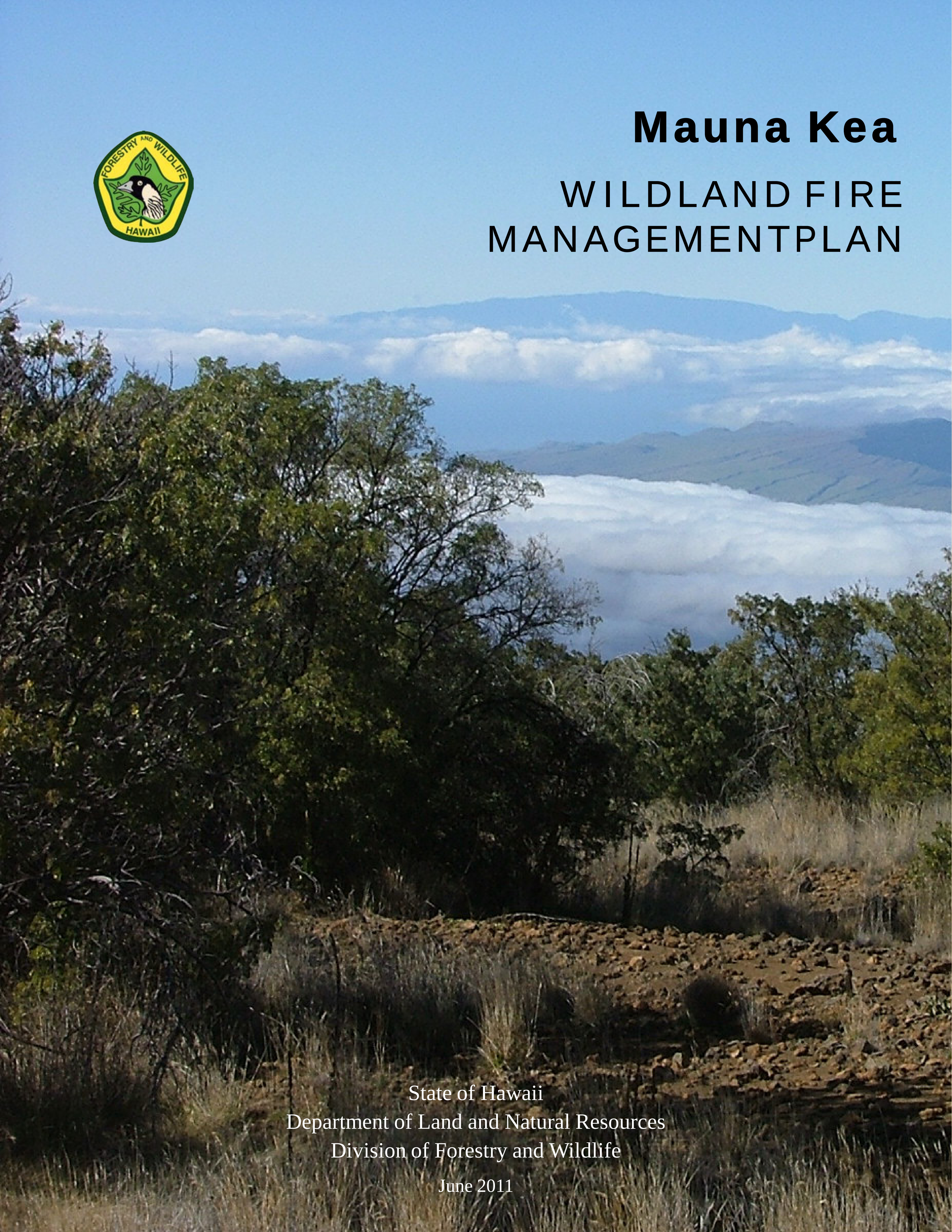
Mauna Kea

WILDLAND FIRE MANAGEMENTPLAN



State of Hawaii
Department of Land and Natural Resources
Division of Forestry and Wildlife

June 2011

Mauna Kea
Wildland Fire Management Plan

Prepared by

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for

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Executive Summary

The palila (*Loxioides bailleaui*) is an endangered bird protected by federal law under the Endangered Species Act. Critical habitat for this species has been designated on much of Mauna Kea to stabilize the palila population. This fire management plan represents an interagency effort to develop a comprehensive approach to protecting palila critical habitat from wildfires and to address general widfire issues on Mauna Kea. Agencies involved in the planning process include the State of Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife, the U.S. Fish and Wildlife Service, the U.S. Department of Transportation Federal Highway Administration, the U.S. Army Garrison Hawaii, the Hawaii Wildfire Management Organization, and the U.S. Geological Survey.

The Mauna Kea Palila Critical Habitat Wildland Fire Management Plan (Mauna Kea FMP) establishes the goals and objectives to be achieved, designates responsibilities, specifies improvements to roads, firebreaks, and fuels management, establishes fire fighting protocols, and establishes a budget for implementation. This plan is a guide, and as such, it is meant to be utilized to inform decisions. Final authority for all decisions lies with the State of Hawaii DLNR.

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List of Acronyms

BO ..... Biological Opinion
BRD ..... Biological Resources Division
DHHL ..... Department of Hawaiian Home Lands
DLNR ..... Department of Land and Natural Resources
DOCARE ..... Division of Conservation and Resources Enforcement
DOFAW ..... Division of Forestry and Wildlife
DOT ..... Department of Transportation
FHA ..... Federal Highway Administration
FMP ..... Fire Management Plan
FMU ..... Fire Management Unit
GIS ..... Geographic Information System
GMA ..... Game Management Area
GPS ..... Geographic Positioning System
HWMO ..... Hawaii Wildfire Management Organization
IC ..... Incident Commander
ICS ..... Incident Command System
LCES ..... Lookouts, Communications, Escape Routes, and Safety Zones
MAA ..... Mutual Aid Agreements
NWR ..... National Wildlife Refuge
PTA ..... Pohakuloa Training Area
RAWS ..... Remote Automated Weather Station
USAGHI ..... United States Army Garrison Hawaii
USFWS ..... U.S. Fish and Wildlife Service
USGS ..... United States Geologic Survey

List of Agencies, Organizations, and Individuals Consulted

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Joan Yoshioka	Hawaii Division of Forestry and Wildlife

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This plan relied heavily on previous work by a wide variety of individuals and agencies. Charles Wakida's 1997 Mauna Kea Ecosystem Wildland Fire Management Plan was a primary source of information as was Jarrod Thaxton and Jim Jacobi's 2009 Assessment of Fuels, Potential Fire Behavior, and Management Options in Subalpine Vegetation on Mauna Kea volcano, Hawaii. Additionally, the author would like to thank all of the agencies and individuals who contributed their data, time, and expertise to this important project.

1 Introduction

1.1 Setting

1.1.1 Location

Mauna Kea is located in the northern region on the Island of Hawai'i, west of the city of Hilo (Figure 1). Along the southern extents of Mauna Kea from the west to the east are the Waikii and Ka'Ohe Game Management Areas, Pohakuloa Training Area, the Mauna Loa Forest Reserve, Upper Waiakea Forest Reserve, Hilo Restricted Watershed, and Kipuka Ainahou Nene Sanctuary. Along the eastern extents of Mauna Kea are the Hakalau Forest National Wildlife Refuge (NWR) and Hilo Forest Reserve. Private ranch lands comprise the remaining lands surrounding Mauna Kea. Landowners on and around Mauna Kea have formed the Mauna Kea Watershed Alliance whose collective area encompasses more than 525,000 acres (MKWMP 2010). The designated critical habitat for the palila (*Loxoides bailleui*), which defines the extent of consideration for this fire management plan (FMP), occurs in a ring around Mauna Kea and totals 60,285 acres.

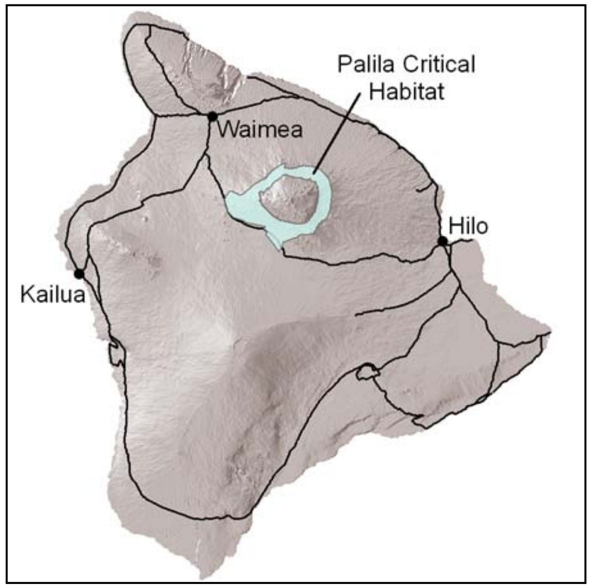


Figure 1. Location of the Palila Critical Habitat, which defines the physical scope of this FMP, on the Island of Hawaii.

1.1.2 Land Use

The lands on and around Mauna Kea are owned by twelve primary landowners with the state of Hawaii, the Department of Hawaiian Home Lands (DHHL), Parker Ranch, US Federal, Omaomao Corp, and R.B. Acree being the largest landholders (Figure 2). Land ownership is split between public and private. The variety of landowners results in a variety of land uses. The Hawaii Land Use Law has divided lands into four land use districts: Conservation, Agricultural, Urban and Rural (MKWMP 2010). The Conservation district is managed by the Department of Land and Natural Resources (DLNR) and further subdivided lands into four subzones: Protective, Limited, Resource, and General (MKWMP 2010). Approximately fifty-six percent of Mauna Kea lands fall within the Conservation district and are within the Resource (68%), Limited (20%), Protective (10%), and General (2%) subzones (MKWMP 2010). Agricultural lands comprise another forty-four percent of Mauna Kea lands which are the responsibility of the counties they are found in (MKWMP 2010). Urban lands make up less than one percent of Mauna Kea lands and are also the responsibility of their counties (MKWMP 2010). Agricultural lands are utilized for timber and grazing animals, primarily cattle, though small crop acreages are present.

1.1.3 Climate

The Island of Hawai'i is influenced by North Pacific Anticyclone and the resulting trade winds that blow toward the Hawaiian Island's eastern shores (SRGII 2009). Mauna Kea's windward side receives convective rainfall produced when moist air rises up the mountain slope and condenses. Coastal areas of Mauna Kea found on the windward side receive 100-150 inches of rain annually, while the higher elevations (2,000-5,000 ft) can receive up to 300 inches annually (MKWMP 2010). The leeward side of Mauna Kea is in the rain shadow produced by the mountain and receives much less precipitation. Rainfall changes drastically over short distances, making generalizations difficult, but annual precipitation on the leeward side of the mountain ranges from nine inches near the coast to 50 inches in some areas, with the saddle between Mauna Kea and Mauna Loa receiving less than 30 inches annually (MKWMP 2010).

1.1.4 Topography

Mauna Kea rises 13,796 ft above sea level and is the tallest mountain in the Hawaiian archipelago. Some of the distinctive topographic features on Mauna Kea have resulted from erosion and deposition by glaciers (MKWMP 2010). Due to the fact that the windward and leeward sides receive different levels of precipitation, the leeward side has experienced less erosion than the windward side (MacDonald et al 1983). The leeward side exhibits many weakly-defined stream channels with intermittent stream flow, while windward side waterways are much more defined, with deep gulches and perennial streams (MacDonald et al 1983)

1.1.5 Geology

Mauna Kea's mass originated from the shield stage where tholeiitic basalts were produced (Sherrod et al 2007). Since that time newer material has been discharged that is mostly alkali and has been divided into two sub-categories (Macdonald et al 1983), Hamakua, which was deposited first, and Laupahoehoe. Both are visible on the surface of Mauna Kea and have covered the majority of the basalts from the shield-development stage (Sherrod et al 2007)

1.1.6 Soils

There are approximately twenty-eight soil series associated with Mauna Kea. There are also non-soil strata including lava flows, rock land, rough broken land, very stony land, and cinder land (MKWMP 2010). Andisols comprise the majority of the soils found on Mauna Kea. These soils develop from parent material containing fifty percent or more volcanic ash or ejecta (MKWMP 2010). Histosols are the second most represented soils on Mauna Kea. The Histosol soils are usually found in areas of high precipitation and they are composed of primarily organic material that is weakly decomposed due to drainage restrictions (MKWMP 2010). Inceptisols and entisols make up the remaining soils. These are young and poorly developed, closely resembling their parent material, and show very little development due to constant exposure or their location in poorly drained areas (MKWMP 2010).

1.1.7 Air Quality

Air quality above the trade-wind inversion layer is considered to be excellent (NASA 2005). Potential contaminants above the inversion layer include exhaust emissions and dust particles from construction projects as well as sulfur-dioxide from the Kilauea volcano (SRGII 2009). Air quality below the inversion layer can be affected by vehicle emissions, agricultural practices, active volcanoes and vents, as well as wildfires. Due to the inversion that occurs at roughly 6,500 feet elevation (Howarth and Mull 1992), air pollutants become trapped in the lower atmosphere and can have an effect on human health.

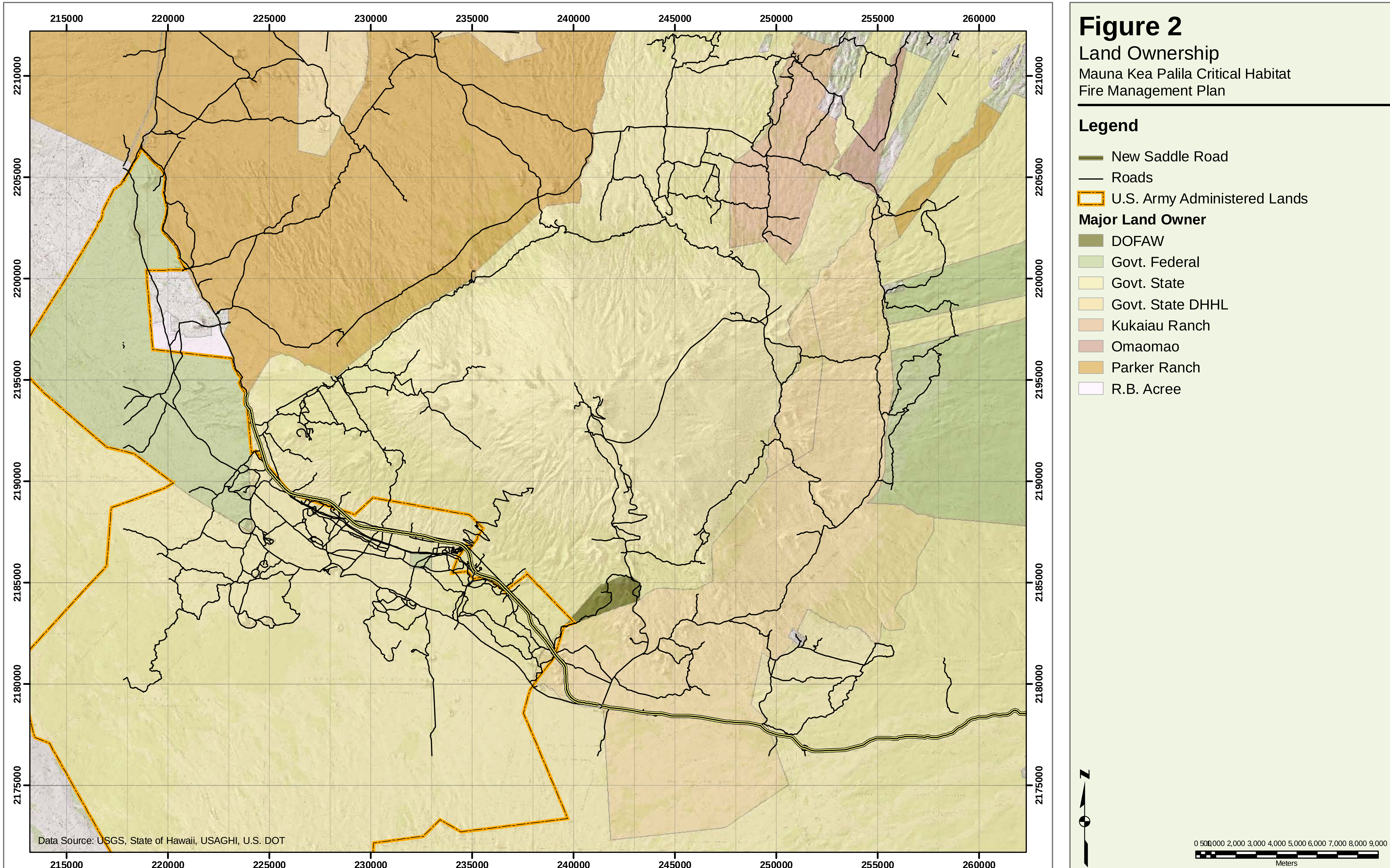


Figure 2

Land Ownership

Mauna Kea Palila Critical Habitat
Fire Management Plan

Legend

- New Saddle Road
- Roads
- U.S. Army Administered Lands

Major Land Owner

- DOFAW
- Govt. Federal
- Govt. State
- Govt. State DHHL
- Kukaiau Ranch
- Omaomao
- Parker Ranch
- R.B. Acree

1.1.8 Water Quality

The primary sources of water on Mauna Kea are rainfall, snow, and fog drip all of which feed into ground and surface waters (MKWMP 2010). Fog drip is of particular importance on the dry, leeward side of the mountain.

A 2006 water quality report (DOH 2008) identified streams in the Mauna Kea watershed that did not meet water quality standards due to excess nutrients, turbidity, or total suspended solids (TSS) (MKWMP 2010). Excess nutrients have resulted from agricultural and residential practices, while excess turbidity and suspended solids have originated from erosion (MKWMP 2010). The vegetation found on Mauna Kea is critical to water quality as it acts to intercept precipitation and allow infiltration into groundwater sources. When vegetation is removed the precipitation quickly runs off, eroding streambanks and hillslopes, taking with it soils and sediments which negatively affect water quality (MKWMP 2010).

The water quality of surface waters on Mauna Kea may impact the quality of groundwater needed for a variety of anthropogenic uses. Groundwater supplies originating on Mauna Kea supply municipal production wells outside of the Mauna Kea area (MKWMP 2010). The East Mauna Kea Aquifer supplies an estimated yield of 388 million gallons per day to 26 production wells (MKWMP 2010). The West Mauna Kea Aquifer supplies 24 million gallons per day to 30 production wells (MKWMP 2010).

1.1.9 Vegetation

Mauna Kea has a diverse array of vegetation because of its size and drastic differences in climate from the windward to leeward side. Lowland rainforests are represented at elevations of 2,500 to 3,000 ft where the forests are characterized by a closed-canopy of ohia (*Metrosideros polymorpha*) and Koa (*Acacia koa*) with well developed sub-canopy and understory strata (Wagner et al 1999). Montane rain forest mixes with the lowland rainforest at higher elevations on the windward side and continues above 5,500 feet. The montane rainforest is characterized by a closed canopy of Koa or Koa/Ohia that is distinctly stratified (Wagner et al 1999) with a less developed understory (MKWMP 2010). On the windward side of Mauna Kea, as elevation increases the montane wet forest transitions to montane mesic forest before giving way to the subalpine habitat found at elevations of 6,000-10,000 ft. Montane mesic forest is characterized by open mamane (*Sophora chrysophylla*) woodlands where it hasn't been converted to open ranching lands. The ranch lands are dominated by grasses (MKWMP 2010), many of which are non-native invasive species. The subalpine zone circles Mauna Kea from elevations of 6,000-10,000 ft and contains vegetation that is adapted to dry conditions (MKWMP 2010). The subalpine zone may contain grasslands, shrublands, and forest all above the inversion layer (Wagner et al 1999). The upper regions of the subalpine zone are home to the endangered Silversword (*Argyroxiphium sandwicense ssp. sandwicense*) (MKWMP 2010). The dry leeward zone on the western flanks of the mountain has been heavily influenced by grazing, fire, feral animals, and alien grass invasion (MKWMP 2010).

Introduced ungulates have negatively influenced the Palila's habitat through grazing and browsing in the mamane forests (Banko 2006). Ungulates were initially introduced for recreational hunting and tend to consume mamane seedlings before they can grow to maturity resulting in poor regeneration (pers. com. Dr. David Leonard). The native vegetation is not adapted to the presence of ungulates and is vulnerable to the presence of these animals (Hess 2008). Regeneration of critical habitat has been encouraging in areas where ungulates have been removed but effects are still being seen

(Banko 2006), indicating that current control efforts need to be improved to prevent continued Palila habitat disturbance. Mouflon have been particularly difficult to control with traditional hunting methods and continue to influence the palila's mamane habitat (Hess 2008).

Wagner et al (1999) categorize the mamane woodlands into the subalpine dry forest category and list two subtypes: one dominated by mamane and a second of mamane with a naio (*Myoporum sanwicense*) codominant. There is evidence that the distribution of the mamane forest and the physiognomy of individual mamane trees has been influenced by non-native ungulate grazing, including a shift from historic single boled trees to the current multi-stemmed architecture (pers. com. Dr. David Leonard).

1.1.10 Wildlife

Mauna Kea is home to many different birds, mammals, invertebrates, and aquatic species. There is only one native mammal found on Hawaii, the Hoary bat (*Lasiurus cinereus semotus*) which roosts by day and forages at night throughout a wide variety of habitats (MKWMP 2010). Invertebrate species found throughout the Mauna Kea landscape are well adapted to the diversity of habitats on the mountain. Aquatic species found on Hawaii and around Mauna Kea are unique and adapted to fast-moving streams, many are found nowhere else on the planet (MKWMP 2010). These aquatic species are threatened by water quality, stream channelization, and reduced stream flow rates (MKWMP 2010).

There are many species of native birds found throughout Hawaii, 42 of which are endemic. One of the most widespread families of Hawaiian birds are the honeycreepers. There are a number of species of honeycreepers found on Mauna Kea that primarily occur in the native montane and mesic ohia/koa forests above 4,100-ft (MKWMP 2010). The endangered palila (*Loxoides bailleui*) is a species of honeycreeper that is dependent on the subalpine mamane woodlands on Mauna Kea and its protection is the impetus for this fire management plan. Palila populations are concentrated on the western slopes of Mauna Kea between elevations of 6,500-9,250-ft and are threatened by browsing sheep, goats, and cattle, predation by feral cats, and habitat loss due to invasive plants, drought, and wildfire risk (MKWMP 2010, pers. com. Robert Stephens).

1.1.11 Cultural Resources

Mauna Kea is known as Mauna a Wakea in native traditions and prayers (Maly and Maly 2005). The native Hawaiians believe that Mauna Kea is the mountain son of Wakea and Papa, who were the progenitors of the Hawaiian race (Maly and Maly 2005). There are a number of cultural sites that are above the vegetation zone (SRGII 2009) and hence, outside of the fire risk zone. Trails on Mauna Kea were originally small foot paths that eventually turned into major trails connecting the east and west sides of the mountain (MKWMP 2010). There may be cultural and archaeological resources, such as burial sites, scattered throughout Mauna Kea that are far off of any trail. These sites have been deemed "not susceptible to fire damage" due to the terrain features (Wakida 1997). It should be noted that they may be damaged by fire suppression activities.

1.2 Stakeholders

1.2.1 State of Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife

The State of Hawaii Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) is the proponent of this FMP and the owner of much of the land this FMP addresses. Their mission includes protecting and conserving the unique natural resources of Hawaii with a focus on watershed protection.

DOFAW is also a party to the Palila Mitigation Memorandum of Understanding which stipulates the development of this FMP.

1.2.2 United States Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) oversees the implementation of the Endangered Species Act of 1973. The Service has been directly involved in the siting and building of the new Saddle Road and its potential impact on federally listed species over which the Service has jurisdiction. Concerns regarding fire from the Service are one of the driving forces behind the development of this FMP and are detailed in the 1998 Saddle Road Biological Opinion (BO) (USFWS 1998) as well as the Palila Mitigation Memorandum of Understanding (USFWS 1999).

1.2.3 United States Army

The United States Army Garrison Hawaii (USAGHI) maintains a training installation abutting and including some of the southern boundary of the palila critical habitat area addressed in this FMP. The realignment of Saddle Road is due, in part, to the interests of USAGHI in improving training opportunities available at Pohakuloa Training Area (PTA). USAGHI is one of the agreeing agencies to the USFWS Saddle Road BO. USAGHI has also funded the development of this FMP.

The Army maintains a full time fire department at PTA. This fire department maintains a Mutual Aid Agreement with DOFAW and is frequently the first responder to fires on the southern flanks of Mauna Kea.

1.2.4 United States Federal Highway Administration

The U.S. Federal Highway Administration (FHA) provided technical support to the design and construction of the new Saddle Road. The U.S. FHA has been closely involved in the negotiations regarding the USFWS Saddle Road BO and is a party to the Palila Mitigation Memorandum of Understanding.

1.2.5 State of Hawaii Department of Transportation

The Hawaii Department of Transportation (DOT), in cooperation with the U.S. FHA, is building the new Saddle Road. The Hawaii DOT is a party to the Palila Mitigation Memorandum of Understanding.

1.2.6 United States Geologic Survey Biological Resources Division

The U.S. Geologic Survey (USGS) Biological Resources Division (BRD) provided technical consultation regarding development of appropriate mitigation measures during Section 7 consultations between the involved agencies and USFWS.

1.2.7 Hawaii Wildfire Management Organization

The Hawaii Wildfire Management Organization (HWMO) is a non-profit organization bringing expertise, experience, and advice to wildfire management on Mauna Kea. They do not have a legal or financial stake in the Mauna Kea FMP, but are a group of professionals advocating for improved fire management throughout the Island of Hawaii.

1.2.8 Mauna Kea Watershed Alliance

The Mauna Kea Watershed Alliance has a great deal of interest in fire management on Mauna Kea as it affects water production and quality. The Alliance is currently drafting a Watershed Management Plan which includes objectives that specifically address wildland fire prevention and suppression.

1.3 Weather

The palila critical habitat is quite large and encompasses a wide variety of weather regimes, from dry to wet, windy to calm, and hot to cool. This analysis is focused on those areas considered most at risk from wildfires.

1.3.1 Weather Stations

Period of record data was acquired for 11 weather stations on the flanks of Mauna Kea. These are listed in the table below. Only two of these weather stations maintain a full suite of variables and have a long enough period of record to be useful in weather analysis. These are the Hakalau RAWS on the eastern flank of Mauna Kea and the PTA West RAWS located roughly 4 miles south of Ka'Ohe Game Management Area.

Table 1. Weather Stations for which period of record data was obtained.

Station Name	Station Type	Data Type*	Period of Record
Ahumoa	RAWS	All Variables	2/23/09 to Present
Bradshaw AAF	Land Surface	All Variables	1/2/73 to Present†
Hakalau	RAWS	All Variables	4/11/02 to Present
Halepohaku	Land Surface Coop	Precipitation	10/1/49 to Present
Keanakolu	Land Surface Coop	Precipitation	2/1/65 to Present
Pohakuloa	Land Surface Coop	Precipitation	10/1/49 to Present
Pohakuloa West	RAWS	All Variables	8/5/99 to Present
Puu Kihe	Land Surface Coop	Precipitation	10/1/49 to 12/31/76
Puu Laau	Land Surface Coop	Precipitation	10/1/49 to 12/31/76
Puu Oo	Land Surface Coop	Precipitation	1/1/19 to 10/1/75
Puu Mali	RAWS	All Variables	12/7/06 to Present

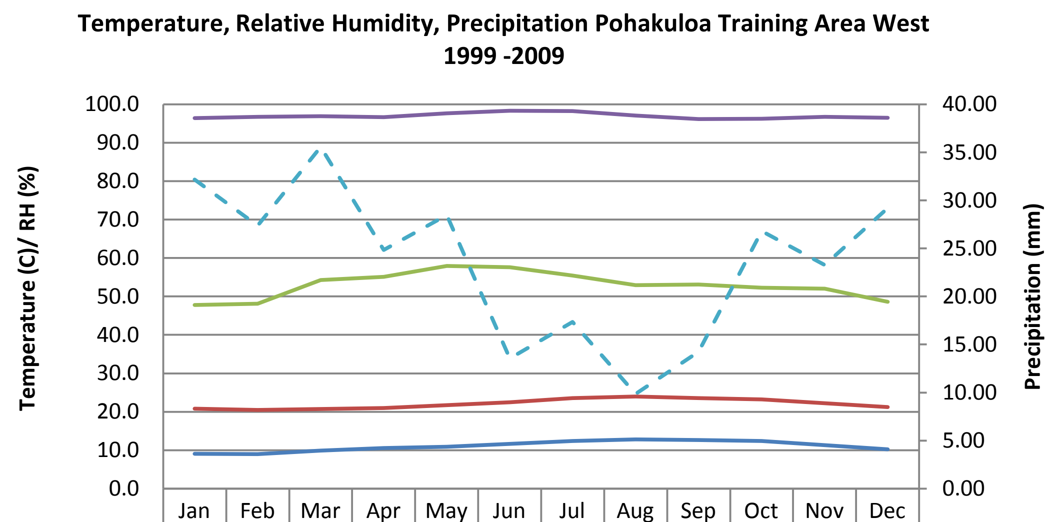
*'All Variables' = Hourly measurements for temperature, relative humidity, precipitation amount and duration, wind speed and direction, solar radiation.
†BAAF only collects data when it is necessary for military training.

1.3.2 Average Weather

At the PTA West RAWS, weather is dry and windy throughout much of the year and average annual precipitation is only 10.97 inches. Monthly average temperatures are relatively steady and never drop below freezing. Daily average relative humidity hovers around the low 70's throughout much of the year. Minimum relative humidity is low for Hawaii, frequently flirting with 50% and dropping below 20% with some regularity. Humidity recovery at night is good, often reaching 100% and reaching into the high 90's on most nights. The annual curve for RH shows relatively higher values during the summer months and lower values in the winter. The difference is small, but notable since it is contrary to what would be expected.

Winds were assessed using data from Bradshaw Army Airfield, which is closer to the southern aspects of Mauna Kea. The station does not record a full set of variables. Winds are strongly diurnal with easterly winds predominant during the day (0800 to 1900) and westerly winds predominant during the night time hours (1900 to 0800). There is very little seasonality in wind speed or direction. During the prime of the burning period (1200 to 1500), winds greater than 13 mph occur almost 25% of the time and winds greater than 8 mph occur 86% of the time. See Appendix 1 for detailed monthly wind data.

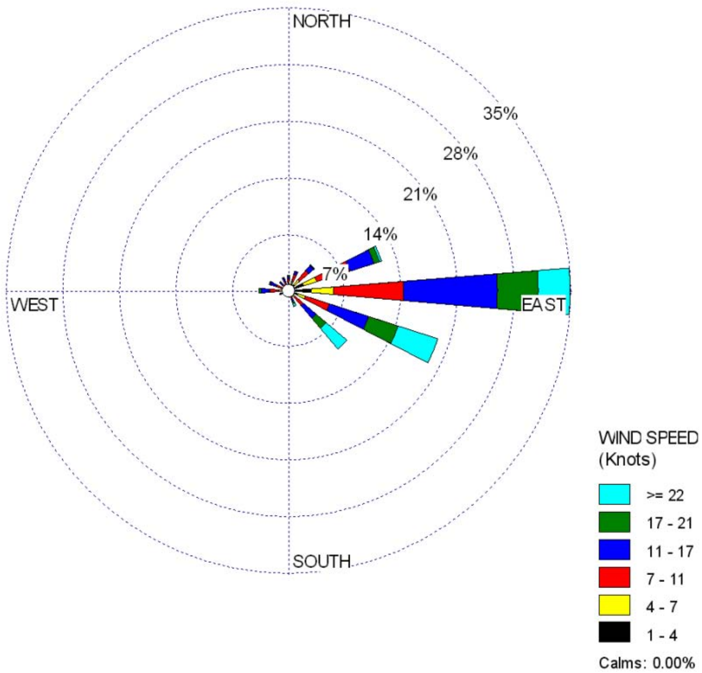
Figure 3. Monthly average maximum and minimum temperature and relative humidity, and monthly average precipitation at the PTA West RAWS 1999 through 2009.



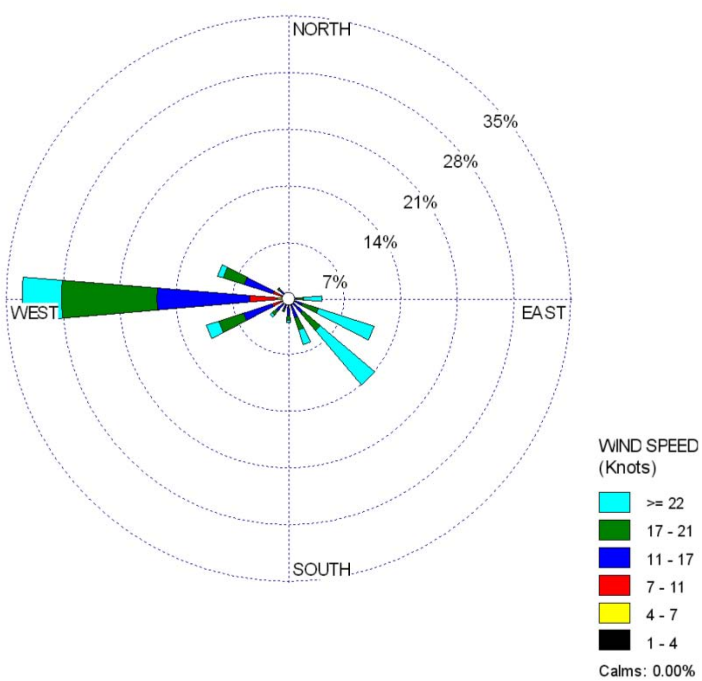
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MinTemp	9.0	8.9	9.9	10.5	10.9	11.6	12.4	12.8	12.6	12.4	11.3	10.2
MaxTemp	20.8	20.5	20.7	21.0	21.7	22.4	23.6	24.0	23.6	23.2	22.2	21.2
MinRH	47.7	48.1	54.3	55.1	57.9	57.6	55.5	53.0	53.1	52.3	52.0	48.7
MaxRH	96.4	96.8	97.0	96.7	97.7	98.4	98.3	97.1	96.2	96.3	96.7	96.5
Precip	32.18	27.38	35.56	24.84	28.48	13.55	17.36	9.86	14.25	26.80	23.27	29.21

Figure 4. Annual daytime (0800-1900) and nighttime (2000-0700) wind roses for Bradshaw Army Airfield. Concentric circles indicate the percentage of the time wind blows from each direction. Colored bars indicate the frequency of windspeed from each direction.

Daytime



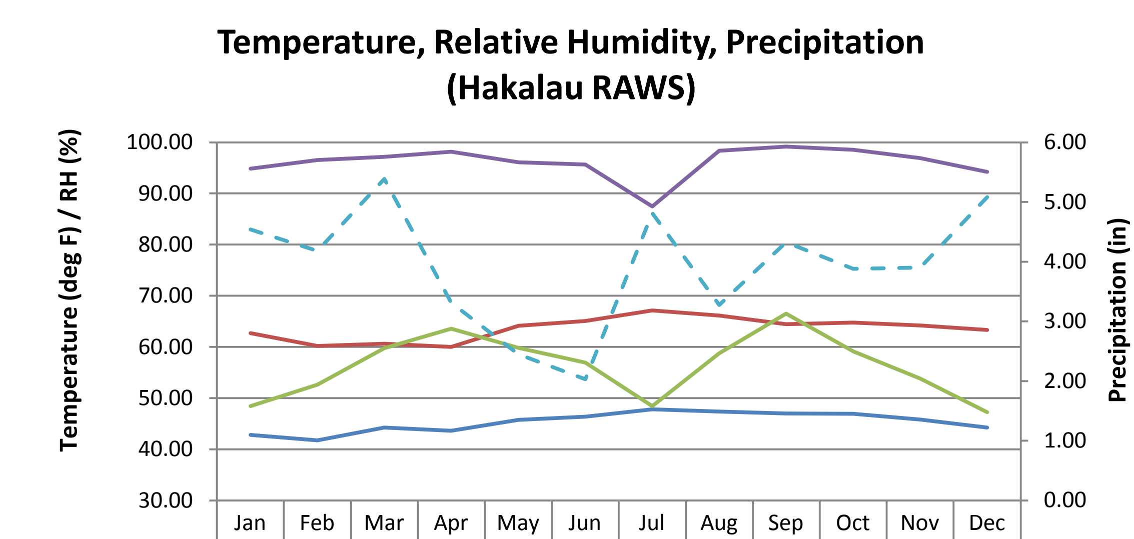
Nighttime



The weather experienced at the Hakalau RAWS, which sits on the southeast flank of Mauna Kea, is markedly different from that at the PTA West RAWS and BAAF. Temperatures are lower by 10 degrees F or more and minimum relative humidity is higher.

Winds are more variable than at BAAF, but are also strongly diurnal (Figure 6). Winds at night are consistently dominated by the west/southwest through south/southwest. Winds during the day are more variable but are largely weighted towards the south through northeast. Wind speeds are much lower than at BAAF, reaching more than 13 mph less than 1% of the time (See Appendix 1).

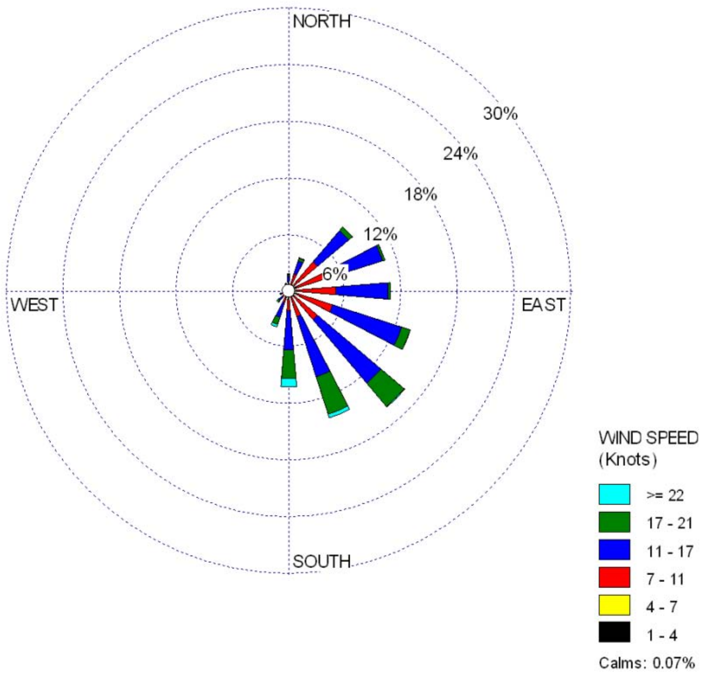
Figure 5. Monthly average maximum and minimum temperature and relative humidity, and monthly average precipitation at the Hakalau RAWS.



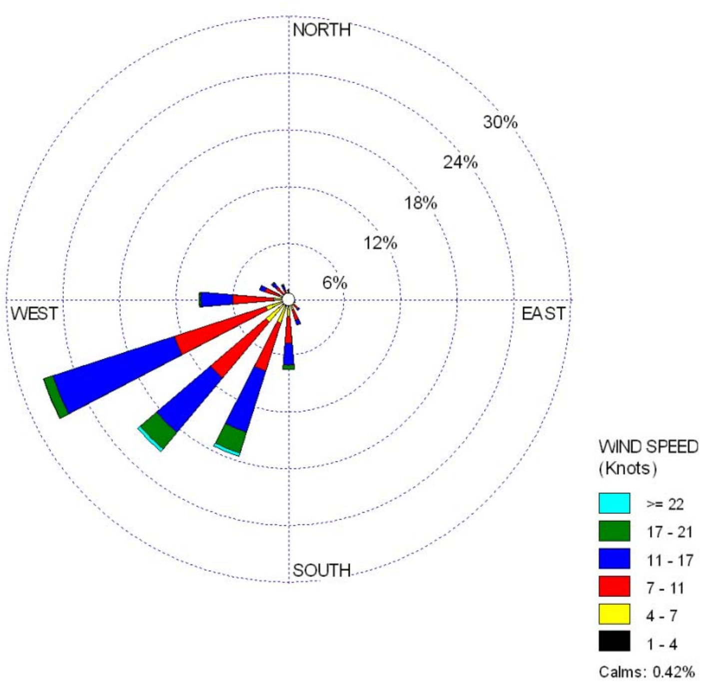
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MinTemp	42.84	41.72	44.24	43.61	45.75	46.36	47.78	47.36	46.97	46.95	45.78	44.22
MaxTemp	62.70	60.22	60.60	60.01	64.12	65.05	67.10	66.15	64.47	64.76	64.22	63.30
MinRH	48.46	52.63	59.75	63.57	59.82	56.95	48.41	58.77	66.48	59.14	53.84	47.22
MaxRH	94.86	96.51	97.17	98.15	96.10	95.64	87.45	98.37	99.14	98.53	96.92	94.24
Precip	4.54	4.18	5.39	3.31	2.45	2.03	4.81	3.28	4.32	3.88	3.90	5.08

Figure 6. Annual daytime (0800-1900) and nighttime (2000-0700) wind roses for the Hakalau RAWS. Concentric circles indicate the percentage of the time wind blows from each direction. Colored bars indicate the frequency of windspeed from each direction.

Daytime



Nighttime



1.3.3 Percentile Weather

Weather and fuel conditions that strongly influence fire behavior are summarized in the tables below by percentile. Notable highlights at PTA West are the extremely low relative humidity readings at the 90th and 97th percentile as well as the consistently low fine fuel moisture. The Hakalau location tends to be wetter overall, but during the dry periods, represented by the 97th percentile, fuel moistures are similar to those found at PTA West. Wind speeds, however, are considerably lower at Hakalau.

Table 2. Percentile weather data from the PTA West RAWS. Settings affecting the calculation of fuel moistures are listed in Appendix 1. The period of analysis is the entire year.

Percentile	Temperature	Relative Humidity	20-foot Wind Speed	One Hour Fuel Moisture	10 Hour Fuel Moisture	100 Hour Fuel Moisture	Live Herbaceous Fuel Moisture	Live Woody Fuel Moisture
50	71	54	11	9	11	18	135	153
80	74	43	13	8	10	16	113	141
90	76	35	14	7	9	15	107	130
97	77	23	17	6	8	14	93	120

Table 3. Percentile weather data from the Hakalau RAWS. Settings affecting the calculation of fuel moistures are listed in Appendix 1. The period of analysis is the entire year.

Percentile	Temperature	Relative Humidity	20-foot Wind Speed	One Hour Fuel Moisture	10 Hour Fuel Moisture	100 Hour Fuel Moisture	Live Herbaceous Fuel Moisture	Live Woody Fuel Moisture
50	61	78	7	10	13	22	249	200
80	65	61	9	8	10	17	170	199
90	67	49	10	7	9	15	149	183
97	70	26	11	4	6	12	94	134

Table 4. Percentile weather data from the Bradshaw Army Airfield weather station. The Bradshaw Army Airfield weather station does not collect all of the variables collected by the PTA West and Hakalau RAWS.

Percentile	Temperature	Relative Humidity	15-foot Wind Speed	One Hour Fuel Moisture	10 Hour Fuel Moisture	100 Hour Fuel Moisture	Live Herbaceous Fuel Moisture	Live Woody Fuel Moisture
50	64	58	8	NA	NA	NA	NA	NA
80	70	43	12	NA	NA	NA	NA	NA
90	72	34	15	NA	NA	NA	NA	NA
97	75	21	20	NA	NA	NA	NA	NA

1.4 Fuels

The fuels situation on Mauna Kea is extremely challenging, particularly when considering that the worst fuels are co-located with the worst fire weather and the most important habitat for the palila. The light and flashy grasses that are common on the south and western flanks of Mauna Kea provide for rapid fire movement and are highly receptive to ignition sources and firebrands from wildfires. The significant shrub component adds intensity to the fires, making containment difficult, as well as a source for spot fires. This is a difficult combination to manage and under severe conditions, many fires will be unstoppable regardless of the management or fire fighting techniques utilized. Therefore, fire prevention is elevated to the utmost importance. Fuels in the area of Mauna Kea have been mapped in Figure 7. Thaxton and Jacobi's more accurate data is represented within the Palila Critical Habitat and LANDFIRE data is utilized for the remainder of the Island.

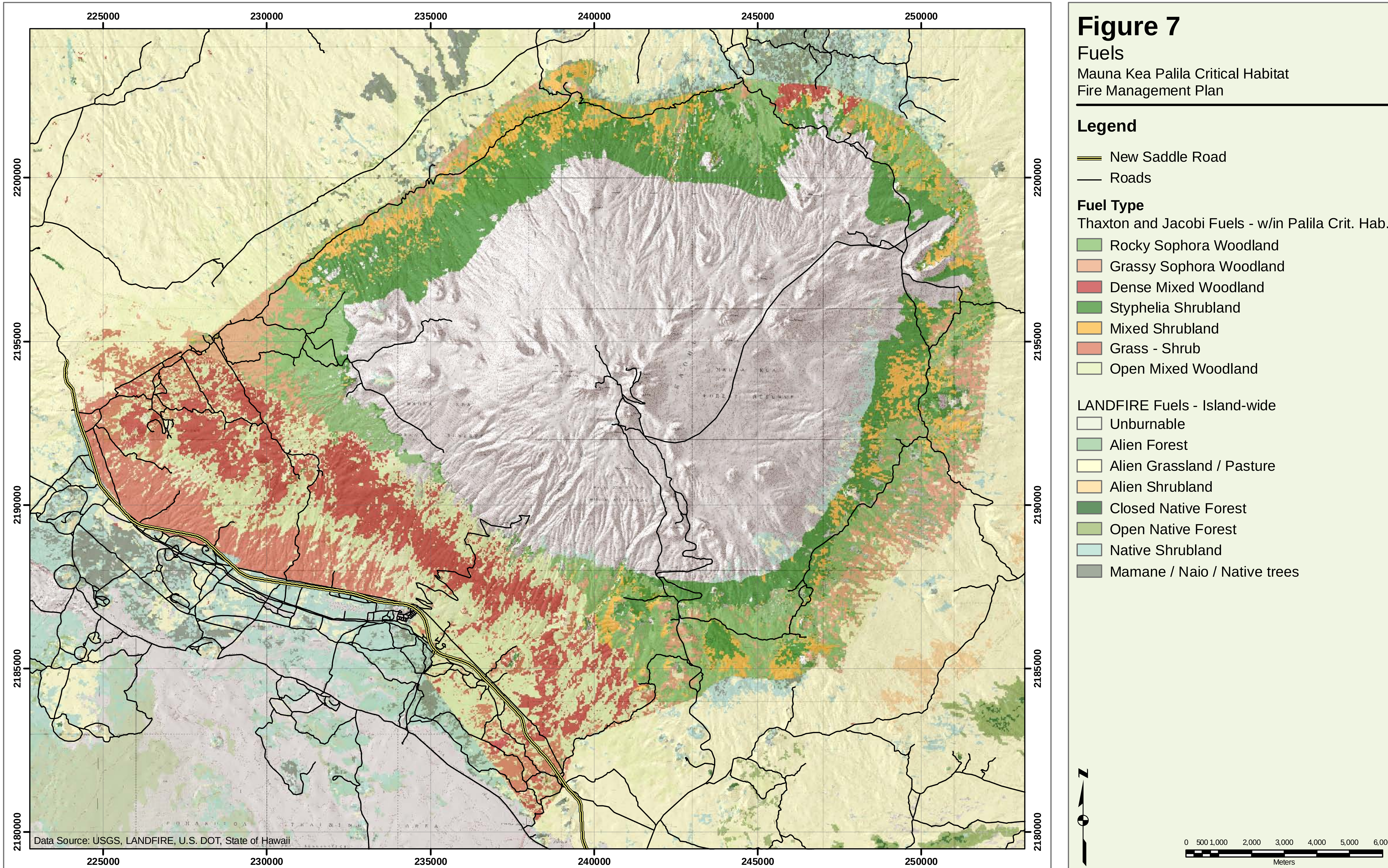


Figure 7
Fuels
Mauna Kea Palila Critical Habitat
Fire Management Plan

Much of the vegetation of the Island of Hawaii was mapped by the National Ecology Research Center of the USFWS in 1989. The data produced is ecologically oriented, though there is some information that is specifically useful for fire management purposes, including categories of canopy height. Vegetation on Mauna Kea has subsequently been mapped by Thaxton and Jacobi (2009). This effort was aimed at filling in information required to assess fire management opportunities and included intensive fuel load and fuel moisture mapping and analysis. The reader is referred to Jacobi and Thaxton's 2009 report for detailed information. This document and the associated data was the primary source for vegetation and fuels information for the analyses in this FMP. Fuels for the State of Hawaii were mapped as part of a national fire fuels mapping effort known as LANDFIRE. Though useful for filling in gaps where other data is absent, the current LANDFIRE data is generally less accurate than site specific fuels maps.

1.5 Fire History

The available fire history on Mauna Kea is very limited, though it is common in Hawaii for wildland fires to be poorly documented. Wakida's 1997 Mauna Kea Fire Management Plan contains a history of 21 fires. Since that time, only 11 additional fires were documented as part of the research effort for this FMP. There is a large gap from 1995 to 2006 during which it is almost certain that additional fires occurred. Other fires are probably missing, particularly small ones.

The primary causes of fires in the past have been military activity at PTA (31%) and traffic on Saddle Road (22%). The military has taken a number of steps to successfully minimize problematic fires including the implementation of a fire danger rating system that restricts training under dry and windy conditions. Partly as a result of these efforts, no military ignited fires have burned onto Mauna Kea in the past 15 years. For most of the vehicle ignited fires, it is not clear whether the ignition source was the vehicle traffic (e.g. catalytic converters) or human activity (e.g. cigarettes thrown out the window). The design of the new Saddle Road should mitigate ignitions from this source to a large degree. Also of note is that two of the last three fires were due to arson. It is worth noting that, according to Wakida (1997), at least one fire was started by lightning, since this ignition source is completely unpredictable. Several firefighters have noted that lightning ignitions appear to have increased in frequency over the years (pers. comm. Steve Bergfeld, Miles Nakahara), and fires have been started by lightning elsewhere on Hawaii. However, on Mauna Kea, only one fire in 40 years has been documented as igniting due to lightning activity. Lightning activity in Hawaii is low relative to the mainland, with thunderstorms occurring somewhere in the State 20 to 30 days per year (WRCC), so the threat of lighting ignition, while present, remains relatively small when compared to human ignitions.

There is a clearly defined 'high risk' area near the Kilohana check-in station on western Mauna Kea. Thirteen of the 32 documented fires started in this area which accounts for only a small portion of the total acreage of the mountain. Seven of these were of military origin and, as stated previously, there has been a great deal of improvement in reducing the military fire threat. Even excluding fires of military origin, this location has the highest density of fire starts on the mountain and deserves special attention.

Table 5. All known recorded fires in the vicinity of Mauna Kea.

Location or Name	Date Fire Started	Final Size	Probable Cause	Comments
PTA-Pu'u Keekee (0.75 mi. S. of KGMA)	October 1971	3.00	Military Activity	
Ranchland (2.5 mi. N. of Pu'u Mali (MKFR))	December 1971	7.00	lightning	
PTA-Pu'u Keekee (1.5 mi. S. of KGMA)	February 1972	30.00	Military Activity	
Kaohe GMA	June 1972	0.25	Abandoned Campfire	Unauthorized Camper
Ranchland (0.5 mi. N. of Kemole (MKFR))	July 1972	7.00	Smoker	fence crew
Ranchland (4.5 mi. NW of Kemole (MKFR))	March 1973	200.00	lightning	
PTA - Pu'u Keekee abutting KGMA	August 1975	170.00	Military Activity	
PTA - Pu'u Keekee (0.5 mi. S. of KGMA)	November 1975	56.00	Military Activity	
PTA - Pu'u Koohi (0.25 mi. S. of MKFR)	July 1976	1.00	Military Activity	
Mauna Kea FR	November 1976	5.00	Search and Rescue Crew	
PTA - Pu'u Keekee (0.25 mi. S. of KGMA)	February 1977	0.25	Military Activity	
Kaohe GMA	July 1977	120.00	Traffic	Saddle Road - confined to the south of Saddle Road
Maune Kea FR	October 1977	1000.00	military personnel	Hiking within PTA
Kaohe GMA	February 1978	3039.00	Traffic	Saddle Road
Maune Kea FR	July 1981	2.00	Undetermined	Unauthorized trespassers seen in area
Maune Kea FR	July 1987	600.00	Military Training	Incediary dev. - started within PTA
Ranchland (2 mi. SE of Kahinahina (MKFR))	May 1988	5.00	Gorse burning	Unattended
Kaohe GMA	August 1990	1160.00	Traffic	saddle road - vehicle fire
Puu Kole/R3	1990's	Unknown	Lightning	At the end of R-3 near Puu Kole. Month and exact year unkown.
Puu Kole/93	1990's	Unknown	Lightning	Also at the end of R-3 near Puu Kole.
PTA - Pu'u Keekee (0.25 mi. S. of KGMA)	July 1991	50.00	Military Activity	
Kaohe GMA	May 1995	48.00	Traffic	Saddle Road
PTA - Pu'u Keekee abutting KGMA	October 1995	190.00	Military Activity	
Aahuwela	February 2000	1300.00	Undetermined	9 miles in Mana Rd and about 1 mile above it (above Hakalau)
Kaaliali	July 2001	0.25	Campfire	Near junction of R1 & R8 in Mauna Kea FR
Humuula	November 2006	739.00	Campfire	
Kaohe GMA	January 2007	65.00	Traffic	
Waikaloa	February 2007	2629.00	Undetermined	
Piha	March 2008	2771.00	Traffic	
Mana Road	November 2008	123.00	Traffic	
Kaohe GMA Arson	Unknown 2009	1.50	Arson	Two arson fires set at the same time. One off the lower fire break and the other at the base of Ahumoa, right off the road.
PTA - Impact Area	April 2010	1000.00	Military Activity	Burned to MPRC road and stopped. Did not affect Mauna Kea.
Mauna Kea 33	August 2010	1378	Arson	Multiple fire starts just off of Saddle Road at the 33 mile marker. Burned north of Saddle Rd.

All entries prior to 2007 are from Wakida 1997.

1.6 Values at Risk


Figure 8. Palila.

The primary purpose of this plan is to aid in protection of the palila (Figure 7). The palila is listed as Endangered under the U.S. Endangered Species Act of 1973. The bird's historical habitat on the Big Island includes much of Mauna Kea and reaches across the saddle region and onto Hualalai, but is now greatly diminished. The birds are currently highly concentrated on the southwest flanks of Mauna Kea with 96% of the known population occurring in a 11.5 square mile area (pers. com. Dr. David Leonard). Their population has declined by 59% in the past 5 years and is currently estimated at fewer than 1,200 individuals (pers. com. Dr. David Leonard). Their primary food source is green mamane seeds (Banko et al. 2002). The palila critical habitat, which by law must also be protected, occurs in a ring around the mountain as shown in Figure 1 and 8.

Rare plant species exist at a number of locations on Mauna Kea, but formal documentation of locations is only available for Mauna Kea Silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*) (pers. com. Dawn Greenlee, Nick Agorastos). There are two documented populations which are identified in Figure 8.

Native ecosystems are present throughout the area considered in this FMP. Many of these have been disturbed, but certainly not to the extent of low elevation ecosystems where replacement by non-native species is often nearly complete. The high elevation ecosystems represent some of the best opportunities for native species and native ecosystem conservation in Hawaii.

Erosion is a significant post-fire risk on Mauna Kea where many soils are poorly developed and highly erodible. When juxtaposed on the steep slopes of Mauna Kea, erosion is a significant concern. Examples of erosion from old road scars and other sources are evident in many locales. Once the organic layer is removed and the underlying soils are exposed, erosion is often severe. Hot fires can easily remove most or all of the organic matter in isolated areas and produce erosion problems that are difficult to overcome.

1.7 Risk Analysis

A risk analysis is a useful tool to visualize potential fire behavior and identify threat areas and probable fire pathways. It is not a decision-maker, but does provide information that can help in the decision making process. Though all of the vegetated portions of Mauna Kea are at some risk of fire, for this analysis, the focus is on the core palila habitat areas on the southern and western sides of the mountain.

A risk analysis using Flammap 3.0 was run for the southwestern portion of Mauna Kea utilizing 97th percentile weather data from the PTA West RAWS, 10,000 ignition points, and fuels data from Thaxton and Jacobi (2009) and LANDFIRE. More detail about inputs and processes is included in Appendix 2. The analysis results are displayed in Figure 9 which represents the minimum time it would take for a fire from any one of the 10,000 ignition points to burn each location on the landscape. These results need to be regarded with a degree of uncertainty due to the fact that none of the fuel models have been validated and the weather data applied, from the PTA West RAWS, though the best available, is not necessarily applicable to the entire area of interest. It can be assumed that the farther one moves from the PTA West RAWS the less accurate the results. Nonetheless, this is a useful exercise and the results can help to inform decision making.

The analysis does not indicate any distinct fire paths (not shown). This is largely due to the relatively homogenous topography which does not create defined chimneys or ridgelines which would influence fire progress.

Perhaps the most notable result of the simulation is that the highest elevation portion of the high density palila nesting area did not burn at all due to a lack of sufficient fuels. Personal observations of the fuels in this locale indicate the simulation is correct. Fires would have a very difficult time burning into the upper reaches of the vegetation anywhere in the Mauna Kea Forest Reserve. Future invasive species colonization may negate this small advantage however.

Under the conditions of the simulations, FlamMap suggests that there is no portion of Kaohe GMA that could not be burned within a couple of hours of a fire ignition. The southern flanks of Mauna Kea fare little better, with a maximum arrival time of roughly two to three hours.

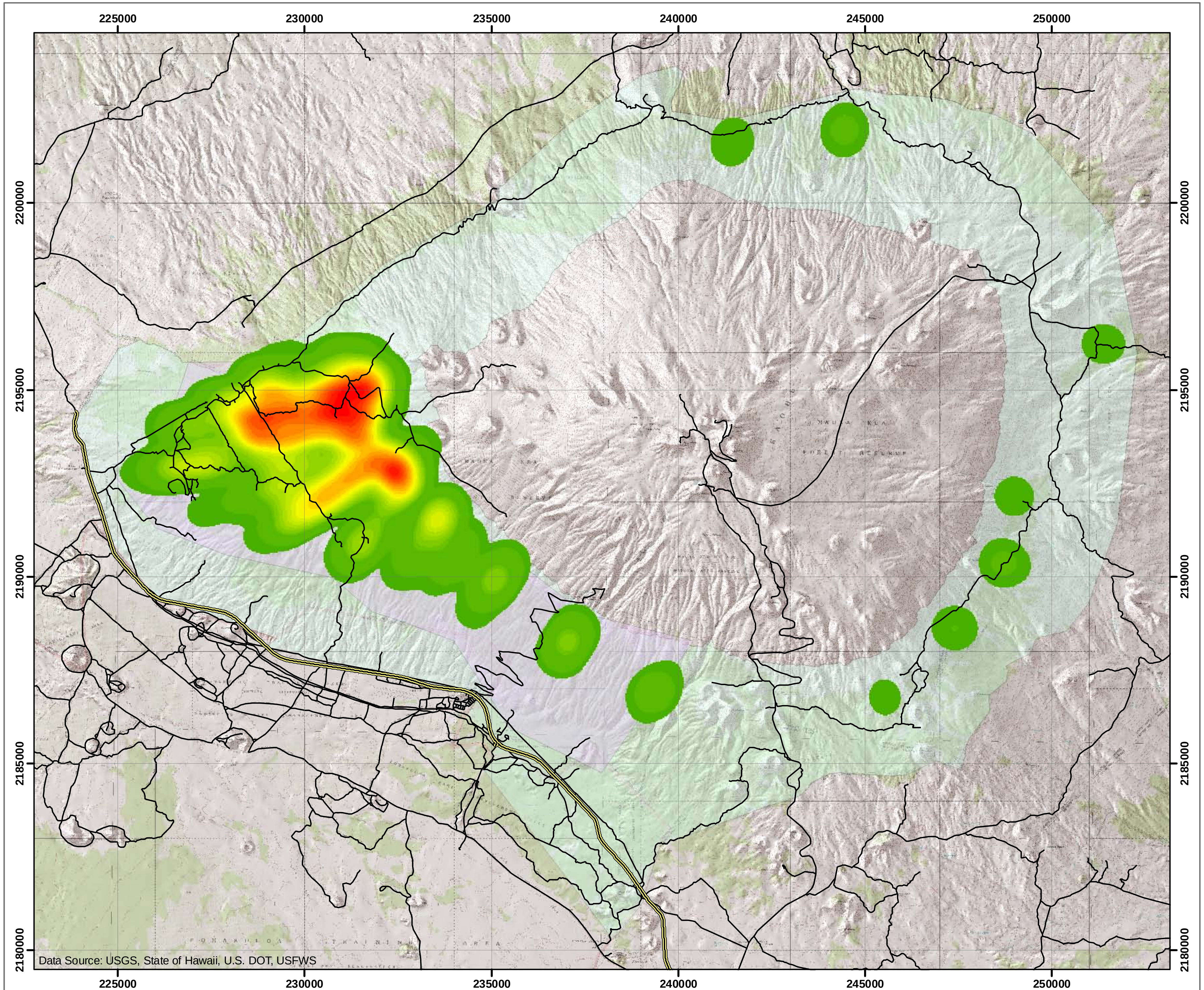


Figure 9

Protected Resources

Mauna Kea Palila Critical Habitat
Fire Management Plan

Legend

Palila Sighting Frequency

- None
- Very Low
- Low
- Moderate
- High
- Very High
- Palila Core Habitat
- Palila Critical Habitat
- New Saddle Road
- Roads

0 500 1,000 2,000 3,000 4,000 5,000 6,000
Meters

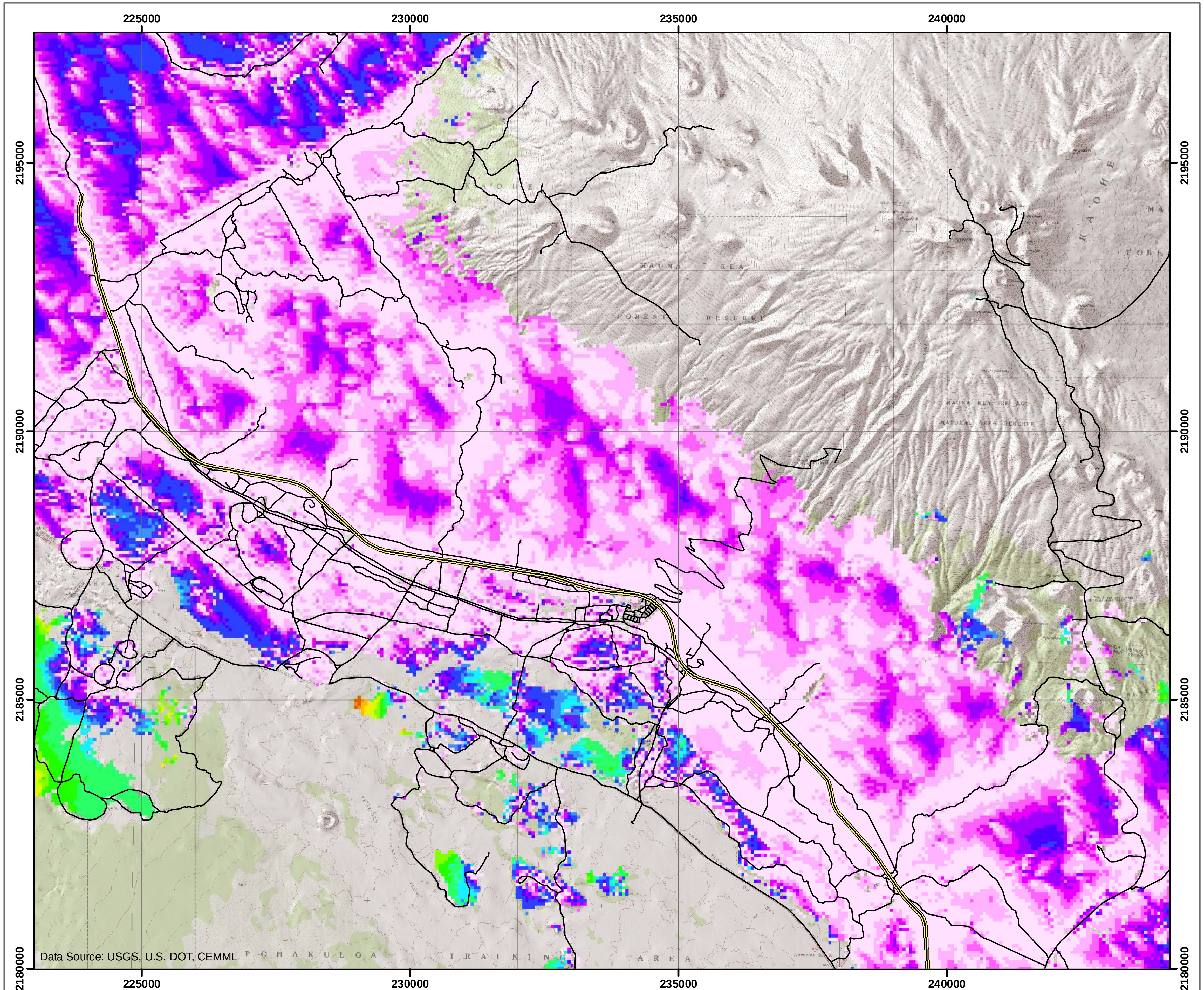


Figure 10

Risk Analysis

Mauna Kea Palila Critical Habitat
Fire Management Plan

Legend

Fire Arrival Time

Minutes

Hours

Days

Roads

New Saddle Road

2 Policy and Organization

2.1 Goals and Objectives

The goal of this FMP is to eliminate large fires within the designated critical habitat of the Palila, while maintaining access for land uses consistent with the objectives of the Department of Land and Natural Resources. Objectives are tailored to regions of the mountain defined as fire management units (FMUs) as defined in Section 2.5 and illustrated in Figure 10. Roads and firebreaks can be referenced in Figures 10 and 11.

2.1.1 Objectives in the Kilohana Fire Management Unit

1) Limit fires above the new Saddle Road to less than 1000 acres.
2) Limit fires above firebreaks R-15 and 8A and south of R-1 to less than 500 acres.
3) Limit fires inside of firebreaks R-1, R-10, FB-6, and R-13 to less than 50 acres.
4) Along Saddle Road, between Kilohana Check in Station and the intersection of Saddle Road with FB-2, maintain at least two firebreaks or fuelbreaks between Saddle Road and the high density palila population that meet standards defined in this FMP.
5) Exterminate all fountaingrass populations.

2.1.2 Objectives in the Southern Fire Management Unit

1) Limit fires above 6600 feet elevation to less than 500 acres.
2) Limit fires below 6600 feet elevation to less than 1500 acres.
3) Exterminate fountaingrass populations.
4) Maintain at least one firebreak or fuelbreak north of Saddle Road on all lands administered by the State of Hawaii DLNR.

2.1.3 Objectives in the Northern Fire Management Unit

1) Limit fires in the Puu Mali Mitigation Area on northern Mauna Kea to less than 50 acres.
2) Limit fires above R-1 to less than 1500 acres.

2.1.4 General Objectives

1) Zero fire fighting fatalities or serious injuries.
2) Increase initial attack success by 20% in the next 10 years.

2.2 Compliance with Law and Policy

This plan is written to comply with existing federal, state, and local laws and regulations pertaining to wildland or prescribed fire as well as the policies of the State of Hawaii DLNR. Pertinent laws include but are not limited to:

- Endangered Species Act
- National Historic Preservation Act
- Clean Air Act
- Clean Water Act
- National Environmental Policy Act
- Invasive Species Executive Order

A programmatic Environmental Assessment will be completed prior to implementation of this FMP for those components requiring National Environmental Policy Act documentation.

2.3 Integration with Existing Plans and Requirements

This plan is informed by other existing plans and documents. These include:

- Saddle Road Biological Opinion (USFWS 1998)
- Saddle Road Record of Decision (USFHA 1999a)
- Palila Mitigation Memorandum of Understanding (USFHA 1999b)
- Natural Resources Management Plan for the U.H. Management Areas on Mauna Kea (SRGII 2009)
- Draft Mauna Kea Watershed Management Plan (Stewart 2010)
- Assessment of Fuels, Potential Fire Behavior, and Management Options in Subalpine Vegetation on Mauna Kea Volcano Hawaii (Thaxton and Jacobi 2009)
- Mauna Kea Ecosystem Wildland Fire Management Plan (Wakida 1999)
- Draft U.S. Army Garrison Hawaii and U.S. Army Hawaii 25th Infantry Division Wildland Fire Management Plan (USAGHI 20011, in prep.)

2.4 Wildland Fire Management Organization

DOFAW is responsible for all fire management activities on their lands. Historically, DOFAW has worked closely with other agencies and private landowners to increase fire management effectiveness. Many of these relationships are not formal, but DOFAW does maintain formal mutual aid agreements with several government agencies (see section 3.1).

2.5 Fire Management Units

Three fire management units (FMU's) have been defined to ease discussion of fire management actions (Figure 10). The smallest, but most important, is the Kilohana FMU on the southwestern flanks of the mountain. This area encompasses the greatest concentration of Palila as well as the most historic fire ignitions and the worst fire weather. The Southern FMU is comprised of the rest of the southern and much of the eastern flank of Mauna Kea. It also contains a small populations of Palila and fire prone vegetation and weather. The northern FMU is made up of the remainder of the mountain and is of lower fire mitigation priority than the other two.

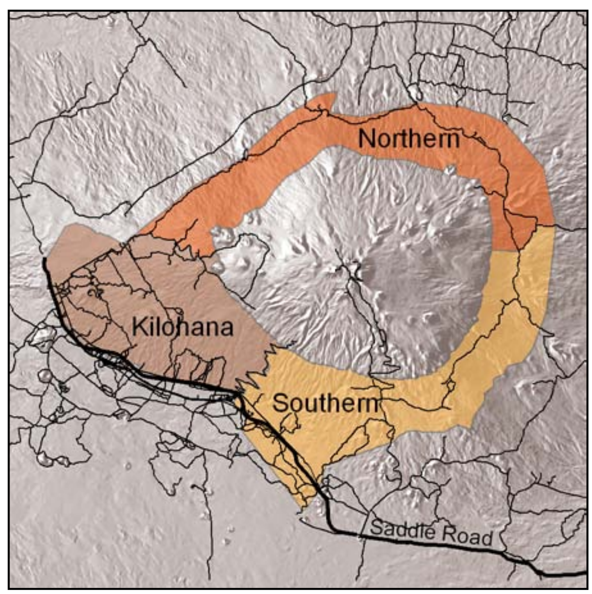


Figure 11. Mauna Kea FMP fire management units.

2.6 Fire Management Plan Updates

The DOFAW State Protection Forester is responsible for updating the Mauna Kea FMP. The plan shall be reviewed once every five years and updated once every 10 years at a minimum. Reviews and updates may occur more frequently at the discretion of the DOFAW Branch Manager.

Reviews shall ensure that fire fighting resources, mutual aid agreements, ignition prevention strategies, and land management practices are still sufficient to meet the FMP's goals and objectives. The DOFAW

Branch Protection Forester shall convene a meeting of major partners, both internal and external to DOFAW, and discuss the effectiveness of the current plan as it has been executed. If necessary improvements are required or objectives are not being met, the FMP shall be updated.

3 Pre-Suppression Actions

3.1 Mutual Aid Agreements

The DLNR maintains wildland fire fighting mutual aid agreements (MAA) with the Hawaii County Fire Department, Hawaii Volcanoes National Park, Pohakuloa Training Area, Hakalau Forest National Wildlife Refuge, and the National Guard. MAAs will be updated per DOFAW policy.

3.2 Training

DOFAW has established training requirements in the DOFAW Operational Policy Handbook for Wildfire Control.

3.3 Ignition Prevention

Ignition prevention needs to play a major part in fire management in the Kilohana FMU, particularly at low elevations. Fires here are more likely to be fast spreading and severe than in other FMUs. The network of firebreaks and roads, while highly effective in mitigating fire spread during low and moderate intensity fires, stand little chance of stopping the rare, but destructive, high intensity events.

During Very High or Extreme fire danger (Table 6), as assessed by the Branch Protection Forester, access to Kaohe GMA and Mauna Kea Forest Reserve may be restricted at the discretion of the DOFAW Branch Manager with input from the Branch Protection Forester. Should a closure be implemented, gates at the Kilohana hunter check-in station and on R-1, north of R-10 will restrict access to the Kaohe GMA. These gates will be located to best prevent vehicles from accessing the area. It is expected that some individuals will circumvent the gates. The DOFAW Branch Manager shall communicate closures to the DLNR Division of Conservation and Resources Enforcement (DOCARE). Pending availability of officers, DOCARE will patrol for violators during closures as time and resources permit, remove offending individuals, and assess fines per standard DLNR regulations.

The Branch Protection Forester will coordinate with the PTA Fire Department to pursue development of a set of signage along major roadways providing access to Kaohe GMA. The signs will indicate the most recently assessed fire danger. It is important that the FDRS be applied consistently and that fire danger signs are updated frequently. Fire danger ratings that do not match field conditions and inaccurate signs will damage the credibility of the fire prevention program and may lead the public to disregard warnings of high fire danger.

A formal FDRS is not yet feasible as the conditions at the PTA RAWS are considerably different from those in the Kilohana FMU, and the Ahumoa RAWS has not been in place long enough to be used in a formal fire danger rating system. Once it has collected five or more years of data, in 2014, a formal fire danger rating system could be created.

All vehicles, including ATV's and other off-road vehicles, are required to park in pullouts or on bare soil to prevent vehicle related fire ignitions.

Table 6. Fire danger categories.

Fire Danger Adjective Rating	Typical Fuel Conditions	Typical Fire Behavior	Restrictions
Low	Vegetation is moist to the touch. Live herbaceous fuel moisture is > 150%.	Ignitions very unlikely. Fires will not spread.	None
Moderate	Dead vegetation is dry, but live vegetation is green and has a moisture content >100%.	Ignitions are possible. Fires will spread with minimal severity.	None
High	Dead vegetation is dry, roughly half of the herbaceous vegetation is cured.	Ignitions are probable. Fires will spread with some intensity and will pose difficulties to containment crews in some situations.	None
Very High	Dead vegetation is dry and brittle. Dead twigs snap easily. Herbaceous vegetation is nearly completely cured.	Ignitions are a near certainty. Fires will spread with high intensity and will be difficult to control. Large fires are probable.	Closures may be instituted at the discretion of the DOFAW State Protection Forester.
Extreme	Severe, extreme, or exceptional drought conditions exist. Herbaceous vegetation is completely cured. Leaves on shrubs may wilt during mid-day or fall off altogether.	Ignitions are a near certainty. Fires will spread with very high intensity and cannot be controlled.	Kaohe GMA closed. Additional closures may be instituted at the discretion of the DOFAW State Protection Forester.

An interpretive sign detailing information about fire and its impacts to resources shall be installed at the Kilohana check in station where visitors and hunters are likely to see it. The sign shall include text and graphic illustrations depicting resources at risk, the consequences of fires, and measures visitors can take to reduce the probability that they will start a fire. Fire prevention pamphlets will be included as part of the information provided to hunters and other users of Mauna Kea Forest Reserve. This literature will include information about proper parking of vehicles, avoiding driving through grassy areas, proper disposal of cigarette butts, and other ignition prevention information. It will also encourage users to report any smoke or fires through the most expeditious means possible.

3.4 Firebreaks, Fuelbreaks, and Fuels Management

3.4.1 Standards

Firebreaks, fire access roads, and fuelbreaks will meet minimum standards, as defined in Table 6, by 2020, provided sufficient funding can be provided by the USFWS. Water bars and other erosion prevention structures/devices will be engineered per existing DLNR standards as defined in the DLNR document *Best Management Practices for Maintaining Water Quality in Hawaii* (1996). Invasive species introductions should be minimized by thoroughly washing machinery before bringing it to Mauna Kea for work. Emergency responses are exempted from both requirements. Firebreaks should be widened every 1/4 mile to provide enough space for parking. Firebreaks, fire access roads, and fuelbreaks have been assigned priority levels to help in budgetary decision making (Figure 11). Priority levels are subjective, but are generally defined by the following guidelines:

- Priority 1 - Critical to protection priorities.
- Priority 2 - Critical to protection priorities, but is a backup to a priority 1 structure in the vicinity or in an area of moderate risk.
- Priority 3 - Highly beneficial to protection priorities but other priority 1 or 2 structures provide protection or alignment or location is not ideal.

- Priority 4 - Beneficial to protection priorities.
- Priority 5 - Beneficial to protection priorities, but in an area of low or moderate risk.
- Priority 0 - Of little consequence to fire suppression success.

Table 7. Firebreak and fuelbreak minimum standards.

	Kilohana FMU	Southern FMU	Northern FMU
Firebreak	15 feet of bare mineral soil or gravel, 20 ft. gap in overhanging branches, cut or dozed brush removed from site or moved at least 100 feet from firebreak. Navigable by Type V brush engine.	12 feet of bare mineral soil or gravel, 15 ft. gap in overhanging branches, cut or dozed brush removed from site or moved at least 100 feet from firebreak. Navigable by Type V brush engine.	10 feet of bare mineral soil or gravel. 15 foot gap in overhanging branches OR shrubs within 20 feet of firebreak limbed to 6 feet. Cut or dozed brush removed from site or moved at least 100 feet from firebreak. Navigable by type VI brush engine or 4x4.
Fire Access Road	10 feet wide, navigable by Type VI engine. Does not have to be bare mineral soil or gravel.	10 feet wide, navigable by Type VI engine. Does not have to be bare mineral soil or gravel.	8 feet wide, navigable by Type VI engine. Does not have to be bare mineral soil or gravel.
Fuelbreak	100 feet wide. Less than 20% crown cover OR less than 1 foot high fuels. Shrubs taller than 12 feet within 50 feet of firebreak limbed to 6 feet.	100 feet wide. Less than 20% crown cover OR less than 1 foot high fuels.	No standard.

3.4.2 Firebreak Maintenance Standards

Where necessary and possible, firebreaks will be hardened using gravel or other materials to develop a hard road bed. Vegetation may be controlled by herbiciding the firebreaks or other means. Vegetation along the sides of the firebreaks will be herbicided at the discretion of the Branch Protection Forester. Some firebreaks may need maintenance more often than others due to topography, washouts, heavy use, or other reasons. Maintenance needs and scheduling will be determined at the discretion of the Branch Protection Forester.

3.4.3 Fuelbreak Maintenance Standards

Fuelbreaks can be maintained in a number of ways including grazing, mowing, and herbicide application. Grazing will be limited to fuelbreaks 1, 1A, 1B, 2, 3, and 4 A,B, and C. Grazing animals are expected to consume a variety of plants and will crush some material simply by moving about. Grazing animals must be kept out of the road right of way (pers. com. State of Hawaii Department of Transportation). In the short term, forest restoration within the grazed area will probably not be possible as a result, but the low elevation and proximity to heavy human presence is not conducive to restoration and it is a relatively small acreage. Over the long term, as the forest is restored on Mauna Kea as a whole, alterations in the grazing prescription, or a shift to mowing, can be made to allow forest restoration within these fuelbreaks. Grass fuels should be continuously managed within the fuelbreaks throughout this transition.

Mowing is the preferred alternative for the remaining fuelbreaks. Mowing will mostly be accomplished with weed whackers and will focus on control of grass fuels. In some locations a single treatment with a bulldozer or grader may allow a mower deck to be utilized, but this application is somewhat limited by terrain and substrate composition. Shrubs will be avoided to encourage recruitment of native species. Over time, this will begin to reduce the effectiveness of the fuelbreaks during fires, particularly while the trees grow through the shrub phase and into full grown trees. Shrubs in the fuelbreak and within 50 feet of a firebreak will be limbed to six feet if they are over 12 feet in height. All vegetation will be cut within 10 feet of the firebreak.

Grass specific herbicides may also be useful, provided they are effective on the grasses present. Herbicide may be a viable alternative in some locations where large acreages can be treated quickly with vehicle mounted herbicide equipment or aerial broadcast spraying. Consideration will be given to pre-emergent herbicides on a case by case basis. No grass specific pre-emergent herbicides are available at this time, and use of a pre-emergent will also kill desirable shrub and tree species. Vegetation growth is dependent on precipitation and varies from year to year. Herbicide application frequency will be determined at the discretion of the Branch Protection Forester.

3.4.4 Kilohana FMU Firebreaks

These are the most important firebreaks on Mauna Kea. They lie in the most fire prone vegetation on the mountain and they protect the highest density palila population (Figure 12).

Many of the improvements listed below have previously been suggested by Wakida (1997) and Thaxton and Jacobi (2009). Both works were repeatedly mentioned during conversations with local fire managers indicating the high degree of agreement among fire managers that some of the improvements included in these previous works are necessary. Most improvements require bringing an existing road up to firebreak standards, though a few are designated as fire access roads and, as such, required to meet a lower standard. All of the firebreaks in this plan are improvements upon existing roads or follow existing disturbance lines left from bulldozer or construction activity due in large part to the sensitivity of the ecosystem. However, some firebreaks will need to be realigned to mitigate erosion issues and to improve navigability.

Some of these firebreaks are sited on property under the jurisdiction of the U.S. Army Garrison Hawaii. DOFAW will work to obtain an agreement with USAGHI to allow DOFAW to construct and maintain these breaks. USAGHI bears no responsibility for financing, constructing, or maintaining any firebreak or fuelbreak in this plan.

R-1

Road R-1 circumnavigates most of Mauna Kea, but in the Kilohana FMU, this road provides critical access as well as protection from fires starting to the north. The road is currently in good condition and meets standards for the most part. It is broken into two different priority levels (Figure 11).

The bottom (western) section of the road is Priority 1 firebreak due to the fact that it provides primary access to the entire Kilohana area and provides protection from fires starting on Saddle Road or Parker Ranch. It provides access to FB-1, FB-3, R-15, FB-5 and R-13 all of which are important in stopping fires originating in the high risk area along Saddle Road near the Kilohana check-in station.

The section between R-13 and R-10 is designated a Priority 3 firebreak. Fires from Parker Ranch are very unlikely due to the low fuel load a minimal human activity, so there is little need to spend finite resources improving this road to firebreak standards. This section of R-1 is important because it provides access to R-10 and to the remainder of R-1.

FB-1
When combined with FB-1A and Fuelbreaks 1, 1A, 1B, and 2 (see section 3.3.3), this is perhaps the most important firebreak on Mauna Kea. It parallels Saddle Road through the area of highest historic ignition density and is far enough upslope to allow fire suppression crews to establish suppression positions prior to most fires reaching the firebreak. Combined with sufficient fuels reduction in Fuelbreaks 1, 1A, and 1B, the fire risk from Saddle Road could be virtually eliminated in this area. This is a Priority 1 firebreak, and should be the top priority for construction and maintenance.

FB-1A
This firebreak would re-establish an existing road and improve it to firebreak standards. It improves the effectiveness of FB-1 by extending its length and increasing standoff distance from the most likely ignition source, Saddle Road.

FB-1B
This is a priority one firebreak that parallels saddle road and provides protection against fires from Saddle Road. Though ignitions have historically been rare in this area, this firebreak is critical since there is no other break in the fuels until fires reach R-13 where it turns west, well over a mile upslope.

R-15
Much of R-15 already meets firebreak standards, however the road degrades into a barely passable track south of Puu Ahumoa. R-15 will be improved to firebreak standards and tie into FB-3. R-15 is designated a Priority 1 firebreak because of its location allowing a second chance to contain fires that escape containment below FB-1 and FB-1A.

FB-8A
This existing road (or possibly a previous dozer line) runs from Puu Ahumoa several miles southeast and connects with FB-2 which ties in to Saddle Road. This section was designated FB-8A by Wakida and he suggested a firebreak be established here, but the road has never been improved. It is designated a Priority 1 firebreak because it is the only impediment to fires starting on Saddle Road.

FB-3
This existing road is split into two functions and priority levels. The firebreak portion runs several miles east from R-1 until it meets FB-8A. Where it meets R-1, it has been realigned from Wakida's suggestion to improve placement relative to the terrain. The segment that runs from R-1 to FB-8A is designated a Priority 2 firebreak.

From FB-8A to Saddle Road, FB-3 will be improved to meet fire access road standards. Parts of it will have to be realigned to mitigate erosion issues. It will improve access to FB-1A, and provide more rapid access to important sections of R-15 and FB-8. It will also provide a containment line for the flanks of fires starting on Saddle Road. It is designated a Priority 4 fire access road.

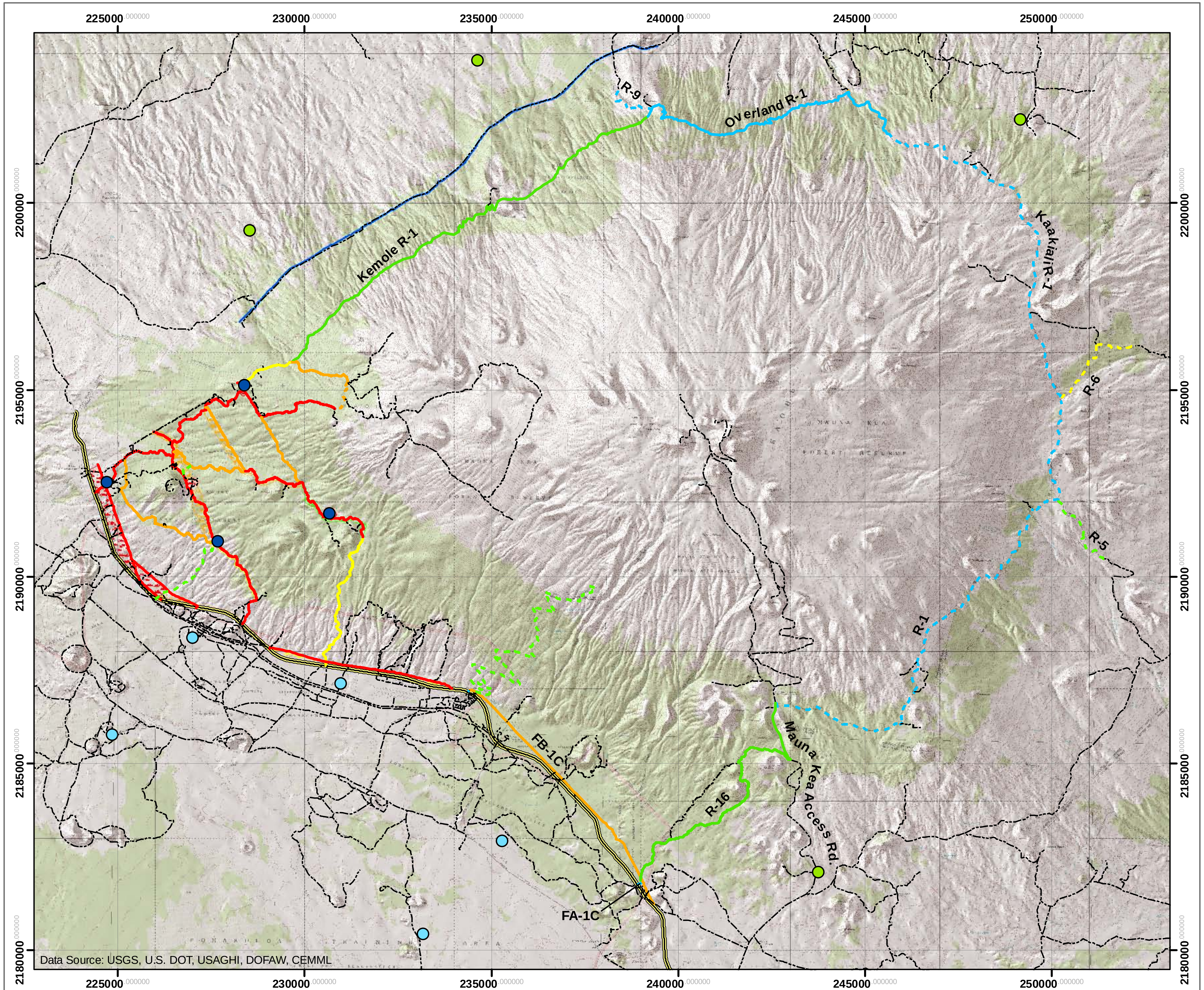


Figure 12

Fire Suppression Resource Locations

Mauna Kea Palila Critical Habitat
Fire Management Plan

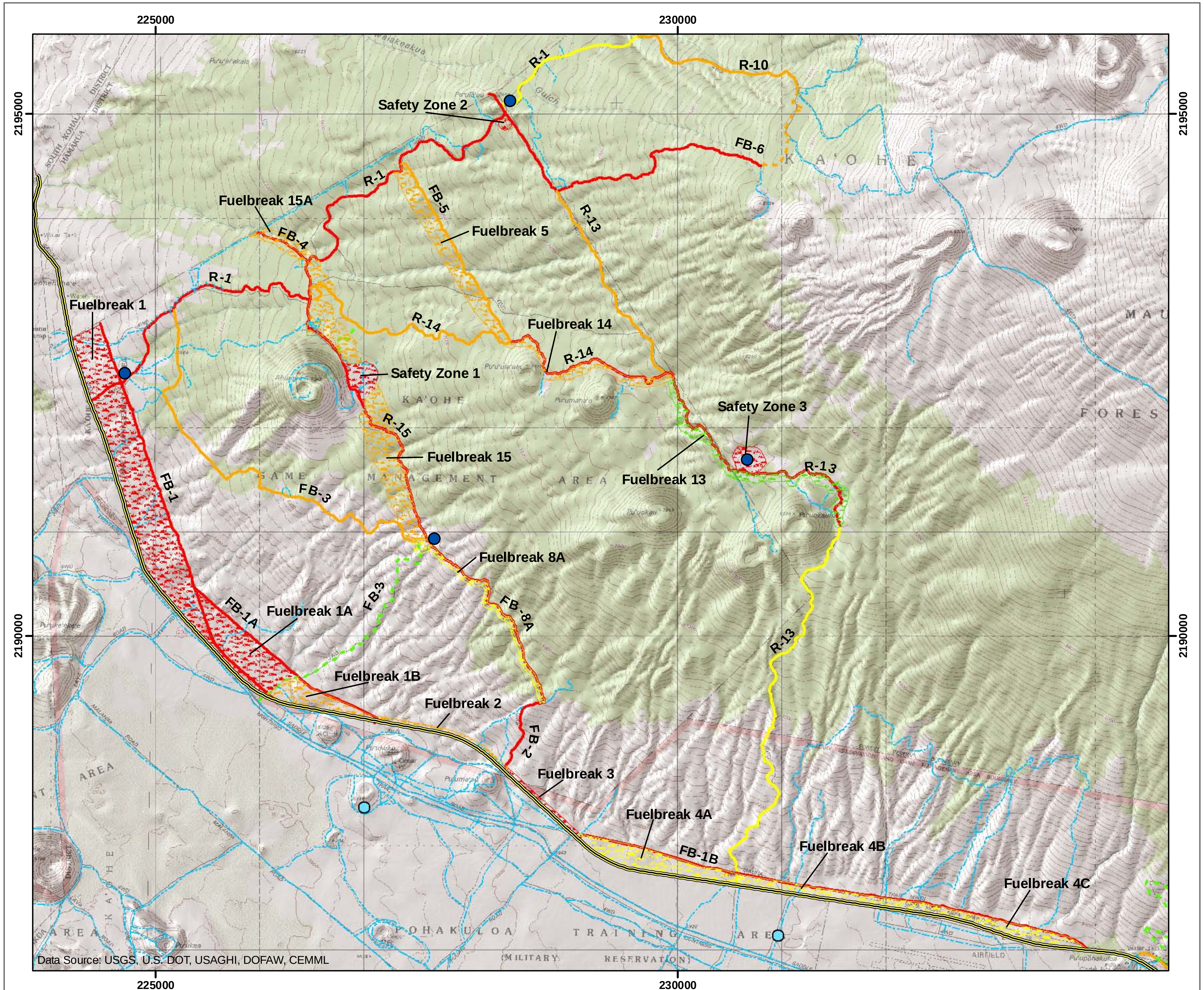


Figure 13

Fire Suppression Resource Locations Kilohana FMU

Mauna Kea Palila Critical Habitat
Fire Management Plan

Legend

Firebreaks

Priority, Designation

- 0, Existing - no designation
- 1, Firebreak
- 2, Firebreak
- 2, Fire Access Road
- 3, Firebreak
- 3, Fire Access Road
- 4, Firebreak
- 4, Fire Access Road
- 5, Firebreak
- 5, Fire Access Road

Fuelbreaks

Priority

- 1
- 2
- 3
- 4

Water Resources

- Reservoir
- Proposed Dip Tank
- Existing Dip Tank
- New Saddle Road

N

0 500 1,000 2,000
Meters

FB-4
This is a short piece of existing road extending northwest from the junction of R-1 and R-15. It is designated a Priority 1 firebreak and will be improved to meet firebreak standards.

R-14
This is an existing road that needs to be widened to meet firebreak standards. This is a Priority 2 firebreak below FB-5 and Priority 1 firebreak from FB-5 to the intersection with R-13. The Priority 2 section forms a secondary line of defense against fires originating downslope and a primary defense against fires starting within the Kaohe GMA. The Priority 1 portion of this firebreak forms the first line of defense against fires starting along Saddle Road between FB-2 and R-13. It is well situated on the topography, often crossing nearly flat ground, which improves its effectiveness as a firebreak.

FB-5
This is an existing road in good condition that needs to be widened to meet firebreak standards. It helps to compartmentalize the area between R-1, R-14, and R-13 and runs directly across one of the primary fire paths in the area. It is designated a Priority 2 firebreak.

R-13
R-13 is broken into three priority sections. The northern Priority 1 firebreak section runs from north of R-1 to the intersection with FB-6. Together with FB-6 (see below), it forms one side of a critical last line of defense against fires burning into the core palila nesting area. The Priority 2 section of this firebreak runs from FB-6 southeast to R-14. From R-14 for roughly 2 miles east to Puu Kauha, R-13 is the only firebreak between saddle road and the high density palila population. This segment is a Priority 1 firebreak. From Puu Kauha to Saddle Road, substantial improvements are needed in road alignment. This section will help to contain fires flanking across the slope and to contain the flanks of fires moving upslope. This is a Priority 3 firebreak.

FB-6
This road is the last line of defense against fires burning into the highest density of palila nests. The portion of this firebreak running east/west is designated a Priority 1 firebreak. The section running north/south lies in sparse fuels and is designated a Priority 2 fire access road.

R-10
This existing road is in reasonable shape but needs to be widened to firebreak standards throughout its length. Though the highest threat of fire comes from the west, this firebreak protects the high density palila nesting area from the rare fires that may approach from the north. It is designated a Priority 2 firebreak.

3.4.5 Kilohana FMU Fuelbreaks

Fuelbreaks along Saddle Road (Fuelbreaks 1 through 4C) are a critical component of this fire management plan, but none currently exist (Figures 11 and 12). Properly executed, they will help to contain fires originating from Saddle Road, the ignition source of greatest concern to local land managers and the USFWS. The fuelbreaks will reduce fire spread rates and intensity. With sufficient fuels removal, spread rates can be lowered to such an extent that first responders can establish defensive positions, and in many cases utilize direct attack, to contain fires west and south of FB-1 and 1A under most circumstances. The key is that fuels must be reduced substantially. As is the case for the firebreaks, some of these fuelbreaks occur on PTA and DOFAW will need to work with USAGHI to obtain an agreement allowing DOFAW access to establish and maintain them.

If desired, fuels could be reduced to the point where ignition is unlikely and fire spread is impossible. From a fire management perspective, this would be the ideal, and in some of the fuel types in the vicinity, this is the current state. Drawbacks to this strategy are wind and water erosion, aesthetic impairment, and visibility issues on Saddle Road due to blowing dust.

There are a number of legal and public relations concerns that must be addressed in order to establish fuels reduction in this area. Due to the irreplaceable nature of the resources at risk, and to the fact that these fuelbreaks can greatly reduce the risk, every option, including upsetting some constituencies, will explored in order to implement these fuelbreaks.

Fuelbreaks 8A, 13, 14, 15, and 15A have been designed to take advantage of low shrub density to the degree possible. These breaks may be established at a fraction of the size suggested in this plan, but should be no less than 150 feet in width from the road centerline. Additional width may be necessary where there is a heavy shrub component within the fuelbreak. As more shrubs are recruited due to the reduction in ungulate grazing pressure, shrub density is expected to rise. Fuelbreaks will need to be expanded as this occurs. The size of the fuelbreaks shall be determined by the Branch Protection Forester as well as during the Environmental Assessment process.

Approximately 15 acres of grassland around and near the Kilohana check-in station are currently mowed to promote habitat for wildlife. The Branch Protection Forester will work with DOFAW Wildlife Biologists to orient the mowed areas to provide the best possible fire mitigation while still serving their intended purpose of wildlife habitat improvement.

Fuelbreak-1

This area runs between FB-1 and Saddle road from Kilohana check in station south for approximately 2.5 miles and is the most important fuelbreak on Mauna Kea. It is roughly 1100 feet wide, though it narrows to well under 200 feet for the southernmost half mile. It is designated a Priority 1 fuelbreak.

This fuelbreak is already fenced, with the new Saddle Road fence on the west and the Mauna Kea ungulate fence on the east. Cattle could easily be brought in from Parker Ranch, provided an agreement with the ranch owners can be reached, but other ranching operations may also be interested in grazing here (Pers. com. Brandi Beaudet). Free grazing rights or, if necessary, payment, will be offered to ranchers for the use their cattle. A number of minor improvements are likely needed to the fences and roads, including adding one or more additional strands of wire to the existing fence to prevent damage from cattle. Additional cross-wise fencing to create paddocks will be necessary to ensure fuels are sufficiently grazed throughout the fuelbreak (Pers. com. Brandi Beaudet). Water, salt licks, and nutritional supplements to account for the low quality forage would also be required to encourage cattle movement throughout the area (Pers. com. Brandi Beaudet). Access to manage cattle and construct and maintain all of these improvements is available via FB-1.

If it is not possible to obtain cattle for grazing, this fuelbreak, as well as fuelbreaks 1A, 1B, 2, and 3 will be weed whacked or mowed.

Fuelbreak-1A

This is a continuation of fuelbreak-1 using FB-1A as the uphill limit. It runs to the intersection with FB-3 and would reinforce the narrow section of fuelbreak-1. This fuelbreak would be implemented in the same way as fuelbreak-1 and is designated a Priority 1 fuelbreak.

Fuelbreak-1B

This is a continuation of fuelbreak-1A. It's position south and east of FB-3 mean that it is of lower importance and it is designated as a Priority 2 fuelbreak. It runs east to the intersection of FB-1A with Saddle Road.

Fuelbreak-2

This is a continuation of fuelbreak-1B, however there is no existing road uphill of Saddle Road. This fuelbreak should be no less than 164 feet (50 m) wide, but would be most effective if it were considerably wider. Though grazing is the preferred management method, a grass specific herbicide may be sufficient to reduce fuel continuity and minimize fire spread, assuming the grasses respond. Dust mitigation will likely be required if herbicide is used as the primary fuels control. This fuelbreak is designated Priority 2 and can be maintained with cattle, mowing, or herbicide. If cattle are used for fuelbreaks 1, 1A, and 1B, it would be logical to use them for fuelbreak 2 as well.

Fuelbreak-3

This is an important area to provide some fire mitigation along Saddle Road. Aside from hastily putting in a dozer line during a fire and aerial bucket operations, there is no impediment to a fire until it reaches R-13 and R-14. Pre-planned breaks would be much more effective. A fuelbreak in this locale would at least give first responders a chance to contain the fire before it grows beyond initial attack capabilities. This fuelbreak is designated a Priority 1 fuelbreak and can be maintained in the same way as Fuelbreak 2.

Fuelbreak-4

Fuelbreak 4 is broken into 3 sections, A, B, and C, where existing roads cross the fuelbreak. This fuelbreak would be 300 to 400 feet wide in most areas with FB-1B acting as the uphill limit. It is far enough east that ignitions from the new Saddle Road here pose a lower threat to the high density palila population. It is designated a Priority 3 fuelbreak and can be maintained in the same way as Fuelbreak 2.

Fuelbreak-5

This fuelbreak takes advantage of existing breaks in the shrub fuels that have been previously constructed on the downhill side of FB-5. These breaks have, in effect, created wind rows. This fuelbreak will be implemented to reduce the grass between FB-5 and the first wind row, despite the fact that this is less than 150 feet in some locations. If funds allow, additional rows will be added to the fuelbreak at the discretion of the Branch Protection Forester.

Fuelbreak-8A

This fuelbreak is 150 feet wide and runs the length of FB-8A on the downhill side of the firebreak. It reinforces firebreak and is designated a Priority 3 fuelbreak.

Fuelbreak-13

This fuelbreak runs along the southern Priority 1 section of R-13 on the downhill side of the firebreak. It will help to reinforce the firebreak and provide some standoff distance for firefighters should burnouts be necessary. There are few natural breaks in the shrub layer here, so a standard distance of 250 feet has been used. This is a Priority 4 fuelbreak.

Fuelbreak-14

Fuelbreak 14 reinforces the Priority 1 segment of R-14 and is placed on the downhill side of the firebreak. It varies in width, following variations in shrub density and taking advantage of open areas where possible. At its widest point it is roughly 380 feet wide. In a few locations, topography constrains the width to less than 150 feet. This is a Priority 2 fuelbreak.

Fuelbreak-15

This fuelbreak takes advantage of relatively low shrub densities and fairly level terrain to provide substantial additional stopping power to R-15. The fuelbreak will be constructed on both sides of R-15 as depicted in Figure 12. This is one of the best locations on Mauna Kea to stop a fire that has escaped initial attack at FB-1. It is quite wide, up to 1000 feet in some locales, to increase its effectiveness. This fuelbreak will be implemented at no less than 200 feet wide and is designated a Priority 2 fuelbreak.

Fuelbreak-15A

This is an extension of fuelbreak 15 and reinforces FB-4. It will be implemented on both sides of FB-4 due to poor terrain location. The downhill side of FB-4 will be implemented first as it is favored by topography. The uphill portion may be difficult to implement because of a gulch just north of FB-4. This is designated a Priority 2 fuelbreak.

Safety Zone 1

This safety zone is integrated into fuelbreak 15 and is located along a primary road (R-15)and next to Puu Ahumoa which is frequently used as a lookout location. This safety zone utilizes an open, flat, grassy area that could also be used as a staging area and/or incident command post. This safety zone will be maintained twice a year in as close to a fuel free state as is possible without inducing substantial erosion. A grass specific herbicide may be appropriate, but it is flat enough that, with some improvements, a tractor mounted mower deck may prove feasible. The area inside the existing roads is sufficiently large for a safety zone, but it would not cost much more to mow the entire open area.

Safety Zone 2

This is located on the southern corner of the intersection of R-13 and R-1, but could be relocated to a number of locations in the immediate vicinity. It should be co-located with the proposed Puu Laau Dip Tank, with the dip tank in the center of the safety zone to provide some additional protection from radiant heat during a burnover. This area will be mowed to stubble height twice a year with additional maintenance occurring at the discretion of the Branch Protection Forester. This safety zone will be no less than 400 feet in diameter.

Safety Zone 3

Located along R-13, this is an important area in which to maintain a safety zone due to its remote location with limited escape routes. It utilizes a relatively open area just uphill of R-13. This area will be cleared of vegetation to the extent practicable to a diameter of no less than 400 feet. Shrubs inside the safety zone will be removed.

3.4.6 Southern FMU Firebreaks

FB-1C
This is an extension of firebreak 1, 1A, and 1B from the Kilohana FMU. It is an existing firebreak that follows the powerline road (also known as Infantry Road) southeast until it ties in with R-16. It helps to protect the eastern end of the core palila habitat and is designated a Priority 2 firebreak.

FA-1C
This is a short (<1/4 mile) connector that provides access from the new Saddle Road to FB-1C. It is designated a Priority 5 fire access road.

R-16
This firebreak runs just outside of the Department of Hawaiian Homelands boundary and ties together FB-1C and the Mauna Kea Access Road. It is of low importance, but serves to ensure there is some form of break in the fuels around the entirety of Mauna Kea. It is designated priority 4.

Mauna Kea Access Road
This road is not under DOFAW jurisdiction. It does not require any improvements or maintenance. It is designated a Priority 4 firebreak for the sake of consistency within the FMP.

R-1
This existing road is generally in reasonable condition and extends to R-6. It is not positioned to provide any protection from fire as it lies uphill of most of the fire prone vegetation. It only provides access during a fire. Maintenance costs will not be funded by the Mauna Kea FMP. It is designated a Priority 5 fire access road.

R-5
This existing road is poorly positioned to stop fires, but it is an important access point to R-1. It is designated a Priority 4 fire access road and maintenance will not be funded by the Mauna Kea FMP.

R-6
This road provides another access point to R-1. It also defines the boundary between the Southern and Northern FMUs. It is designated a Priority 3 fire access road and maintenance will not be funded by the Mauna Kea FMP.

3.4.7 Northern FMU Firebreaks

R-1
From R-6 to Puu Kea, R-1 (Kaaliali) continues to run through lightly vegetated terrain, thus only making it useful as a fire access road. This stretch is designated a Priority 5 fire access road. From Puu Kea to R-9 (Overland), the road passes through a number of vegetated areas where a firebreak may occasionally be useful. This segment is designated a Priority 5 firebreak.

From R-9 to R-10 (Kemole), R-1 is the only firebreak providing protection to the upper slopes of the mountain. Though the likelihood of ignition is relatively low and vegetation that is thick enough to carry fire is patchy, a firebreak in this locale will likely be of use at some point in the future. This segment is designated a Priority 4 firebreak. None of maintenance of R-1 in the Northern FMU will be funded by the Mauna Kea FMP.

R-9
This road provides important access to R-1. It is designated a Priority 4 fire access road and maintenance will not be funded by the Mauna Kea FMP.

3.4.8 Fuels Management

Aerially Spray Fountaingrass
Aside from reducing fuels within the fuelbreaks, fountaingrass should be removed wherever feasible. This is a major fire promoting grass that will increase the fire fighting burden if it becomes entrenched over large areas. It currently has colonized portions of the southern aspects of Mauna Kea. These populations will be aerially sprayed with roundup or another herbicide proven to be effective at killing fountaingrass. Efforts will be concentrated in the core palila habitat and move eastward towards Mauna Kea State Park as funds allow.

Restore the Mamane/Naio Shrublands
Forest restoration will occur as a result of this plan, but active restoration (planting) will not be implemented by the fire management program. Planting may be implemented by other programs. There is some disagreement about whether the reduction in ungulate populations on Mauna Kea has released mamane seedlings from the suppressive effects of browsing. It is evident that recruitment from seed is occurring, at least in isolated locations, within Kilohana FMU (pers. obs. and pers. com. with Miles Nakahara). This is expected to continue in the future, producing greater canopy cover and associated alterations in the fuel bed, as described in Thaxton and Jacobi (2009).

Active restoration will not be undertaken as a part of this FMP. While it holds some promise, particularly on the northern and eastern aspects of the mountain where the moisture regime is wetter, it is unproven as a fire risk mitigation measure. Though there may be some fire mitigation benefits from forest restoration, these benefits have not been quantified in terms of their impact on fire behavior. The mamane/naio fuel complex is itself quite flammable under dry conditions. Active restoration is also expensive, requiring the hiring of a crew of 2 to 10 people for at least several years to plant enough trees to create enough restored acreage to have an impact on large scale fire risk. Finally, even presuming a substantial improvement in fire risk from forest restoration, it takes a very long time to establish a mature mamane/naio forest. The length of time is currently unknown, but is certainly on the order of decades, if not a century or more. It is not financially feasible at this time to implement an effective set of firebreaks and fuels management and at the same time carry out restoration on a large scale. Given the choice between time honored fire mitigation measures and an unproven one, the only responsible course of action is to utilize those tools that are known to be effective.

3.5 Water Sources

3.5.1 DOFAW Maintained Water Sources

Dip Tanks
Two dip tanks will be constructed in the Kilohana FMU, one at the Kilohana hunter check-in station and the other at Puu Laau. Each will have an 40,000 gallon capacity and valves to allow engines and pumpers to replenish. Liners will be spray-on "rhino" liners or similar type to prevent damage from rotor wash during aerial bucket operations that affects fabric or sheet plastic liners. Water levels in the dip tanks will be maintained at 75% of capacity or better year-round. The two tanks will be connected by a pipeline allowing water to be exchanged between tanks as needed. A pump will be installed at the Kilohana tank allowing water to be pumped uphill to the Puu Laau tank. Water will

also be able to be drained from the Puu Laau tank to the Kilohana tank via gravity feed. Covers to limit evaporation will be installed at the discretion of the Branch Protection Forester. Each tank will have an associated dipping site comprised of a portable tank of several thousand gallons and a valve allowing water from the dip tank to be used to fill the portable tank.

Two additional dip tanks of as yet undetermined size may be installed in the future at the discretion of the Branch Manager. One would be located in Safety Zone 3 and the other at the intersection of FB-3, R-15, and FB-8A, though exact locations may be altered by the Branch Manager in consultation with the Branch Protection Forester. The intersection tank could be filled by water truck provided R-15 is upgraded sufficiently to allow passage of such large vehicles. It is unlikely that R-13 will ever be upgraded sufficiently to support a large water tanker. Alternatively, these tanks can be connected via pump and pipeline to the Kilohana and/or the Puu Laau tanks.

Water Pipeline

DOFAW will work with Parker Ranch to establish an agreement to use water from existing Parker Ranch water sources to resupply the dip tanks. Once an agreement is reached, DOFAW will build a pipeline to resupply the Puu Laau dip tank. Because the Parker Ranch water infrastructure is of limited capacity in this area, filling the tanks may take days or weeks, so water from this source cannot be relied upon to refill tanks during a fire.

If no agreement can be reached with Parker Ranch, or if it is not cost-effective, water for the dip tanks will be supplied via tanker trucks refilling the Kilohana tank. From there, water will be pumped to the Puu Laau tank.

3.5.2 U.S. Army Maintained Water Sources

Pohakuloa Training Area

There are dip tanks throughout Pohakuloa Training Area that may be used for fire fighting operations. These have an 80,000 gallon capacity and water levels are maintained throughout the year. Six of these are currently operational and are regularly maintained and filled. Two more are proposed.

Keamuku Maneuver Area

Three dip tanks are proposed for the Keamuku Maneuver Area. These will also be 80,000 gallon capacity and will be maintained regularly.

All Army dip tanks are engineered to allow watering of ground resources.

3.5.3 Privately Owned Water Sources

Department of Hawaiian Homelands Reservoir

This is a lined reservoir accessed via the Mauna Kea Access Road. It can be a viable water source for all fire fighting vehicles, including large tankers, and rotary winged aircraft, but it is often nearly empty. No pump is available, but ground resources may be able to draft water from the reservoir depending on how low the water level is and the drafting equipment available (Wakida 1997).

Mauna Kea Ranch Reservoir

This is located next to Puu Kihe on the northeastern side of Mauna Kea. It has a capacity of one million gallons, but almost always is well below capacity. It is very remote and is not useful for ground resources except when a fire occurs in the immediate vicinity. It is a valuable resource for aerial bucket operations, particularly when considering the total lack of other water sources in the area (Wakida 1997).

Parker Ranch Water System

Parker ranch maintains a water line along the northwestern flank of Mauna Kea less than a mile below R-1. There are at least two water storage ponds along the length of this line which are almost always empty. Theoretically, these could be filled during fires, though DOFAW would have to work out an agreement with Parker Ranch to do so and to provide compensation for water used. DOFAW may also want to consider working with Parker Ranch to enlarge and/or deepen one or more of the ponds, particularly at the northern end of the water line where water resources are scarce (Wakida 1997).

4 Suppression Actions

4.1 Fire Response

4.1.1 Fire Detection and Reporting

There is no formal fire detection program on Mauna Kea. Fires are reported by any individual spotting a fire or smoke through 911.

4.1.2 Initial Attack

Initial attack will be carried out by the closest mutual aid agency. It is Hawaii County Fire Department's responsibility to provide initial attack on Mauna Kea, but on the southern flanks, PTA Fire Department typically carries out initial attack due to their proximity.

Fires will be fought using standard wildland fire fighting techniques. All fire fighting activities will fall under the Incident Command System (ICS) with a single Incident Commander. Multi-jurisdictional fires may utilize a unified command. Containment at a minimum size is the goal within the constraints of due concern for firefighter and civilian safety and sensitivity to valuable ecological resources (see section 4.2).

4.1.3 Extended Attack

State of Hawaii DLNR DOFAW personnel will take command of all fires on DOFAW lands and a DOFAW representative will assume command of the incident.

Table 8. Water resource locations in the vicinity of Mauna Kea.

Name of Resource	Resource Type	General Location	Capacity (Gallons)	Latitude	Longitude	Elevation (ft)	Status
Kilohana Dip Tank	Dip Tank	Kilohana GMA	30,000	19°48'29.28	155°37'41.84"	5787	Proposed
Puu Laau Dip Tank	Dip Tank	Kilohana GMA	30,000	19°50'02.18	155°35'39.37"	7438	Proposed
Skeet Range Dip Tank	Dip Tank	Northern Keamuku	80,000	19°54'12.28	155°40'39.22"	3250	Proposed
Steven's Hole Dip Tank	Dip Tank	Western Keamuku	80,000	19°51'51.52	155°43'39.56"	2574	Proposed
Tank Trail Dip Tank	Dip Tank	Central Keamuku	80,000	19°49'22.95	155°40'31.99"	4097	Proposed
West Firebreak Dip Tank	Dip Tank	Western PTA	80,000	19°46'12.53	155°41'55.77"	4210	Regularly Maintained
MPRC Dip Tank	Dip Tank	Western PTA	80,000	19°40'22.18	155°43'30.23"	5129	Regularly Maintained
Old Kona Hwy Dip Tank	Dip Tank	Western PTA	80,000	19°45'20.14	155°40'18.40"	4881	Regularly Maintained
FARP 17 Dip Tank	Dip Tank	Northern PTA	80,000	19°44'54.14	155°37'31.61"	5583	Regularly Maintained
Puu Maile Dip Tank	Dip Tank	Northern PTA	80,000	19°46'19.57	155°36'19.40"	5716	Regularly Maintained
Bradshaw AAF Dip Tank	Dip Tank	Northern PTA	80,000	19°45'41.74	155°34'02.59"	6002	Regularly Maintained
Redleg Trail Dip Tank	Dip Tank	Eastern PTA	80,000	19°42'05.02	155°32'43.16"	6353	Regularly Maintained
LZ Brad Dip Tank	Dip Tank	Northern PTA	80,000	19°43'26.72	155°31'32.13"	6387	Regularly Maintained
DHHL Reservoir	Lined Reservoir	Southern Mauna Kea	1,000,000	19°43'03.75	155°26'40.89"	7166	Often Low
Mauna Kea Ranch Reservoir	Lined Reservoir	Northeastern Mauna Kea	1,000,000	19°54'00.71	155°23'45.16"	7582	Often Low
Parker Ranch Water System	Pond	Western Mauna Kea	Unknown	19°54'45.25	155°32'05.61"	5427	Ponds often empty.
Parker Ranch Water System	Pond	Western Mauna Kea	Unknown	19°52'14.72	155°35'02.19"	6158	Ponds often empty.
Parker Ranch Water System	Pipeline	Western Mauna Kea	N/A	19°55'00.83	155°29'21.36"	6339	No access valves on water line.
Parker Ranch Water System	Pipeline	Western Mauna Kea	N/A	19°50'55.23	155°35'41.46"	6938	No access valves on water line.

4.1.4 Fire Protection Priorities

After providing for firefighter and civilian safety, the primary goal in all fire fighting operations will be to minimize area burned. The IC shall be responsible for setting protection priorities for each fire, however, some values warrant specific mention.

The purpose of this FMP is protection of federally designated palila critical habitat. This requires minimizing damage to mamane and naio shrublands, both from the fire itself and from fire fighting efforts. A Minimum Impact Suppression Tactics Plan will be explored by DOFAW for implementation on Mauna Kea. In the interim, a set of guidelines for bull dozer use in the palila critical habitat is provided here. Further MIST tactics can be found in the NWCG Incident Response Pocket Guide (2010).

- Never jeopardize containment of a fire in order to minimize impacts. Containment is the top priority.
- Whenever possible, utilize existing dozer lines. These are mapped in Figures 10 and 11.
- Avoid destroying mamane and naio trees where possible.
- Where possible, utilize hand crews on lower intensity fires and lower intensity portions of large fires. Reserve dozer lines for areas where hand crews are insufficient to stop the fire or are unavailable.

Federally protected silversword ferns are known to occur in the Southern FMU but are located at elevations where contiguous fuels do not exist and fire is not possible.

4.1.5 Communications

DOFAW will work with other wildland fire fighting agencies to ensure communications within and between agencies are sufficient to allow effective execution of fire fighting tactics under even the most exceptional fire conditions. Every firefighter must have a communication link with the IC, either directly or through the chain of command.

Radio frequencies to be used on each incident will be determined at the time of the incident. DOFAW utilizes their 'Green' or 'tac 3' frequencies for fire fighting operations.

4.1.6 Air Operations

The high elevation of Mauna Kea severely limits the payload capacity of helicopters and there are few water sources available to dip from. Given these constraints, bull dozers are sometimes the best way to control fires. Nonetheless, steep terrain and lack of vehicle access in some locales increase response times and limit the ability of ground forces to effectively fight fires. Helicopters may not be capable of containing a fire on their own, but they help fire fighters on the ground to control portions of the fire front and they can respond to remote areas almost immediately, providing valuable time for ground forces and equipment to arrive on site.

DOFAW will maintain contracts for rotary winged fire bucket support. At least one of these contracts will be for support from an aircraft with an experienced fire fighting pilot as long as an experienced pilot is available on the Island of Hawaii.

4.1.7 Safety

Lookouts, Communications, Escape Routes, and Safety Zones (LCES) are the foundation of every safe firefighting operation. All four of these measures must be in place before firefighters are committed to the fireline. In the Kilohana FMU, three safety zones are proposed, one at the Puu Laau Dip Tank Site, one in the open area just east of Puu Ahumoa, and one in an open area at the east end of R-13 (Figure 12). Above 8500 to 9000 feet elevation, insufficient fuel exists to carry a fire making this a possible safety zone, depending on the location of the fire. At the bottom of Mauna Kea, there are several areas with little or no fuel as well. The distance between safety zones is substantial and in situations where stepping into the black is not an option for escaping the fire, firefighters should be cognizant of how long it may take to reach one of them. Suggested radii for safety zones on Mauna Kea are included in Table 10. The NWCG Incident Response Pocket Guide (NWCG 2010) includes further information for constructing safety zones.

In other FMUs ash and cinder deposits provide areas free of fuel in some locales, but these tend to be at high elevations. Existing safety zones are not present in many areas and the IC will have to make a determination about safety measures to account for this fact. Previously burned areas are one possible solution.

Table 10. Minimum radius of safety zones in each FMU.

FMU	Safety Zone Radius (feet)
Kilohana	250
Southern	250
Northern	200

4.2 Special Considerations for Fire Fighting on Mauna Kea

4.2.1 Sensitive Habitats

Nearly the entire area of interest for this FMP falls within designated Palila Critical Habitat. Virtually all of the vegetation on Mauna Kea is protected under this umbrella and damage to it should be avoided whenever possible. Of particular concern is the Mamane and Naio shrublands which harbor the vast majority of palilas.

Also of concern are the individuals of silversword fern on the eastern slopes. These endangered plants tend to occur in areas of low fuel continuity, so in most cases will not be in danger from a fire. Firefighting operations should include measures to ensure they are not harmed.

4.2.2 Erosion

Hastily dug firelines can become erosion problems over time. Within the constraints of safety and fire suppression priorities, fireline will be oriented to minimize erosion. After fire fighting operations have concluded, and within the constraints of the DOFAW budget, DOFAW will rehabilitate fireline that poses a severe erosion risk by filling in hand and bull dozer firelines with material that was removed during their construction, constructing water bars on slopes, or covering with cut vegetation. Because no funding source for this work currently exists, DOFAW will explore acquiring funding through the USFWS and other agencies as well as the use of volunteers to offset costs.

5 Post-Fire Actions

5.1 Records and Reports

Every fire, regardless of size, location, or responding agency will be recorded in a fire report per Section 5.2.5 of the DOFAW Operational Handbook for Wildfire Control. Additional information that should be recorded if available is listed below. This is optional, but will greatly improve future efforts to assess fire risk factors.

- Fire danger rating at time of ignition if in the Kilohana FMU.
- Weather observations from a fireline weather observer or general weather observations (e.g. windy from the southeast).
- Notes about fire behavior.
- Map of the fire (Use GPS/GIS).
- Remarks about the fire, fire fighting operations, or unusual events.

Many small fires will be extinguished solely by a mutual aid agency without any representative of DOFAW ever arriving on site. All mutual aid agencies shall report any fire that they respond to on DOFAW lands to the Branch Protection Forester to ensure DOFAW is aware of all fires that have occurred on their property.

5.2 Post-Fire Reviews

All responding units to each fire will conduct an informal post-fire review prior to demobilization of the incident management team per Section 5.2.5 of the DOFAW Operational Handbook for Wildfire Control. The review shall allow all involved parties to make suggestions to enhance fire fighting effectiveness and set goals for improvement on future fires. This review shall be documented in a concise report of no more than 1 page.

5.3 Surveys

DOFAW may choose to survey the burned area for damage to resources. Surveys shall be conducted at the discretion of appropriate individuals within the State of Hawaii DLNR.

5.4 Investigations and Accident Reporting

A post-fire review is required for fires of 100 acres or more and/or during which unusual events occurred, including failure to follow instructions. The Branch Protection Forester or the State Protection Forester may request a formal investigation for any reason. However, formal investigations are required for fires involving any of the following:

- Entrapments
- Fire shelter deployments
- Major injury
- Fire fatality

6 Budget

Table 11 depicts the timeline for implementation of each Mauna Kea FMP project. Given budget fluctuations and other confounding factors, this timeline will need to be adjusted over time. The timeline may be adjusted at the discretion of the State Protection Forester with input from and in coordination with the Branch Protection Forester.

The most critical projects to complete are construction of the Kilohana and Puu Laau dip tanks, the improvements to FB-1 and 1A, and implementation of fuelbreaks 1 and 1A. These projects not only are ideally located to maximize protection of the high density nesting area of the palila, but they also are relatively inexpensive. The goal for initiation of these projects is 2012.

Table 12 summarizes the cost estimates of all actions in this plan over a 20 year timeline. Inflation is applied at a flat rate of 3% per year to all costs. The FMP gives the Branch Protection Forester, the Branch Manager, and the State Protection Forester a great deal of latitude to adjust scheduling of capital improvements and maintenance. Therefore, budget figures are best guesses with assumptions for typical road usage, vegetation growth, and other factors.

Table 11. Twenty year implementation schedule for the Mauna Kea FMP. Timelines may be adjusted at the discretion of the State Protection Forester in coordination with the Branch Protection Forester.

			Fiscal Year																				
Project Type	**Project Name**	**Priority Level**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
NEPA	Programmatic EA	1	X																				
Firebreak	R-1	1	M																				
Firebreak	FB-1	1		X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-1A	1		X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-1B	1		X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 1	1		X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Fuelbreak	Fuelbreak 1A	1		X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Safety Zone	Safety Zone 1	1		X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Dip Tank	Kilohana & Laau	NA		X										M									
Water Line & Pump	Tank Connect Line	NA		X		M		M		M		M		M		M		M		M		M	
Firebreak	R-15	1			M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-8A	1			X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-4	1			M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 1B	2			X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Fuelbreak	Fuelbreak 2	2			X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Fuelbreak	Fuelbreak 3	1			X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Fuelbreak	Fuelbreak 4A	3			X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Fuelbreak	Fuelbreak 4B	3			X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Fuelbreak	Fuelbreak 4C	3			X	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr	Gr
Aerial Spraying	Spray fountaingrass	N/A			M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-3	2				M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 15	2				X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 15A	2				X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Safety Zone	Safety Zone 2	1				X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-6	1					X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	R-14	1 & 2					M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	R-13	1 & 2					M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-2	1					X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Safety Zone	Safety Zone 3	1					X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 14	2						X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 5	2						X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-1C	2						M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	FB-5	2						M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	R-10	2						M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	FA-1C	4						M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	R-16	4						X	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	FB-6	2							X	M	M	M	M	M	M	M	M	M	M	M	M	M	M

Firebreak	R-1	3							M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	R-13	3							X	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	R-6	3							M/X	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	FB-3	4							X	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fuelbreak	Fuelbreak 13	4							X	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	Kemole R-1	4								M	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	Mauna Kea Access Rd.	4								NA	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	R-5	4								M/X	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	Kaaliali R-1	5								M	M	M	M	M	M	M	M	M	M	M	M	M	M
Fire Access Road	R-9	5								M/X	M	M	M	M	M	M	M	M	M	M	M	M	M
Firebreak	Overland R-1	5								M	M	M	M	M	M	M	M	M	M	M	M	M	M

X = Initial Implementation
M = Maintenance
M/X = Reduced cost due to current good condition
Gr = Graze
Blank = No Action

Table 12. Twenty year cost estimation for implementation of Mauna Kea FMP firebreaks, fuelbreaks, fuels management, and dip tank construction.

Project Type	Project Name	Priority Level	2012	2013	2014	2015	2016	2017	2018	2019	2020
NEPA	Programmatic EA	1	$75,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	R-1	1	$543.48	$148,183.85	$576.58	$157,208.24	$611.70	$166,782.22	$648.95	$176,939.26	$688.47
Firebreak	FB-1	1	$0.00	$346.84	$94,567.03	$367.96	$100,326.16	$390.37	$106,436.02	$414.14	$112,917.98
Firebreak	FB-1A	1	$0.00	$117,058.99	$194.49	$53,028.58	$206.33	$56,258.02	$218.90	$59,684.13	$232.23
Firebreak	FB-1B	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 1	1	$0.00	$182,107.00	$18,757.02	$19,319.73	$19,899.32	$20,496.30	$21,111.19	$21,744.53	$22,396.86
Fuelbreak	Fuelbreak 1A	1	$0.00	$96,342.98	$9,923.33	$10,221.03	$10,527.66	$10,843.49	$11,168.79	$11,503.86	$11,848.97
Safety Zone	Safety Zone 1	1	$0.00	$5,515.21	$3,787.11	$3,900.73	$4,017.75	$4,138.28	$4,262.43	$4,390.30	$4,522.01
Dip Tanks	Kilohana & Laau	NA	$0.00	$61,800.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Water Line & Pump	Tank Connect Line	NA	$0.00	$92,384.56	$0.00	$980.11	$0.00	$1,039.80	$0.00	$1,103.12	$0.00
Firebreak	R-15	1	$0.00	$0.00	$62,128.16	$116.43	$31,746.49	$123.53	$33,679.85	$131.05	$35,730.96
Firebreak	FB-8A	1	$0.00	$0.00	$182,173.62	$341.41	$93,087.79	$362.20	$98,756.84	$384.26	$104,771.13
Firebreak	FB-4	1	$0.00	$0.00	$25,260.62	$52.92	$14,430.22	$56.15	$15,309.02	$59.57	$16,241.34
Fuelbreak	Fuelbreak 1B	2	$0.00	$0.00	$53,641.65	$5,525.09	$5,690.84	$5,861.57	$6,037.42	$6,218.54	$6,405.09
Fuelbreak	Fuelbreak 2	2	$0.00	$0.00	$39,276.03	$4,045.43	$4,166.79	$4,291.80	$4,420.55	$4,553.17	$4,689.76
Fuelbreak	Fuelbreak 3	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 4A	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 4B	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 4C	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Aerial Spraying	Spray Fountaingrass	NA	$0.00	$0.00	$15,026.91	$15,477.72	$15,942.05	$16,420.31	$16,912.92	$17,420.31	$17,942.92
Firebreak	FB-3	2	$0.00	$0.00	$0.00	$195,504.50	$416.66	$113,605.25	$442.04	$120,523.81	$468.96
Fuelbreak	Fuelbreak 15	2	$0.00	$0.00	$0.00	$38,580.66	$26,492.05	$27,286.81	$28,105.42	$28,948.58	$29,817.04
Fuelbreak	Fuelbreak 15A	2	$0.00	$0.00	$0.00	$5,373.45	$3,689.77	$3,800.46	$3,914.48	$4,031.91	$4,152.87
Safety Zone	Safety Zone 2	1	$0.00	$0.00	$0.00	$891.26	$612.00	$630.36	$649.27	$668.75	$688.81
Firebreak	FB-6	1	$0.00	$0.00	$0.00	$0.00	$112,948.48	$228.90	$62,409.92	$242.84	$66,210.68
Firebreak	R-14	1 & 2	$0.00	$0.00	$0.00	$0.00	$191,964.59	$427.40	$116,532.97	$453.43	$123,629.83
Firebreak	R-13	1 & 2	$0.00	$0.00	$0.00	$0.00	$265,470.74	$580.91	$158,388.02	$616.29	$168,033.85
Firebreak	FB-2	1	$0.00	$0.00	$0.00	$0.00	$48,241.08	$85.28	$23,253.10	$90.48	$24,669.21
Safety Zone	Safety Zone 3	1	$0.00	$0.00	$0.00	$0.00	$4,637.43	$3,184.37	$3,279.90	$3,378.29	$3,479.64
Fuelbreak	Fuelbreak 14	2	$0.00	$0.00	$0.00	$0.00	$0.00	$9,252.18	$6,353.16	$6,543.76	$6,740.07
Fuelbreak	Fuelbreak 5	2	$0.00	$0.00	$0.00	$0.00	$0.00	$20,799.77	$14,282.51	$14,710.98	$15,152.31
Firebreak	FB-1C	2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	FB-5	2	$0.00	$0.00	$0.00	$0.00	$0.00	$100,790.41	$207.66	$56,618.74	$220.30
Firebreak	R-10	2	$0.00	$0.00	$0.00	$0.00	$0.00	$89,687.37	$187.91	$51,234.25	$199.35
Fire Access Road	FA-1C	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	R-16	4	$0.00	$0.00	$0.00	$0.00	$0.00	$270,889.69	$737.82	$201,170.81	$782.75
Fire Access Road	FB-6	2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$63,915.15	$116.32	$119.80
Firebreak	R-1	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$45,015.54	$175.16	$47,756.99
Firebreak	R-13	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$196,988.84	$446.62	$121,772.88
Fire Access Road	R-6	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	FB-3	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$127,678.20	$272.11	$74,192.22
Fuelbreak	Fuelbreak 13	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$15,747.63	$10,813.37	$11,137.78
Firebreak	Kemole R-1	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	Mauna Kea Access Rd.	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	R-5	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	Kaaliali R-1	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	R-9	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	Overland R-1	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		Total	**$75,543.48**	**$703,739.42**	**$505,312.54**	**$510,935.25**	**$955,125.91**	**$928,313.19**	**$1,187,052.42**	**$805,602.73**	**$1,037,613.09**

Project Type	Project Name	Priority Level	2021	2022	2023	2024	2025	2026	2027	2028	2029
NEPA	Programmatic EA	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	R-1	1	$187,714.86	$730.40	$199,146.70	$774.88	$211,274.73	$822.07	$224,141.36	$872.13	$237,791.57
Firebreak	FB-1	1	$439.36	$119,794.68	$466.12	$127,090.18	$494.51	$134,829.97	$524.62	$143,041.12	$556.57
Firebreak	FB-1A	1	$63,318.90	$246.37	$67,175.02	$261.38	$71,265.98	$277.30	$75,606.07	$294.18	$80,210.48
Firebreak	FB-1B	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 1	1	$23,068.77	$23,760.83	$24,473.66	$25,207.87	$25,964.10	$26,743.03	$27,545.32	$28,371.68	$29,222.83
Fuelbreak	Fuelbreak 1A	1	$12,204.44	$12,570.57	$12,947.69	$13,336.12	$13,736.20	$14,148.29	$14,572.74	$15,009.92	$15,460.22
Safety Zone	Safety Zone 1	1	$4,657.67	$4,797.40	$4,941.32	$5,089.56	$5,242.25	$5,399.52	$5,561.50	$5,728.35	$5,900.20
Dip Tanks	Kilohana & Laau	NA	$0.00	$0.00	$13,842.34	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Water Line & Pump	Tank Connect Line	NA	$1,170.30	$0.00	$1,241.57	$0.00	$1,317.18	$0.00	$1,397.40	$0.00	$1,482.50
Firebreak	R-15	1	$139.03	$37,906.97	$147.50	$40,215.51	$156.48	$42,664.63	$166.01	$45,262.91	$176.12
Firebreak	FB-8A	1	$407.66	$111,151.69	$432.49	$117,920.83	$458.83	$125,102.21	$486.77	$132,720.94	$516.42
Firebreak	FB-4	1	$63.19	$17,230.44	$67.04	$18,279.78	$71.13	$19,393.01	$75.46	$20,574.05	$80.05
Fuelbreak	Fuelbreak 1B	2	$6,597.25	$6,795.16	$6,999.02	$7,208.99	$7,425.26	$7,648.02	$7,877.46	$8,113.78	$8,357.19
Fuelbreak	Fuelbreak 2	2	$4,830.46	$4,975.37	$5,124.63	$5,278.37	$5,436.72	$5,599.82	$5,767.82	$5,940.85	$6,119.08
Fuelbreak	Fuelbreak 3	1	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 4A	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 4B	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fuelbreak	Fuelbreak 4C	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Aerial Spraying	Spray Fountaingrass	NA	$18,481.21	$19,035.64	$19,606.71	$20,194.91	$20,800.76	$21,424.78	$22,067.53	$22,729.55	$23,411.44
Firebreak	FB-3	2	$127,863.71	$497.52	$135,650.60	$527.82	$143,911.73	$559.96	$152,675.95	$594.06	$161,973.92
Fuelbreak	Fuelbreak 15	2	$30,711.55	$31,632.90	$32,581.88	$33,559.34	$34,566.12	$35,603.10	$36,671.20	$37,771.33	$38,904.47
Fuelbreak	Fuelbreak 15A	2	$4,277.45	$4,405.78	$4,537.95	$4,674.09	$4,814.31	$4,958.74	$5,107.50	$5,260.73	$5,418.55
Safety Zone	Safety Zone 2	1	$709.48	$730.76	$752.68	$775.26	$798.52	$822.48	$847.15	$872.57	$898.74
Firebreak	FB-6	1	$257.63	$70,242.91	$273.31	$74,520.71	$289.96	$79,059.02	$307.62	$83,873.71	$326.35
Firebreak	R-14	1 & 2	$481.04	$131,158.88	$510.34	$139,146.46	$541.42	$147,620.48	$574.39	$156,610.56	$609.37
Firebreak	R-13	1 & 2	$653.82	$178,267.11	$693.64	$189,123.58	$735.88	$200,641.21	$780.69	$212,860.26	$828.24
Firebreak	FB-2	1	$95.99	$26,171.56	$101.83	$27,765.41	$108.04	$29,456.33	$114.61	$31,250.22	$121.59
Safety Zone	Safety Zone 3	1	$3,584.03	$3,691.55	$3,802.30	$3,916.37	$4,033.86	$4,154.88	$4,279.52	$4,407.91	$4,540.15
Fuelbreak	Fuelbreak 14	2	$6,942.27	$7,150.54	$7,365.06	$7,586.01	$7,813.59	$8,048.00	$8,289.44	$8,538.12	$8,794.27
Fuelbreak	Fuelbreak 5	2	$15,606.88	$16,075.09	$16,557.34	$17,054.06	$17,565.68	$18,092.65	$18,635.43	$19,194.50	$19,770.33
Firebreak	FB-1C	2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	FB-5	2	$60,066.83	$233.72	$63,724.90	$247.95	$67,605.74	$263.05	$71,722.93	$279.07	$76,090.86
Firebreak	R-10	2	$54,354.42	$211.49	$57,664.60	$224.37	$61,176.38	$238.04	$64,902.02	$252.53	$68,854.55
Fire Access Road	FA-1C	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	R-16	4	$213,422.11	$830.42	$226,419.52	$881.00	$240,208.47	$934.65	$254,837.16	$991.57	$270,356.75
Fire Access Road	FB-6	2	$32,665.43	$127.10	$130.91	$35,694.40	$138.89	$143.05	$39,004.24	$151.77	$156.32
Firebreak	R-1	3	$185.82	$50,665.39	$197.14	$53,750.91	$209.14	$57,024.34	$221.88	$60,497.13	$235.39
Firebreak	R-13	3	$473.82	$129,188.85	$502.67	$137,056.45	$533.29	$145,403.19	$565.76	$154,258.25	$600.22
Fire Access Road	R-6	3	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	FB-3	4	$288.68	$78,710.53	$306.26	$83,504.00	$324.91	$88,589.39	$344.70	$93,984.49	$365.69
Fuelbreak	Fuelbreak 13	4	$11,471.91	$11,816.07	$12,170.55	$12,535.66	$12,911.73	$13,299.09	$13,698.06	$14,109.00	$14,532.27
Firebreak	Kemole R-1	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	Mauna Kea Access Rd.	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	R-5	4	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	Kaaliali R-1	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fire Access Road	R-9	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Firebreak	Overland R-1	5	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
		Total	**$887,205.97**	**$1,100,803.72**	**$920,555.30**	**$1,203,402.23**	**$961,931.78**	**$1,238,964.29**	**$1,059,370.32**	**$1,314,417.21**	**$1,082,662.70**

Project Type	Project Name	Priority Level	2030	2031	2032	Total
NEPA	Programmatic EA	1	$0.00	$0.00	$0.00	**$75,000.00**
Firebreak	R-1	1	$925.25	$252,273.08	$981.59	**$1,969,631.36**
Firebreak	FB-1	1	$151,752.32	$590.47	$160,994.04	**$1,256,340.45**
Firebreak	FB-1A	1	$312.10	$85,095.30	$331.11	**$731,275.86**
Firebreak	FB-1B	1	$0.00	$0.00	$0.00	**$0.00**
Fuelbreak	Fuelbreak 1	1	$30,099.51	$31,002.50	$31,932.57	**$653,224.62**
Fuelbreak	Fuelbreak 1A	1	$15,924.03	$16,401.75	$16,893.80	**$345,585.87**
Safety Zone	Safety Zone 1	1	$6,077.20	$6,259.52	$6,447.31	**$100,635.62**
Dip Tanks	Kilohana & Laau	NA	$0.00	$0.00	$0.00	**$75,642.34**
Water Line & Pump	Tank Connect Line	NA	$0.00	$1,572.79	$0.00	**$103,689.33**
Firebreak	R-15	1	$48,019.42	$186.84	$50,943.80	**$429,641.67**
Firebreak	FB-8A	1	$140,803.64	$547.87	$149,378.58	**$1,259,805.19**
Firebreak	FB-4	1	$21,827.01	$84.93	$23,156.27	**$192,312.21**
Fuelbreak	Fuelbreak 1B	2	$8,607.91	$8,866.15	$9,132.13	**$183,008.52**
Fuelbreak	Fuelbreak 2	2	$6,302.65	$6,491.73	$6,686.48	**$133,997.50**
Fuelbreak	Fuelbreak 3	1	$0.00	$0.00	$0.00	**$0.00**
Fuelbreak	Fuelbreak 4A	3	$0.00	$0.00	$0.00	**$0.00**
Fuelbreak	Fuelbreak 4B	3	$0.00	$0.00	$0.00	**$0.00**
Fuelbreak	Fuelbreak 4C	3	$0.00	$0.00	$0.00	**$0.00**
Aerial Spraying	Spray Fountaingrass	NA	$24,113.78	$24,837.20	$25,582.31	**$377,428.98**
Firebreak	FB-3	2	$630.24	$171,838.13	$668.62	**$1,328,353.45**
Fuelbreak	Fuelbreak 15	2	$40,071.61	$41,273.76	$42,511.97	**$615,089.79**
Fuelbreak	Fuelbreak 15A	2	$5,581.11	$5,748.54	$5,921.00	**$85,668.70**
Safety Zone	Safety Zone 2	1	$925.71	$953.48	$982.08	**$14,209.36**
Firebreak	FB-6	1	$88,981.62	$346.23	$94,400.60	**$734,920.48**
Firebreak	R-14	1 & 2	$166,148.15	$646.48	$176,266.57	**$1,353,322.35**
Firebreak	R-13	1 & 2	$225,823.45	$878.68	$239,576.09	**$1,843,952.44**
Firebreak	FB-2	1	$33,153.36	$129.00	$35,172.39	**$279,979.48**
Safety Zone	Safety Zone 3	1	$4,676.35	$4,816.64	$4,961.14	**$68,824.32**
Fuelbreak	Fuelbreak 14	2	$9,058.09	$9,329.84	$9,609.73	**$127,414.13**
Fuelbreak	Fuelbreak 5	2	$20,363.44	$20,974.34	$21,603.57	**$286,438.89**
Firebreak	FB-1C	2	$0.00	$0.00	$0.00	**$0.00**
Firebreak	FB-5	2	$296.07	$80,724.79	$314.10	**$579,407.12**
Firebreak	R-10	2	$267.91	$73,047.79	$284.23	**$522,787.22**
Fire Access Road	FA-1C	4	$0.00	$0.00	$0.00	**$0.00**
Firebreak	R-16	4	$1,051.96	$286,821.47	$1,116.02	**$1,971,452.17**
Fire Access Road	FB-6	2	$42,620.98	$165.84	$170.81	**$215,321.01**
Firebreak	R-1	3	$64,181.40	$249.73	$68,090.05	**$448,456.02**
Firebreak	R-13	3	$163,652.57	$636.77	$173,619.02	**$1,225,699.21**
Fire Access Road	R-6	3	$0.00	$0.00	$0.00	**$0.00**
Fire Access Road	FB-3	4	$99,708.14	$387.96	$105,780.37	**$754,437.66**
Fuelbreak	Fuelbreak 13	4	$14,968.24	$15,417.29	$15,879.80	**$200,508.44**
Firebreak	Kemole R-1	4	$0.00	$0.00	$0.00	**$0.00**
Firebreak	Mauna Kea Access Rd.	4	$0.00	$0.00	$0.00	**$0.00**
Fire Access Road	R-5	4	$0.00	$0.00	$0.00	**$0.00**
Fire Access Road	Kaaliali R-1	5	$0.00	$0.00	$0.00	**$0.00**
Fire Access Road	R-9	5	$0.00	$0.00	$0.00	**$0.00**
Firebreak	Overland R-1	5	$0.00	$0.00	$0.00	**$0.00**
		Total	**$1,436,925.20**	**$1,148,596.86**	**$1,479,388.16**	**$20,543,461.77**

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Appendix 1

Detailed Weather Information

Fire Family Plus settings used for the weather analyses

Station Details:
hptw PTA West Fuel model: N (Use 88?: N)

Slope class: 1 Climate class: 1 Greenup: 01/01 Freeze: 12/01
Start KBDI: 0 Start FM1000:15 Avg. Precip: 12.00
FM1 = FM10? N Herb Annual? N Deciduous? N
Aspect: 2 Slope posit.: Elevation: 4290
Latitude: 19.00 Longitude: NA
Weighed Stick Moistures Used: Yes

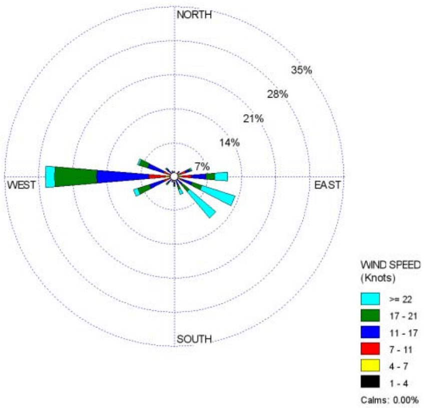
Station Details:
hhak hakalau Fuel model: L (Use 88?: N)

Slope class: 1 Climate class: 3 Greenup: 01/01 Freeze: 12/31
Start KBDI: 300 Start FM1000:30 Avg. Precip: 51.00
FM1 = FM10? N Herb Annual? N Deciduous? N
Aspect: 2 Slope posit.: M Elevation: 6540
Latitude: 19.82 Longitude: 155.33
Weighed Stick Moistures Used: Yes

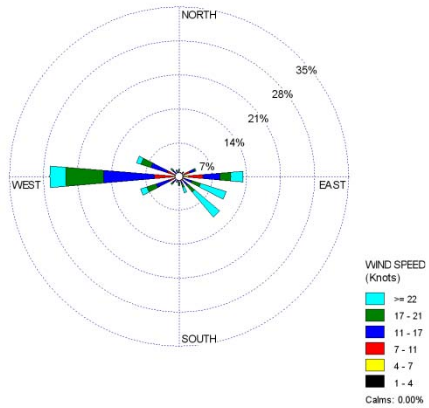
Station Details:
BAAF Bradshaw Army Airfield
Non-RAWS weather station.

Monthly Wind Roses for the Bradshaw Army Airfield weather station.

January



February



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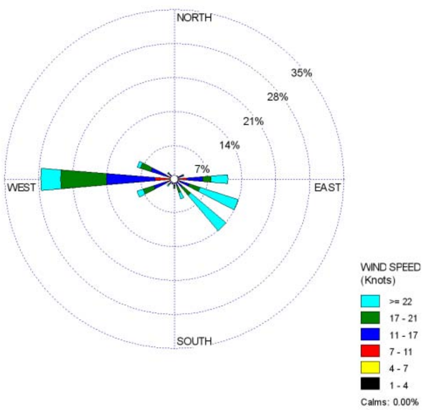

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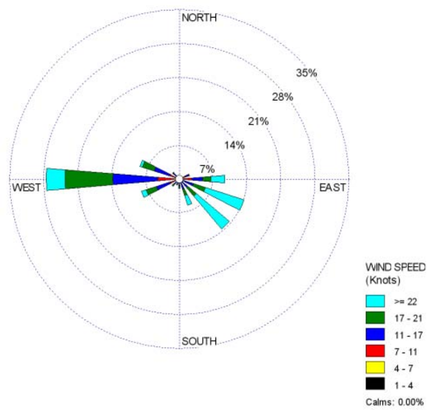

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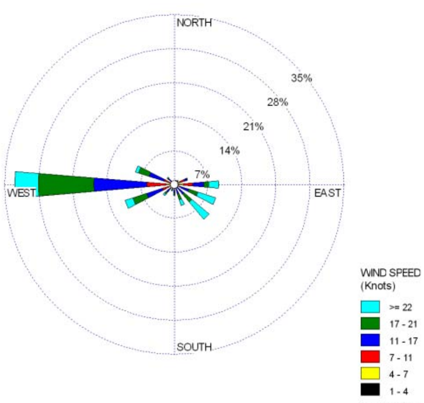

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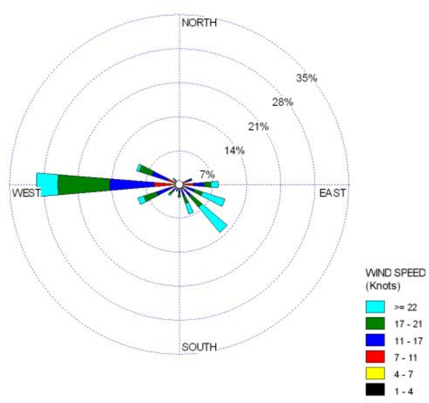
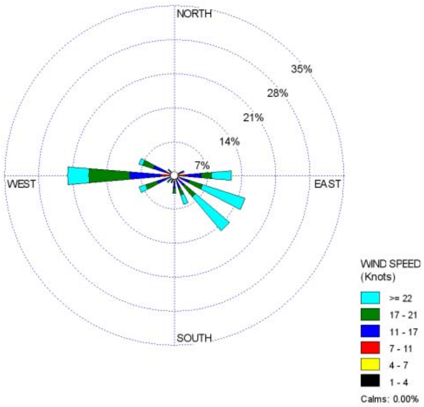
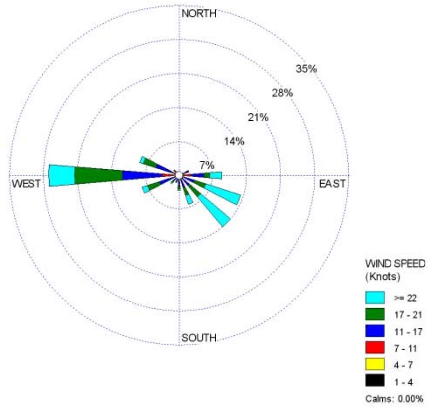


July



August



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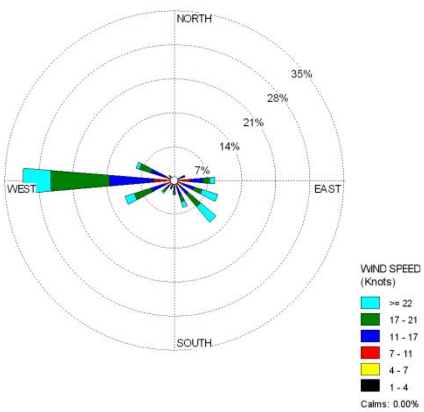
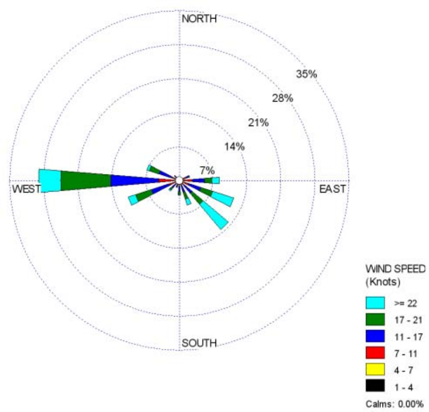


October



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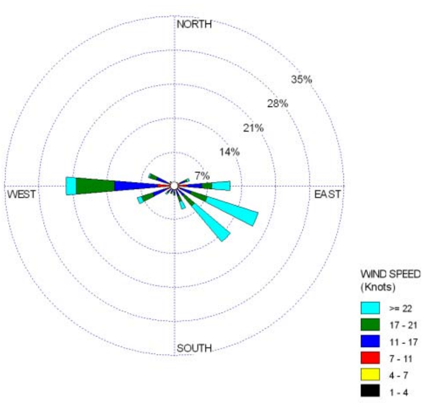

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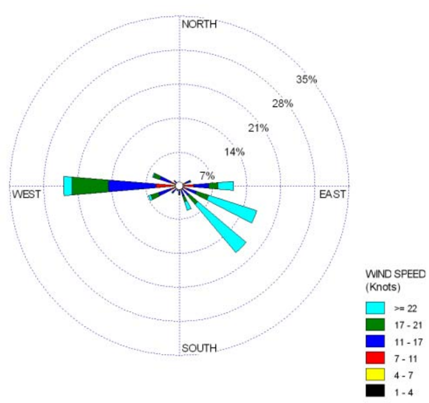
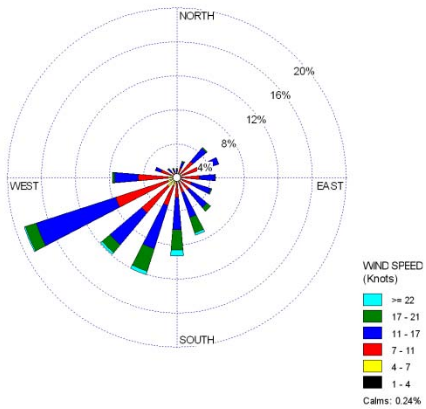


Annual Wind Data Table for the Bradshaw Army Airfield weather station.

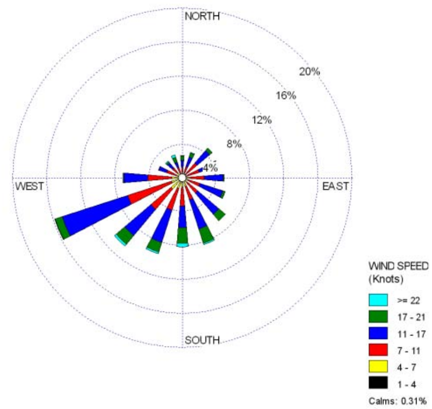
Range (Knots)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1-4	0.1	0.2	0.2	0.4	0.6	0.4	0.2	0.2	0.3	0.2	0.2	0.4	0.7	0.3	0.2	0.2	4.9
4-7	0.1	0.1	0.2	0.4	0.6	0.3	0.2	0.2	0.2	0.1	0.2	0.3	0.7	0.4	0.2	0.1	4.2
7-11	0.2	0.2	0.3	0.9	1.9	0.9	0.6	0.6	0.6	0.4	0.5	1.2	3.0	1.4	0.4	0.3	13.4
11-17	0.1	0.1	0.2	0.7	2.8	2.1	1.8	1.4	0.9	0.5	0.9	3.0	9.4	3.1	0.7	0.3	27.9
17 - 21	0.1	0.0	0.0	0.2	1.7	2.4	2.6	1.4	0.5	0.3	0.5	2.6	9.6	2.2	0.3	0.1	24.3
>= 22	0.0	0.0	0.0	0.1	2.6	6.9	7.7	1.6	0.2	0.1	0.2	1.3	3.9	0.6	0.1	0.0	25.4
Total (%)	0.6	0.6	1.0	2.8	10.2	12.8	13.2	5.3	2.6	1.6	2.6	8.9	27.3	8.0	1.8	0.9	100.0

Monthly Wind Roses for the Hakalau RAWS. Wind roses are not all to the same scale.

January



February



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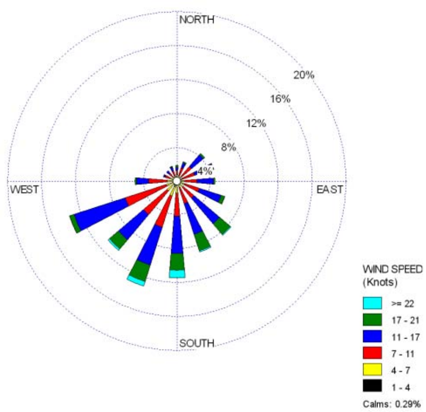

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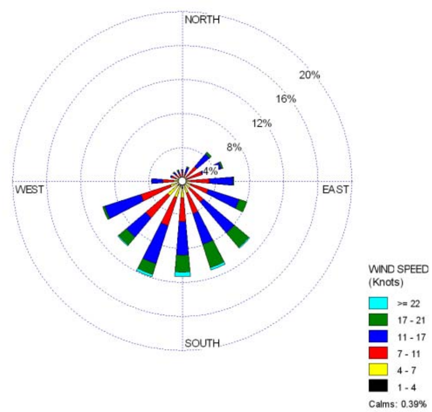

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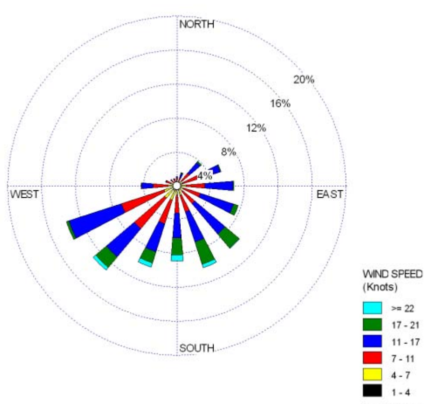

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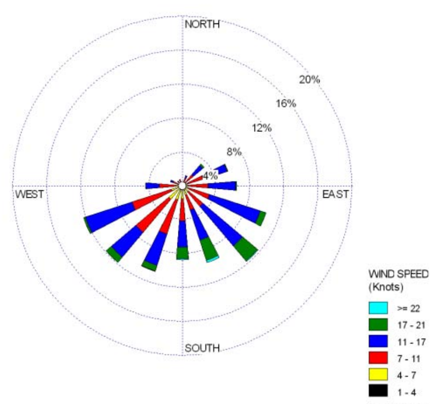

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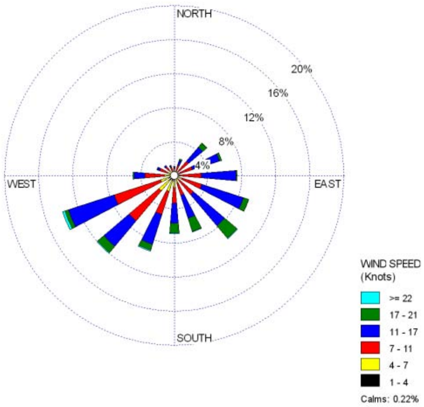
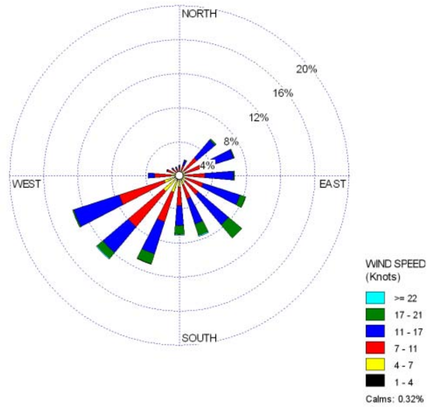


August



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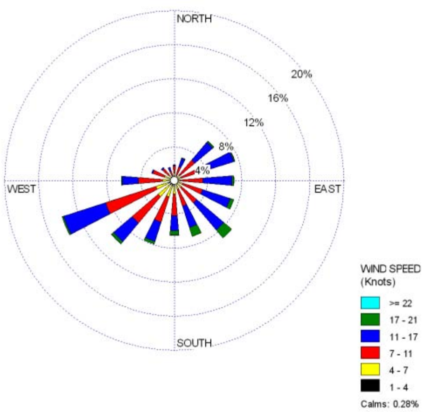

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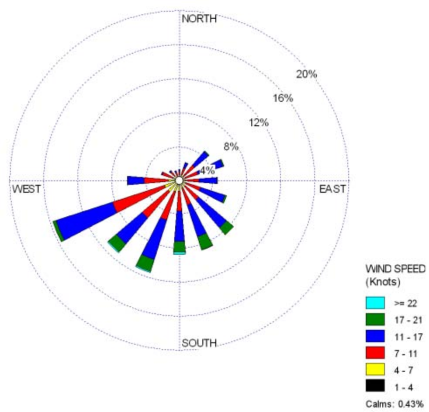

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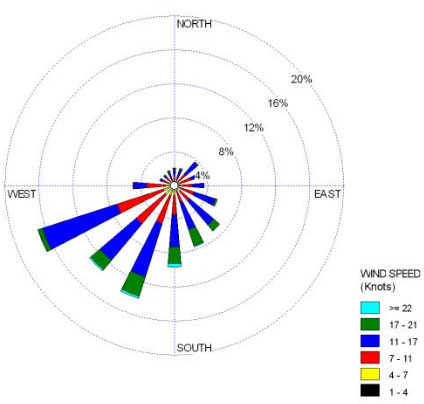

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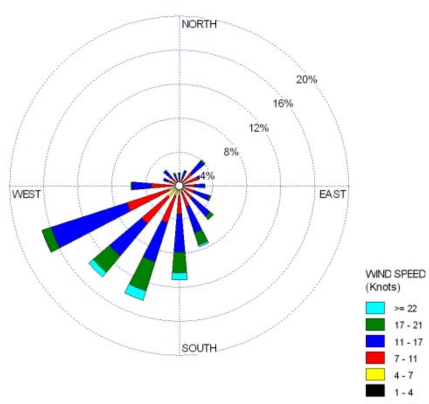

Annual Wind Data Table for the Hakalau RAWS.

Range (Knots)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
1-4	0.3	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.5	0.4	0.4	0.3	0.2	6.0
4-7	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.8	1.1	1.4	1.1	0.7	0.4	0.3	0.3	9.6
7-11	0.5	0.8	1.6	1.9	2.0	2.0	1.9	1.8	2.3	3.3	4.2	5.5	2.3	0.9	0.6	0.5	32.1
11-17	0.3	0.7	2.0	2.7	2.6	3.6	4.2	3.4	3.2	4.3	4.1	6.9	1.7	0.3	0.4	0.3	40.8
17 - 21	0.1	0.2	0.2	0.1	0.1	0.5	1.5	1.9	1.6	1.6	1.2	0.5	0.1	0.0	0.0	0.1	9.8
>= 22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	1.4
Total (%)	1.5	2.2	4.6	5.4	5.5	6.8	8.4	8.4	9.0	11.2	11.8	14.5	5.3	2.1	1.6	1.5	99.7

Appendix 2

Fire Simulation Inputs and Procedures

FlamMap Data Inputs

Landscape Inputs

Input Type	Source	Comments
Elevation	LANDFIRE	
Slope	LANDFIRE	
Aspect	Generated from elevation data	LANDFIRE aspect data was faulty.
Fuel Models	Thaxton and Jacobi (2009) and LANDFIRE	Data beyond the extent of the Thaxton and Jacobi data was acquired from LANDFIRE.
Canopy Cover	LANDFIRE	
Stand Height	LANDFIRE	Where naio and mamane dominate, reclassified the data to remove very high values and replace them with a maximum of 8 m to more closely represent the actual stand heights.
Canopy Base Height	LANDFIRE	Data from LANDFIRE did not accurately represent canopy base heights. Reclassified the data so that canopy base height is 1 m wherever canopy is present.
Canopy Bulk Density	LANDFIRE	Assumed to be .01 kg/m^3 wherever canopy is present.

Fuel Moisture and Weather Inputs

Fuel moisture data for the 97th percentile was acquired from the PTA West RAWS. A five day fuel moisture conditioning period, ending at 1300 on the fifth day to ensure day time fuel moistures, was utilized to help ensure that fuels moistures were representative of their aspect and elevational position on the mountain. The conditioning period was chosen utilizing 97th percentile 1000 hour fuel moisture as an indicator of drought and ensuring that no rain fell during the conditioning period. Wind speed was the 97th percentile from the PTA West RAWS. For the wind direction, wind data was limited to the daytime (the burning period) and to the months of July through September. From this data, a predominant wind direction was determined. We ran the model twice, once using this wind direction and once using the uphill option.

Parameter	PTA West RAWS 97th Percentile Value
1 hour time lag dead	6%
10 hour time lag dead	8%
100 hour time lag dead	14%
Live Herbaceous	93%
Live Woody	120%
Wind Speed	17 mph @ 20'
Wind Direction	315°
Foliar Moisture Content	100%

Standard Fire Behavior Outputs

Standard outputs included rate of spread, flame length, and maximum spread direction.

Minimum Travel Time

We used the Minimum Travel Time capabilities of FlamMap to help address the temporal component of fire behavior (e.g. the way fire moves across the landscape). We defined 10,000 ignition points for this purpose. One thousand (10%) of these were randomly allocated to represent lightning strikes. The other 9,000 (90%) were randomly allocated but weighted heavily based on the proximity to roads. All of these 9,000 points were within 200 m of a road. The magnitude of the split between lightning and human caused fires was based on the known fire history of the area. Ignition points were not allowed to fall in unvegetated areas.

Output resolution was set at 60 m. Maximum simulation time was set at 10080 minutes (7 days) and the minimum interval between major paths was set at 1000 m.

The risk analysis assumes that ignitions are equally likely on any road on the mountain. This is probably not realistic. Information on road traffic volumes or other measures of human presence would improve the accuracy of the simulation.

Outputs included major fire path vectors, arrival time grid, and the node influence grid (which cells are most important in the movement of fires across the landscape). We utilized the arrival time grid to represent risk since the most important factor is whether or not a pixel burns (as opposed to some measure of fire severity). We used ArcGIS to calculate the minimum of the two arrival times simulated by FlamMap (predominant wind direction and uphill).

Appendix 3

Fire Orders and Watchout Situations

The 10 Standard Fire Orders were developed in 1957 by a task force studying ways to prevent firefighter injuries and fatalities. Shortly after the Standard Fire Orders were incorporated into firefighter training, the 18 Situations That Shout Watch Out were developed. These 18 situations are more specific and cautionary than the Standard Fire Orders and described situations that expand the 10 points of the Fire Orders. If firefighters follow the 10 Standard Fire Orders and are alerted to the 18 Watch Out Situations, much of the risk of firefighting can be reduced.

The 10 Standard Fire Orders

Fire Behavior

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.

Fireline Safety

4. Identify escape routes and safety zones and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.

Organizational Control

7. Maintain prompt communications with your forces, your supervisor and adjoining forces.
8. Give clear instructions and insure they are understood.
9. Maintain control of your forces at all times.

If 1-9 are considered, then...

10. Fight fire aggressively, having provided for safety first.

The 10 Standard Fire Orders are firm.
We don’t break them; we don’t bend them.
All firefighters have the right to a safe assignment.

The 18 Watch Out Situations

1. Fire not scouted and sized up.
2. In country not seen in daylight.
3. Safety zones and escape routes not identified.
4. Unfamiliar with weather and local factors influencing fire behavior
5. Uninformed on strategy, tactics, and hazards.
6. Instructions and assignments not clear.
7. No communication link between crewmembers and supervisors.
8. Constructing line without safe anchor point.
9. Building line downhill with fire below.
10. Attempting frontal assault on fire.
11. Unburned fuel between you and the fire.
12. Cannot see main fire, not in contact with anyone who can.
13. On a hillside where rolling material can ignite fuel below.
14. Weather gets hotter and drier.
15. Wind increases and/or changes direction.
16. Getting frequent spot fires across line.
17. Terrain or fuels make escape to safety zones difficult.
18. Feel like taking a nap near fireline.