



Wildfire

Wildfires are unplanned and uncontained fires that burn in undeveloped land. Many Hawai'i communities and elements of infrastructure are in wildfire risk areas. Each island has unique wildfire risk areas, firefighting access, and local planning and preparedness efforts. The statistics below represent the statewide high wildfire risk area.

CHANGES SINCE 2018

+2

Declared Disasters

+27

Wildfire Events

COUNTIES MOST VULNERABLE



Kaua'i Honolulu Maui Hawai'i

SOCIALLY VULNERABLE POPULATION

9.8%

Of Total Population

139,126

Persons

CLIMATE PROJECTIONS



Dry vegetation from increased temperatures may intensify wildfire danger



Average temperatures in Hawai'i could increase by as much as 5–7.5° F by the end of the century



Rainfall Changes
An increase in consecutive dry days and decrease in total rainfall may increase wildfires.

HAZARD RANKING



Low Medium High

COMMUNITY LIFELINES

239

Total



Greatest

2,896

State Buildings



SQUARE MILES

82

Environmental Resources



51

Hawaiian Home Lands



39

Cultural Resources



335

Miles of State Road





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SECTION 4. RISK ASSESSMENT

4.15 WILDFIRE

2023 SHMP Update Changes

- ❖ New and updated figures from federal and state agencies are incorporated.
- ❖ This section now includes a discussion of how wildfires impact socially vulnerable populations and community lifelines.
- ❖ Wildfire events that occurred in the State of Hawai'i from January 1, 2018, through December 31, 2022 were researched for this 2023 SHMP Update.
- ❖ Six types of cultural resources (archaeology, burial sensitivity area, historic building, historic district, historic object, and historic structure) are added to the vulnerability assessment.

4.15.1 HAZARD PROFILE

Wildfires in the State of Hawai'i destroy native forests, alter soil composition, and threaten human safety and infrastructure. The State of Hawai'i's native ecosystems are not fire adapted. In many cases, once an area burns, it is generally replaced by fire-prone non-native species, permanently changing the State of Hawai'i's landscape (DLNR 2013). Over 25% of the state contains non-native, fire-prone grasses and shrubs, which fuels the fires that occur in the state (Figure 4.15-1). This percentage grows each time fire burns into native forest because the forest is then further invaded by fire-prone non-native species (DLNR 2021).

Each year, approximately 0.5% of the State of Hawai'i's total land area burns, which is equal to or greater than the proportion burned of any other state (DLNR 2021). Over 98% of the total wildfires are human-caused. In the last 10 years, nearly 1,000 wildfires burned an average of 20,000 acres per year statewide. On the Hawaiian Islands, damages spread mauka to makai (from the mountain to the ocean) quickly, leading to catastrophic impacts to natural resources (Trauernicht, et al. 2015).

HAZARD DESCRIPTION

"Wildfire" is the term applied to any unwanted and unplanned fire burning in undeveloped land regardless of whether it is naturally or human-induced. While sometimes caused by lightning, between 2001-2010, 85% of fires in the United States were caused by humans (FEMA 2015).

Fire hazards present a considerable risk to native ecosystems and biodiversity, including threatened and endangered plant and animal species. As a consequence of wildfire, vulnerability to flooding increases due to the reduction or elimination of plant materials and root systems to stabilize soils resulting in negative impacts, including potential destruction of watersheds affecting water quality and availability. Wildfire near coastal areas and increased erosion is a key threat to coral reef ecosystems. While wildfire damages terrestrial and aquatic systems, losses to cultural and economic resources and community infrastructure also occur.





Figure 4.15-1. 2022 Leilani Wildfire in Hawai'i County Burns Fire-Prone Grasses and Shrubs



Credit: DLNR

The potential for significant damage to life and property exists in areas designated as “wildland urban interface (WUI) areas,” where development is adjacent to densely vegetated areas. Across the mainland U.S. the WUI is roughly defined as the zone where natural areas and development meet. In the State of Hawai'i, this definition has been expanded. Steep slopes create linkages between upland wildland fires and downslope impacts on communities, coastal areas, and municipal resources. Conversely, wildfires ignited near developed areas quickly spread into forested areas because of invasive grasses, putting threatened and endangered plant and animal species at risk (DLNR 2016).

The State of Hawai'i is also unique in that the vegetation surrounding communities is rapidly undergoing changes that yield higher wildfire risk, in large part due to increased invasion by fire-prone species from changes in land uses (such as active agriculture becoming unmanaged fallow land). In 2013, Hawai'i Wildfire Management Organization (HWMO) updated the Communities at Risk From Wildfire (CAR) map (discussed in the Location section of this profile). All developed areas across the state were assessed for risk and rated from Low to High based on 36 hazard characteristics that contribute to wildfire risk.

The WUI is the approximate area where the natural environment and development meet. According to the 2016 Hawai'i Forest Action Plan, the wildland areas in the WUI are made up of vast tracts of land that were once used and maintained for agricultural purposes but are now fallow and dominated by highly fire-prone invasive grasses. Wildfires in the WUI move quickly into forested areas because of the invasive grasses, putting threatened and endangered plant and animal species at risk (DLNR 2016).

Overall, WUI fires can be as damaging or even potentially more damaging than urban structural fires. This is due to the fact that wildland fires are often more difficult to control and behave differently from structural fires. When these fires erupt, people and structures must take priority, often at a devastating expense to natural resources. Current home and structure





building standards allow structures to be built and maintained in a manner that leaves them and their occupants vulnerable (National Wildfire Coordinating Group 2006). Thus, wildfires become a significant threat to both humans and natural resources and often result in ecological losses to the State of Hawai'i.

According to National Geographic, there are four types of wildfires: ground wildfires, surface wildfires, crown wildfires, and spotting wildfires.

- **Ground Wildfires**—These wildfires burn in natural litter, duff, roots, or sometimes high-organic soils. Once they start, they are very difficult to detect and control. In addition, ground fires may rekindle.
- **Surface Wildfires**—These wildfires burn in grasses and low shrubs (up to 4 feet tall) or in the lower branches of trees. Surface wildfires may move rapidly, and the ease of control depends upon the fuel involved. Brush fires are a type of surface fire, which the State of Hawai'i is quite vulnerable to during periods of prolonged drought and high winds. Brush fires burn vegetation that is less than six feet tall, such as grasses, grains, brush, and saplings.
- **Crown Wildfires**—These wildfires burn on the tops of trees. Once started, they are very difficult to control since wind plays an important role in the spread of this type of wildfire.
- **Spotting Wildfires**— These wildfires can be started by surface wildfires and crown wildfires and carried by wind. A characteristic of spotting wildfires is that large embers are thrown ahead of the main fire. Once spotting begins, the wildfire will be very difficult to control (National Geographic 2022).

LOCATION

Steep slopes, rough terrain, strong winds, and a large percentage of highly ignitable invasive grasses characterize the landscape for much of the State of Hawai'i. Coupled with warm weather, recurring drought conditions, changes in land use and maintenance, and a history of human-caused fires put the state at increased risk to wildfire (DLNR 2016).

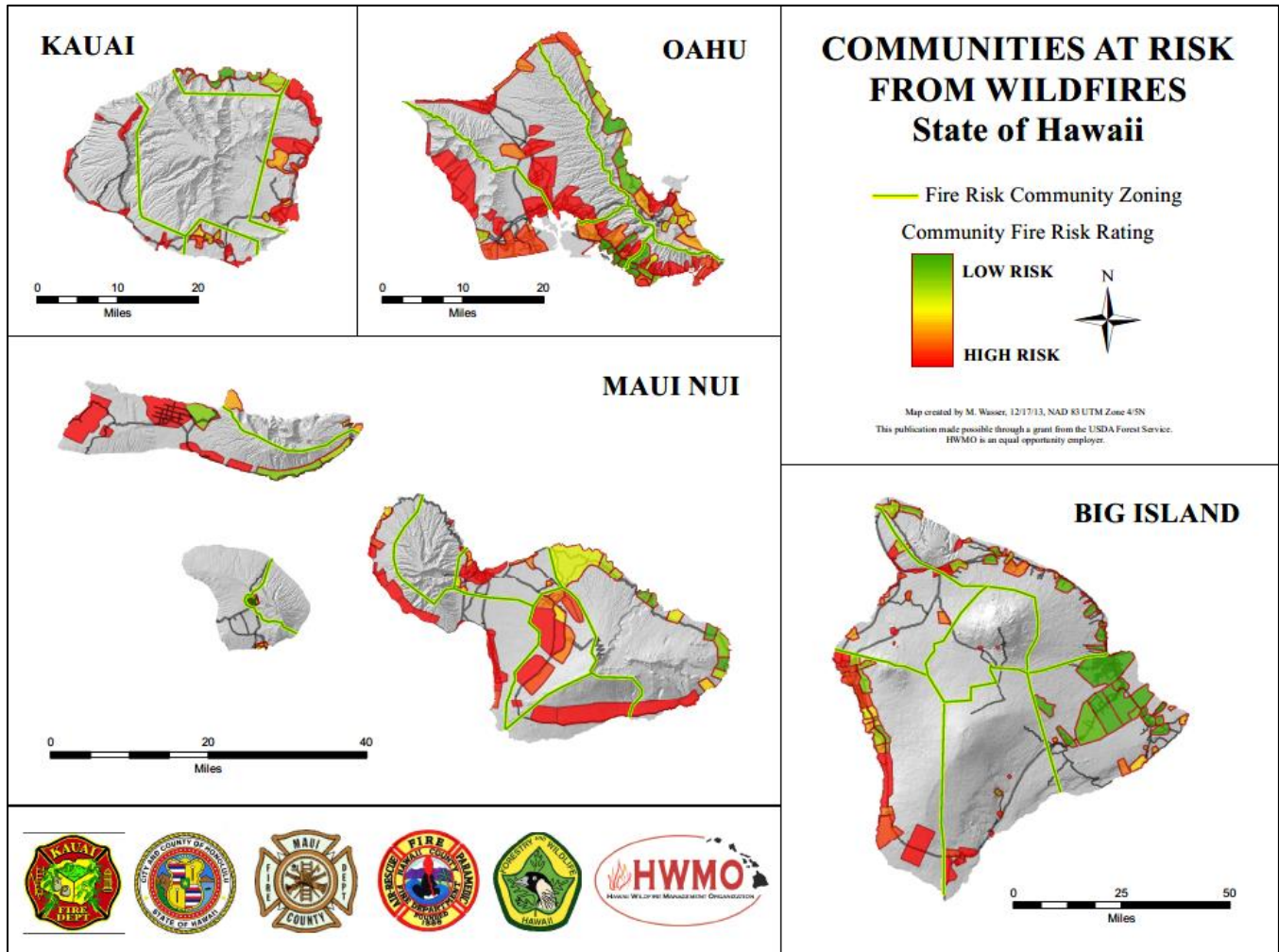
In the State of Hawai'i, most wildfire ignitions occur in the WUI which impacts the state's population, infrastructure, and environmental resources. The WUI areas often experience significant risk of losses to property and life, and to natural resource function. As stated, a majority of wildfires in the State of Hawai'i are human-caused. These fires typically occur near developments, power line rights-of-way, and along roadways. Additionally, sprawling dry, non-native grasslands surround many of the communities. Once ignited along the WUI, wildfire can spread quickly through residential areas, threatening both property and life. Wildfires can also spread from the interface to higher elevations, threatening natural areas and protected species (NASA 2021). Nationally, CAR maps delineate communities that share similar environmental conditions, land use characteristics, fuel types, hazards, and general wildfire issues, and provide ratings to characterize generalized hazards in each area. The U.S. Department of Agriculture's Forest Service recently updated the Wildfire Risk to Communities interactive online tool to include tribal and trust lands in all 50 states (USDA 2022). The State of Hawai'i Department of Land and Natural Resources (DLNR)-Division of Forestry and Wildlife (DOFAW) has been developing the State of Hawai'i CAR maps for more than a decade and has developed streamlined community boundaries for the purposes of the Hawai'i CAR map. In 2013, HWMO partnered with DLNR-DOFAW and the county fire departments across the State of Hawai'i to update the Hawai'i CAR maps. The original community boundaries were replicated in the 2013 map update, with changes made to reflect current hazards and subdivision expansions. The CAR for the entire State of Hawai'i is shown in Figure 4.15-2.

Many communities in the State of Hawai'i are located in high-risk areas due unmitigated fuels, limited community engagement, insufficient water and firefighting resources, and under-addressed pre- and post-fire planning and preparedness. These characteristics make fire suppression difficult and can promote fire spread, thus endangering communities (HWMO 2021).





Figure 4.15-2. Communities at Risk from Wildfires – State of Hawai‘i



Source: HWMO 2013

The HWMO is in the process of developing Community Wildfire Protection Plans (CWPPs) in partnership with local agencies to address the intent and requirements of the Healthy Forests Restoration Act (HFRA) of 2003 – HR1904, which describes the CWPP as a fire mitigation and planning tool for an “at-risk” community. A CWPP identifies and prioritizes areas for hazardous fuel reduction treatments and recommends the types and methods of treatment on federal and non-federal land that will protect one or more at-risk communities and essential infrastructure and recommends measures to reduce structural ignitability throughout the at-risk community. A CWPP may address issues such as wildfire response, hazard mitigation, community preparedness, structure protection, or all of the above (National Wildfire Coordinating Group n.d.). These locally administered plans serve to provide an indication of risk throughout the state, focusing on developed areas. Plans listed below are available online at: [Community Wildfire Protection Plans \(CWPPs\) — Hawaii Wildfire Management Organization](#) and [Division of Forestry and Wildlife: Forestry Program | Community Wildfire Protection Plans \(hawaii.gov\)](#).

The statewide status of CWPPs is as follows:

- **Kaua‘i County**—Kaua‘i Community Wildfire Protection Plan (2016)





- **Honolulu County**—North Shore O‘ahu Community Wildfire Protection Plan (2021); West O‘ahu Community Wildfire Protection Plan (2016)
- **Maui County**—Moloka‘i Community Wildfire Protection Plan (2016); South Maui Community Wildfire Protection Plan (2016); Upcountry Maui Community Wildfire Protection Plan (2016); Western Maui (2014)
- **Hawai‘i County**— Ka‘ū Community Wildfire Protection Plan (2015); North Hawai‘i Community Wildfire Protection Plan (2007); North Kona Community Wildfire Protection Plan (2016); Ocean View Community Wildfire Protection Plan (2015); South Kona Community Wildfire Protection Plan (2015); Volcano Community Wildfire Protection Plan (2015)

A comprehensive assessment of statewide wildfire risk, including undeveloped areas, is not available at this time. Information related to developed areas has been used to inform this plan. Figure 4.15-2 illustrates all developed areas in the State of Hawai‘i that have been assessed with a gradient color scale used to indicate the overall risk rating for each area (from low to high risk). Gray areas represent undeveloped wildland areas; these areas were not assessed or rated for the purpose of the CAR map. Table 4.15-1 lists the area of high wildfire risk areas by county. The high wildfire risk areas were used to assess vulnerability for the purposes of the 2023 SHMP Update (discussed later in the vulnerability assessment subsection).

Table 4.15-1. High Wildfire Risk Hazard Area by County

County	Total Area (Square Miles)	Square Miles in the High Wildfire Risk Hazard Area	Percent (%) of Total Area
County of Kaua‘i	624.2914	37.5	6.01%
City and County of Honolulu	598.5707	138.7	23.17%
County of Maui	1,176.28	163.1	13.87%
County of Hawai‘i	4,039.64	192	4.75%
Total	6,438.78	531	8.25%

Source: Hawai‘i Wildfire Management Organization, Division of Forestry and Wildlife

The following provides the context to the high wildfire risk hazard areas identified to date in each county. For further details of each, as well as mapping of the high-risk areas among communities, please refer to the CWPP.

County of Kaua‘i

Steep slopes, rough terrain, difficult access, and a large percentage of highly ignitable invasive grasses, and numerous threatened and endangered native species characterize the County of Kaua‘i landscape. This, coupled with warm weather, recurring drought conditions, changes in land use, and a history of human-caused fires, puts the area at increased risk of wildfire. The proximity of development to fire-prone wildlands present hazardous conditions that now threaten Kaua‘i communities and natural resources. Overgrown vegetation close to homes, pockets of open space within subdivisions, and an increase of non-native high fire-intensity plants around developed areas and native forests pose increasing threats to commercial, community, environmental, and residential resources. Together, these factors create the fire environment that puts the County of Kaua‘i at risk of wildfire (HWMO 2016).

City and County of Honolulu

North Shore O‘ahu

Wildfire threats on the North Shore are imminent and can lead to widespread damage to watersheds, natural resources, and human communities. Located in an area of O‘ahu that is less developed than many other parts of the island, the North Shore region is considered at high risk of wildfire due to frequent human-caused ignitions, windy and seasonally dry conditions,





steep and inaccessible terrain, extensive fire-prone grassland and shrubland areas (e.g., Mokule‘ia), and limited access and traffic congestion that slows emergency response times. (Department of Land and Natural Resources 2023)

West O‘ahu

In Western O‘ahu, wildfire occurrence is tied to broad climate patterns. More and larger fires typically occur in drier leeward areas. Rainfall in Western O‘ahu is highly variable over space and time and can greatly influence fire risk.

The widespread establishment of non-native grasslands and shrublands, especially in lower elevation areas, is a leading cause of increased fire risk in Western O‘ahu. Recurrent fires in these lower elevation grasslands and shrublands effectively “erode” the edges of upland forested areas, which become replaced by grasses and increase the risk of future fires over time. Upper elevation forests in the Wai‘anae mountains contain some of the few remaining tracts of native mesic forest. Lower elevation forests are more exposed to loss from wildfire due to the proximity of fire-prone grasslands and shrublands.

Typical of many areas, larger fires tend to occur during droughts and drier seasons, but wet periods may increase the quantity of available vegetative fuels, leading to an increase both in fire risk and in the frequency that mitigation measures such as firebreaks and fuels reduction need to be applied. Drier conditions tend to persist at lower elevations, making neighborhoods and lands near the coast particularly vulnerable to wildfire starts. Rainfall is typically greater in mauka (upland) areas, which may result in lower fire risk on average in these areas. However, due to more abundant vegetation in the higher elevations, mauka areas frequently experience moderate to high wildfire risk during periods of drought. Daily weather patterns, including diurnal thermal winds, also influence fire risk (HWMO 2016).

County of Maui

The County of Maui consists of distinct regions with differing risk to wildfire due to land use change, climate, topography, vegetation, natural resources, and availability of water sources.

The majority of wildfires in the County of Maui are caused by human error or arson, especially near developments, power line right of ways, and along roadsides. Additionally, sprawling dry, invasive, fire-prone grasslands surround many communities. Once ignited along the interface, wildfire can spread rapidly through residential areas, threatening both property and life. In coastal areas, increased erosion after fire degrades nearshore resource quality through increased sedimentation that damages coral reef ecosystems. Wildfires in the higher elevations threaten natural areas and watershed forests, creating changes to soil that affect groundwater infiltration and drinking water. Upland fires also threaten numerous protected species.

After 180 years of sugar production in the state, the last crop of sugarcane was harvested on Maui in 2016 as the last remaining plantation phased out their sugar operations (Agricultural Marketing Resource Center 2022), leaving unmanaged fallow land susceptible to wildfires.

Both the shoreline and upland areas have access roads (multiple ignition points) and include older settlement areas, historical buildings, and irreplaceable cultural and natural resources. Many of these roads are unpaved. Unmanaged fire fuels (primarily grasses and shrubs) in these areas create a significant hazard, as vehicles are common sources of fire ignition. Once ignited, these fires spread rapidly and threaten nearby community infrastructure, neighborhoods, grazing lands, and valuable native flora and fauna.

Brief overviews of the Upcountry Maui, South Maui, and Moloka‘i areas are provided below. A CWPP addressing Lāna‘i is not available at this time.





Figure 4.15-3. A 2019 Brush Fire Closes Kuihelani Highway in Maui County



Credit: The Maui News/Matthew Thayer

Upcountry Maui

Upcountry Maui sits entirely on the western slopes of Haleakalā, a 10,023-foot shield volcano, which makes up more than 75% of the County of Maui and spans from the island's eastern coast to its central plains. It is characterized by a combination of residential and agricultural areas and rugged, often inaccessible terrain. The communities of Waiakoa, Lower Kula, Ulupaiakua, and Kula Hawaiian Homesteads have the highest risk from wildfires in Upcountry Maui (HWMO 2016).

Western Maui

Steep slopes, rough terrain, strong trade winds, and a large percentage of highly ignitable invasive grasses characterize the Western Maui landscape. This, coupled with warm weather, recurring drought conditions, and a history of human-caused fire starts puts the area at increased risk of wildfire. The proximity of development to fire-prone wildlands present hazardous conditions that now threaten every Western Maui suburban and rural community.

Abundant fire fuels and heavy winds in the lowland coastal areas promote rapid spread of fires, quickly endangering historical sites, recreational areas, forested watersheds, grazing lands, homes, and community infrastructure. Overgrown vegetation close to homes, pockets of open space within subdivisions, fallow agricultural fields, and an increase of non-native high fire-intensity plants around developed areas pose increasing threats to commercial, community, environmental, and residential resources (HWMO 2014).

South Maui

The South Maui landscape is characterized by residential areas surrounded by highly ignitable fire-prone grasses on its upland side and the Pacific Ocean on its coastal boundary. South Maui stretches along a coastal region of the downslope edge of two volcanic mountain areas and the saddle between them: Haleakalā, the West Maui Mountains to the northwest, and the central plains connecting the two. The South Maui CWPP planning area is characterized by a combination of residential,





agricultural, and wildland areas. It stretches along a coastal region of the downslope edge of two volcanic mountain areas and the saddle between them: Haleakalā, the 10,023-foot shield volcano that comprises much of the Island of Maui, the West Maui Mountains to the northwest, and the central plains connecting the two.

Topography plays a key role in wildfire behavior and post-fire impacts in South Maui and its surrounding (and contributing) environs. Wildfires spread more quickly as they progress upslope and burn at higher intensity. Following wildfires, surface water from rain quickly travels downslope and increases soil erosion, causing downslope flooding and adding sediment to nearshore waters. These post-fire impacts can affect traffic and transportation routes, tourism and economic activities, and harm natural resources by way of runoff that smothers coral reefs and reduces water quality (HWMO 2016)

Molokaʻi

Molokaʻi is characterized by a combination of residential, commercial, and agricultural areas as well as rugged, often inaccessible terrain. A majority of Molokaʻi is dominated by non-native vegetation such as Christmas berry, kiawe, and several fire-promoting shrubs and grasses. These non-native, fire-prone grass, shrub, and tree species provide abundant fine fuels that cure quickly in dry conditions and are easily ignitable even in humid conditions. This allows fires to spread rapidly, creating dangerous conditions for communities and fire responders. These conditions are the leading cause of increased fire risk in the area. The communities of Kaluakoʻi, Maunaloa, Hoʻolehua, Kalamaʻula, Kaunakakai, and Kaweia have the highest risk from wildfires in Molokaʻi (HWMO 2016)

Lanaʻi

No CWPP exists for Lānaʻi.

County of Hawaiʻi

The County of Hawaiʻi is prone to wildfire conditions. On the leeward side, conditions are affected by a greater number of days with dry conditions and expansive grasslands. The windward side of the island has significant grassland cover and, although it has less number of dry days, becomes just as vulnerable to wildfire impacts during a drought. In addition, windward areas, including Puna and Hawaiʻi Volcanoes National Park, deal with lava-ignited wildfires (Trauernicht, et al. 2015).

Available information is provided for the communities of Kau, Northwest Hawaiʻi Island, Ocean View, and Volcano.

Kaʻu

The Kaʻu CWPP area is situated within the larger Hawaiʻi County district of Kaʻu. Formed from Mauna Loa and Kīlauea volcanoes and the prehistoric Ninole Volcano, the region is characterized by areas of barren lava, rocky substrate, and soil areas derived from volcanic ash. Elevations range from sea level to over 13,000 feet at the top of Mauna Loa. The Kaʻu region has a wide range of climatic conditions in a relatively small distance, providing diverse physical environments from the coastline to high elevations. Hazardous conditions exist throughout the Kaʻu area. Steep slopes, rough terrain, strong trade winds, and a prevalence of fire-promoting fuels characterize the Kaʻu landscape. This, coupled with warm weather, recurring drought conditions, and a history of human-caused fire starts puts the area at risk of wildfire. Both the shoreline and upland areas have access roads (multiple ignition points) and include older settlement areas, historical buildings, and irreplaceable cultural and natural resources. Many of these roads are unpaved. Unmanaged fire fuels (primarily grasses) in these areas create a significant hazard, as vehicles are common sources of fire ignition. Once ignited, these fires spread rapidly and threaten nearby community infrastructure, neighborhoods, grazing lands, and valuable native flora and fauna. Kaʻu is extremely isolated, and the closest water source can be many miles away. Catchment systems and hauled water are the only source of water for those residents not serviced by the two small municipal systems. The distances to water resources and





the high cost of hauled water are problematic for residents, business owners, and farmers and hinder fire suppression capabilities in the area (HWMO 2015)

South Kona

South Kona stretches for approximately 30 miles between Kailua-Kona and Ka'u on the leeward side of island. The South Kona area includes Kealahou, Captain Cook, Honaunau, Napo'opo'o, Ke'ei, Miloli'i, Ho'okena, Papa Bay, Kona Paradise, and other smaller communities and farm areas. Steep slopes and rough terrain dominate most of South Kona, with residential areas, businesses, community infrastructure, cultural resources, and farms spread throughout the district and ranging from sea level to upland areas. The region is primarily rural with low-density development. Over half of these residents depend on rain catchment and hauling or delivery of potable water.

Differences in climate, topography, and soils have resulted in unique natural ecosystems. In the past several hundred years of human habitation, pristine native ecosystems have diminished. Human activity and introduction of non-native plants and animals have displaced many of the historic plant and animal communities. Today, invasive grasses and shrubs and human-caused fire contribute to a cycle of hazardous wildfire conditions and increased post-burn conversion to non-native fire-promoting species. Despite the widespread alteration of native ecosystems, a few areas in South Kona remain as habitat for rare and endangered species and are protected. Upland areas are less disturbed and contain abundant 'ohia and koa forests (HWMO 2015)

Northwest Hawai'i Island

Within Northwest Hawai'i there are several communities, including, from north to south, Kawaihae, Waimea, Puako, Pu'uana'hulu, and Waikoloa. Communities covered by this CWPP vary in size from 100 single-family home subdivisions to more than 2,700 dwellings with single-family homes, condominiums, retail outlets, schools, historical sites, recreational areas, and commercial facilities. Some of the subdivisions in the coverage area are: Waiki'i, Puakea Ranch, Kohala by the Sea, Kohala Ranch, Kohala Estates, Kawaihae Village, Pu'u Kapu, Pu'u Lani Ranch Estates, Kona Palisades, Kealahou, and Hina Lani Estates. In addition, there are several internationally known world-class resorts that draw thousands of visitors from around the world.

The WUI areas in Northwest Hawai'i communities have a high risk of wildfire based on a wildfire hazard assessment. Wildland fires occur frequently throughout Northwest Hawai'i, threatening area residents. The largest wildfire in state history was in Northwest Hawai'i in 1969 and burned more than 47,000 acres. In 2005 a wildfire event burned 25,000 acres forcing the evacuation of thousands of people. The continued invasion of non-native plant species, which are considered high intensity burning fuels, increases the wildfire risk. Grazing of animals traditionally assisted in reducing fuel loads and wildfire risk. However, due to a variety of circumstances, grazing has been reduced or eliminated in many areas, which has contributed to the accelerated wildfire risk in areas that were previously less prone to wildfire. The lack of reliable water resources for both ground and helicopter fire suppression crews have also compromised the rapid response to these disasters and have contributed to the increased fire spread. Communities vary in their access of water, with some communities relying on private water systems or catchment water basins, with others accessing county water (HWMO 2007).

Ocean View

The community of Ocean View in the County of Hawai'i abuts Hawai'i Volcanoes National Park (HAVO) and is in a WUI environment. Covering a swath from sea level to a 13,000-foot mountaintop, the 377-square miles (333,000 acres) of Hawai'i Volcanoes National Park encompasses Mauna Loa, the world's largest volcano, as well as Kilauea, the world's most active volcano. The Park's ecological zones include coastal strand, dry lowland, mesic and wet rain forest, seasonally dry montane, sub-alpine, and alpine. It is home to more than 50 federally listed endangered, threatened, and candidate endangered species, as well as numerous rare species. Kilauea has made HAVO the state's largest tourist attraction, with more than 2.5 million visitors annually. In addition, Ocean View has experienced tremendous development in recent years. Many new residents are from other parts of the United States and unfamiliar with the wildfire risks of the community (HWMO 2015).



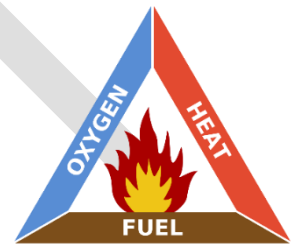


Volcano

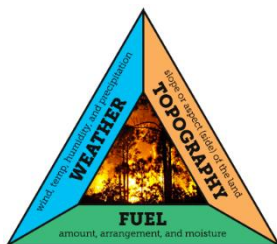
The community of Volcano in the County of Hawai'i also abuts HAVO and is in a WUI environment. Due to its location in proximity to HAVO, the community is impacted by lava flows within the Park which have caused several wildfires, some as large as 5,000 acres. Wildland fires originating within the Park have threatened the community of Volcano, which encompasses Volcano Village, the Volcano Golf Course Community, including the Golf Course Subdivision, Mauna Loa Estates, and Ohia Estates. Conversely, wildland fires caused by human error in neighboring towns, such as Volcano, could impact the Park. The Kilauea Forest Reserve separates Volcano Village and the Golf Course Subdivision. To the east of Volcano Village is the Ola'a Forest Reserve, a land tract of Native Hawaiian forest largely untouched by invasive species. Volcano has experienced tremendous development in recent years. Volcano Fairway Estates is a new subdivision (HWMO 2015).

EXTENT

Heat, fuel, and oxygen are all required for the creation and maintenance of any fire as depicted in the fire triangle shown in the adjacent image. The final element to the fire triangle is the chemical reaction between the components. When not enough heat is generated or when water is used to reduce the heat level; when the fuel is exhausted, removed, or isolated; when the oxygen supply is limited, then a side of the triangle is broken; or if the chemical reaction does not occur, the fire is extinguished.



- **Heat**—A heat source is needed for the initial ignition of fires. Heat is also generated by the fire. For a fire to grow, heat must be transferred to the initial and surrounding fuel. It allows fire to spread by removing the moisture from the nearby fuel, enabling it to ignite or travel more easily.
- **Fuel**—The fuel side of the triangle (as shown in the image above) refers to both the external and internal properties of the fuel. External properties refer to the type and the characteristics of the fuel material. Internal properties of fuel address aspects of fuel chemistry. Fuel is characterized by its moisture content, size and shape, quantity, and the location of the fuel type (ground, surface, ladder, or aerial).
- **Oxygen**—Air contains about 21% oxygen. Most fires require air with at least 16% oxygen content to burn under most conditions. Oxygen supports the chemical processes that occur during a land fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products (OSHA 2019) (US NPS 2016).



Fire Behavior Triangle

All wildfires begin with an ignition source. Fire behavior describes the manner in which fuels ignite, flames develop, and fire spreads. The “fire behavior triangle” illustrates how the three primary factors influence wildfire behavior: fuel, topography, and weather. Each point of the triangle represents one of the three factors; the sides represent the interplay between the factors. For example, drier and warmer weather combined with dense fuel loads and steeper slopes will cause more hazardous fires than light fuels on flat ground (US NPS 2017).

Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. However, there are tools used to identify the possibility of fire weather in an area. Fire weather watches and red flag warnings are used to convey the possibility of severe fire weather to wildland fire agencies.

The National Weather Service (NWS) issues Fire Weather Watches and Red Flag Warnings to alert fire departments and residents of the onset, or possible onset, of critical weather and dry conditions that could lead to rapid or dramatic increases in wildfire activity (NWS 2019). Fire weather forecasts are available on the NWS website accessed at





<https://www.weather.gov/fire/> and provides a hazard/overview map, the NWS Fire Wx Forecast Map, Today's SPC Outlook, the Latest Wildland Fire Outlook, and Current Large Incidents.

- **Fire Weather Watch** – The NWS issues a Fire Weather Watch when potentially dangerous fire weather conditions are possible over the next 12 to 72 hours.
- **Fire Weather/Red Flag Warning** – The NWS issues a Fire Weather Warning or Red Flag Warning when fire danger exists and weather patterns that support extreme fire behavior are either occurring or expected to occur within 24 hours. Authorities may issue a Fire Weather Watch before a Warning, but a Warning may also be the initial notification. Your community may also use the National Fire Danger Rating System to provide a daily estimate of the fire danger (i.e., low, moderate, high, very high, and extreme).
- **Evacuation Notice** – If the danger is imminent, local authorities may issue an evacuation notice to alert residents that a fire is nearby, and it is important to leave the area. Evacuation orders vary by state and community and may range from voluntary to mandatory. When authorities issue a mandatory evacuation notice, leave the area immediately. (FEMA n.d.)

PREVIOUS OCCURRENCES AND LOSSES

The first reported disastrous wildfire in the State of Hawai'i was in 1901 on the Hāmākua Coast of the Island of Hawai'i. Over 30,000 acres of agricultural and forested lands burned during this fire over a period of three months (Trauernicht, et al. 2015). This event led to the establishment of Hawai'i's Forest Reserve System and the integration of wildfire management into government forest management policy (DLNR 2021).

An abundance of wildfire information, specifically previous occurrences and losses associated with wildfire events, exists throughout the State of Hawai'i. The 2018 SHMP discussed specific wildfire events that occurred in the State of Hawai'i through 2017. For the 2023 SHMP Update, only wildfire events that burned over 100 acres between January 1, 2018, and December 31, 2022, were summarized. However, to provide a context for the overall frequency of wildfires, regardless of size, the state average number of wildland fires over the last decade is more than 1,000 wildfires burning more than 20,000 acres each year (Pacific Fire Exchange 2023). Table 4.15-2 provides the number of wildfires by year (from 2018 to 2022). On average, there were about 5 fires per year burning an average of more than 23,200 acres per year, though averages are not truly beneficial as wildfire incidents vary widely due to contributing factors. Table 4.15-3 lists the major wildfire events from 2018 to 2022.

Table 4.15-2. Summary of Wildfires from 2018 to 2022

Year	Wildfires	
	Number	Acres
2018	9	33,727
2019	9	16,835
2020	5	5,200
2021	2	41,400
2022	2	19,000

Sources: NOAA 2023





Table 4.15-3. Wildfire Events in the State of Hawai'i, 2018 to 2022

Date(s) of Event	Event Type	Counties Affected	Description
February 10, 2018 – February 12, 2018	Wildfire	Hawai'i	A lightning strike was thought responsible for a blaze on the Big Island of Hawai'i that scorched about 1000 acres of brush in the leeward part of the isle. The fire burned along Highway 190, Mamalahoa Highway, between Daniel K. Inouye Highway in South Kohala and Makalei in North Kona. The highway in that area was closed for more than 24 hours because of the fire. However, there were no reports of serious injuries or property damage.
March 11, 2018	Wildfire	Honolulu	A fire charred about 50 acres of brush near Whitmore Village in central O'ahu. The blaze closed Kamehameha Highway in the area for several hours. Several abandoned vehicles and other items within homeless camps were damaged by the fire. However, no injuries were reported.
June 27, 2018	Wildfire	Hawai'i	A fire blackened about 52 acres of brush and kiawe in leeward Big Island. No structures were threatened by the blaze. No other property damage or injuries were reported as the fire raged near the Mauna Lani resort.
July 03, 2018	Wildfire	Maui	A fire blackened about 2,500 acres of fallow sugar cane and dry brush in Maui's Central Valley between Haleakalā Highway and Pulehu Road near Pukulani. Several homes and a few businesses were evacuated as a precaution. However, no structures were damaged, and no injuries were reported. The cause of the blaze was undetermined.
August 01, 2018 – August 06, 2018	Wildfire	Hawai'i	A blaze charred about 18,000 acres of mainly brush near Waikoloa on the leeward side of the Big Island of Hawai'i. The fire did not threaten any homes or other structures, and there were no reports of serious injuries. The cause of the blaze was under investigation.
August 04, 2018 – August 09, 2018	Wildfire	Honolulu	Two fires scorched around 9,000 acres of brush on O'ahu's leeward section, one near Waianae and the other in Makaha Valley. The fires caused the Department of Education to delay the opening of two elementary schools in the area by one day. One family described how the Waianae blaze destroyed their home and livelihood. The fires also threatened other properties in the area and the schools for a time. The cost of damages was not available. No significant injuries were reported. The causes of the fires were unknown.
August 24, 2018 – August 25, 2018	Wildfire	Honolulu	A fire near the Kahe Power Plant in West O'ahu scorched 275 acres of dry brush. The blaze did not damage any structures or other property. A woman in the area was treated for smoke inhalation. The cause of the fire was believed to be from arcing from the power plant.
August 24, 2018 – August 26, 2018		Maui	Three fires blackened 2800 acres of brush in leeward West Maui near Lahaina. The blazes were fueled by dry vegetation and whipped up by winds from Hurricane Lane that was south of Maui County at the time. The fires damaged or destroyed 22 structures, including 13 homes with 60 individuals displaced; and 30 vehicles, along with a base yard that stored heavy equipment. Also, more than 100 homes had to be evacuated. A woman was injured by one of the fires and was taken to a hospital. The cost of damages had not yet been tabulated. The causes of the blazes were not known.
December 28, 2018	Wildfire	Hawai'i	A fast-moving blaze charred about 50 acres of brush in the North Kona District on the Big Island of Hawai'i. The fire started in the middle of the afternoon on the 28th near Hinalani Street and Ane Keohokalole Highway and was put under control by firefighters later that day. It had threatened several businesses and the Ulu Wini housing complex, but no damages or injuries were reported. A cause for the blaze was not provided.
January 06, 2019 – January 08, 2019	Wildfire	Hawai'i	A blaze charred about 200 acres of dry brush near Wailea in leeward East Maui. Around 100 people had to evacuate the area, including guests at a luxury hotel. Firefighters struggled for a time with the blaze because of breezy, swirling winds. No injuries were reported, and the cost of any damages was not available. The cause of the fire was not known.





Date(s) of Event	Event Type	Counties Affected	Description
February 05, 2019 – February 07, 2019	Wildfire	Hawai'i	A blaze charred more than 110 acres of brush in the US Army's Pohakuloa Training Area on the slopes of Mauna Kea on the Big Island. The fire was about two miles north of the Daniel K. Inouye Highway and on the Kona (west) side of Mauna Kea Access Road. No significant property damage or injuries were reported. The cause of the blaze was unknown.
March 10, 2019 – March 11, 2019	Wildfire	Honolulu	A blaze charred about 500 acres of dry brush in leeward O'ahu. The fire came close to some homes in the area near Nānākuli, but firefighters were able to stop it before any damage could be done. The fire began in Nānākuli Valley and then branched off into Waianae Valley. No serious injuries or property damage were reported. The cause of the blaze was unknown.
May 19, 2019 – May 22, 2019	Wildfire	Honolulu	A blaze scorched around 525 acres of dry brush in rough terrain on O'ahu. The fire started upslope of Kaukonahua Road north of Schofield Range near Wahiawa. It was difficult to contain because of the mountainous location of the blaze. No vegetation or structures or were threatened, and no injuries were reported. The cause of the fire was not known.
June 11, 2019 – June 12, 2019	Wildfire	Kaua'i	A fire charred about 500 acres of dry brush on the south side of Kaua'i near Poipu. The blaze prompted some evacuations of local residents and road closures as a precaution. However, the fire did not result in any serious property damage or injuries. Its cause was not known.
July 11, 2019 – July 15, 2019	Wildfire	Maui	A pair of brush fires combined to create a major hazardous episode over a portion of Maui. The blaze blackened around 9200 acres of old, dry sugarcane plantation fields and unmanaged grasslands in the isle's Central Valley. The fire was first reported in the later morning on July 11th, south of Kahului and south of the intersection between Kuihelani Highway and Waiko Road. Many residents were evacuated from the area, roads were closed, power was lost for a time, and many flights from the Kahului Airport were canceled. The Maui Humane Society also had to evacuate the animals at its shelter. The fire was fully contained by the morning of the 15th. No significant injuries were reported. The cost of damages was not available, and the cause of the blaze was not known.
September 04, 2019 – September 05, 2019	Wildfire	Honolulu	Two fires burned about 200 acres of dry brush in leeward O'ahu in Kunia. Five individuals were asked to leave their homes for a time as firefighters contained the combined blaze. Three storage containers were damaged in the Kunia Farm lots. However, no injuries were reported. The cost of damages was not available. The cause of the fires was not known.
October 02, 2019 – October 07, 2019	Wildfire	Maui	A wind-swept fire began upslope from Maalaea in Maui, in the West Maui Mountains, that eventually consumed around 4600 acres of dry brush. The flames forced the evacuation of more than 450 residents along Maalaea Bay Road as the blaze moved close to homes in the area. The fire also forced the closure of streets and highways in parts of West and central Maui. However, in the end, there were no significant injuries or structural damages. The cause of the blaze was under investigation.
October 22, 2019 – October 24, 2019	Wildfire	Maui	Dry vegetation and a breezy wind flow contributed to the ignition and spreading of a nearly 1000-acre blaze over leeward West Maui. It started in Kahana above the Kapalua Airport and spread along the ridge line in that section of the West Maui Mountains. The fire closed the airport for a time because of a power outage, and flights were diverted to Kahului. Traffic in the area was also affected from time to time, and some residents were asked to evacuate as a precaution as the flames threatened to spread farther afield. However, no significant injuries were reported. The costs of any damages were not available. The cause of the blaze was not provided. Resulted in disaster declaration FM-5294.
April 23, 2020 – April 24, 2020	Wildfire	Hawai'i	An arcing electrical wire was the likely cause of a blaze that scorched about 400 acres of brush north of Kawaihae, near 59-125 Halekai Place, on the lee side of the Big Island. No injuries were reported, and no structures were threatened by the fire.





Date(s) of Event	Event Type	Counties Affected	Description
August 16, 2020 – August 18, 2020	Wildfire	Honolulu	A fire blackened around 2,000 acres of mainly dry brush in rugged terrain in the northwest part of O’ahu. The cause of the blaze was not known, but it did close Kaukonahua Road near Waialua for a time as firefighters battled the flames. There were no reports of serious injuries or property damage.
August 30, 2020 – August 31, 2020	Wildfire	Maui	A blaze scorched a little more than 1,500 acres of dry brush south of Kahului in Maui's Central Valley. The fire damaged fiber cable in the area, but the cost of the damage was not reported. No significant injuries were reported.
September 30, 2020	Wildfire	Maui	A blaze charred about 550 acres of mainly blush on the slope above Kapalua Airport in West Maui. Personnel from a nearby water treatment plant were evacuated for a time as firefighters worked to bring the fire under control. There were no reports of significant property damage or injuries. The cause of the blaze was not known. The fire was not fully contained until noon on the 2nd of October.
December 26, 2020 – December 28, 2020	Wildfire	Maui	A wind-whipped fire in leeward West Maui near Olowalu charred more than 750 acres of mainly dry brush, although the blaze also destroyed the Olowalu Community Center, several vehicles and storage units, and partially damaged a residence on Luawau Street. No serious injuries were reported. Property damages totaled \$266,000.00.
June 04, 2021 – June 07, 2021	Wildfire	Hawai’i	A fire blackened about 1,400 acres of dry brush in the Hāmākua District on the Big Island of Hawai’i, near Paauilo. The blaze forced the closure of Highway 19 between mile markers 34 and 36 for a time, but no residents needed to evacuate the area. The cause of the fire was not known.
July 30, 2021 – August 06, 2021	Wildfire	Hawai’i	One of the largest brush fires in Hawai’i County history started in the morning hours of Friday, July 30th, in the South Kohala District along Mana Road near Parker Ranch land. The wind-swept blaze blackened more than 40,000 acres of mainly dry pastureland and grasses, though the fire forced the evacuation of Waikoloa Village for a time as the month turned to August. The blaze also destroyed two homes in the area. The fire, as mentioned above, stretched into August. The cost of damages was unavailable, and the cause of the blaze was unknown. Resulted in disaster declaration FM-5404.
July 21, 2022 – July 22, 2022	Wildfire	Hawai’i	A fire blackened more than 2,000 acres of brush in the Army's Pohakuloa Training Area. No homes or other structures were threatened by the blaze. No injuries were reported. The cost of any damages was not available.
August 10, 2022 – August 17, 2022	Wildfire	Hawai’i	A fire in and around the U.S. Army's Pohakuloa Training area on the Big Island of Hawai’i reignited in August. The original blaze charred more than 2,000 acres of brush in July, but the area affected grew to about 17,000 acres in August. The fire was 90% contained by August 17. There were no reports of serious injuries. The cost of any damages was not available.

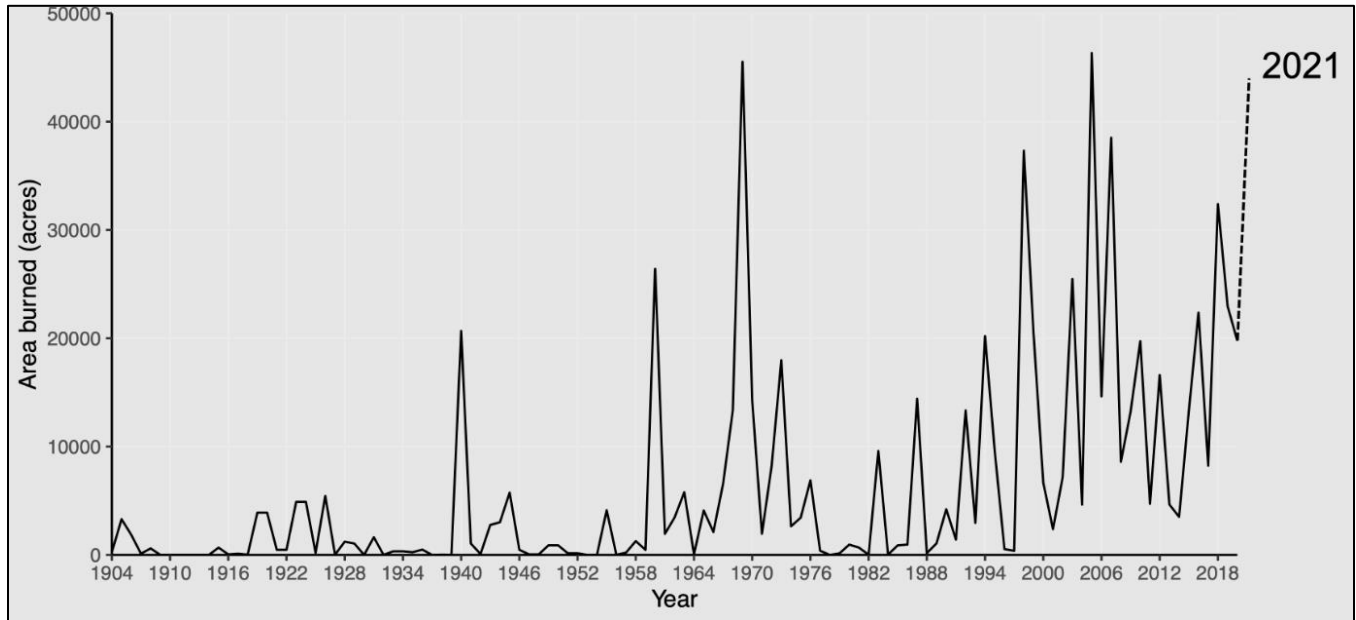
Sources: NOAA 2023

Figure 4.15-4 shows acres burned by wildfires since 1904 and Figure 4.15-5 illustrates wildfire incident locations that have been reported throughout the state. The location of these wildfires corresponds to the CARs previously discussed. A majority of these incidents occurred in the medium and high-risk areas previously documented.



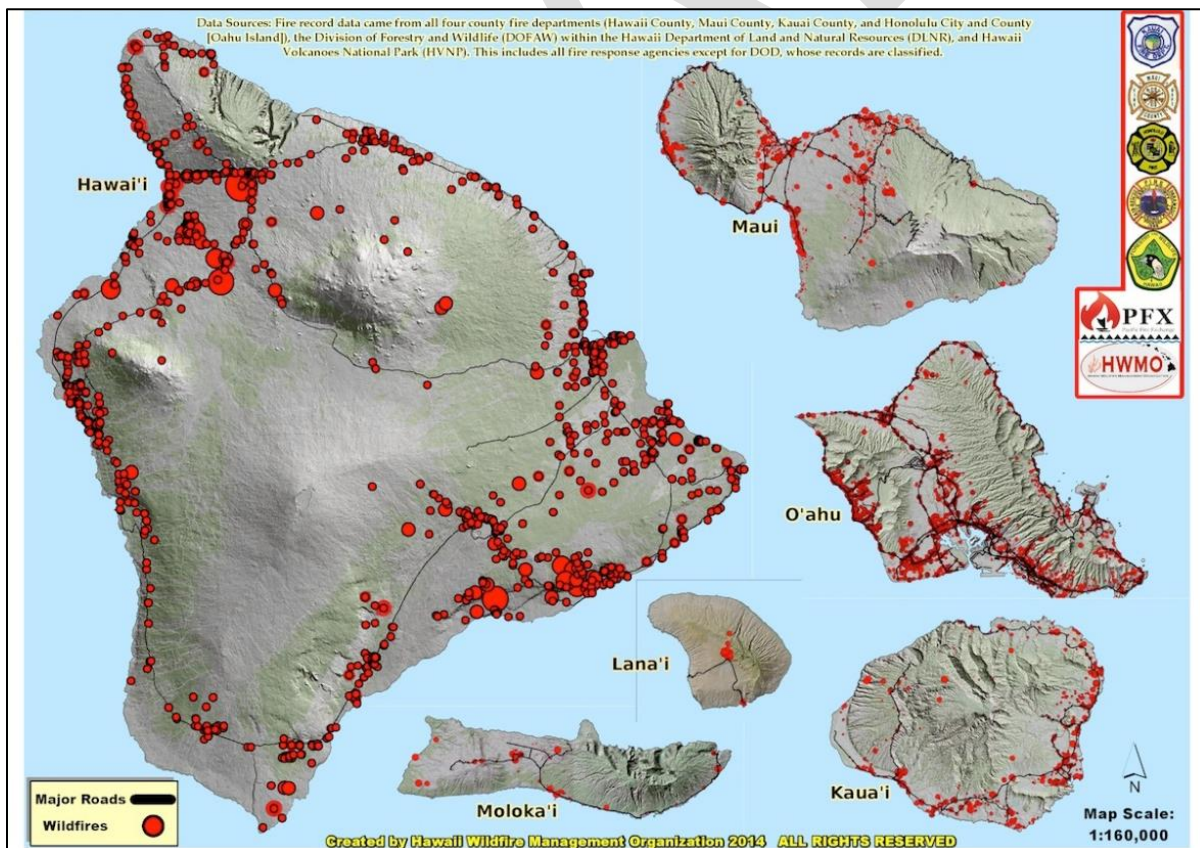


Figure 4.15-4. Wildfire Occurrence In Hawai'i, 1904-2021



Source: (Pacific Fire Exchange 2023)

Figure 4.15-5. Wildfire Incidents for the State of Hawai'i



Source: Pacific Fire Exchange 2016





Disaster and Emergency Declarations

The following disaster declarations, emergency proclamations, and fire management assistance declarations related to wildfires have been issued for Hawai'i:

- Federal disaster (DR), emergency (EM), or fire management assistance (FM) declarations, 1955 – 2022: 20 events classified as wildfire
- Hawai'i State Emergency Proclamations, 2018 – 2022: 2 wildfire events
- USDA Agricultural Disaster Declarations, 2012 – 2022: 7 wildfire events

Table 4.15-4 summarizes federally-declared wildfire events between 2018 and 2022. For events prior to 2018, please refer to Appendix E (Hazard Profile Supplement).

Table 4.15-4. Fire Management Declarations (2018 to 2022)

Incident Date	Declaration Number	County Affected	Name	Date Declared
October 22, 2019	FM-5294	Maui	Hawai'i Kahana Ridge Fire	October 23, 2019
August 1, 2021 – August 3, 2021	FM-5404	Hawai'i	Hawai'i Mana Road Fire	August 1, 2021

Source: FEMA 2023

PROBABILITY OF FUTURE HAZARD EVENTS

Overall Probability

In the State of Hawai'i, although wildfires can occur year-round, the fire season typically runs from the dry months of April through October. However, dry periods or periods of drought can extend the season. With drought and dry seasons, there is increased likelihood of wildland fires. See Section 4.5 for a discussion of the drought hazard.

For the 2023 SHMP Update, the best available information was collected to calculate the probability of future occurrence of wildfire events, of all magnitudes, for the State of Hawai'i. Information from the 2018 State SHMP, HWMO, DLNR, and HI-EMA were used to identify the number of wildfire events of 100 acres or greater, that occurred between 1953 and 2022. Based on these statistics, the State of Hawai'i has a 100% chance of a wildfire occurring in any given year and may experience approximately 12 wildfire events each year.

There are additional factors that may increase the future occurrence of wildfires in the State of Hawai'i. Changing environmental conditions can lead to larger and more intense wildfires in the future. During an El Niño year, the Hawaiian Islands experience more rainfall than normal in the summer months and less rainfall than average during the winter months (NOAA 2015). The El Niño rainfall patterns have important consequences for the Pacific Islands:

- Wetter summer/fall increases fuel loads, particularly in typically dry areas, which are then more susceptible to increased wildfire activity during dry conditions
- Drier winters increase the potential for wildfire occurrence and spread (Trauernicht, et al. 2015).

Wildfire records from the State of Hawai'i show an increase in annual area burned during El Niño events. These patterns show that the state can anticipate late onset drought during the winter months following El Niño development and a higher fire danger throughout the winter (Trauernicht, et al. 2015).





Additionally, the number of CARs has increased over time due to changing land use patterns with increased commercial and residential development and more people living proximate to wildland areas. Also, some CARs that had a lower risk designation in the past are now at higher risk (DLNR 2016).

All of the factors listed above increase the risk of wildfires across the state and increase the probability of future occurrences each year.

Climate Change Impacts

Climate change has the potential to affect multiple elements of the wildfire system: fire behavior, frequency of ignition and ignition points, fire management practices, and vegetation fuels and fuel loading. By the middle of the 21st century, it is anticipated that there will be a 35% increase in days with high fire danger across the world (Trauernicht, et al. 2015).

In Hawai'i, temperatures are increasing by 0.3°F every decade, at four times the rate of half a century ago. It is predicted that average temperatures in the state could increase by as much as 5–7.5° F by the end of the century (State of Hawai'i 2022a). Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildfires changes.

Wildfire is tied to rainfall patterns in the State of Hawai'i much more than temperature. Fires are more frequent in the dry leeward areas and larger fires occur under drought conditions. In the past 30 years, the state has experienced longer droughts, an increase in consecutive dry days, and decrease in the days of intense rainfall (State of Hawai'i 2022). All of which lead to perfect conditions for wildfires throughout the state. Additionally, a warming, drying climate, as well as increased frequency and strengths of El Niño events have led to drought conditions that are greatly increasing the risk of wildfires across the state (State of Hawai'i 2022).

4.15.2 VULNERABILITY ASSESSMENT



Wildfire Hazard Area Definition

To assess vulnerability to wildfire, the high-risk communities delineated by the Communities at Risk from Wildfire (CAR) data was used.

A spatial analysis was conducted utilizing the CAR data. For the purposes of this risk assessment, an asset is considered potentially vulnerable to the wildfire hazard if it is located in a high-risk community (noted as a high wildfire risk hazard area above). The wildfire risk data used for this analysis focuses on communities or developed areas. Therefore, the wildfire risk to state assets located outside of these communities could not be determined. Refer to Appendix F (State Profile and Risk Assessment Supplement), which provides more detailed results for the high wildfire risk hazard area analysis and the exposure analysis results for the assets located in the moderate wildfire risk areas.

ASSESSMENT OF STATE VULNERABILITY AND POTENTIAL LOSSES

To assess wildfire vulnerability and potential losses, a spatial analysis was conducted to review the state assets located in the high wildfire risk hazard area. This section discusses the vulnerability of state assets (state-owned or state-leased buildings and state roads) and critical facilities.





State Assets

The spatial analysis for the wildfire hazard determined there are 6,095 state buildings located in the high wildfire risk hazard area with the greatest number of state buildings located in the City and County of Honolulu (3,472 buildings with a replacement cost value of \$17.393 billion). The majority of these buildings are occupied by the Department of Education and University of Hawai'i. Table 4.15-5 and Table 4.15-6 summarize the state buildings located in the high wildfire risk hazard area by county and agency, respectively.

Table 4.15-5. State Buildings Located in the High Wildfire Risk Hazard Area by County

County	Total Number of State Buildings	Total Replacement Cost Value	High Wildfire Risk Area			
			Number of State Buildings in Hazard Area	Percent (%) of Total	Total Value of State Buildings in Hazard Area	Percent (%) of Total
County of Kaua'i	531	\$990,850,824	377	71.00%	\$723,336,152	73.00%
City and County of Honolulu	3,472	\$17,393,945,915	1,645	47.38%	\$3,732,170,912	21.46%
County of Maui	831	\$3,097,491,689	626	75.33%	\$2,162,488,835	69.81%
County of Hawai'i	1,261	\$4,638,567,141	247	19.59%	\$743,270,564	16.02%
Total	6,095	\$26,120,855,568	2,895	47.50%	\$7,361,266,463	28.18%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; State of Hawai'i Risk Management Office 2017

Table 4.15-6. State Buildings Located in the High Wildfire Risk Hazard Area by Agency

Agency	Total Number of State Buildings	Total Replacement Cost Value	Number of State Buildings in Hazard Area	Percent (%) of Total Buildings	Replacement Cost Value in the Hazard Area	Percent (%) of Total Value
Dept of Accounting & General Services	66	\$953,963,738	18	27.27%	\$136,984,302	14.36%
Dept of Agriculture	70	\$147,607,399	27	38.57%	\$65,504,797	44.38%
Dept of Attorney General	15	\$108,425,480	5	33.33%	\$11,375,127	10.49%
Dept of Budget & Finance	16	\$28,968,679	6	37.50%	\$1,500,219	5.18%
Dept of Business, Economic Development and Tourism	25	\$645,480,379	2	8.00%	\$31,908,972	4.94%
Dept of Commerce & Consumer Affairs	2	\$40,197,360	0	0.00%	\$0	0.00%
Dept of Defense	69	\$267,352,836	28	40.58%	\$130,366,498	48.76%
Dept of Education	4,090	\$10,598,205,739	2,170	53.06%	\$4,237,875,756	39.99%
Dept of Hawaiian Home Lands	12	\$110,427,352	2	16.67%	\$2,485,998	2.25%
Dept of Health	44	\$387,068,440	10	22.73%	\$18,295,256	4.73%
Dept of Human Resources Development	1	\$5,973,872	0	0.00%	\$0	0.00%
Dept of Human Services	130	\$480,212,294	42	32.31%	\$78,926,078	16.44%





Agency	Total Number of State Buildings	Total Replacement Cost Value	Number of State Buildings in Hazard Area	Percent (%) of Total Buildings	Replacement Cost Value in the Hazard Area	Percent (%) of Total Value
Dept of Labor and Industrial Relations	22	\$90,076,209	14	63.64%	\$21,784,179	24.18%
Dept of Land and Natural Resources	90	\$101,441,821	32	35.56%	\$27,890,769	27.49%
Dept of Public Safety	154	\$440,774,415	54	35.06%	\$200,908,551	45.58%
Dept of Taxation	1	\$7,174,162	0	0.00%	\$0	0.00%
Dept of Transportation	68	\$2,935,208,214	31	45.59%	\$344,031,772	11.72%
Hawai'i State Ethics Commission	1	\$984,533	0	0.00%	\$0	0.00%
Hawai'i Health Systems Corporation	106	\$1,230,852,871	51	48.11%	\$759,713,058	61.72%
Hawai'i Housing Finance & Development Corporation	86	\$360,851,671	79	91.86%	\$239,092,499	66.26%
Hawai'i Public Housing Authority	273	\$982,981,701	108	39.56%	\$225,056,578	22.90%
Hawai'i State Legislature	2	\$48,555,381	0	0.00%	\$0	0.00%
Hawai'i State Public Library System	53	\$525,584,082	28	52.83%	\$105,523,199	20.08%
Judiciary	41	\$534,877,354	17	41.46%	\$108,926,672	20.36%
Legislative Reference Bureau	1	\$2,996,162	0	0.00%		0.00%
Office of Hawaiian Affairs	11	\$54,125,645	4	36.36%	\$1,479,962	2.73%
Office of the Auditor	2	\$1,921,180	0	0.00%	\$0	0.00%
Office of the Governor	1	\$2,996,162	0	0.00%	\$0	0.00%
Office of the Lieutenant Governor	2	\$4,588,849	1	50.00%	\$2,257,785	49.20%
Office of the Ombudsman	1	\$1,818,060	0	0.00%	\$0	0.00%
Research Corporation of the University of Hawai'i	3	\$4,189,026	0	0.00%	\$0	0.00%
University of Hawai'i	637	\$5,014,974,503	166	26.06%	\$609,378,436	12.15%
Total	6,095	\$26,120,855,568	2,895	47.50%	\$7,361,266,463	28.18%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; State of Hawai'i Risk Management Office 2017

Roads provide a vital transportation link between populated areas. Road closures, as a result of a wildfire event, will have significant impacts on those communities and each island as a whole. The state has more than 1,100 miles of state-owned roads located in the high wildfire risk areas.

Table 4.15-7 summarizes the length of state roads in the high wildfire hazard areas by county. The City and County of Honolulu has the greatest number of road miles (374.9 miles) exposed which is 33.97% of the total length of state roads in the County. A complete list of state roads located in the low, moderate, and high wildfire risk areas is included in Appendix F (State Profile and Risk Assessment Supplement).





Table 4.15-7. State Roads Located in the High Wildfire Risk Hazard Area by County

County	Length (in miles)		
	Total Length	Length of Road in Hazard Area	Length as Percent (%) of Total Length
County of Kaua'i	103.7	32.8	31.63%
City and County of Honolulu	374.9	164.4	43.85%
County of Maui	245.9	71.4	29.04%
County of Hawai'i	379.2	66.7	17.59%
Total	1,103.70	335.3	30.38%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; State of Hawai'i Department of Transportation 2022

Community Lifelines and Critical Facilities

Due to the state's geography, each county needs to be self-sufficient in terms of wildfire response and recovery personnel and equipment. The City and County of Honolulu has the greatest number of community lifeline facilities (71) located in the high wildfire risk hazard area compared to the other counties. Table 4.15-8 summarizes the total number of critical facilities by core category located in the high wildfire risk area by county. Table 4.15-9 summarizes the number and percentage of exposed critical facilities by core category. Transportation Services has 47.05% of their facilities located in the high wildfire risk hazard area.

Table 4.15-8. Community Lifelines and Critical Facilities Located in the High Wildfire Risk Hazard Area, by County

County	Community Lifeline Categories								Additional Critical Facilities
	Communications	Energy	Food, Water, Shelter	Hazardous Material	Health & Medial	Safety & Security	Transportation	Total in the Hazard Area	
County of Kaua'i	9	7	16	4	11	42	5	94	8
City and County of Honolulu	45	26	87	1	31	129	4	323	12
County of Maui	12	1	50	0	41	52	16	172	20
County of Hawai'i	7	1	24	0	8	16	4	60	5
Total	73	35	177	5	91	239	29	649	45

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; Hawai'i Emergency Management Agency 2017; Federal Emergency Management Agency Lifeline Data 2020





Table 4.15-9. Community Lifelines and Critical Facilities Located in High Wildfire Risk Hazard Area, by Category

Category	Total Number of Facilities	Total Replacement Cost Value	Number of Facilities in Hazard Area	Percent (%) of Total Facilities	Value in the Hazard Area	Percent (%) of Total Value
Communications	188	\$776,797,683	73	38.83%	\$266,485,971	34.31%
Energy	89	\$3,093,949,530	35	39.33%	\$1,207,734,600	39.04%
Food, Water, Shelter	345	\$11,847,189,588	177	51.30%	\$6,061,744,738	51.17%
Hazardous Material	12	\$436,474,800	5	41.67%	\$181,470,000	41.58%
Health and Medical	193	\$4,606,713,364	91	47.15%	\$2,116,439,676	45.94%
Safety and Security	486	\$38,164,188,232	239	49.18%	\$24,943,225,762	65.36%
Transportation	56	\$2,039,091,600	29	51.79%	\$1,052,526,000	51.62%
Additional Critical Facilities	106	\$447,698,794	45	42.45%	\$240,606,490	53.74%
Total	1,475	\$61,412,103,591	694	47.05%	\$36,070,233,237	58.73%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; Hawai'i Emergency Management Agency 2017; Federal Emergency Management Agency Lifeline Data 2020

ASSESSMENT OF LOCAL VULNERABILITY AND POTENTIAL LOSSES

A wildfire has the potential to kill people, livestock, fish, and wildlife. Wildfires often destroy property, valuable forested watersheds, native species and their habitats, and recreational and scenic resources. Many communities in the State of Hawai'i are at high risk from wildfire due to unmitigated fuels, limited community engagement, insufficient water and firefighting resources, and under-addressed pre- and post-fire planning and preparedness (HWMO 2015). A wildfire would impact not only residents, visitors, and valued resources but also the state's economy, which relies heavily on revenues from the tourism industry. This section provides a summary of vulnerability and potential losses to population, general building stock, environmental resources, and cultural assets by county. Statewide exposure is examined; however, it is highly unlikely that a wildfire event would take place across all islands at the same time.

Socially Vulnerable and Total Population

Given the historic response times to reported fires, the potential of injuries and casualties is minimal. Many communities and populations are especially vulnerable to wildfires, including low-income communities, migrant populations, populations whose primary language is not English, indigenous populations, communities of older adults, and those with respiratory and other health concerns. Members of immigrant communities may be concerned about impacts to their immigration status and do not seek help. When a wildfire impacts an area with high rents where multiple families live in one structure, it may be difficult for those not listed on the lease to prove that they were affected by the fire; this could result in a lack of access to services. Additionally, fires quickly increase housing prices and rent prices, further displacing people already affected by the fire. Homelessness can increase.

Wildfires can also pose significant threats to the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke.

Table 4.15-10 lists the estimated population living in the high wildfire risk hazard areas that could be impacted should a wildfire occur. The analysis indicates that the population in the County of Maui has the greatest percent of its population exposed, and the City and County of Honolulu has the greatest number of people located in the high wildfire risk hazard areas. This analysis does not include the number of tourists and visitors in the state whose lodgings are also located in these high-risk areas. Therefore, these results may be underestimating exposure and vulnerability.





Table 4.15-10. 2020 U.S. Census Population Located in the High Wildfire Risk Hazard Area by County

County	Population				
	Total Population	Population in the Hazard Area	Population Exposed as % of Total Population	Socially Vulnerable Population in the Hazard Area	Socially Vulnerable Population Exposed as % of Total Population
County of Kaua'i	71,949	27,604	38.37%	725	1.01%
City and County of Honolulu	979,682	427,293	43.62%	117,049	11.95%
County of Maui	167,093	81,424	48.73%	20,679	12.38%
County of Hawai'i	201,350	32,080	15.93%	672	0.33%
Total	1,420,074	568,401	40.03%	139,125	9.80%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; U.S. Census Bureau 2020; Centers for Disease Control and Prevention 2018

Population living along the WUI may only have one ingress/egress to their communities, making them highly vulnerable in the event of an evacuation. Additional vulnerabilities include communicating risks about the hazard. It can take days to translate information into languages other than English, hindering communication about evacuations and health and safety alerts. Indigenous populations may lose sacred sites; fisheries and hunting and gathering grounds may be degraded (National Academies Press 2020). Older adults do not have the mobility many others have, which can slow or prevent evacuation. Health problems related to wildfire smoke exposure can be as mild as eye and respiratory tract irritation and as serious as worsening of heart and lung disease, including asthma, and even premature death (US EPA 2022).

The high vulnerability population in the hazard area makes up about 24.5% of the total population of the State of Hawai'i located in the high wildfire risk hazard area. Overall, the County of Maui has the highest population exposed as a percentage, both for population in the hazard area (48.73%) and high vulnerability population in the hazard area (12.38%).

Land Use Districts

Table 4.15-11 shows the square miles of high wildfire risk areas in each State Land Use District statewide; refer to Appendix F (State Profile and Risk Assessment Supplement) for results by county. Urban Districts in the state have a significant portion of their total land area in the high-risk areas, though Agricultural lands have the most with 322.3 square miles. Conservation District land in the state has the greatest number of total square miles; however, it has the smallest percentage of the state's total area (2.1%). Conservation District lands contain valuable environmental resources. Additional discussion of exposure and vulnerability of these resource areas can be found in the Environmental Resources section below.

Table 4.15-11. State Land Use Districts Located in the High Wildfire Risk Hazard Area

Land Use District	Total (square miles)	Square Miles in High Wildfire Risk Area	% of Total Area
Agricultural	2,973.6	322.3	10.8%
Conservation	3,202.9	67.0	2.1%
Rural	16.3	5.7	34.8%
Urban	319.1	139.4	43.7%
Total	6,511.9	534.4	8.2%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; State Land Use Commission, Hawai'i Statewide GIS Program 2021; Honolulu County GIS 2022





General Building Stock

Similar to the analyses presented earlier, the general building stock data was overlaid with the high wildfire risk hazard area to assess vulnerability. Table 4.15-12 summarizes these values by county. Approximately \$166 billion, which represents 44.6% of the total building stock replacement cost value in the state, is located in the high wildfire risk hazard area. As noted earlier, due to the state's geography, it is highly unlikely that wildfire loss will occur statewide as events are typically isolated to one island. The County of Maui has the largest percent (70.15%) of their building stock located in the high wildfire risk hazard area while the City and County of Honolulu has the highest dollar amount exposure with over \$99 billion. The replacement cost value of buildings exposed is provided as an estimate for total loss. Appendix F (State Profile and Risk Assessment Supplement) provides the general building stock values located in the low and moderate wildfire hazard areas.

Table 4.15-12. General Building Stock Located in the High Wildfire Risk Hazard Area by County

County	Total Value	Replacement Value in Hazard Area	Replacement Value Exposed as % of Total
County of Kaua'i	\$24,246,497,228	\$15,446,334,294	63.71%
City and County of Honolulu	\$239,152,051,766	\$99,773,338,383	41.72%
County of Maui	\$50,796,693,140	\$35,635,679,142	70.15%
County of Hawai'i	\$58,395,349,136	\$15,477,544,144	26.50%
Total	\$372,590,591,270	\$166,332,895,963	44.64%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; NIYAM IT 2022; United States Army Corps of Engineers 2022

From an economic perspective, traffic and road closures during fire events and post-fire flooding resulting in blocked access to critical transportation facilities, such as airports, leads to loss of productivity. Impacts to environmental resources, such as damage to nearshore resources (e.g., fishponds, coral reefs, fisheries), recreational areas discussed below could have a negative impact on tourism as well (HWMO 2016).

Environmental Resources

Overall, wildfires have physical, chemical, and biological impacts on ecosystem resources and the environment (DeBano, Neary and Ryan 2005). Wildfires threaten air quality, water quality, soil properties, nutrient cycling, vegetation and wildlife habitat. During periods of heavy rainfall, the burned areas can erode becoming mud flows, debris flows, thereby increasing sedimentation loads in streams and rivers and the ocean and potentially impacting water quality, fisheries and long-term coral health. Further impacts include stream bank destabilization, which could worsen impacts of heavy rainfall and lead to riparian flooding.

The State of Hawai'i's native ecosystems have evolved with little or no fire. Therefore, wildfire is a significant threat to native forested watersheds and native species, including threatened and endangered species. According to the Hawai'i Forest Action Plan, approximately 90 percent of the state's 10,000 native species are endemic; in some cases being endemic to a portion of one island making them extremely vulnerable and potentially one wildfire away from extinction (DLNR, DFW 2016). Approximately 38 square miles of parks and reserves and 31 miles of critical habitat are located in high wildfire risk areas for CARs (refer to Table 4.15-13 below). As noted, the wildfire risk rankings used for analysis are based on the CAR data and focus on communities and developed areas. Therefore, these results are underestimating environmental resources' exposure and vulnerability to wildfire. Refer to Appendix F which summarizes the environmental resources located in the moderate and low wildfire risk areas by county.



**Table 4.15-13. Environmental Resources Located in the High Wildfire Risk Hazard Area**

Environmental Resource	Statewide		
	Total Square Miles of Resources	Square Miles in High-Risk Area	Percent (%) of Total Resource Area
Critical Habitat ^a	951	31	3.3%
Wetlands	3,637	13	0.3%
Parks and Reserves	2,778	38	1.4%
Reefs ^b	55	0	0.5%
Total ^c	7,420	82	1.1%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; U.S. Fish and Wildlife Service, Pacific Islands Office, 2022a, U.S. Fish and Wildlife Service 2021, 2017; Hawai'i State Department of Land and Natural Resources, Division of Forestry and Wildlife 2022; NOAA raster nautical charts 2020; State of Hawai'i Department of Land and Natural Resources, Division of State Parks 2021

Note: a. Critical area mileage includes the combined area of coverage of individual critical habitat areas.
 b. Reefs include artificial and coral reefs.
 c. Total square miles includes environmental assets within 3 nautical miles of each county and may be over-reported as some environmental asset areas may overlap.

Wildfires impact watershed function—they destroy vegetation in watersheds resulting in a diminished capacity of the soils to absorb rainfall and fog drip that replenishes groundwater resources. Watersheds on all islands are subject to frequent tropical downpours, and these brief but intense events can quickly cause erosion and landslides in areas impacted by wildfire. Without vegetation that is resilient to fire and/or does not carry heavy fuel loads, terrestrial plants and animals, fresh and marine water species, and the quality of streams and wetland ecosystems will diminish, and their capacity to function properly will degrade (DLNR 2010).

The watershed areas in high wildfire hazard areas were evaluated by county and are summarized in Table 4.15-14. Approximately 1.5% of the total in these areas is affected by high wildfire risk areas for CARs. Risk rankings have not been developed for most watershed partnership areas.

The DLNR-DOFAW is the primary responder for wildfires on lands they managed. The DOFAW-managed land accounts for 26% of the land statewide. The DOFAW co-responds with county fire departments and federal agencies to wildfires on an additional 32% of statewide lands, as determined by Mutual Aid Agreements and Memoranda of Agreement or Memoranda of Understanding. Therefore, the DOFAW is responsible for fire response on nearly 60% of the lands statewide. The DOFAW-managed lands and the wildfire hazard risk exposure for these lands are listed in Table 4.15-15. Statewide, more than 18 square miles of DOFAW-managed lands are located in high wildfire risk areas for CARs. Risk rankings have not been developed for most DOFAW-managed lands.

Cultural Assets

Consistent with Native Hawaiian culture, Hawaiian Home Lands include areas from mauka to makai (from the mountain to the ocean). Structures located on Hawaiian Home Lands are considered more vulnerable to wildfire events if located in the categorized high wildfire risk areas (Table 4.15-16). The County of Hawai'i has the greatest number of square miles (191.5), and the City of County of Honolulu has the highest percentage (42.1%) of Hawaiian Home Lands located in high wildfire risk hazard areas.

Table 4.15-17 shows the cultural resources in high wildfire risk hazard areas. The cultural resource type with the largest total area and largest area in the hazard area is the Historic District; however, the district with the largest percentage of area in the high wildfire risk hazard area is the Burial Sensitivity Area.





Table 4.15-14. Watershed Partnership Areas Located in the High Wildfire Risk Hazard Area

Watershed Partnership	Area (in square miles)		
	Total Area	Hazard Area	Hazard Area as % of Total Area
County of Kaua'i			
Kaua'i Watershed Alliance	225.61	1.852	0.82%
City and County of Honolulu			
Ko'olau Mountains Watershed Partnership	160.62	4.889	3.04%
Wai'anae Mountains Watershed Partnership	73.59	7.408	10.07%
County of Hawai'i			
Kohala Watershed Partnership	115.81	1.868	1.61%
Mauna Kea Watershed Alliance	400.39	0.384	0.10%
Three Mountain Alliance	1767.20	22.727	1.29%
County of Maui			
East Maui Watershed Partnership	173.01	2.867	1.66%
East Moloka'i Watershed Partnership	105.27	2.640	2.51%
Leeward Haleakalā Watershed Restoration Partnership	53.56	2.220	4.14%
West Maui Mountains Watershed Partnership	73.94	0.091	0.12%
Lanai Forest and Watershed Partnership	14.84	0.000	0.00%
Overlap East Maui Watershed Partnership and Leeward Haleakalā Watershed Restoration Partnership	13.72	0.000	0.00%
Total	3177.57	46.946	1.48%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; Department of Land & Natural Resources, Division of Forestry and Wildlife 2020

Table 4.15-15. DOFAW-Managed Lands Located in High Wildfire Risk Hazard Area

County	Area (in square miles)						
	Total Area	Low Hazard Area	Hazard Area as Percent (%) of Total Area	Moderate Hazard Area	Hazard Area as Percent (%) of Total Area	High Hazard Area	Hazard Area as Percent (%) of Total Area
County of Kaua'i	166.2	0	0%	0.2	<1%	0.5	<1%
City and County of Honolulu	69.5	1.5	2%	3.1	5%	1.7	2%
County of Maui	217.2	0.1	<1%	0	<1%	5	2%
County of Hawai'i	1,124.50	37.8	3%	1.8	0%	11.1	1%
Total	1,577.40	39.5	3%	5.1	<1%	18.2	1%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife



**Table 4.15-16. Hawaiian Home Lands Located in the High Wildfire Risk Hazard Area**

County	Area (in square miles)		
	Total Area	Hazard Area	Hazard Area as % of Total Area
County of Kaua'i County	32.1	2.2	6.8%
City and County of Honolulu	10.6	4.5	42.1%
County of Maui	102.6	38.3	37.3%
County of Hawai'i	191.5	6.1	3.2%
Total	336.7	51.0	15.1%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; Hawai'i State Department of Hawaiian Homelands 2021

Table 4.15-17. Cultural Resources Located in the High Wildfire Risk Hazard Area

Cultural Resource Site Type	Area (in square miles)		
	Total Square Miles of Asset	Total Square Miles in the Hazard Area	Percent (%) of Total Asset Area
Archaeology	90.9	11.5	12.7%
Burial Sensitivity Area	2.1	1.1	54.1%
Historic Building	2.7	0.8	28.9%
Historic District	849.4	24.8	2.9%
Historic Object	9.6	0.0	0.1%
Historic Structure	20.7	0.3	1.6%
Total	975.4	38.6	4.0%

Source: Hawai'i Wildfire Management Organization, Division of Forestry and Wildlife; Department of Land and Natural Resources, Hawai'i State Historic Preservation Division 2022

FUTURE CHANGES THAT MAY IMPACT STATE VULNERABILITY

Understanding future changes that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The state considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Potential or Projected Development

Non-urban zoned lands throughout the state are being urbanized rapidly. From 2000 to 2030, housing density is projected to substantially increase on approximately 8% (65,000 acres) of Hawai'i's private forest land (Stein, et al. 2014). On O'ahu, the directed growth policy of the City and County of Honolulu encourages growth to occur beyond the primary urban center (City and County of Honolulu 2021). Some new developments have sprawled into dry parts of O'ahu while encroaching into the WUI. In wildfire-prone areas across the state, new developments would benefit from ensuring that the state fire code, including WUI codes, as well as recommendations are followed. This includes the design of roads (adequate width, fire truck access and turn-arounds, more than one ingress/egress, etc.), layout of structures (spacing), building materials (non-combustible and fire resistant), and maintenance of internal and surrounding vegetation. In other areas where land use changes have occurred due to the removal of active agriculture, fire hazard has increased and would be mitigated if converted





and hardened for development. The number of communities rated to be at high risk from wildfire in the state has increased over time due to more people living proximate to wildland areas, unmitigated fuels, limited community engagement, insufficient water and firefighting resources, and under-addressed pre- and post-fire planning and preparedness (HWMO 2015).

Projected Changes in Population

As stated previously, over 98% of wildfires in the State of Hawai'i are caused by humans. As the overall resident population increases, there may be an increase in the number of human-caused wildfires as more people move into currently less developed parts of the state and as more people engage in activities that may accidentally spark wildfires. In addition to the resident population, the visitor population coming to the state is also increasing. Visitors may be less familiar with wildfire risk and the precautions that should be taken to prevent or limit wildfire ignition. The increase in both resident and visitor populations may stress existing resources available for wildfire suppression activities as more water will be needed for human use and consumption.

Other Factors of Change

Climate change has the potential to significantly increase vulnerability to wildfire in the state. In the past 30 years, the state has experienced longer droughts, an increase in consecutive dry days, and decrease in the days of intense rainfall, all of which lead to perfect conditions for wildfires throughout the state (HWMO 2017).

As drought conditions become more frequent and as sea level rise "squeezes" land available for development, this will result in development expansion closer to upland forest ecosystems. Increasing temperatures and, in some areas, reduced rainfall will stress native plant and animal populations and species, especially in high-elevation ecosystems, with increased exposure to non-native biological invasions and fire, and with extinctions a likely result (The Pacific Islands Regional Climate Assessment 2012).

Overall, an increase in wildfire events means fewer native forests and drinking water, and more erosion/runoff, coastal brownouts, and communities at risk in the State of Hawai'i (HWMO 2017).

