

Tragedy in Maui: A review of the factors behind the Lahaina wildfires and solutions for a safer future.

Tae Lee

Author affiliation & contact: Kalani High School, taepersonal@gmail.com

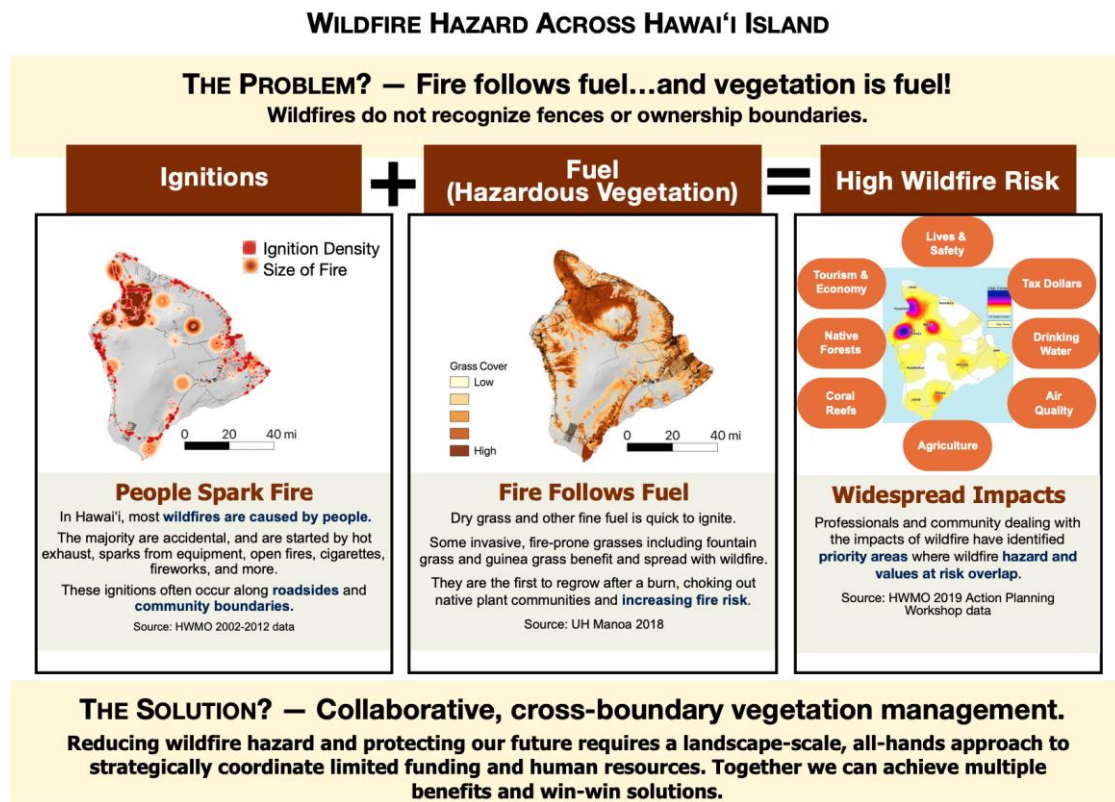
Abstract (250 words)

The recent fires in Lahaina, Maui, were initiated by a multitude of factors. Firstly, miscommunication and a lack of preparedness enabled the fire to spread uncontrollably: the lack of a fire evacuation plan, untimely use of sirens, and poor staff training together led to the failure to contain the fire and to evacuate residents. Secondly, Maui's vegetation and ecology also played a significant role in facilitating the fire's growth. Lahaina's invasive grasses, e.g. *Megathyrsus maximus* (guinea grass), are extremely drought-resistant and raise flame heights when burned. This, coupled with the species' tendency to outcompete native vegetation, fostered extremely dry and flammable land. Thirdly, most houses in Lahaina lacked adequate fireproof materials, allowing flames to spread rapidly within and between homes. The chain reaction of events triggered from the Lahaina fire highlights the need to reevaluate the variables that initially caused the fire and devise solutions for them. Solutions to the miscommunication and lack of preparedness, include effective evacuation plans, automated broadcasts, modifications to emergency protocol, and dry hydrants. The implementation of community gardening and land restoration programs can combat the issues arising from Maui's invasive grasses. Finally, Lahaina's infrastructure can be fortified through enhancements to fireproof technology, such as Class A roofs and wind-rated vents, and modular housing, which can provide temporary shelter to affected families. By synthesizing the factors behind the Lahaina fire as well as potential solutions, this paper identifies critical areas for future improvement and proposes suggestions for community fire protection to the Hawaiian government.

Keywords (4-6 words/ phrases): Wildfires, Lahaina Fire, Invasive Grasses, Infrastructure, Fireproof, urban-wildland interface

Introduction

Wildfires are widely recognized as natural disasters that are capable of generating massive economic, environmental, and social consequences. While all fires can be started or exacerbated by human behavior, the environment and the infrastructure surrounding a given area can heavily influence a fire's magnitude, as well as its ability to spread (Figure 1). Globally, intensifying droughts in the U.S. and other parts of the world are associated with higher fire risks. For instance, the 2019-2020 Australian bushfires, which burned 42 million acres, were caused by extreme drought and were further exacerbated by a flammable landscape covered with native eucalyptus and grazing land. In this case, the combination of a lack of moisture with an abundance of dead fuel enabled the fires to spread rapidly, inflicting tremendous damage (Deb et al., 2020).



Project Background

Hawai'i Island Report

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Figure 1. A diagram illustrating how vegetation can influence the rate at which a fire spreads. Source: Hawaii Wildfire Management Organization, image downloaded from hawaiiwildfire.org on 10/7/2023.

In recent cases, such as the wildfires in Lahaina, Maui, the abundance of dry vegetation, as well as the lack of infrastructure and preparedness, all contributed to the catastrophic damages. This study will focus on the 2023 Lahaina fire as a case study. By analyzing and pinpointing the causes and contributing factors behind the devastating wildfires, I aim to provide recommendations for decision-makers and the public for preventing and mitigating future fire risks. The first section of this analysis will discuss how the inadequate communication systems, evacuation plans, and overall lack of preparedness within Lahaina left citizens uninformed, as well as how poor staff training led to an inefficient emergency response. Next, the article will shift focus to how the vegetation and ecology of Lahaina, in addition to climate change, fostered incredibly dry vegetation and landscape, which enabled flames to spread rapidly. The third portion of the article will include an analysis of Lahaina's infrastructure and urban planning, and how the flaws regarding both could be improved to protect the city from future wildfires. Finally, the article will end with an actionable step for readers as well as a conclusion, ultimately summarizing key details and compounding them into a comprehensive summary.

Communication Systems & Preparedness

Contrary to what most would assume, the county of Lahaina completely lacked a fire evacuation plan. Despite displaying warning signs of fires months before the fires were initiated, Lahaina had no evacuation plan available to the public (Lin, Lin II, Winton, Petri, 2023). In fact, the county of Maui's website (<https://www.mauicounty.gov/983/MEMA-Alerts>) only contains evacuation plans for tsunamis—not wildfires. When compared to states such as California, which highlights evacuation sites and procedures very clearly, it is clear that Lahaina was extremely unprepared and did not prioritize public safety with ample effort. The lack of evacuation plans was a very likely cause of the high death count, further demonstrating the incompetence and irresponsibility of those in charge of the emergency systems and public safety.

The second aspect that significantly amplified the effects of the Lahaina fires was poor staff training. Current evidence suggests that firefighters left the scene of the disaster after the fire was contained—but this doesn't mean that the fire was fully extinguished (Kovaleski, S. F., & Baker, M., 2023). The fire department of Lahaina made this decision because they deemed the threat of the fire to be minuscule after its containment. In most cases, this would have led to the fire burning out and halting. However, one factor that the fire department did not consider thoroughly was the strong winds in the area. Powerful currents of wind blew embers from the contained area into other parts of the town, leading flames to spread (Kovaleski & Baker, 2023). This indicates that the fire department and its workers failed to holistically analyze the fire, which led to poor containment and management. In addition to the poor decision-making made by the fire department, Lahaina police inhibited residents from evacuating by blocking the exits leading out of Lahaina. Maui Police Chief John Pelletier defends this stance by stating how there were downed power lines, which could pose the dangers of electrocution if driven over (HNN Staff, 2023). While this may appear to be a valid concern, the police department set up barricades to block the Lahaina Bypass Road and prevent people from leaving Lahaina. A few families narrowly escaped the flames by driving around the barricade and escaping to a neighboring town (Sforza, 2023). This underscores how the barricades had the opposite of their intended effect and instead led to increased congestion and death.

Another flaw within the aspect of communication systems was the inadequate alert systems. The Maui Emergency Management Agency (MEMA) is managed by registered users and functions to send alerts to the public during emergency crises and natural disasters. "Watch" level alerts are sent by email to notify people of environmental threats and to watch news or television for further details. "Warning" level alerts indicate that these threats are life-threatening and citizens should take action to find safety. At first glance, these technological systems seem useful: possibly reaching all those in possession of a smartphone, tablet, or computer. However, these alerts are only sent through digital communication, such as email or text, and cannot reach the majority of people who do not rely on technology, such as the elderly. This becomes a major issue when power lines or cell service is down. In Lahaina, residents did not have enough time to evacuate because many didn't receive the notifications due to power outages. Despite having numerous sirens capable of producing noise up to 120 decibels loud within a 300 foot radius, MEMA did not utilize them in order to alert people of the flames (Sowby & Porter, 2023). Interestingly, there was no valid reason as to why the officials did not sound the sirens apart from not seeing the fire's possible magnitude, not having enough time to respond,

and not wanting to confuse residents, as these sirens are generally used for tsunamis. Furthermore, despite being loud and easily broadcasted, these sirens don't tell people what to directly do, which can lessen their functionality. Finally, Maui County Mayor Richard Bissen, who was responsible for sending out these alerts failed to do so in a timely manner—specifically, almost 12 hours after the fire was reported and “contained” (Arkin & Hasty, 2023). This led most people to discover the threatening circumstances after the fire had left significant damages.

Recommendations:

- 1)** With respect to the lack of a fire evacuation plan, both the city of Lahaina and the Island of Maui should write out a carefully detailed plan and set of steps/procedures that all locals can follow to get to safety in the case of a wildfire. This should include designated evacuation zones, telephone numbers of emergency services, and other general principles that citizens can abide by in order to stay safe. Another solution that could help prepare the county of Maui for future fires is the implementation of safe zones: Designated areas that people can go to before evacuation routes open up or before conditions are alleviated. Examples of safe zones can include sports fields and other open spaces that allow large sums of people to congregate. Signs that lead to safe zones can be built near schools or resident areas and can include information as to how to arrive quickly as well as a small map of the reader's area (Weber, 2023). Combining these safe zones with current fire drills and protocols within the workplace or classrooms can facilitate efficient evacuations, making people more prepared for fires. These drills should also be practiced frequently, to ensure proper memory and prevent public amnesia.
- 2)** Poor staff training in the fire department can be fixed by revising the current training protocol in order to make extinguishing fires mandatory as opposed to just containing them and waiting for them to pass on their own. Furthermore, police should be informed on how to notify the government and those in charge of power lines to shut down. In this instance, electrocution from downed power lines was a point of concern, therefore, the power should have been shut off so that residents could leave through the Lahaina bypass. While some may argue that this can prevent residents from communicating with others, it would likely provide greater benefit, as those in affected areas could simply escape the city and use a neighboring town's power to access their cell phones and other devices.
- 3)** Lahaina's inadequate alert systems can benefit from an automated voice message that can be broadcast during fires in order to spread awareness of the disaster, as well as to give residents a procedure to get to safety. Another alternative would be to create another siren with an easily differentiable noise. This would prevent residents from becoming confused when the sirens are activated, as they would be able to perceive which natural disaster—between a fire and a tsunami—the county is attempting to warn them about. Furthermore, wireless EAs alerts, sent through TVs and radios, as well as WEA text message alerts, sent to cellphones, can be used in synergy with the sirens or broadcasts in order to inform the public about possible threats posed by fires (Castillo, 2023).
- 4)** One final solution that may improve the efficiency of emergency fire services in the future is the use of dry hydrants. These mechanisms are placed alongside water reservoirs, lakes, and rivers, and utilize a not pressurized system. More importantly, dry hydrants grant firefighters an

external source of water if emergency supplies are depleted (Sowby & Porter, 2023). Dry hydrants are a relatively inexpensive solution and the county of Lahaina would significantly benefit from installing these systems around local bodies of water.

Vegetation, Ecology, and Climate Change

Another crucial, but often overlooked, variable that can determine a fire's magnitude is the surrounding areas' vegetation, ecology, and sensitivity to climate change. After Hawaiian sugar plantations became untended in the 1950s, plants native to Africa, such as *Megathyrsus maximus* (guinea grass), *Cenchrus ciliaris* (buffel grass), and *Melinis minutiflora* (molasses grass) began spreading rapidly (Kim, 2023) (Figure 2.).

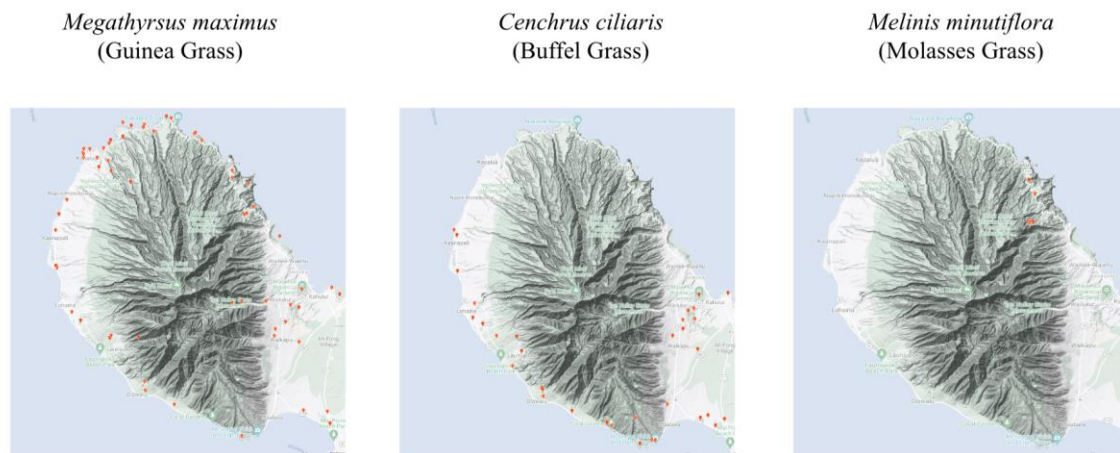


Figure 2. A map showing the geographical distribution of *Megathyrsus maximus* (guinea grass), *Cenchrus ciliaris* (buffel grass), and *Melinis minutiflora* (molasses grass). The orange points indicate discoveries of the species. Source: iNaturalist, image downloaded on 10/21/2023.

These invasive plants are extremely resilient, drought adaptive, and flammable and are often the first to repopulate the land after a fire (Soti & Thomas, 2021). This prevents other plants from growing due to competition, making nearby houses and land even more susceptible to fires. The grasses spread during the rainy season and follow a simple life cycle in which water, animals, and wind transport their seeds all over the island. In summer, these plants become dry and arid, making them a phenomenal catalyst to start fires when they are hit by embers (Kim, 2023). The areas in which these invasive plants spread are not limited by the amount of space within a given area. In fact, a large area of grasses, within schools and the State of Hawaii, caught fire within a close proximity of one another (Figure 3). Furthermore, in a study comparing non-native forests and invasive grasslands, rates of fire spread in the grasslands were 3-5 times greater compared to those in forests and flame heights for grasslands was also 2-3 times higher (Ellsworth et al. 2014). The evidence additionally highlights that invasive grasses, in addition to increasing the flammability of a region, affects the magnitude of fires by raising flame heights, allowing flames to touch nearby vegetation and continue burning. Whilenative Hawaiians used to frequently manage vegetation to get rid of dry

grass, these traditional practices are not carried on due to time constraints within modern schedules, leading invasive species to be inadequately managed as a result.

Ownership of burnt nonnative grassland in Lahaina

State of Hawaii Kamehameha Schools Peter Martin & Associates

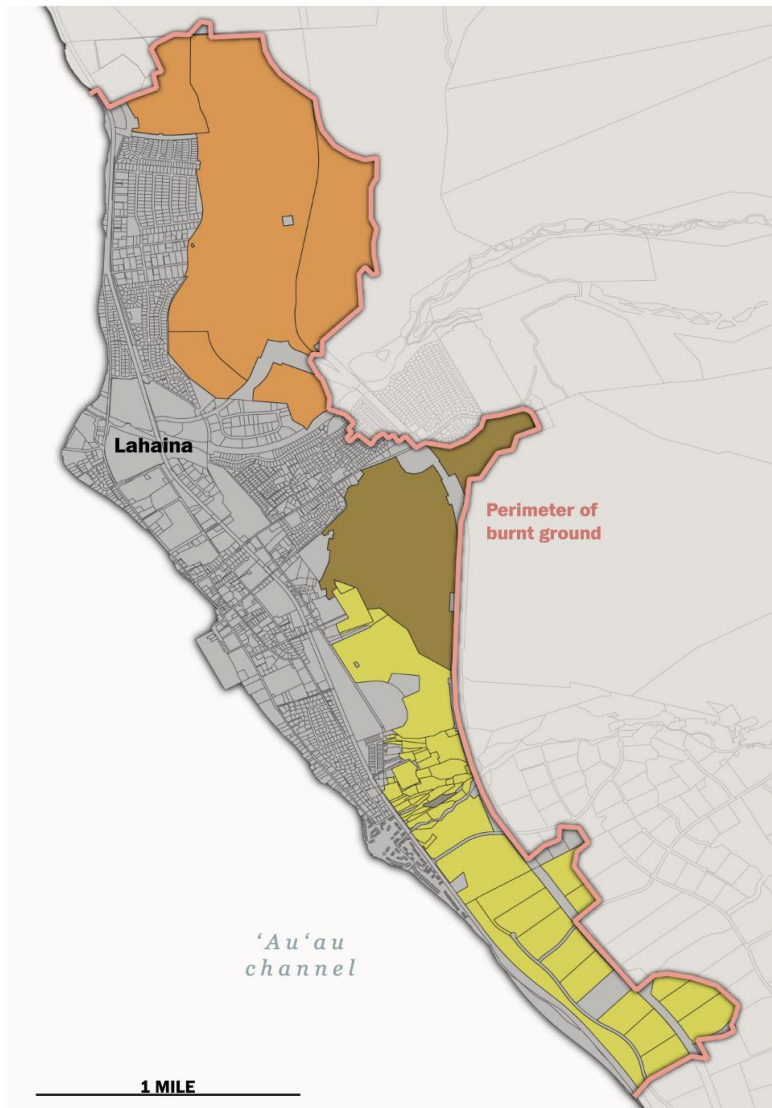


Figure 3. A map highlighting the distribution of ownership of grassland in Lahaina. The highlighted areas are places that were damaged by flames during the fires. Source: Maui County, image downloaded/accessed from washingtonpost.com on 10/13/2023.

Furthermore, the adverse effects of climate change have had a significant impact on Maui, leaving counties like Lahaina in severe drought (Figure 4.) This amplifies the effects of the dry land and increases flammability. Warmer global climates also heavily contribute to hurricanes and other storms, which, in the case of the Lahaina fires, played a huge role in

allowing the fire to spread. Although the data illustrating the relationship between climate change and its effect on hurricanes is limited, current evidence suggests that hurricanes are primarily caused by the following factors: Warm water temperatures, unstable weather conditions, humidity, and a constant flow/direction of wind (Coffmann & Noy, 2010). These factors can all be influenced by global warming—an increase in global temperature subsequently increases the rate of evaporation, further increasing the rate of heat transfer from the ocean to the air, leading to a rise in humidity.

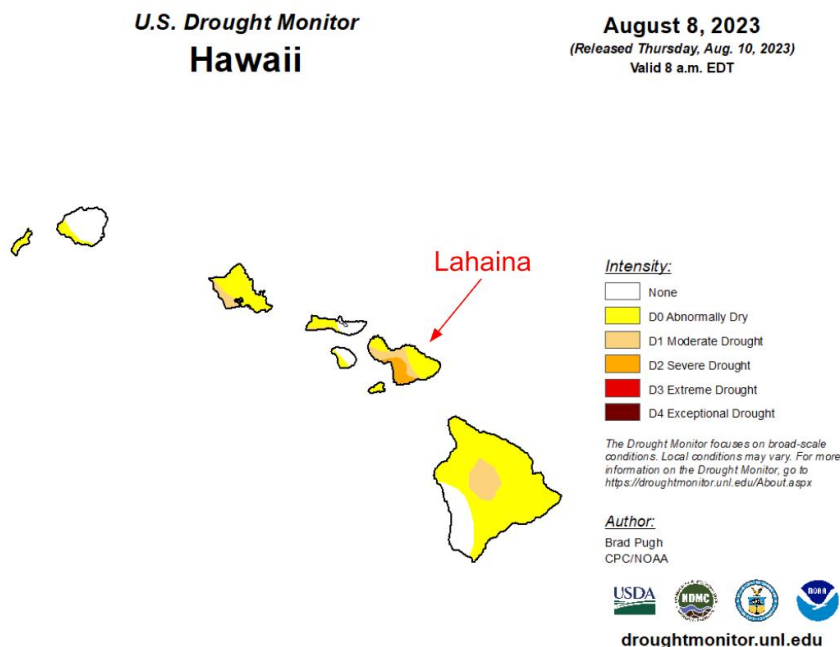


Figure 4. A drought monitor for Hawaii for August 8th, 2023. The dark orange indicates areas in severe drought. Source: Drought.gov, image downloaded on 10/21/2023.

Recommendations:

1) The management of invasive species will require a community effort and lots of volunteers. One solution to further limiting the spread of invasive plants is through school programs. The Maui Invasive Species Committee (MISC) is an organization dedicated to addressing the rapid spread of invasive pieces. As shown in Figure 2, a notable portion of invasive grasses are present on land owned by Kamehameha schools. The introduction of community service programs through schools can provide an incentive for students to take care of their island's land and bring their communities closer together.

2) Another method that can be used is to convert large patches of invasive plants back to orchards or reforested woodlands. Plants such as dragonfruit, pineapple, and bananas would help cut off the spread of fires. This is highlighted in a 2014 study that demonstrated how an

increase in native shrub cover, or surface area, subsequently inhibits the spread of invasive graminoids. In a restoration area, when native plant coverage increased from 3.1% to 81.9% in 2012, the coverage of non-native grasses decreased from 5.4% to 3.3% (Medeiros et al., 2014). Moreover, encouraging home owners to plant high water retaining or fireproof plants, such as *Metrosideros polymorpha* (Lehua trees) and *Dicranopteris linearis* (Uluhe Ferns) can help block flames from spreading (Firdaus, 2023). This would further connect communities through gardening projects and increase food security.

Infrastructure and Urban Planning

From an infrastructure perspective, the county of Lahaina's houses were resistant to small flames and embers, but were incapable of withstanding the wildfire's immense strength and flames. Both Lahaina's infrastructure and urban planning had many limitations. To begin, the majority of houses in Hawaii are composed of lumber, which is inherently prone to catching and spreading fires. Additionally, households that sustained damage were owned by the middle and low income class and were built in the late 1900's (Chappel, 2023; Philips, 2023). Conversely, a recent residential development built between 2019-2020 suffer from a lesser degree of catastrophic damage compared to older infrastructure.

Furthermore, the county of Lahaina faced a housing shortage that was worsened by the catastrophic effects of the fire. Housing costs have nearly tripled since the 90's, giving Hawaii the most expensive housing market in the United States (Fernandez, 2022). Additionally, 11.8% of Hawaiians are in poverty (U.S. Census Bureau 2022). Thus, rebuilding could push housing prices further up, making previous residents unable to buy houses in their own communities.

Recommendations:

1) There are many ways the houses in the future can be better optimized for fire protection. When comparing the distinct characteristics of both older and modern infrastructure, the primary differentiators were the degrees of fire retardant technology within each household. This technology ranged from fire resistant roof covers and exterior walls, ind rated attics, and sparse vegetation. For instance, one house, known as the "Miracle House," managed to survive the flames as a result of these traits (Chappell, 2023).

The first, and arguably most important factor that ensured the house's safety was roofing. Roofs are crucial because they must be formed with the intent of functioning as fuel breaks, as opposed to fuel sources. The material for roofs is a huge factor in determining how much damage a house sustains. Roofs are a very good landing pad for embers, hence why a Class A roof, composed of asphalt and metal shingles would be superior for preventing embers from igniting houses compared to wood. (Insurance Institute for Business & Home Safety, 2023). Next is wind-rated vents. A similarity between the miracle house and the recent 2010-2020 infrastructure is that both had screens within their wind vents. These screens act as a shield and prevent embers from entering and transporting to other areas of houses. Utilizing wind-rated vents can also reduce the risk of carbon monoxide and additional chemicals that can cause death through suffocation. The third solution is foundational planting. Replacing dry vegetation with paver stones or gravel can also reduce the risk of buildings catching fire. However it should be noted that the process of replacing dry plants with gravel pavements is more likely to

increase local temperature due to the urban island heat effect (absorption and reflection of heat). Oftentimes, heat that transfers from burning bushes or shrubs can burst windows, allowing fires to spread into houses. Another prevention that Lahaina can make is spacing houses further away from each other, as burning buildings can easily spread flames if they are within close proximity of one another.

2) To combat the problem of affordable housing for prior residents, the county of Lahaina can utilize modular housing. Modular houses are currently being distributed to families who have been displaced by the fires and range from 16 feet by 20 feet to 8 by 20 feet. They function as temporary homes with kitchen essentials such as microwaves, laundry machines, stoves, as well as free security. This solution is not the most sustainable in the long term. However, it will help prevent substantial increases in homelessness and poverty while also rebuilding the Lahaina community and keeping them safe from entering the burned land and being exposed to harmful chemicals. Additionally, individuals seeking to contribute to the rebuilding process can donate to the Maui Strong Fund (<https://www.hawaiicommunityfoundation.org/maui-strong>) to support the financial needs of affected communities.

Conclusion

In the recent wildfires in Lahaina, Maui, catastrophic damages were sustained in both residential and commercial areas. Upon examining these factors, we can conclude that the intensity of the fires was influenced by a diversity of factors. Lahaina's lack of preparedness can be improved through a comprehensive fire evacuation plan, the creation of safe zones, and the utilization of dry hydrants. Poor staff training must be revised to educate the fire and police departments on the proper protocols for dealing with fires. This will subsequently benefit communication systems, as the county of Maui and Government of Hawaii will better be able to send emergency resources towards the public. To combat the environmental factors, Maui officials should implement incentives for local communities to take care of land and manage the invasive species that can amplify the strength of fires. Another solution is to convert these patches of invasive species back into orchards or woodlands. Planting fruits and other plants with high water content or natural flame retardants can help prevent fires from spreading and act as a secondary food source. Finally, Maui's infrastructure can benefit greatly from asphalt, or metal, roofs and wind-rated vents. Both structures will block embers from bouncing onto neighboring land and homes and ensure that toxic fumes cannot enter houses as easily. In order to counter the housing shortage, modular homes can be used to house residents until new homes are built. The tragedies in Lahaina reflect a broader issue – Hawaii needs to proactively improve its fire preparedness. Using Lahaina fire as a case study, this comprehensive overview will guide local agencies and citizens in other areas of Hawaii to be better prepared for the warming climate and the increasingly flammable landscape.

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