In most cases, wildfires occur analogous to droughts, and their effects are exacerbated in persistent conditions of droughts. The state of California has seen increasing numbers of acres burned across the state over the past 20 years, and it is expected that the number of acres burned annually by wildfires may increase to as much as 310% of the current burn by 2050 (UC Berkeley, 2014). This significant increase in burned land has to do with the extended droughts that are happening more often in the state. All major fires and fire seasons since 1996 have occurred during drought years. The drought season dries out local vegetation and makes it more susceptible to catching fire, and subsequently developing into a wildfire rapidly. The lack of rain and lower levels of humidity dries out trees and vegetation, providing fuel for the wildfires. In this case, Butte County was remarkably dry prior to the event. California was in its sixth consecutive year of a drought, and the county had not had a rainfall event producing more than a half an inch of rain for seven months (NASA Goddard Spaceflight Center, 2019). This was the prime time for a fire to start, and consequently, a stray spark from a power line was the flashpoint for the Camp Fire.

Credit: Noah Berger (Washington Post)

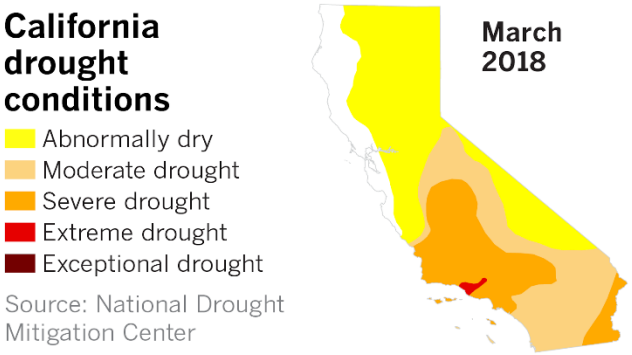
2.1 What is the Effect of Climate Change on these Hazards?

The most disastrous fires in California have been observed to occur in the fall. The long and dry spells of summer transform vegetation into the perfect fuel for the annual winds that blow across this dry landscape (Borunda, 2019). Many of California's ecosystems have evolved to burn frequently.

Since the 1980s, the coverage and ferocity of these fires have trended upwards. 15 out of the 20 most massive fires in California history have occurred since 2000; the amount of area burned in the state has multiplied by a factor of five since the 1970s. Moreover, California has warmed by three degrees Fahrenheit over the last century, surpassing the global average of one degree Fahrenheit. This hotter air draws the water out of plants and soils, leaving vegetation and grasslands of the state dry and primed to burn (Borunda, 2019).

Figure 3 Lake Oroville, Oroville, California, August 2014-April 2017

Recently, these major fires that have started to devastate the state in the past few years have occurred in the fall season, which is at the end of long, hot summers that sucked the waters out of all vegetation before the winter rains have kicked in. The fire season, which is the period before the winter rains dampen the vegetation, has lengthened by 75 days (Borunda, 2019).



At least for the precipitation cycle, the most significant climate-induced changes are observed to be the variability of rainfall. When it rains, it rains more intensely, but when it's dry, the droughts are worse. Droughts are lasting longer, and longer, it seems throughout the entire state of California. The effect of climate change intensifies wildfires tremendously. Record powerful seasonal winds drove the recent wildfires in California. In the fall and winter, offshore winds blow across the state. The downward flow of air gets channeled into canyons or valleys, speeding as it falls. These gusts can reach 70-80 miles per hour (Borunda, 2019). If those gusts pass over a flame, that fire is going to be spread far and rapidly. This phenomenon was observed during the Camp Fire in 2018.

2.2 How do Wildfires Impact Us?

Wildfires impact the Earth's ecosystem at all levels. It takes away plants and trees, which are the most effective defense against carbon emissions and forcing out or killing off the species in that ecosystem at the same time. Wildfires have been occurring for years, and the cycle of the wildfire season has been a natural occurrence; however, we now are experiencing a new and worse wildfire season. Today, the wildfires are happening at different times, and the damage done by them is devastating. Anthropogenic climate change has taken a toll, and the fact of the matter is with wildfires damaging forests while injecting aerosols in the air. According to Bob Berwyn, from insideclimatechange.org, substances being sent in the air that are damaging the ozone layer are aerosols such as Soot and Black Carbon. Soot is an accumulation of carbon that is produced from wood, oil, coal, among others, while black carbon, according to the EPA, is a "problem that has negative implications for both human health and our climate" (EPA). Both results from the same materials being burned, and most of these materials are used in our buildings, roads, and machinery, all of which were burnt during the paradise fires. There is an estimation that in the last 20 or so years, wildfires contribute to 5-10% of the annual carbon emissions, which is approximately 8 billion tons in total. Massive carbon emission is the most significant impact that comes from wildfires, but much more negativity comes from wildfires as well.

Credit: Noah Berger (Washington Post)

The impact of wildfire is not only just the damage it does to the natural environment, but wildfires also take a toll on the world's economy. California itself lost approximately $400 billion in 2018 alone. The costs are high for wildfires, which is due to the cost of firefighters, health-care, and clean-up. The damage is done, and Paradise still has not gained back even a glimpse of what it was before the 2018 fire, and still are missing 92% of the population. Large portions of Paradise are still left empty, and it was 4 months after the first building permit was given out. There are signs of life in Paradise; especially, with community organizations such as 'Love Paradise' that are helping with the clean-up and rebuild.

3 The Disaster

3.1 Response & Recovery

State and federal agencies strategically co-located and worked tirelessly to coordinate resources, aid survivors, and help local communities begin the process of recovery. The efforts of some of the most prominent agencies and services are detailed below.

California Office of Emergency Services

California's statewide Emergency Operations Center and its Regional Emergency Operations Centers worked round the clock since these wildfires began to facilitate shelter operations, debris removal, impact to schools, fire and law enforcement mutual aid, disaster assistance, and long term recovery needs (FEMA, 2018).

California Fire Departments

Fire departments in the state of California deployed their assets to combat this unprecedented event. Approximately 8,400 firefighters covering 980 fire engines, 106 dozers, 155 hand crews, 99 water tenders, 40 helicopters and numerous firefighting air tankers from throughout the state, along with numerous out-of-state resources, were engaged in battling two massive wildfires in California – in Butte and Ventura counties (FEMA, 2018).

Credit: Los Angeles Times

California Highway Patrol

The California Highway Patrol (CHP) rendered aid and assistance to the affected populace by providing support to the Butte County Sheriff's Office and the Paradise Police Department and augmenting their efforts in search and rescue (SAR) operations and the apprehension of looters (FEMA, 2018).

California National Guard

The California National Guard has been a close supporting partner of the California Office of Emergency Services during every major disaster. During the Camp Fire, the National Guard provided general use shelters and 28 “Alaska Shelters” (a type of Quonset Hut) at the Chico Airport staging area for Wildland Forest Fire operations. The National Guard had deployed 930 personnel, 13 aircraft (both rotary and fixed-wing), and 115 vehicles (FEMA, 2018). Pictured adjacent, members of the California Army National Guard don protective suits in preparation to search for human remains at the Camp Fire on November 14, 2018.

Credit: VOA News

Federal Emergency Management Agency

FEMA provides grants to homeowners and renters with uninsured and unmet needs to help begin the recovery process. Through the Individual & Households Program, FEMA approved $814,164, in the first three days of operation (FEMA, 2018).

- Individual Assistance Applications Approved: 8,064
- Designated Counties (Individual Assistance):
  Butte, Los Angeles, Ventura

- Total Individual & Households Program Dollars Approved: $90,138,424.88
- Total Public Assistance Grants Dollars Obligated: $678,173,749

Small Business Administration

The SBA is the primary source of money for the federal government incorporated for the long-term rebuilding of private property damaged by disasters. SBA helps businesses, private non-profit organizations, renters, and homeowners fund repairs and rebuilding efforts, also covering the reimbursement of lost or damaged personal property (FEMA, 2018). The SBA staffed many of the FEMA offices during the Camp Fire to render assistance and information.

4 Paradise

Vulnerability & Mitigation

The signs or more knowledge on what Paradise is doing in mitigation terms. The town of Paradise has updated its informational platforms to show that it is situated in a California zone defined as a "very high fire hazard severity zone." This shows situational awareness on the town's part, indicating a move towards resiliency. Paradise has implemented many limitations to combat potential fire damage, such as restrictions on grass height by trees and structures, or tree branches being near fireplaces. There is much more the town of Paradise is doing to fight the potential of another fire. In 2019 Butte County, which Paradise is located, has made fire hazard its main concern and released a multi-chapter book covering mitigation, titled "Local Hazard Mitigation Plan 2019", two of the annex sections cover Paradise. Here you can find more details covering the entirety of the mitigation plan. Without a doubt, today, Paradise is a much safer place for future generations and so on. Roughly 3,00 or so people have returned to Paradise, and there is much time to grow and come back for the city and as time has gone on more and more signs of life returns. More would have to be done at all levels from federal to local to the communities to make a full comeback, but there is a constant battle against wildfires and the responses so far, so the signs of that.

4.1 Which Communities are the Most Vulnerable?

Living in California means living with the ever-present threat of fire. Experts insist that "wildfire season" is now year-round. The year 2018 saw the state's worst year of wildfires. Most fatalities in the Camp Fire were among the elderly, disables, and impoverished. FEMA reports that adults over 65 had 2.5 times the relative risk of dying in a fire than the general population in 2016; people with disabilities are at increased risk during a disaster since their mobility may be impaired. Events like wildfires are harder on the impoverished, who may have a harder time evacuating and whose financial straits can be worsened even further by a disaster (Meyers, 2019).

4.2 Wildfire Mitigation

Wildfires are a somewhat tricky natural disaster to dry and combat. Although they are tricky, some things can be done, and have been proven to work. Wildfires have always been around. But before 1950, the term hazard mitigation was rarely, if ever, used, and mitigation activities were not a focus of federal policy. (Rubin, 2020) Different things can be done on different scales. For example, for houses, you can maintain a simple metal roof. This will prevent the roof of your house from catching fire. You will also have to make sure that the leaf litter in your gutter is cleaned out regularly or else that can catch fire easily (Jolley, 2018). You can also incorporate and maintain a non-combustible zone of about three feet around the outside of your home. This will create a buffer on the outside of your home that won't be able to catch fire at all. Instead of siding on your house, you could use stucco, which hardens when it dries and can't catch fire (Jolley, 2018). In the case that fire does get close to your house, then the stucco should not be able to catch fire. On a larger scale, while much can't be done about mitigating wildfires, there are still some things that can be done. In one study during the Camp Fire in California in 2018, about 1,700 acres near the boundary of the Whiskeytown National Recreation Area were treated with a combination of prescribed fire and mechanical thinning (Jolley, 2018). They tried this three times, and two of the past three mitigation efforts reduced the severity of the fire and allowed for a lower tree mortality rate. Two productive mitigation strategies are firebreaks and fuel breaks. Fire breaks are strips of bare soil or fire-retarding vegetation meant to stop or control fire. Fuel breaks

are strips or blocks of vegetation that have been altered to slow or control a fire (NRCS, 2011). Both strategies have many purposes and benefits to mitigate wildfires. Overall, the wildfire hazards are reduced since this takes away combustible plants. Even if these zones were to catch fire, the intensity of the wildfire would be nowhere near the intensity if these were not in place. Another plus is nature. If these are applied in a woodland, trees may respond to increased growing space with improved growth (NRCS, 2011).

4.2.1 Policies Measured by Robustness and Redundancy

According to Tierney, robustness means the ability to withstand stresses and demands without loss of function. Some examples of this would be engineering interventions such as levees and seawalls. Sadly, for wildfires, there is not much that you can really do. A policy that physically has to do something in Paradise is taking care of overgrown vegetation. Another policy in the Butte County mitigation plan is to harden buildings. This means to make the buildings a material that doesn't burn as easily. Since there isn't much that can be done about robustness, this is something that could go along with that. As for redundancy, Tierney describes it as the degree to which other units of analysis or elements can be substituted for those that are lost or disrupted. She also mentioned that "the more variations available to respond to a shock, the greater the ability to absorb the shock." This is done in Paradise by planting different types of vegetation. It is also done by having controlled burns in the area. The controlled burns prevent the vegetation there from growing out of control. If the vegetation grows out of control, then it will be able to catch fire very quickly and burn violently. Paradise doesn't do the best job of robustness with wildfires, although, to be fair, it is hard to incorporate robustness with wildfire. As for redundancy, Paradise does a much better job of planting different vegetation and having controlled burns throughout the area.

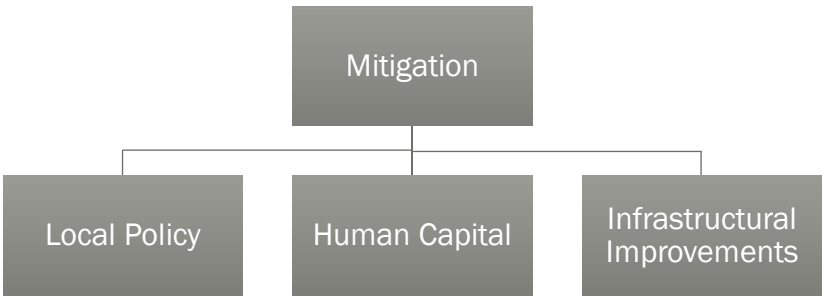


Figure 4 Paths to Mitigation

4.2.2 Policy Implementation

Paradise has been discussing and has implemented policies to help keep the area safe as it can from wildfires. The town can proclaim a local emergency earlier than they could before (Paradise Town Council, 2018). As of 2019, the Butte County mitigation plan has yet to address climate change though the impact is becoming more relevant in the region (Butte County, Local Hazard Mitigation Plan, 2019). There is an acknowledgment of climate change, but there is no set plan to combat it. Paradise has implemented grant opportunities for community growth and small businesses, which would help with disaster recovery for infrastructure damage and the impact of an "economic injury" (Butte County Local Hazard Mitigation Plan, 2019). Throughout the mitigation plan, wildfires, droughts, and flooding are the topics that receive the most

attention. One such plan is to help *"remove ladder fuels and dead and dying vegetation, thin, unhealthy overstocked trees and overgrown vegetation"* while creating space around structures to combat the intensity of a wildfire as well as preventing fires from crowning on the trees. (Butte County Local Hazard Mitigation Plan, 2019) This project of the plan is the most detailed section of the 100 page-long mitigation plan, along with other set plans it seems a top priority is to limit the intensity of the next potential fire to be able to answer more sustainably. This plan of attack seems to be one that could start a continuous defense against wildfires. Butte County does deem droughts and floods as hazards to be worried about as well but does not have as many pieces of the plan as wildfires do. In the long run, fighting the wildfires needs more attention to climate change, and from the looks of it, Paradise has the information to use when creating new project plans; however, it has yet to dive in more on the impacts of climate change for Butte county which, in turn, can be harmful, but Paradise seems to be on the right path and can soon figure out a much more cohesive plan that does indeed limit the risk of fires in the area.

4.2.3 Capacity Building Initiatives

The targeted universalism approach advocated by the Center for American Progress can address the vulnerabilities and performance gaps that often amplify the impact of a disaster event.

The targeted universalism approach can be most effectively utilized to increase resident and government capacity with the support of the state government. Funding and resource allocation directed towards grass-roots human capital investment would go a long way in ensuring that the impact of effects would never be replicated. State government policy recommendations to ensure optimal incorporation of the targeted universalism approach are described below:

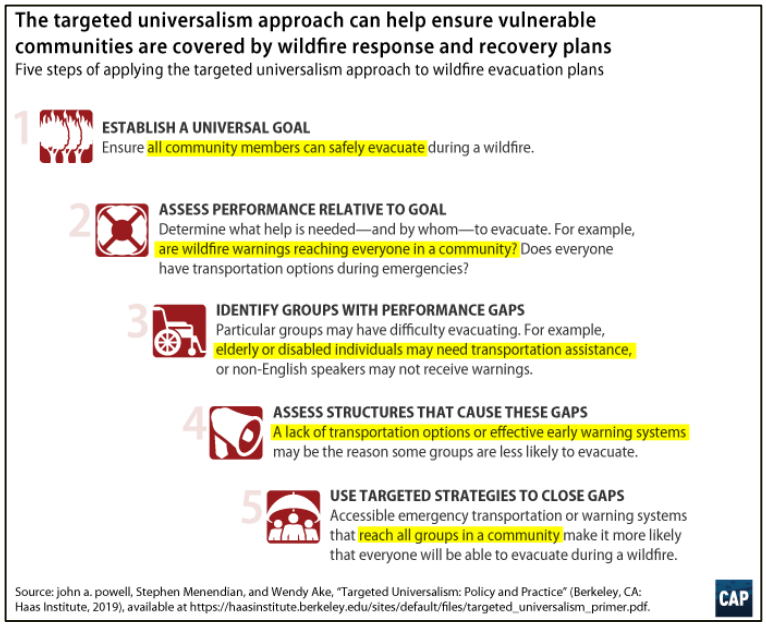


Figure 5 Targeted Universalism Approach

- Disaster response planning should include at-risk populations in a meaningful way.
- Federal and state agencies should allocate more considerable disaster response resources to training local jurisdictions on reimbursement and cost-sharing programs to help at-risk populations.
- Disaster response policies should be implemented at the statewide or regional level to prepare for wildfire at the appropriate scale.
- Reform disaster relief housing programs to accommodate renters and at-risk populations.
- Monitor recovery in communities affected by wildfire.

4.2.4 Infrastructural Improvements

The optimal solution to negate the effects of wildfires on human society would be to discourage or prohibit (by zoning) construction of homes in wildfire-prone areas. However, this can be expensive and unpopular, especially in California, where there is a housing shortage (Flavelle, 2018). Thus, some alternative measures must be looked at considering there will be people who are going to reside in wildfire-prone areas. Some

construction techniques and materials would mitigate the impact of wildfires, augmented by the increase in human capital and policy initiatives.

Fire-resistant materials and building techniques can increase the cost of construction; however, they are worthwhile in such areas. An effective measure is to apply the latest building codes retroactively to all homes in vulnerable areas (Flavelle, 2018).

Wooden roofs and asbestos false-ceilings catch fire extremely fast and must be considered for replacement with Reinforced Cement Concrete (RCC). RCC and Masonry structures would provide the most effective insulation in the event of a wildfire and would certainly protect structures from any significant damage.

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