



## SECTION 4. RISK ASSESSMENT

### 4.15 Wildfire

#### 2018 HMP UPDATE CHANGES

- ❖ The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, and probability of future occurrence (including how climate change may impact the hazard). New and updated figures from federal and state agencies are incorporated.
- ❖ Wildfire events that occurred in the State of Hawai'i from January 1, 2012 through December 31, 2017 were researched for this 2018 HMP Update.
- ❖ The high wildfire risk areas provided by the Hawai'i Wildfire Management Organization were used to assess vulnerability (HWMO 2013).

#### 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 Hawaii's native ecosystems are not fire adapted. In many cases, once an area burns, it is replaced by fire-prone non-native species, permanently changing the State of Hawaii's landscape. Over 25% of the State contains non-native, fire-prone grasses and shrubs which fuels the fires that occur in the State. This percentage grows each time fire burns into native forest because the forest is then further invaded by fire prone non-native species (Hawai'i Wildfire Management Organization [HWMO] 2016a).

Each year, approximately 0.5% of the State of Hawaii's total land area burns, which is equal to or greater than the proportion burned of any other state. 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 (State of Hawai'i HMP 2013). While sometimes caused by lightning, nine out of ten wildfires are estimated to be human-caused in the State.

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.

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 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 become unmanaged fallow land). In 2013, 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 wildfire urban interface (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 (USDA 2013). Thus, wildfires becomes a significant threat to both humans and natural resources and often result in ecological losses to the State of Hawai'i.



According to NOAA, there are four specific 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 also be started by surface fires – basically any fuel type with a significant woody component – shrubs or trees – has potential to spot. A characteristic of spotting wildfires is that large burning embers are thrown ahead of the main fire. Once spotting begins, the wildfire will be very difficult to control (NOAA 2018).

## 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 (HWMO 2016b).

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 earlier, a majority of wildfires in the State of Hawai'i are human caused. These fires typically occur near developments, power line right-of-ways, and along roadways. Additionally, sprawling dry, nonnative 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 (HWMO 2016b through 2016h). 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 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 4.14-1. Table 4.14-1 summarizes the square miles of high wildfire risk areas as defined by the CAR maps in each County. The table indicates the City and County of Honolulu has the largest wildfire high risk areas and the County of Hawai'i has the smallest wildfire high risk areas.

Many communities in the State of Hawai'i are located in high risk areas due to a variety of factors including: one point of ingress/egress into neighborhoods; narrow streets; few fire truck turnaround options; unmanaged/untended fire fuels interspersed within developed areas; very limited firefighting access and water 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 2016a).

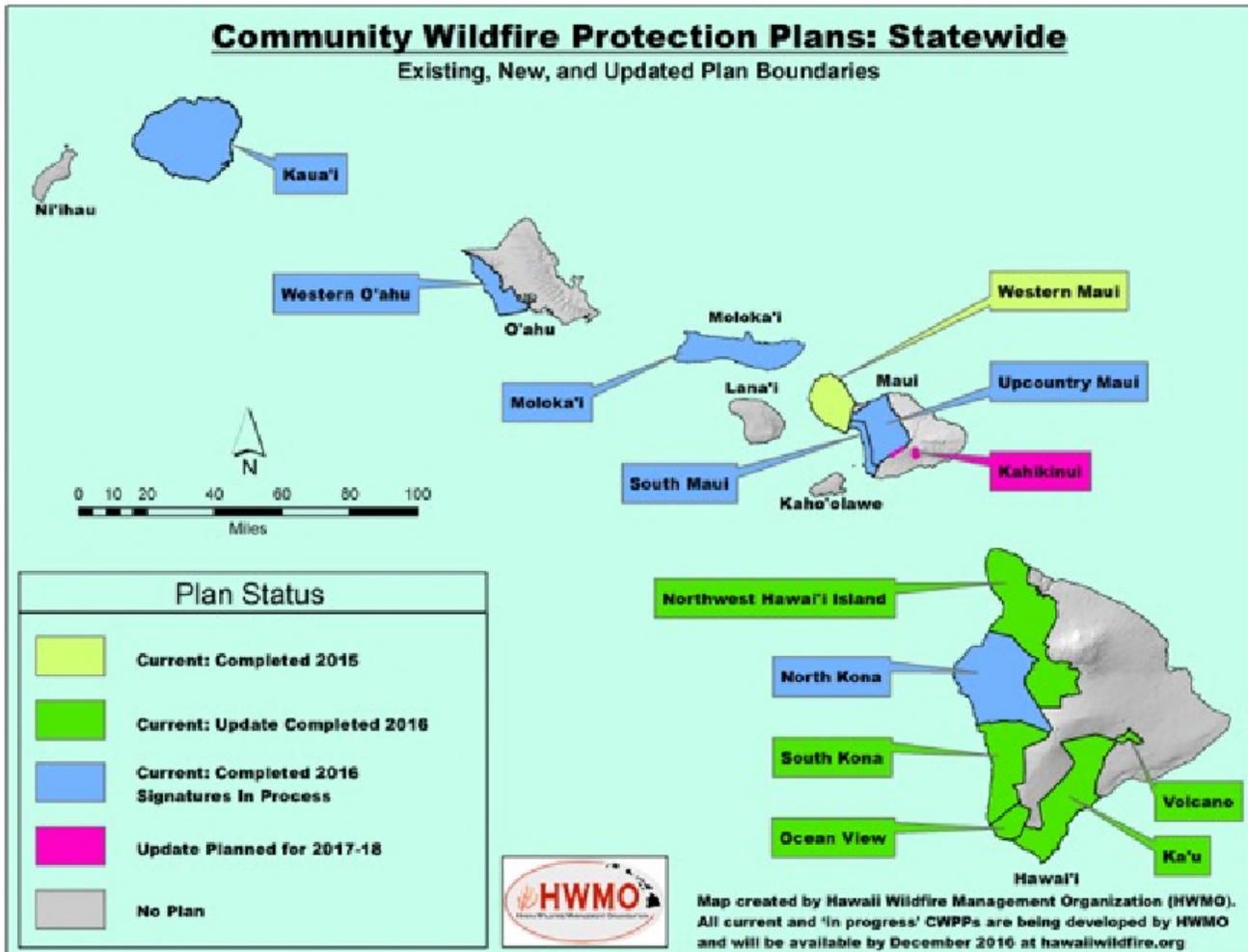
The HWMO is in the process of developing Community Wildfire Protection Plans (CWPPs) in partnership with local agencies to address the intent and requirements of the Healthy Forests Restoration Act (HFRA) of 2003 – HR1904, which describes the CWPP as a fire mitigation and planning tool for an 'at risk' community. The CWPPs provide a



community level overview of the fire environment, to include climatic, topographic, and vegetative influences on wildfire. These locally administered plans serve to provide an indication of risk throughout the State, focusing on developed areas.

The statewide status of CWPPs is shown in the map below and are available through contacting the HWMO. Selected plans are available on line at <http://www.hawaiiwildfire.org/home>.

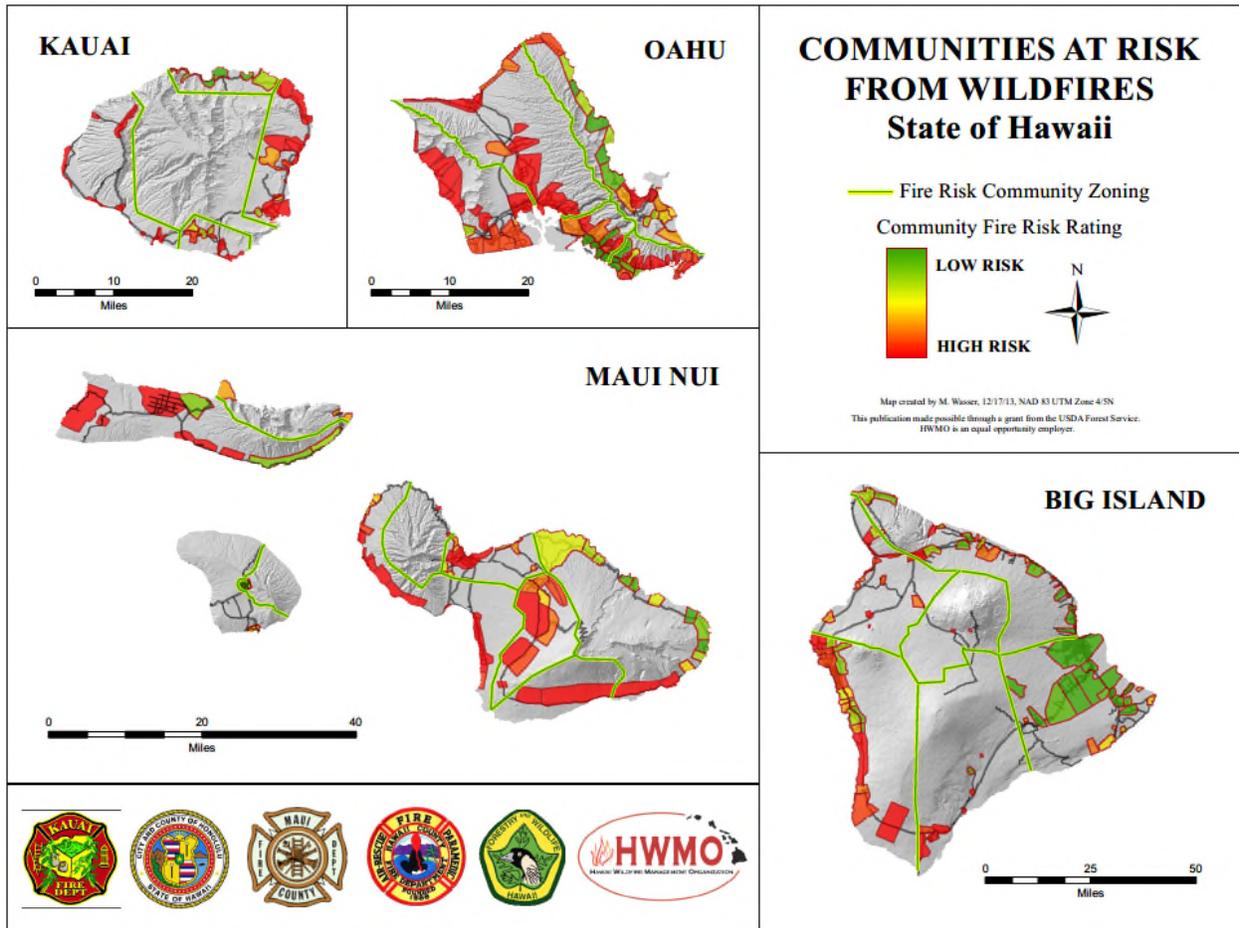
**Figure 4.15-1. Community Wildfire Protection Plans – State of Hawai'i**



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 2018 HMP Update (discussed later in the vulnerability assessment subsection).



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



Source: HWMO 2013

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	620.0	37.5	6.0%
City and County of Honolulu	600.7	138.7	23.1%
County of Maui	1,173.5	163.1	13.9%
County of Hawai'i	4,028.4	192.0	4.8%
<b>Total</b>	<b>6,422.6</b>	<b>531</b>	<b>8.3%</b>

Source: HWMO 2013

Note: Total area for each County calculated using coastline spatial layer downloaded from State of Hawai'i GIS Program Geospatial Data Portal. The calculated area is based on the high wildfire risk areas delineated to date.

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 amongst 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 nonnative 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 2016d).

## City and County of Honolulu

Available information is provided for Western O'ahu where wildfire occurrence is tied to broad climate patterns, in that 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 nonnative 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 nonnative forests are more exposed to loss from wildfire due to the proximity of fire-prone grasslands and shrublands (HWMO 2106g).

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 2016g).

## County of Maui

The County of Maui is comprised of distinct regions with differing risk to wildfire due to climate, topography, vegetation and natural resources. Brief overviews of the Upcountry Maui, South Maui, and Moloka'i areas are provided below. A CWPP addressing Lanai is not available at this time.

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 (HWMO 2014b).

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 (HWMO 2014b).

### *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, Ulupaikua, and Kula Hawaiian Homesteads have the highest risk from wildfires in Upcountry Maui (HWMO 2016e).

### *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 2014b).

### *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 2016c).

### *Moloka'i*

Moloka'i is characterized by a combination of residential, commercial, and agricultural areas, as well as rugged, often inaccessible terrain. A majority of Moloka'i 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 Kaluako'i, Maunaloa, Ho'olehua, Kalama'ula, Kaunakakai, and Kaweia have the highest risk from wildfires in Moloka'i (HWMO 2016b).

### *Lana'i*

No CWPP exists for Lana'i.

## **County of Hawai'i**

The County of Hawai'i is prone to wildfire conditions. On the leeward side, conditions are affected by a greater number of days with dry conditions expansive grasslands. The windward side of the island has significant grassland cover and, although has less number of dry days, becomes just as vulnerable to wildfire impacts during a drought. In addition, windward areas including Puna and Hawai'i Volcanoes National Park, deal with lava-ignited wildfires (Trauernicht, 2018).

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

### *Kau*

The Ka'u CWPP area is situated within the larger Hawai'i County district of Ka'u. Formed from Mauna Loa and Kilauea 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 Ka'u 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 Ka'u area. Steep slopes, rough terrain, strong trade winds, and a prevalence of fire-promoting fuels characterize the Ka'u 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. Ka'u 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 2010; 2015a).



### *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 2010; 2015b).

### *Northwest Hawai'i Island*

Within Northwest Hawai'i there are several communities, including, from north to south, Kawaihae, Waimea, Puako, Pu'uuanahulu, 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



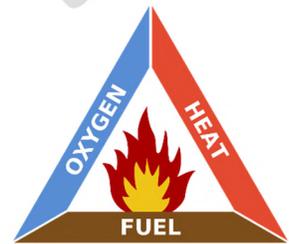
endangered, threatened, and candidate endangered species, as well as numerous rare species. Kīlauea has made HAVO the State's largest tourist attraction with more than 2.5 million visitors annually. In addition, Ocean View has experienced tremendous development in recent years. Many new residents are from other parts of the United States and unfamiliar with the wildfire risks of the community (HWMO 2006; 2015a).

### *Volcano*

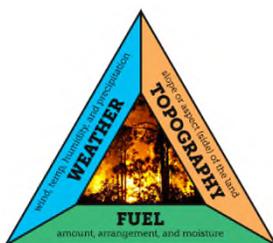
The community of Volcano in the County of Hawai'i also abuts HAVO and is in a WUI environment. Due to its location in proximity to HAVO, the community is impacted by lava flows within the Park which have caused several wildfires, some as large as 5,000 acres. Wildland fires originating within the Park 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 Kīlauea 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 2006; 2015b).

## EXTENT

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



- **Heat**—A heat source is needed for the initial ignition of wildfires. 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 wildland fire. When fuel burns, it reacts with oxygen from the surrounding air, releasing heat and generating combustion products (National Interagency of Fire Center [NIFC] 2018).



**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 (NIFC 2018).



## 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. The watches, warnings, and evacuation notices are science-based predictions that are intended to provide adequate time for evacuation (NWS 2018). 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.

A fire weather watch is issued by the NWS when the potential for severe fire weather exists in the near future. A watch is used when there is a relatively low probability of occurrence and less chance of verifying. The fire danger rating is usually in the high to extreme category. It is normally issued 12 to 24 hours in advance of the expected onset of severe fire weather conditions and typically in conjunction with the routine forecasts. The area affected, onset time, and a statement describing the conditions are included in the forecast. A Red Flag Warning is issued by the NWS to indicate the imminent danger of severe fire weather combined with a relatively high probability of occurrence. At issuance, the fire danger is usually in the high to extreme category. A Red Flag Warning may or may not be preceded by a Fire Weather Watch.

## 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 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 2016).

A plethora of wildfire information and specifically previous occurrences and losses associated with wildfire events exists throughout the State of Hawai'i. The 2013 HMP discussed specific wildfire events that occurred in the State of Hawai'i through 2012 (see Appendix F for events prior to 2012). For the 2018 HMP Update, only wildfire events that burned over 100 acres between January 1, 2012, and December 31, 2017 were summarized. However, to provide a context for the overall frequency of wildfires, regardless of size, it is noted that the State average number of wildland fires is 1,000 and burning 16,945 acres annually (PFX 2017). Table 4.15-2 provides the numbers of wildfires by year (from 2012 to 2016) and ignition source. This table includes data through 2016 as 2017 information was not available at the time of this 2018 HMP Update. During the reporting period, on average there were 7 fires per year burning an average of 9,000 acres per year though it should be noted that averages are not truly beneficial as wildfire incidents vary widely due to contributing factors. Table 4.15-3 lists the major wildfire events from 2012 to 2017.



**Table 4.15-2. Summary of Wildfires from 2012 to 2016**

Year	Miscellaneous	
	Number	Acres
2012	11	13,065
2013	2	700
2014	2	554
2015	9	5,691
2016	13	25,514

Sources: Dible 2016; Epping 2015; Hawai'i 24/7 Staff 2017, 2014, 2012; Hawai'i DLNR 2012; Hawai'i Tribute Herald 2017; HNN Staff 2015; Jansen 2012; Kakesako 2012; MauiNow 2016; Osher 2016; Pacheco 2016; Star Advertiser Staff 2012a, 2012b; State of Hawai'i 2017; The Associated Press 2013; The OANRP 2012; West Hawai'i Today 2012; Inefuku 2016

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**Table 4.15-3. Wildfire Events in the State of Hawai'i – 2012 to 2017**

Date(s) of Event	Event Type	Counties Affected	Description
February 18, 2012	Wildfire	Hawai'i	Approximately 80 acres burned near the Waikoloa Elementary School. No structures were threatened, and no roads were closed. A nearby car show was evacuated as a precaution. Waikoloa Emergency Operations Center (EOC) was activated.
May 28 to June 5, 2012	Wildfire (Miloli'i Hikimoe Fire)	Kaua'i	Approximately 220 acres burned
June 4 to 11, 2012	Wildfire (Kukahi Fire)	Honolulu	Fire burned approximately 1,200 acres, starting in the Lualualei Naval Magazine and burning through the Lualualei Valley into the Wai'anae Kai Valley Forest Reserve. By June 5, nearly half of the Honolulu Fire Department's assets were dedicated to battling the fire. Many farms were evacuated and roads were closed.
June 6 to 7, 2012	Wildfire	Honolulu	Approximately 1,000 acres burned in the Wai'anae Valley, unrelated to the fire burning from June 4 to 11, 2012. Sixty firefighters responded, and prevented the fire from threatening structures. The County of O'ahu EOC was partially activated.
June 18, 2012	Brush Fires	Hawai'i	The Hawai'i EOC was partially activated in response to two wildfires burning in the Pāhala area. One wildfire burned approximately 5,200 acres, the other burned 400 acres.
June 25 to July 4, 2012	Wildfire (Hikimoe Ridge)	Kaua'i	The Hikimoe Ridge Fire burned 765 acres of a eucalyptus tree plantation. A voluntary evacuation order was put in place as a precaution. The fire cost the State \$375,000, mostly for the cost of hiring fire suppression helicopters.
July 4, 2012	Wildfire	Honolulu	A fire flared along the north side of the Kaloko New Industrial Area road. Smoke was visible in Kailua Village.
July 14 to 15, 2012	Wildfire (Yokahama Cecily fire)	Honolulu	Approximately 500 acres burned
August 17 to 22, 2012	Wildfire (Pōki'i Ridge Fire)	Kaua'i	Approximately 3,000 acres above Kekaha burned. It started on the Pōki'i Ridge, and spread to the Paua and Waiaka Ridges. The fire approached a high voltage power line, which was shut down. The fire damaged power, radio, and fiber optic lines. Residents and businesses in Kekaha and Waimea were asked to limit water consumption to essential uses only. The fire chief issued a voluntary evacuation order of Kōke'e. The County of Kaua'i EOC was activated.
November 10, 2012	Wildfire (Iroquois Point Fire)	Honolulu	'Ewa Beach experienced its largest wildfire between 2001 and 2012 on November 10, 2012. The fire started near the intersection of Ho'omaka Street and Iroquois Road in an area of dry grass and brush. One hundred acres of brush and grasses burned along Iroquois Point Road in western O'ahu.
November 15, 2012	Wildfire (PTA Training Area 22 Fire)	Hawai'i	Approximately 1,000 acres burned
August 18, 2013	Wildfire (Makua Kea'au Keolu Fire)	Honolulu	Approximately 100 acres burned



Date(s) of Event	Event Type	Counties Affected	Description
November 25 to 26, 2013	Wildfire (Pu'u Anahulu Fire Complex)	Hawai'i	Nearly 600 acres on the Island of Hawai'i burned. Three fires made up this incident. No structures were damaged. The Hawai'i County EOC was activated.
April 24, 2014	Wildfire	Hawai'i	Four acres burned near Mile Marker 29 of Highway 190 in Kona. Traffic was limited to one lane on the highway. No injuries or structure damage were reported. The County of Hawai'i EOC was partially activated.
August 22, 2014	Wildfire (Makakilo First Goal Fire)	Honolulu	Approximately 550 acres burned.
January 20 to February 17, 2015	Wildfire (Lau Strike Kipapa Fire)	Honolulu	Approximately 460 acres burned.
March 23, 2015	Wildfire (Waimea Canyon Drive Fire)	Kaua'i	Approximately 130 acres burned.
May 4, 2015	Brush Fire	Hawai'i	Over 20 acres within the Nīnole Loop on the southeast side of Highway 11 burned. Highway 11 was closed for several hours due to low visibility. The fire burned through vacant pasture land. The County of Hawai'i EOC was partially activated.
May 11, 2015	Brush Fire	Hawai'i	A runaway brush fire consumed 20 acres and one home in the Green Sands and Mark Twain Estates subdivision in Ka'ū. No injuries were reported. The County of Hawai'i EOC was partially activated.
June 5 to 9, 2015	Wildfire (Pōki'i Ridge 2015 Fire)	Kaua'i	Approximately 365 acres burned.
August 1 to 11, 2015	Wildfire (Malevolence Poamoho Fire)	Honolulu	Approximately 500 acres burned.
August 8, 2015	Wildfire (Kawaihae Fire)	Hawai'i	Approximately 3,300 acres burned.
August 14, 2015	Wildfire (Pu'ukoli'i Fire 2015)	Maui	Approximately 356 acres burned.
August 22, 2015	Wildfire	Honolulu	The Makakilo Fire was human-caused and one of the largest wildfires in Makakilo's history. The fire burned 1,000 acres near homes along 'Umena Street and up toward Honouliuli Forest Reserve. Dozens of homes and cabins were evacuated, including Camp Timberline visitors and occupants. Red Cross established an emergency shelter at Makakilo Community Park, where they hosted approximately residents.
January 16, 2016	Wildfire	Hawai'i	Palamanui Campus fire burned 200 acres near Queen Ka'ahumanu Highway.



Date(s) of Event	Event Type	Counties Affected	Description
February 10 to 11, 2016	Wildfire	Hawai'i	A string of Pu'u Anahulu fires burned 1,150 acres in total in North Kona. These included a fire mauka of intersection of Daniel K. Inouye Hwy (Mile Marker 50) and Highway 190; a fire at Highway 190 at Mile Marker 16; and a fire at Highway 190 near Mile Marker 17 on the mauka side of the highway.
February 15 to 24, 2016	Brush Fire	Maui	Approximately 5,300 acres of the southern slopes of Haleakalā burned between February 15 and 24, 2016. The Kahikinui Homesteads area was evacuated. Shelters for displaced residents were opened at Kēōkea Park in Kula. The County of Maui EOC was activated.
March 5, 2016	Wildfire	Maui	The Kahikinui Fire, caused by arson, burned 5,800 acres and threatened 15 residences and 3 other structures. No structures were destroyed.
March 17, 2016	Wildfire	Honolulu	The Nānākuli Valley Fire was one of the largest wildfires in Western O'ahu's history, burning 2,500 acres. The wildfire began atop a steep cliff on the southeastern edge of the valley and moved downslope toward homes along Pikaiolela Street, Waiea Place, and Huikala Place. The fire burned right to the edge of homes, prompting voluntary evacuations. Westbound lanes of Farrington Highway at Ko 'Olina were shut down by police.
March 23 to 24, 2016	Wildfire	Hawai'i	A wildfire burned 2,500 acres of brush and grass mixture along Highway 190 between Mākālei and Daniel K. Inouye Highway.
March 28, 2016	Brush Fire	Hawai'i	A runaway brush fire that started in a residential area burned 125 acres on the mauka side of Waimea. The fire destroyed a ranch shed, but no homes or businesses. The County of Hawai'i EOC was activated.
March 29, 2016	Brush Fire	Honolulu	Due to drought conditions, the slopes of Diamond Head on O'ahu were impacted by a brush fire. The fire was moving quickly upslope and spreading due to strong winds. Roads were closed and 12 fire companies responded. The brush fire burned approximately two acres.
July 2, 2016	Wildfire (Mā'alaea Nui Fire)	Maui	Approximately 4,700 acres burned after equipment caused the Mā'alaea Nui wildfire.
July 8 to 10, 2016	Wildfire (Ukumehame Fire)	Maui	Approximately 1,242 acres burned
November 18 to 22, 2016	Wildfire	Honolulu	Approximately 1,235 acres burned
March 22 to 23, 2017	Bush Fire	Hawai'i	Approximately 10 acres of brush makai of the Queen Ka'ahumanu Highway shut down southbound lanes of the highway and other roads. The County of Hawai'i EOC was partially activated.
May 4 to 18, 2017	Wildfire	Kaua'i	The Kapalawai Wildfire resulted in the County of Kaua'i EOC being partially activated. Approximately 750 acres burned. Total costs in equipment and personnel to suppress the fire reached over \$80,000.
July 7, 2017	Brush Fire	Hawai'i	Approximately 2,176 acres burned near the Puukapu Farm Lots and Parker ranch area over two days. No injuries were reported. The County of Hawai'i EOC was partially activated.



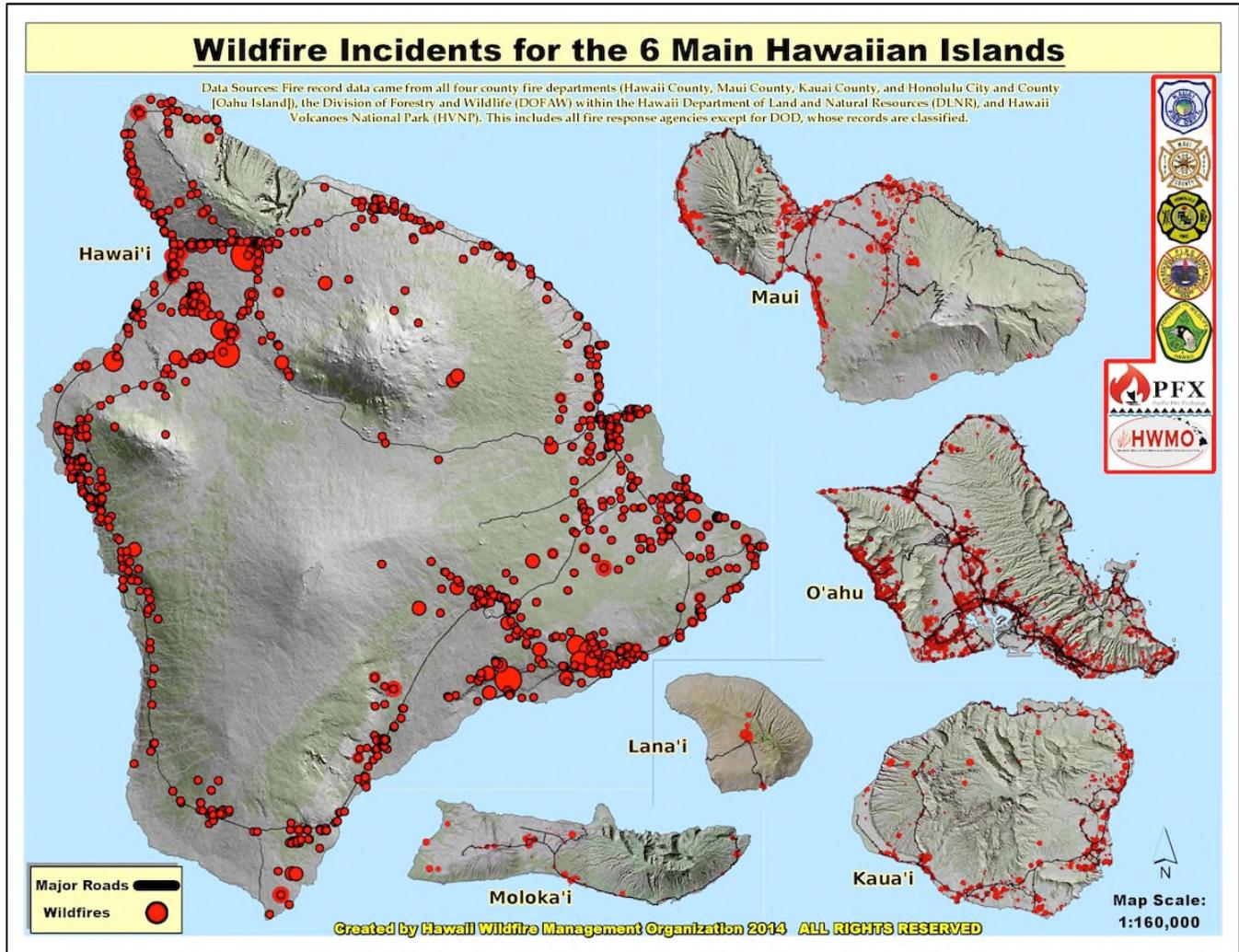
Sources: Dible 2016; Epping 2015; Hawai'i 24/7 Staff 2017, 2014, 2012; Hawai'i DLNR 2012; Hawai'i Tribute Herald 2017; HNN Staff 2015; Jansen 2012; Kakesako 2012; MauiNow 2016; Osher 2016; Pacheco 2016; Star Advertiser Staff 2012a, 2012b; State of Hawai'i 2017; The Associated Press 2013; The OANRP 2012; West Hawai'i Today 2012; Inefuku 2016  
EOC Emergency Operations Center

DRAFT



Figure 4.15-3 illustrates wildfire incidents 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 4.15-3. Wildfire Incidents for the State of Hawai'i**



Source: HWMO 2018

Note: HWMO Hawai'i Wildfire Management Organization

**FEMA Disaster Declarations**

During the years of 1954 through 2017, no wildfire-related disasters (DR) or emergencies (EM) were designated in the State by FEMA. However, FEMA did provide Fire Management Declaration Assistance to the State 18 times during that time period. They are summarized in Table 4.15-4.



**Table 4.15-4. Fire Management Declarations (1954 to 2017)**

Incident Date	Declaration Number	County Affected	Name	Date Declared
March 4, 1993	FM-2044	--	Hawai'i Kīlauea	March 4, 1993
February 16, 1998	FM-2195	--	Hawaiian Beaches Subdivision Fire	February 18, 1998
March 14, 1998	FM-2196	--	Hawai'i Puna District Wildfire	March 16, 1998
August 25, 1998	FM-2236	--	Hawai'i Moloka'i Fire 98	August 25, 1998
March 20 to 23, 2000	FS-2293	Hawai'i	Hawai'i County Fire Complex	March 20, 2000
May 18 to 21, 2003	FM-2468	Hawai'i	Hawai'i Waikoloa Village Fire	May 18, 2003
September 12 to 16, 2004	FM-2556	Hawai'i	Hawai'i Kawaihae Road Fire	September 14, 2004
August 1 to 6, 2005	FM-2573	Hawai'i	Hawai'i Lālāmilo Fire	August 2, 2005
August 2 to 6, 2005	FM-2574	Hawai'i	Hawai'i Akoni Pule Highway Fire	August 4, 2005
August 14 to 20, 2005	FM-2576	Honolulu	Hawai'i Nānākuli Brush Fire	August 15, 2005
August 17 to 20, 2005	FM-2577	Honolulu	Hawai'i Waikele Fire	August 19, 2005
September 1-6, 2006	FM-2673	Maui	Hawai'i Mā'alaea Fire	September 2, 2006
June 27 to July 4, 2007	FM-2701	Maui	Hawai'i Olowalu Fire	June 28, 2007
August 14 to 21, 2007	FM-2720	Honolulu	Hawai'i Waiialua Fire	August 14, 2007
August 16 to 22, 2007	FM-2722	Hawai'i	Hawai'i Kohala Mountain Road Fire	August 17, 2007
October 28 to November 7, 2007	FM-2740	Hawai'i	Hawai'i Puakō Fire	October 28, 2007
August 29 to September 7, 2009	FM-2834	Maui	Hawai'i Kaunakakai Fire	August 31, 2009
June 8 to 13, 2010	FM-2844	Maui	Hawai'i Mā'alaea Fire	June 9, 2010

Source: FEMA 2018

## PROBABILITY OF FUTURE HAZARD EVENTS

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 during which occur the majority of ignitions. 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 4.4 for a discussion of the drought hazard.

For the 2018 HMP 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 2013 State HMP, HWMO, DLNR and HI-EMA were used to identify the number of wildfire events of 100 acres or greater, that occurred between 1953 and 2017. Based on these statistics, the State of Hawai'i has a 100% chance of a wildfire occurring in any given year and can experience approximately 12 wildfire events each year.

It should be noted that there are additional factors which 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 (Pacific Fire Exchange 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 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 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 on Future Probability of Events

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 21<sup>st</sup> century, it is anticipated that there will be a 35% increase in days with high fire danger across the world (Trauernicht, 2015).

The projected annual surface air temperature for the State of Hawai'i is estimated to increase in a range from 1.5°F to 3.5°F (U.S. Global Change Research Program 2017). 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. All of which lead to perfect conditions for wildfires throughout the State (HWMO 2018). 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.

## 4.15.2 Vulnerability Assessment

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). It is important to note that 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 G (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.

### 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.*



**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 2,895 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 (1,645 buildings with a replacement cost value of \$3.548 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	\$957,679,537	377	71.00%	\$690,290,935	72.08%
City and County of Honolulu	3,472	\$16,750,785,426	1,645	47.38%	\$3,548,483,643	21.18%
County of Maui	831	\$2,862,316,819	626	75.33%	\$2,047,144,499	71.52%
County of Hawai'i	1,261	\$4,209,774,236	247	19.59%	\$662,854,284	15.75%
<b>Total<sup>a</sup></b>	<b>6,095</b>	<b>\$24,780,556,017</b>	<b>2,895</b>	<b>47.50%</b>	<b>\$6,948,773,361</b>	<b>28.04%</b>

Source: Hawai'i State Risk Management Office 2017; HWMO 2013

Notes: Totals do not include assets that were not able to be geocoded. Please see Section 4.0 for further discussion.

HWMO Hawai'i Wildfire Management Organization

**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	\$946,504,656	18	27.3%	\$135,477,027	14.3%
Dept of Agriculture	70	\$133,065,375	27	38.6%	\$58,329,017	43.8%
Dept of Attorney General	15	\$95,151,863	5	33.3%	\$9,867,852	10.4%
Dept of Budget & Finance	16	\$26,624,294	6	37.5%	\$1,314,797	4.9%
Dept of Business, Economic Development and Tourism	25	\$612,574,032	2	8.0%	\$31,908,972	5.2%



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 Commerce & Consumer Affairs	2	\$35,611,360	0	0.0%	\$0	0.0%
Dept of Defense	69	\$246,099,477	28	40.6%	\$118,869,059	48.3%
Dept of Education	4,090	\$9,604,111,443	2,170	53.1%	\$3,923,400,182	40.9%
Dept of Hawaiian Home Lands	12	\$100,471,477	2	16.7%	\$2,184,543	2.2%
Dept of Health	44	\$387,068,440	10	22.7%	\$18,295,256	4.7%
Dept of Human Resources Development	1	\$5,523,320	0	0.0%	\$0	0.0%
Dept of Human Services	130	\$420,004,555	42	32.3%	\$68,850,782	16.4%
Dept of Labor and Industrial Relations	22	\$79,322,626	14	63.6%	\$19,066,946	24.0%
Dept of Land and Natural Resources	90	\$98,666,185	32	35.6%	\$26,218,269	26.6%
Dept of Public Safety	154	\$427,884,909	54	35.1%	\$197,856,566	46.2%
Dept of Taxation	1	\$6,864,408	0	0.0%	\$0	0.0%
Dept of Transportation	68	\$2,912,510,888	31	45.6%	\$332,820,414	11.4%
Hawai'i State Ethics Commission	1	\$891,212	0	0.0%	\$0	0.0%
Hawai'i Health Systems Corporation	106	\$1,223,962,810	51	48.1%	\$759,605,877	62.1%
Hawai'i Housing Finance & Development Corporation	86	\$333,526,064	79	91.9%	\$211,766,892	63.5%
Hawai'i Public Housing Authority	273	\$933,255,767	108	39.6%	\$214,609,563	23.0%
Hawai'i State Legislature	2	\$43,024,855	0	0.0%	\$0	0.0%
Hawai'i State Public Library System	53	\$525,584,082	28	52.8%	\$105,523,199	20.1%
Judiciary	41	\$511,093,204	17	41.5%	\$101,539,545	19.9%
Legislative Reference Bureau	1	\$2,686,408	0	0.0%	\$0	0.0%
Office of Hawaiian Affairs	11	\$53,991,251	4	36.4%	\$1,400,487	2.6%
Office of the Auditor	2	\$1,789,788	0	0.0%	\$0	0.0%
Office of the Governor	1	\$2,686,408	0	0.0%	\$0	0.0%
Office of the Lieutenant Governor	2	\$3,977,640	1	50.0%	\$1,956,330	49.2%



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
Office of the Ombudsman	1	\$1,620,944	0	0.0%	\$0	0.0%
Research Corporation of the University of Hawai'i	3	\$3,713,497	0	0.0%	\$0	0.0%
University of Hawai'i	637	\$5,000,692,783	166	26.1%	\$607,911,786	12.2%
<b>Total</b>	<b>6,095</b>	<b>\$24,780,556,017</b>	<b>2,895</b>	<b>47.5%</b>	<b>\$6,948,773,361</b>	<b>28.0%</b>

Source: Hawai'i State 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 336 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 (166.1 miles) exposed which is 44.3% 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 G (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	104.0	32.8	31.5%
City and County of Honolulu	375.3	166.1	44.3%
County of Maui	238.6	70.1	29.4%
County of Hawai'i	378.7	67.4	17.8%
<b>Total</b>	<b>1,096.5</b>	<b>336.4</b>	<b>30.7%</b>

Source: State of Hawai'i SDOT State Routes GIS layer 2017; HWMO 2013

Notes: GIS Geographic Information System  
 HWMO Hawai'i Wildfire Management Organization  
 SDOT State Department of Transportation

### 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 critical facilities (335) 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 51.8% of their facilities located in the high wildfire risk hazard area.



**Table 4.15-8. Critical Facilities by County Located in the High Wildfire Risk Hazard Area**

County	Core Category of Critical Facilities										Total in the Hazard Area
	Commercial Facilities	Communications	Emergency Services	Energy	Food and Agriculture	Government Facilities	Healthcare and Public Health	Mass Care Support Services	Transportation Services	Water, Waste, and Wastewater Systems	
County of Kaua'i	2	7	19	7	3	8	11	23	5	17	102
City and County of Honolulu	14	31	34	26	0	17	31	90	4	88	335
County of Maui	2	12	14	2	3	18	41	44	16	40	192
County of Hawai'i	3	4	7	1	11	1	8	14	4	12	65
<b>Total<sup>a</sup></b>	<b>21</b>	<b>54</b>	<b>74</b>	<b>36</b>	<b>17</b>	<b>44</b>	<b>91</b>	<b>171</b>	<b>29</b>	<b>157</b>	<b>694</b>

Source: Makani Pahili 2017 Emergency Power Prioritization Workshop Series final report; Hazus v4.2; HWMO 2013

Note: HWMO Hawai'i Wildfire Management Organization

**Table 4.15-9. Critical Facilities by Core Category Located in High Wildfire Risk Hazard Area**

Core Category	Total Number of Critical Facilities	Total Replacement Cost Value	Number of Critical Facilities in Hazard Area	Percent (%) of Total Facilities	Value in the Hazard Area	Percent (%) of Total Value
Commercial Facilities	60	\$206,894,206	21	35.0%	\$109,837,686	53.1%
Communications	130	\$523,848,060	54	41.5%	\$183,739,490	35.1%
Emergency Services	149	\$1,017,628,710	74	49.7%	\$530,341,080	52.1%
Energy	90	\$2,591,975,628	36	40.0%	\$1,027,752,170	39.7%
Food & Agriculture	39	\$829,869,410	17	43.6%	\$321,855,340	38.8%
Government Facilities	100	\$399,781,575	44	44.0%	\$181,478,175	45.4%
Healthcare & Public Health	193	\$3,399,521,375	91	47.2%	\$1,652,077,958	48.6%
Mass Care Support Services	353	\$11,497,547,155	171	48.4%	\$6,244,829,525	54.3%
Transportation Services	56	\$1,739,256,960	29	51.8%	\$897,784,320	51.6%
Water, Waste, & Wastewater Systems	305	\$9,481,445,760	157	51.5%	\$4,870,026,240	51.4%
<b>Total<sup>a</sup></b>	<b>1,475</b>	<b>\$31,687,768,838</b>	<b>694</b>	<b>47.1%</b>	<b>\$16,019,721,983</b>	<b>50.6%</b>

Source: Makani Pahili 2017 Emergency Power Prioritization Workshop Series final report; Hazus v4.2; HWMO 2013

Note: HWMO Hawai'i Wildfire Management Organization

### 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 2018b). 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.

**Population**

Given the historic response times to reported fires, the potential of injuries and casualties is minimal. Smoke and air pollution from wildfires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. It should be noted that 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.

Population living along the WUI may only have one ingress/egress to their communities making them highly vulnerable in the event of an evacuation. In addition, the elderly (persons over the age of 65) and individuals living below the U.S. Census poverty threshold are also considered highly vulnerable based on a variety of factors including their physical and financial ability to react or respond during a hazard, the location and construction quality of their housing, and the ability to be self-sustaining for prolonged periods of time after an incident because of limited ability to stockpile supplies. The population over 65 makes up about 6.4% of the total population of the State of Hawai'i located in the high wildfire risk hazard area. Overall, 7.4% of the total population of the State of Hawai'i is classified as low-income population, and the County of Kaua'i has the highest percent with 14.9% located in the high wildfire risk areas.

**Table 4.15-10. 2010 U.S. Census Population Located in the High Wildfire Risk Hazard Area by County**

County	Population						
	Total Population	Population in Hazard Area	Population Exposed as % of Total Population	Population Over 65 in Hazard Area	Population Over 65 Exposed as % of Total Population	Income <\$30K/yr in Hazard Area	Income <\$30K/yr Exposed as Percent (%) of Total
County of Kaua'i	67,091	39,493	58.9%	6,064	9.0%	10,008	14.9%
City and County of Honolulu	953,207	454,509	47.7%	61,690	6.5%	57,492	6.0%
County of Maui	154,924	94,000	60.7%	13,089	8.4%	21,819	14.1%
County of Hawai'i	185,079	42,045	22.7%	5,729	3.1%	11,172	6.0%
<b>Total</b>	<b>1,360,301</b>	<b>630,047</b>	<b>46.3%</b>	<b>86,572</b>	<b>6.4%</b>	<b>100,491</b>	<b>7.4%</b>

Source: U.S. Census 2010; HWMO 2013



Note: HWMO Hawai'i Wildfire Management Organization  
Yr Year

The poverty threshold for the State is \$24,000/year (Federal Register 2017). Utilizing the demographic layer in Hazus, the total households with an income of \$30,000 or less was calculated. Per the U.S. Census Bureau QuickFacts, the average number of persons per household (2012-2016) is 3.03 for the State of Hawai'i. To convert households to residents, three people per household was used.

### 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 G (State Profile and Risk Assessment Supplement) for results by county. Urban Districts in each county have a significant portion of their total land area in the high-risk areas. This can be explained by the fact that only communities which were included in the CAR data were used to determine the high-risk areas. Agricultural District land in each county, aside from the City and County of Honolulu, has the greatest number of square miles located in high wildfire risk areas. Conservation District land is exposed to high, moderate, and low wildfire risk areas in each county; however, the percent of each county's total Conservation District lands in high wildfire risk areas is generally low (between 1% and 7%). 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	2,942.8	321.1	10.9%
Conservation	3,156.3	66.0	2.1%
Rural	16.1	5.7	35.3%
Urban	319.7	139.8	43.7%
<b>Total</b>	<b>6,434.9</b>	<b>2.6</b>	<b>8.3%</b>

Source: HWMO 2013; State Land Use Commission, 2016

Notes: Total area was calculated from the State of Hawai'i State Land Use District GIS layer

Hazard area clipped to coastline were downloaded from State of Hawai'i GIS Program Geospatial Data Portal

Total area may differ slightly between this and other calculations due to slight differences in the shoreline geography. GIS Geographic Information System

### 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 \$101 billion, which represents 42% 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 Kaua'i has the largest percent (64.4%) 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 \$65 billion. The replacement cost value of buildings exposed is provided as an estimate for total loss. Appendix X 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	\$13,287,882,000	\$7,773,287,000	58.5%
City and County of Honolulu	\$164,787,212,000	\$65,492,432,000	39.7%
County of Maui	\$31,320,693,000	\$20,169,285,000	64.4%
County of Hawai'i	\$33,326,392,000	\$8,416,647,000	25.3%
<b>Total</b>	<b>\$242,722,179,000</b>	<b>\$101,851,651,000</b>	<b>42.0%</b>

Source: State of Hawai'i GIS layer Trust Land, State of Hawai'i GIS Program Geospatial Data Portal; Hazus 4.2; HWMO 2013

Notes: GIS Geographic Information System

HWMO Hawai'i Wildfire Management Organization

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 to tourism as well (HWMO 2018).

**Environmental Resources**

Overall, wildfires have physical, chemical, and biological impacts on ecosystem resources and the environment (DeBano et al. 1998). 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 ('Ohu Gon 2016). Approximately 39 square miles of parks and reserves and 30 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 G 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 <sup>c</sup>	Square Miles in High Risk Area	Percent (%) of Total Resource Area
Critical Habitat <sup>a</sup>	915.2	30.4	3.3%
Wetlands	260.0	10.8	4.2%
Parks and Reserves	2,607.7	38.8	1.5%
Reefs <sup>b</sup>	54.7	0.0	0.0%
<b>Total</b>	<b>3,837.6</b>	<b>80.0</b>	<b>2.1%</b>



Source: State of Hawai'i GIS Program Geospatial Data Portal; HWMO 2013

Notes: a. Critical habitat includes the habitats that are known to be essential for an endangered or threatened species. The area mileage includes the combined area of coverage of individual critical habitat areas.

b. Reefs include artificial and coral reefs

c. Total square miles may be over reported as some environmental asset areas may overlap.

GIS Geographic Information System

HWMO Hawai'i Wildfire Management Organization

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 2016).

The watershed areas in high wildfire hazard areas were evaluated by county and are summarized in Table 4.15-14. Approximately 2% 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.

**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
<b>County of Kaua'i</b>			
Kaua'i Watershed Alliance	144,004.4	1,185.5	0.8%
<b>City and County of Honolulu</b>			
Ko'olau Mountains Watershed Partnership	100,899.5	3,097.1	3.1%
Wai'anae Mountains Watershed Partnership	46,412.1	4,688.0	10.1%
<b>County of Hawai'i</b>			
Kohala Watershed Partnership	74,120.5	1,195.4	1.6%
Mauna Kea Watershed Alliance	256,250.4	245.7	0.1%
Three Mountain Alliance	1,131,012.0	14,545.3	1.3%
<b>County of Maui</b>			
East Maui Watershed Partnership	119,504.9	1,835.2	1.5%
East Moloka'i Watershed Partnership	41,668.5	1,689.8	4.1%
Leeward Haleakalā Watershed Restoration Partnership	43,058.0	1,420.5	3.3%
<b>Total</b>	<b>2,004,251.9</b>	<b>29,960.9</b>	<b>1.5%</b>

Source: State of Hawai'i GIS layers, State of Hawai'i GIS Program Geospatial Data Portal, 2017

Note: GIS Geographic Information System

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 is 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.



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

County	Area (in square miles)						Hazard Area as Percent (%) of Total Area
	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	
County of Kaua'i	166.2	0.0	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%	0.0	<1%	5.0	2%
County of Hawai'i	1,124.5	37.8	3%	1.8	0%	11.1	1%
<b>Total</b>	<b>1,577.4</b>	<b>39.5</b>	<b>3%</b>	<b>5.1</b>	<b>&lt;1%</b>	<b>18.2</b>	<b>1%</b>

Source: State of Hawai'i GIS layers, State of Hawai'i GIS Program Geospatial Data Portal, 2017

Notes: DOFAW-managed lands are included in the Parks and Reserves Environmental Resource Area included in Table 4.14-12.

DOFAW Division of Forestry and Wildlife  
GIS Geographic Information System

### 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 4.14-16). The County of Maui has the greatest number of square miles (36.6) and the City of County of Honolulu has the highest percentage (44.7%) of Hawaiian Home Lands located in high wildfire risk hazard areas.

**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	32.0	2.0	6.3%
City and County of Honolulu	10.9	4.9	44.7%
County of Maui	92.6	36.6	39.5%
County of Hawai'i	190.3	5.9	3.1%
<b>Total</b>	<b>325.8</b>	<b>49.4</b>	<b>15.2%</b>

Source: State of Hawai'i GIS layer Trust Land, State of Hawai'i GIS Program Geospatial Data Portal; HWMO 2013

Notes: GIS Geographic Information System  
HWMO Hawai'i Wildfire Management Organization

### 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 (Stein, Carr, Liknes, Comas, 2014). 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, Carr, Liknes, Comas 2014). On Oahu, 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 2014). Some new developments have sprawled into dry parts of Oahu 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 because of more people living proximate to wildland areas (DLNR 2016).

## 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 2018c).

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 (Pacific Islands Regional Climate Assessment 2012).

Overall, an increase in wildfire events means less native forests and drinking water, and more erosion/runoff, coastal brownouts and communities at risk in the State of Hawai'i (HWMO 2018c).