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# Ka'ū Forest Reserve Management Plan

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September 2012

Prepared by:

State of Hawai'i  
Department of Land and Natural Resources  
Division of Forestry and Wildlife

## EXECUTIVE SUMMARY

This plan is one in a series of site-specific plans to be prepared by the Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW) for individual forest reserves in the State of Hawai'i. These plans present a brief history of the specific forest reserve, a description of cultural and natural resources, and proposed management actions for the area.

The Ka'ū Forest Reserve (or Reserve) was established by Governor's Proclamation on August 2, 1906 to protect the forest on the lower slopes of Mauna Loa in the Ka'ū District on the southeastern side of the island of Hawai'i. The Reserve is public land, managed by the DOFAW, and consists of 61,641 acres (ac) (24,945 hectares (ha)) of forested lands. The Reserve was established to maintain the necessary water supply for agricultural lands in Ka'ū. Native Hawaiians recognized the importance of forests in water production and water quality, as is reflected in the saying, "Haihai ka ua i ka ulu la au" (The rain follows the forests). Early foresters also recognized the importance of Hawaiian forests as the primary water source. For example, Ralph Hosmer, Hawaii's first Territorial Forester, stated "In Hawai'i, the most valuable product of the forest is water, rather than wood."

The Ka'ū Forest Reserve is a critical watershed for the people of Ka'ū. The Reserve's water sources are used for domestic supplies as well as agriculture, and maintaining this water supply is important for the future viability of agriculture in Ka'ū. The native forest replenishes springs and other groundwater, and reduces flooding and erosion. The water resources of Ka'ū are threatened by invasive animals and plants, which degrade the native forest and lead to reduced quantity and quality of water.

The Ka'ū Forest Reserve is important for preserving Hawaii's unique native forest ecosystems and its species. These include a wide variety of rare or endangered plants and animals. Endangered birds for which the continuing health of the Reserve may be a critical factor include the 'Akiapōlā'au (*Hemignathus munroi*), Hawai'i Creeper (*Oreomystis mana*) and Hawai'i 'Akepa (*Loxops coccineus*). Survival and recovery of these rare native plants and animals depend upon preservation of habitat by reducing impacts from threats such as ungulates, disease-bearing mosquitoes and other invasive insects, non-native predators, introduced diseases and invasive plants.

Up until the 1970s the Ka'ū Forest Reserve supported the endangered 'Alalā or Hawaiian Crow (*Corvus hawaiiensis*). The 'Alalā is extinct in the wild. The entire population of less than 100 birds is housed in two captive breeding facilities, making the 'Alalā one of the rarest birds in existence. The 'Alalā was restricted to the forests in the western and southern portions of the island, associated with 'ohi'a and 'ohi'a-koa forests with an understory of native fruit-bearing trees and shrubs. This understory is essential to the survival of the 'Alalā in the wild, providing food as well as cover from natural predators. The Ka'ū Forest Reserve has been identified by the 'Alalā Recovery Team as one of the high priority sites to restore this rare bird.

The Ka'ū Forest Reserve contains resources that are vital for maintaining Hawaiian culture and practices. Hawaiians consider native plants and animals as family and have a strong spiritual connection to the mountain landscape and the forest itself. Gathering plants such as ferns, maile (*Alyxia oliviformis*), flowers, fruits, and other materials cannot be perpetuated into the future unless the forest remains relatively pristine.

The Ka'ū Forest Reserve is an important area for public use which includes hunting, recreational opportunities, cultural uses, personal gathering, and educational programs and activities. There is currently limited public access to much of this large Reserve, and existing access needs to be maintained as well as improved by working with adjacent landowners to provide additional access, particularly across state-leased and private land below the Reserve.

The Ka'ū Forest Reserve Management Plan describes the natural resources found in the Reserve, identifies the threats to those resources, and proposes management actions to address threats and better protect the area. Proposed management activities will benefit watershed, native forest ecosystems and unique native species as well as the people who use the area for recreation and cultural practices. The following management actions would be undertaken throughout or in selected parts of the Ka'ū Forest Reserve as part of a 15 year management plan for this area:

- Fence management areas in an approximately 12,000 acre portion of the Reserve and remove feral and introduced ungulates from within fenced management areas for watershed and native ecosystem health.
- Remove high priority non-native, invasive plants.
- Implement non-native predator control.
- Restore 'Alalā to the wild.
- Continue forest bird surveys to assess changes in bird population and distribution.
- Survey and inventory rare native plants and animals (including insects and snails).
- Improve habitat and recover rare and endangered plants by propagation and re-introduction of plants into appropriately fenced and protected habitat.
- Maintain existing public access roads and develop new routes to increase access, particularly across private and state-leased lands below the Reserve.
- Continue to facilitate public hunting in the Reserve by developing new access routes to increase hunter access.
- Develop trails and recreational amenities.
- Hire outreach staff and work with partners to provide outreach and education (e.g. volunteer service trips, student internships, and school programs) for the community to enhance public understanding of the Reserve's unique native forest.
- Respond to fires, as needed.
- Monitor forest for insects and disease and conduct other management as required (control of damaging insects, slugs, and/or plant disease).
- Consider environmentally and socially appropriate ways to make the Reserve economically self-supporting to support protection and management.
- Work with adjacent private landowners on cooperative management to make better use of limited funding and resources and more effectively manage interconnected landscapes.

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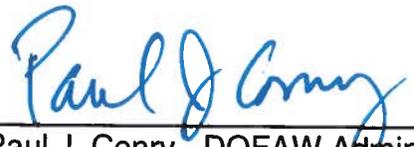
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**KA'Ū FOREST RESERVE  
MANAGEMENT PLAN SIGNATURE PAGE**

Hawai'i District certification: This plan was prepared by a team of Division of Forestry and Wildlife (DOFAW) staff to provide a management framework for Ka'ū Forest Reserve.

  
\_\_\_\_\_  
Roger Imoto - DOFAW Hawai'i Branch Manager 11/5/12  
Date

DOFAW Administrator's approval: I have reviewed the Ka'ū Forest Reserve Management Plan and concur with the recommendations herein. I agree this Management Plan will serve as a guiding document for the management of Ka'ū Forest Reserve.

  
\_\_\_\_\_  
Paul J. Conry - DOFAW Administrator 11/8/12  
Date

Department of Land and Natural Resources Board approval: This plan meets the criteria established for State Forest Reserve Management Plans as mandated by Chapter 183, Section 16-4, Hawai'i Revised Statutes.

  
\_\_\_\_\_  
William J. Aila - BLNR Chairperson 11/15/12  
Date

Approved by the Board of  
Land and Natural  
Resources at its meeting  
held September 28, 2012

## DEVELOPMENT PROCESS TIMELINE

Ka'ū Forest Reserve, Hawai'i

| <b>Stage of Development</b>   | <b>Date Achieved</b> |
|---|----------------------|
| DOFAW Review  | September 2011       |
| Public/Partner Agency Pre-Consultation  | October - May 2012   |
| Draft Environmental Assessment (DEA)  | May 23, 2012         |
| BLNR Approval   | September 28, 2012   |
| Final Environmental Assessment (FEA) and Finding of No Significant Impact (FONSI) | October 23, 2012     |

## I. INTRODUCTION

The Division of Forestry and Wildlife (DOFAW) has management responsibility for the Ka'ū Forest Reserve (Reserve), which is part of the State Forest Reserve System. The Reserve has numerous assets that this plan aims to protect and manage for current and future generations:

- fresh water supply for humans (capturing and filtering rainwater and fog drip for drinking water and agricultural uses)
- native forest ecosystems
- native birds, plants and invertebrates
- cultural and recreational resources for people

DOFAW conducts on-going planning efforts to develop and update management plans for all forest reserves across the State. These efforts serve to organize field management and assist in budgeting and funding requests. DOFAW aims to make the planning process transparent and will seek input and guidance on the plan from its partners and the general public throughout the planning process.

This plan was developed using a variety of methods, including:

- Use of DOFAW's standard management plan format
- Review of DOFAW historic and current files (both at the Administrative and Hawai'i Branch office) and documents obtained from the Land Division, Survey Division, Bureau of Conveyances, as well as State Archives
- Reviewing State of Hawai'i Geographic Information Systems (GIS) maps of biological, historical, and environmental resources in the forest reserve
- Reviewing other plans that identified the forest reserve or the area, such as the Hawaiian Forester and Agriculturalist, the Hawai'i Biodiversity and Mapping Program reports, Hawaii's Comprehensive Wildlife Conservation Strategy, and U.S. Fish and Wildlife Service Recovery Plans
- Input from DOFAW staff from all program areas both at the Hawai'i Island Branch and Administrative offices

The plan identifies management actions for the Reserve to protect the native forest and watershed, and may also be used to help the agency plan budget and staffing needs. The development of the plan may trigger the following actions:

1. Preparation of regulatory compliance documents such as an Environmental Assessment and associated public review process.
2. DOFAW efforts to secure operational and planning funding for plan objectives.
3. Prioritized implementation of plan objectives by DOFAW.
4. Periodic solicitation of requests for proposals or bids for implementation of plan objectives, including issuance of permits, licenses, or contracts (Hawai'i Administrative Rules §13-104-22), as necessary.

## II. PROJECT AREA DESCRIPTION

### A. Location and Description

The Ka'ū Forest Reserve is located in the Ka'ū District on the southeastern side of the island of Hawai'i (Figure 1). The Reserve is adjacent to the Kahuku section of the Hawai'i Volcanoes National Park, on Mauna Loa Volcano and extends from 2,000 - 7,000 feet (ft) (610 - 2,134 meters (m)) elevation. The nearest towns are Pāhala, Nā'ālehu and Wai'ōhinu.

On Hawai'i Island, DOFAW has direct management responsibility for 20 Forest Reserves, which include approximately 476,000 ac (192,630 ha). Adjacent DOFAW lands in the Ka'ū District include Kapāpala Forest Reserve and Kapāpala Koa Canoe Management Area. These lands are not included in this plan, and their management needs will be addressed in the future through the development of other management plans and/or revision of this plan.

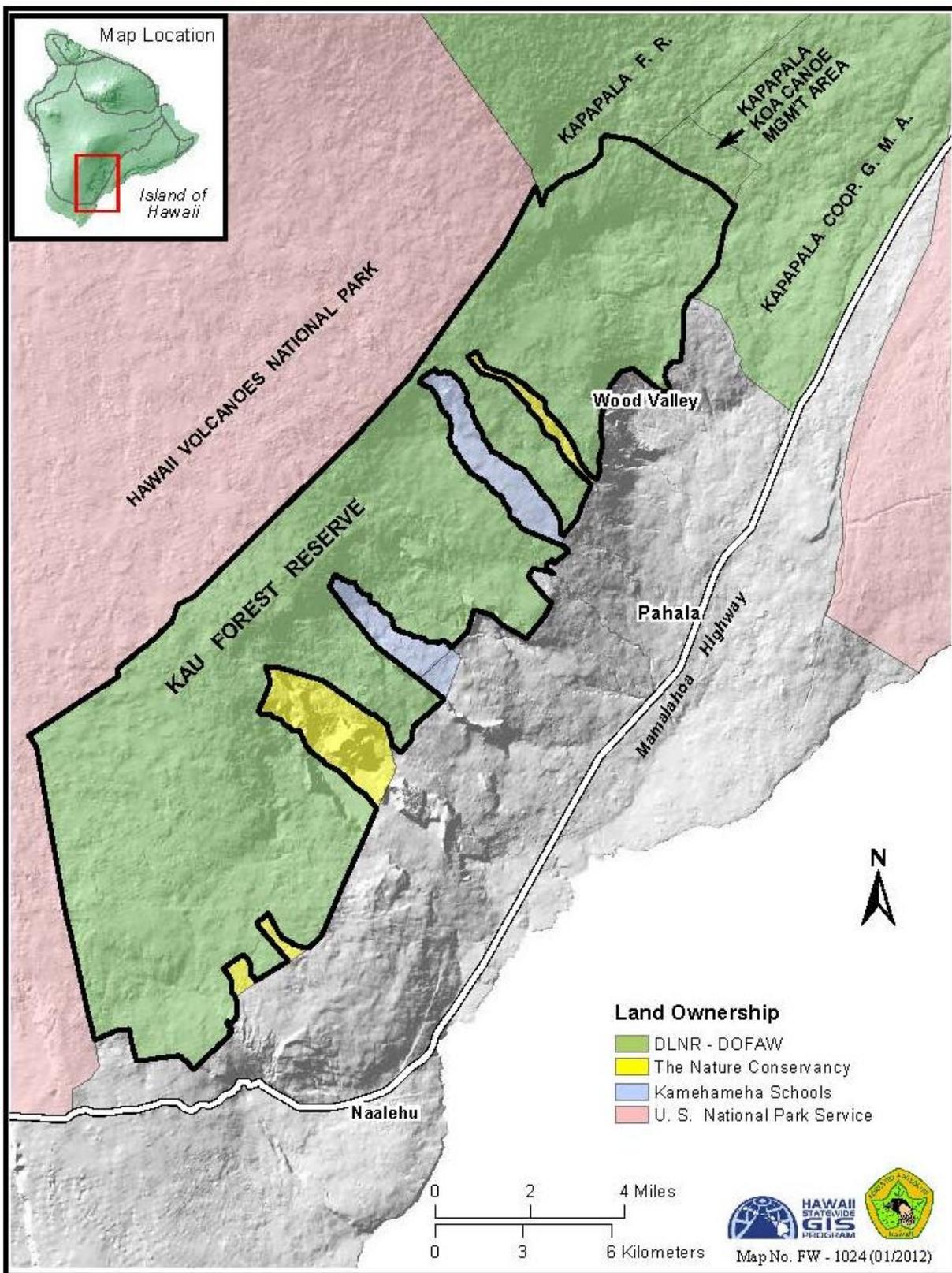
The Reserve is adjacent to federal, private and other state lands managed for natural and cultural resource protection. Adjacent major landowners include the U.S. National Park Service (NPS), Kamehameha Schools (KS), and The Nature Conservancy of Hawai'i (TNC) (Figure 1). DOFAW and these adjacent landowners are all members of the Three Mountain Alliance (TMA), a watershed partnership with the goal of cooperative management of Hawai'i's natural and cultural resources. The Reserve is also bordered by multiple private land owners, including ranchers, farmers, and residents.

**Table 1. Ka'ū Forest Reserve and Adjacent TMA Partnership Lands\***

\*Data obtained from Hawai'i Statewide GIS Program and DOFAW archives.

| Name  | TMK Number  | Owner        | GIS Acres |
|---|---|--------------|-----------|
| Hawai'i Volcanoes National Park – Kahuku Ka'ū | (3) 9-2-001:002   | NPS          | 150,194   |
| Ka'ū Forest Reserve                           | (3) 9-7-001:001,009,013,014,015,016,017,018,019,020,021,022;<br>(3) 9-6-006:009,010,015,018;<br>(3) 9-5-015:003 [portion] | DOFAW        | 61,641    |
| Kapāpala Forest Reserve                       | (3) 9-8-001:004   | DOFAW        | 37,276    |
| Kapāpala Cooperative Game Management Area     | (3) 9-8-001:010   | State (DLNR) | 22,109    |
| Kapāpala Koa Canoe Management Area            | (3) 9-8-001:014   | DOFAW        | 1,244     |
| TNC Ka'ū Preserve                             | (3) 9-7-001:002,003,004,007   | TNC          | 3,561     |
| Kamehameha Schools Ka'ū Forest                | (3) 9-7-001:005,006,012;<br>(3) 9-6-006:011   | KS           | 2,891     |

Figure 1. Ka'ū Forest Reserve and Adjacent TMA Partnership Lands



## **B. Physical Site Data**

### 1. Geology

The island of Hawai'i is the youngest and largest of the main Hawaiian Islands and lies at the southeastern end of the Hawaiian Archipelago. The island was formed by five shield volcanoes that are less than 1 million years old: Kōhala, Hualālai, Mauna Kea, Mauna Loa, and Kīlauea (Stearns and MacDonald 1946). Mauna Loa and Kīlauea are currently active (Takasaki 1993) and their lava flows cover almost two-thirds of the island's land surface.

The geology of the Ka'ū District is derived from volcanic eruptions from Kīlauea and Mauna Loa volcanoes. The forests of the Reserve lie over a variety of different types and ages of volcanic materials from these eruptions. The age and type of volcanic material influences the development of soils and types of forest in the Reserve as well as watershed features such as stream channels and underground water collection.

Geological series (age/type of volcanic material) found in the area include Ninole, Kahuku, Pāhala, and Ka'ū (U.S. Geological Survey 2007, Figure 2). The oldest exposed rocks found in the area originated from the Ninole Volcanic Series and can be seen in steep slopes such as Pu'u Enuhe (Stearns and MacDonald 1946). The Kahuku lava flows are highly permeable and consist of pāhoehoe and 'a'ā flows with some interbedded ash. The Kahuku lava flows lie on top of the Ninole Volcanic Series and underneath the Pāhala Ash. Pāhala Ash consists of pumice fragments carried by the wind from lava fountains during eruptions of Kīlauea, Mauna Loa, and Mauna Kea as well as dust from Ka'ū Desert. The Ka'ū Volcanic Series covers the majority of the district and includes pāhoehoe and 'a'ā basalts of more recent eruptions.

Mauna Loa is still active and has erupted 33 times between 1843 and 1984 (Lockwood and Lipman 1987). Forty percent of Mauna Loa's surface is covered by lava flows less than 1,000 years old, and flows in 1950 reached the upper elevation of Ka'ū Forest Reserve. Portions of the Reserve could potentially be covered by lava from future volcanic eruptions. The Ka'ū Forest Reserve is located within Volcanic Hazard Zones 3 and 6 for Mauna Loa (USGS). During the past 750 years, lava flows have covered about 15 to 20 percent of Zone 3 on Mauna Loa. The portion of the Reserve above Nā'ālehu is classified as Zone 6 because it is currently protected from lava flows by the local topography.

Kīlauea Volcano is also currently active. The Ka'ū District is in the path of volcanic emissions from Kīlauea, particularly from the second active vent at Halema'uma'u. Trade winds blow the volcanic fumes to the southwest, towards Ka'ū, and at times volcanic emissions (which contains sulfur dioxide and other pollutants) have built up to levels that are hazardous to human health and damaging to agriculture. Volcanic emissions may also adversely affect the health of some native plant and animal species (USGS 1997; UH 2008).

The Reserve may also be affected by the frequent seismic activity, including earthquakes and associated landslides and tsunamis. Seismic activity in the region is related to the movement of magma within Kīlauea and Mauna Loa or due to movement along numerous fault lines. In 1868, an earthquake caused a large destructive landslide that buried a village in Wood Valley and caused a large seismic sea wave that swept away numerous settlements along the Ka'ū coast (Stearns and MacDonald 1946).

## 2. Soils

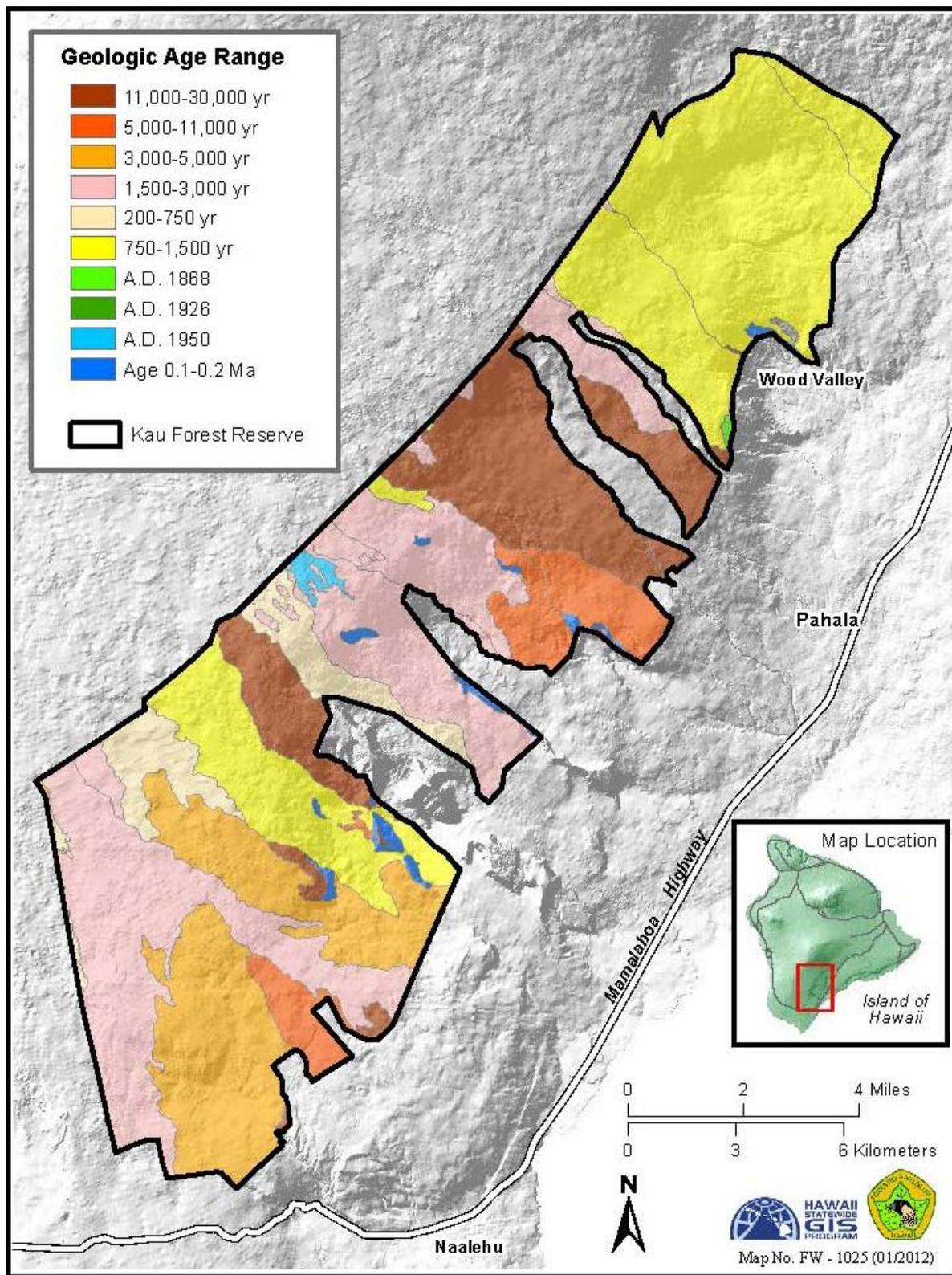
Soils in Ka'ū have developed from volcanic rocks, cinders, and ash. Soil age and composition is a major influence on plant community composition and hydrology. Pāhoehoe, 'a'ā, cinders, and weathered ash provide differing contributions of minerals and drainage characteristics (Mitchell *et al.* 2005). Accumulations of organic matter in the soil and ground litter are the most important factor in soil development on these relatively young substrates. In areas with greater rainfall, deposits of Pāhala Ash developed into soils that are important for agriculture in lower elevations and for watershed functions in higher elevations (University of Hawai'i 1965). The USDA Natural Resources Conservation Service has mapped 36 types of soils in Ka'ū Forest Reserve (U.S. Department of Agricultural 2011) (Figure 3, Appendix A).

## 3. Climate and Rainfall

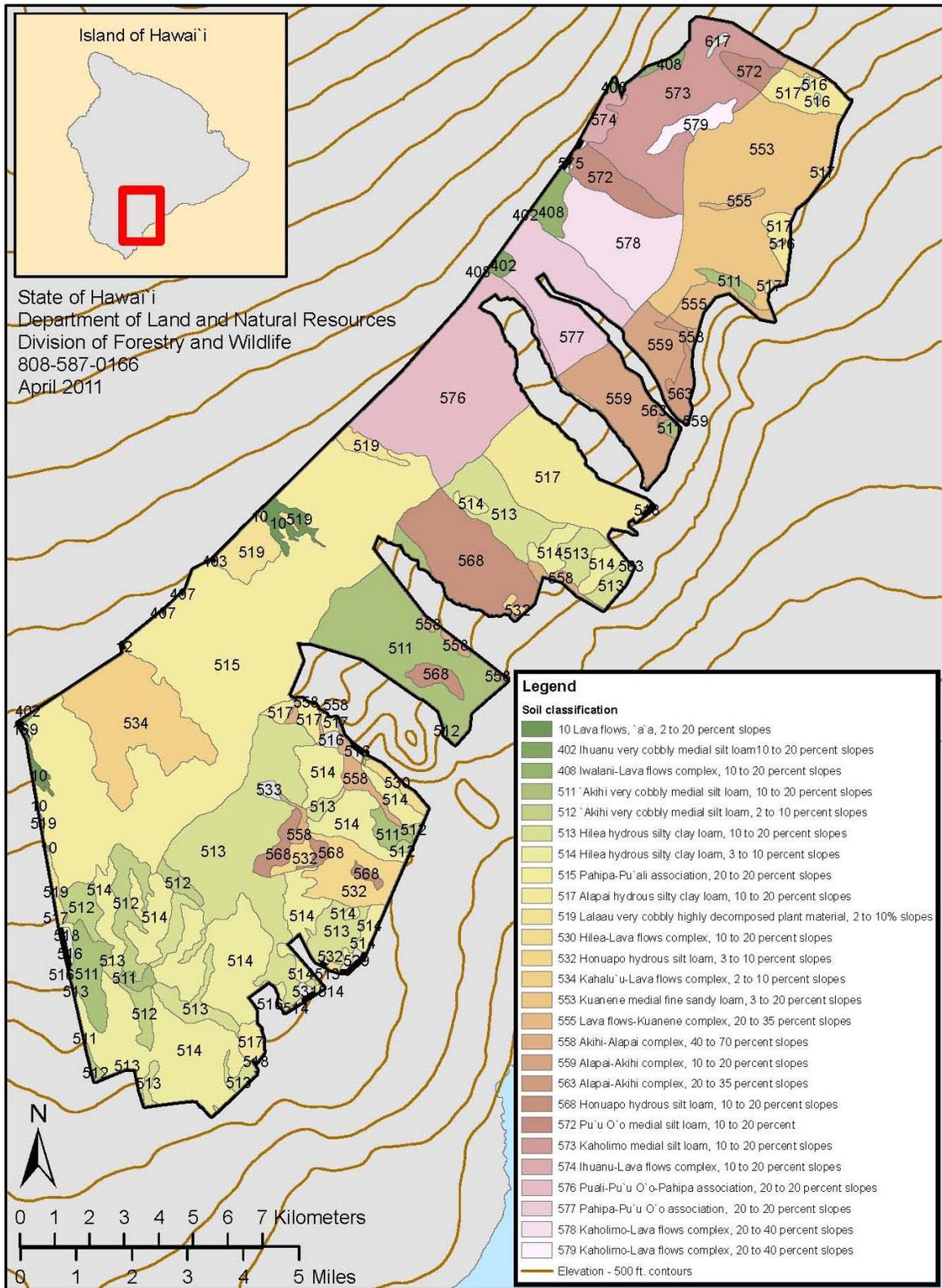
Average temperature for the Ka'ū Forest Reserve decreases with increasing elevation and ranges from 55° to 75°Fahrenheit (13 - 24°Celsius). Rainfall in the Hawaiian Islands depends greatly on topography and the mountains affect the pattern of annual rainfall (Giambelluca *et al.* 1986). Average annual rainfall in the area ranges from 60 in (1,500 mm) - 120 in (3,000 mm) (Juvik and Juvik 1998) and is highest in the central portions of the forest reserve (Figure 5). Mauna Loa affects the climate in the area, as winds are driven around and upward creating three rainfall regimes: trade wind dominated (Pāhala to Nā'ālehu), rain-shadow (southwest of Kīlauea summit), and high elevation. The frequent rainfall between Pāhala and Nā'ālehu is thought to be caused by a combination of trade winds and a thermally-driven sea breeze/land breeze cycle (Scholl *et al.* 1995).

The region experiences flooding from storm runoff and steep slopes. Flash flooding occurs often along the Mamalahoa Highway when streams in the area exceed culvert and bridge capacity. Flooding causes major disruption to Ka'ū communities as it can geographically isolate them and warrant emergency government response, as in 2000.

Figure 2. Ka'ū Forest Reserve Geologic Age



**Figure 3. Soils**



#### 4. Water Resources

The Reserve was originally established in 1906 to protect the water supply of the district, and the forest continues to provide important watershed services for the community. Native Hawaiians recognized the importance of forests in water production and water quality, as reflected in the Hawaiian proverb, “Haihai ka ua i ka ulu la au” (The rain follows after the forests). Early foresters also recognized the importance of Hawaiian forests as watershed. Ralph Hosmer, the first Territorial Forester stated "In Hawai'i, the most valuable product of the forest is water, rather than wood."

The Hawai'i Stream Atlas defines a watershed as a catch-basin or drainage basin for rain and condensate funneled into stream beds that either join other stream beds or terminate at the edge of the sea (Parham et al. 2008). The Stream Atlas identifies eight watershed basins within the Ka'ū District (Table 2, Figure 5).

Watershed services include providing a fresh water supply, habitat for native plants and animals, allowing better flood control, mitigating climate change impacts, and providing economic, social, recreational and educational opportunities for the human communities in the area. Watershed economic value can be measured in dollars. A University of Hawai'i study estimated the economic value of watershed services provided by the Ko'olau Mountains watersheds on O'ahu to be between \$7.44 billion to \$14 billion (Roumasset et al. 1997). Although a similar analysis has not yet been done for Ka'ū Forest Reserve, the economic value of the Reserve's watersheds is undoubtedly high.

**Table 2. Watersheds of the Ka'ū Forest Reserve**

| Watershed Basin Name | Streams   |
|----------------------|---|
| Hī'onamoa Gulch      | Hī'onamoa, Mo'a'ula, Uwēwale, Ka'ala'ala, Pā'au'au, Waiakaloa Kauhuhuula, Peleli'ilī'i, Waihaka, Keāiwa, Pi'ikea, Waloala, Makakupu, Punalu'u |
| Ninole Gulch         | Ninole  |
| Hīlea Gulch          | Hīlea   |
| Honuapo              | Honuapo   |
| Kaunāmano            | Kaunāmano   |
| Nā'ālehu             | Alapai Gulch  |
| Wa'ōhinu             | Kaluapuhi, Wa'ōhinu   |
| Kawela               | Kaalualu  |

Protecting the forests of the Reserve is important because of the direct impact to humans and our water supply. While many people are familiar with the water cycle and how rainfall ends up in groundwater that is used by humans, fewer people may be aware of the large role forests play in supplying and purifying our fresh water. Fog condensing on trees is an important source of moisture and can increase measurable precipitation by 20% (Juvik and Perreira 1973; Juvik and Nullet 1995). Forests collect and filter water into the groundwater and streams. A healthy forest without soil

disturbance limits aquatic pollutants (e.g. siltation, suspended solids, turbidity, nutrients, organic enrichment, toxins and pathogens) due to erosion and runoff. Forests may also reduce the impacts of flooding and erosion by slowing down water as it flows down the mountain.

Despite the large amount of rain in the upland forests of Ka'ū, there are no perennial streams because the water is absorbed quickly into the highly permeable lava flows (Davis and Yamanaga 1966). Surface water reaches the sea only after periods of heavy rainfall and flooding. The water absorbed into the lava sinks rapidly to the basal water table where it either floats on salt water or is perched on impermeable ash beds and becomes groundwater. Some basal water seeps out at springs at or near sea level along the coast (Stearns and MacDonald 1946).

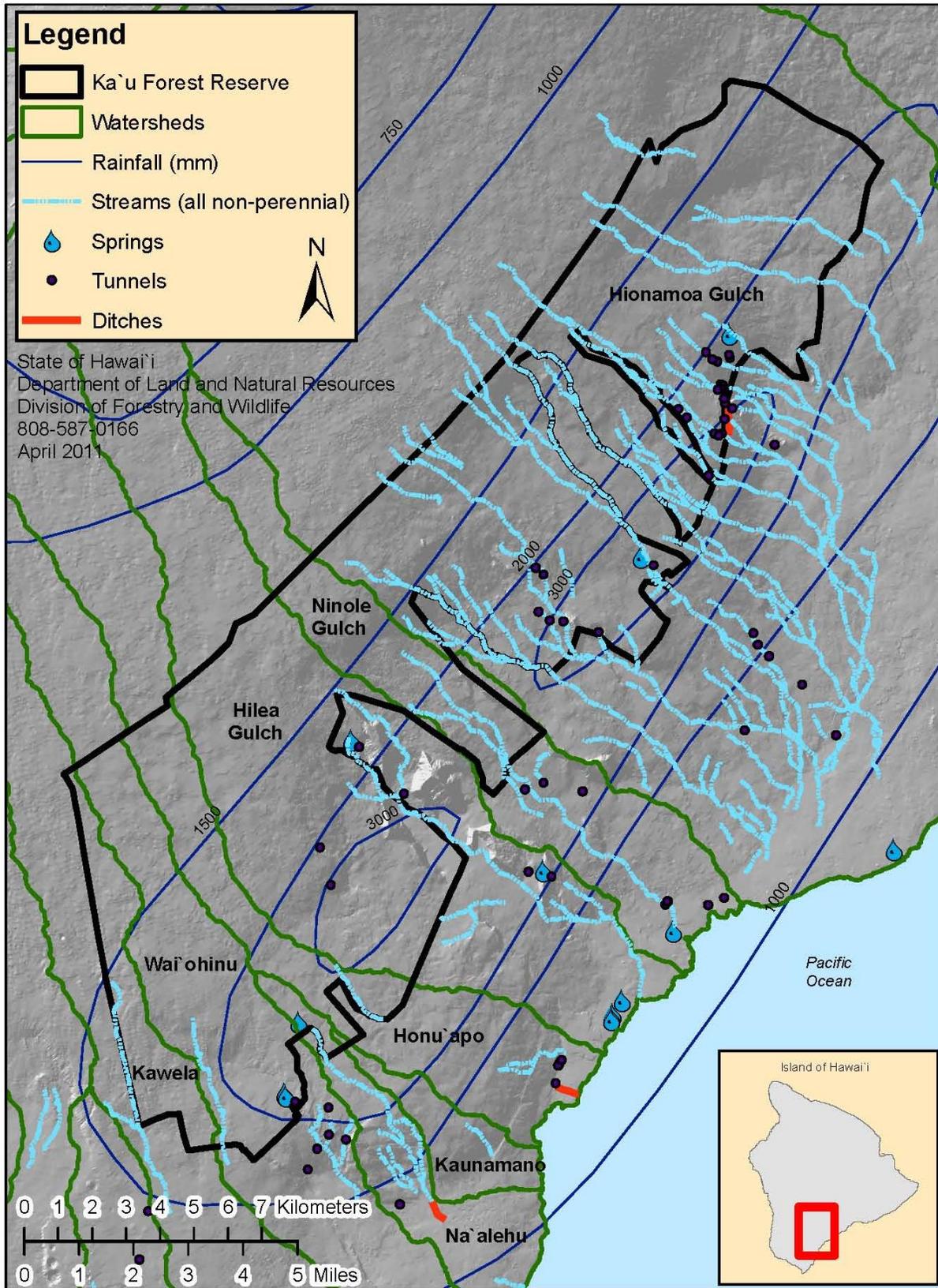
Water from Ka'ū Forest Reserve has been particularly important for Ka'ū agriculture. From the early 1920's to the late 1930's the two sugarcane companies in the district, Hawaiian Agricultural Company in the Pāhala area and Hutchinson Sugar Company in the Nā'ālehu area developed tunnels to recover perched groundwater for sugarcane irrigation and transport to mills via flumes (County of Hawai'i 2005). By 1950, the tunnel and flume transport system had fallen into disrepair (County of Hawai'i 2005). Sugarcane company leases for the water expired in 1973.

Of the 30 tunnels in the Reserve, three are currently being used under an agreement with the Hawai'i County Department of Water Supply (DWS). The DWS receives water for its Pāhala Water System from the Alili Tunnel and the Pāhala well. After the closure of the sugar plantation, the DWS also assumed management of the Wai'ōhinu-Nā'ālehu Water System which serves the communities of Wai'ōhinu, Nā'ālehu and South Point. This system depends primarily on the New Mountain House Tunnel Spring and Haao Spring for its water supply. Over 20 percent of the water drawn from the DWS system is used for agriculture.

The Department of Agriculture's Agribusiness Development Corporation (ADC) is actively working on getting a long-term agreement from DLNR to manage and improve various springs, tunnels and water infrastructure in Ka'ū Forest Reserve for agricultural uses. The ADC was established in 1994 to provide direction for the transition of Hawaii's agriculture industry from one dominated by sugar and pineapple to one composed of a diversity of crops. The mission of the ADC is to acquire and manage in partnership with farmers, ranchers and aquaculture groups high-value lands, water systems and infrastructure for commercial agriculture use for the economic, environmental, and social benefit of the people of Hawai'i. The ADC achieves its goals by facilitating the transition of agricultural infrastructure from plantation operations into other agricultural enterprises; by organizing farmers and users into cooperatives that benefit from participants' common interests and collective efforts; by conducting economic and feasibility studies relating to agriculture; and by providing leadership for the development, financing, improvement, and enhancement of agricultural enterprises. In Ka'ū, many users of springs and tunnels in Ka'ū Forest Reserve formed the Ka'ū Agricultural Water Cooperative (KAWC) in 2006 to work with the ADC on getting the

long-term agreement for the use of water and water infrastructure in Ka'ū Forest Reserve. The Ka'ū Forest Reserve Management Plan recognizes the established uses and planned upgrades to water infrastructure for agricultural and domestic systems. The ADC will be coordinating with DLNR to obtain a long-term agreement and implement practices that protect that values of the Forest Reserve and maintain consistency with the Management Plan.

**Figure 5. Ka'ū Forest Reserve Water Resources**



## **C. Land Use**

The Forest Reserve System was created by the Territorial Government of Hawai'i through Act 44 on April 25, 1903. With Hawaii's increase in population, expanding ranching industry, and extensive agricultural production of sugarcane and later pineapple, early territorial foresters recognized the need to protect mauka (upland) forests to provide the necessary water for the agriculture and surrounding communities.

DOFAW has management responsibility for the Ka'ū Forest Reserve, which is part of the State Forest Reserve System. Forest reserves provide recreational and hunting opportunities; aesthetic benefits; watershed restoration; native, threatened, and endangered species habitat protection and management; cultural resources; and fire protection, among many other things.

The Hawai'i State Constitution Article 11 states: "For the benefit of present and future generations, the State ... shall conserve and protect Hawaii's natural beauty and all natural resources, including land, water, air, minerals and energy sources, and shall promote the development and utilization of these resources in a manner consistent with their conservation and in furtherance of the self-sufficiency of the State. All public natural resources are held in trust by the State for the benefit of the people." The Forest Reserve System is managed under the guidance of the Hawai'i Revised Statutes (Chapter 183) and associated Hawai'i Administrative Rules (Chapter 104). Through these directives, DOFAW focuses its resources to protect, manage, restore, and monitor the natural resources of the Forest Reserve System, with the highest priority placed on watershed function and native ecosystem preservation, as applicable.

The public is generally welcome into any forest reserve provided it is not dangerous to human life or detrimental to public trust resources such as watershed. The Forest Reserve System accounts for over 642,000 acres of state managed land. Without continued management, these resources would disappear, jeopardizing Hawaii's fresh water supply for people, as well as contributing to the further loss of native ecosystems. Information on the Forest Reserve System can be found at:

<http://hawaii.gov/dlnr/dofaw/forestry/FRS>

### 1. Reserve History

The Ka'ū Forest Reserve was established by Governor's Proclamation on August 2, 1906 to protect the forest on the lower slopes of Mauna Loa. The Reserve was established because of its importance in maintaining the favorable conditions on which the water supply of the agricultural lands in the Ka'ū District depend (Hawaiian Forester and Agriculturist 1906).

In 1906, The Board of Commissioners of Agriculture and Forestry, on the basis of a report by Ralph S. Hosmer, Superintendent of Forestry, recommended to the Governor that a forest reserve be established in Ka'ū. Lands proposed for this Reserve had been

under a lease to Hawaiian Agricultural Company and Hutchinson Sugar Plantation Company and many of those leases were about to expire. The leases required protection of the forest, including fencing out cattle, and these companies installed 52 miles of fencing around the forest and developed a water supply with tunnels and ditches.

Although the sugar plantations had installed a system of irrigation, it was deemed the responsibility of the Territory to perpetuate the forest for the procurement of water. The Ka'ū Forest Reserve boundaries were drawn to exclude private land at Kahuku, grazing land at Kāpāpala and land considered important for agriculture along the lower Reserve boundary (Hawaiian Forester and Agriculturist 1906).

Ralph Hosmer, Hawaii's first Territorial Forester, noted the importance of the Ka'ū forest stating "perhaps nowhere in the Territory is there a finer example of the fern jungle, with its dense mass of tree and other high-growing species". Hosmer also noted that "since the forest fence was completed ten years ago [1896] a wonderful difference has been noticed in the appearance of the forest" (Hawaiian Forester and Agriculturist 1906).

Hosmer's report recommending the establishment of the Reserve discussed both the direct benefits to the plantation as well as indirect economic benefits to the Territory through taxation and agricultural activities. Most portions of the Reserve were recommended for protection, with no cattle grazing proposed and limited areas for growing trees for timber and fuel collection (Hawaiian Forester and Agriculturist 1906).

Hosmer summarized the locations and condition of existing fences to protect the forest in a 1912 report on the Reserve in DOFAW files. The report noted that the Hawaiian Agricultural company completed 35 miles of fencing to protect the eastern half of the Reserve in 1896, including fencing through the interior of the forest from Kahuku to Pu'u Enuhe. In 1903-1904, The Hutchinson Sugar Plantation Company constructed a fence, about 17 miles in length, around most of the western end of the Ka'ū Forest Reserve, connecting on the mauka side with the existing Hawaiian Agricultural Company's fence. Only some portions of the lower boundary of the Reserve were left unfenced, most being protected by cane field and other fences.

Various parcels have been added and withdrawn from the Reserve since its establishment (summarized in Appendix A). The Board of Land and Natural Resources has approved the addition of two additional parcels, Kamilo and Kāpāpala Canoe area, which will be added to the Ka'ū Forest Reserve sometime in the next decade, following survey and subdivision. As written, this plan does not apply to those areas; once they are added, the management plan will be revised to address them.

DOFAW lands in the vicinity of Ka'ū Forest Reserve include the Kiolaka'a Ranger Station, which was originally turned over to the Board of Land and Natural Resources for a nursery, arboretum and ranger station in 1929. DOFAW staff currently use the Kiolaka'a Ranger Station to house staff and volunteers working in the area. DOFAW

also owns a cabin situated on NPS lands in upper Kahuku, which DOFAW staff use when working in the upper elevations of Ka'ū Forest Reserve.

## 2. Surrounding Communities

The Ka'ū District is rural and historically isolated. However, the population has grown substantially over the past 40 years. According to the 2010 U.S. Census, the Ka'ū District experienced a 45% increase in population growth from 5,827 individuals to 8,451 between 2000 and 2010. Increases in population growth during this time were primarily due to 103.7% population growth in the Hawaiian Ocean View area. Pāhala and Nā'ālehu both experienced negative population growth during this same time period (-5.8% and -1.6% respectively). The overall growth rate for the island was 24.5% (U.S. Census 2010).

There are few economic resources in the Ka'ū District. Commercial centers are located in Pāhala, Nā'ālehu, Wai'ōhinu, and Ocean View. Development in the area includes residential, small retail commercial centers, and family-owned or commercial farms. Major government facilities include schools, a police facility and a hospital. The median household income in 2000 was \$29,000. In 1999, 23.9 percent of the Ka'ū population was below the poverty level. Typically, residents live on fixed incomes or are young families and desire a rural lifestyle. The median age in Nā'ālehu is 36.5 yrs and in Ocean View is 44.3 (U.S. Census Bureau).

The primary economic resources in Ka'ū currently are macadamia nut farms, schools, medical services, cattle ranching, and construction. Agriculture is the region's main economic base and the Hawai'i Department of Agriculture classifies sections of land in the Wai'ōhinu, Nā'ālehu, and Pāhala area as Prime Agricultural Land. Sugarcane production dominated the economy between 1868 and 1996, when the last mill closed in Pāhala. Large tracts of plantation land were sold, and many of these lands are now owned or leased for agriculture or cattle ranching. Major crops include macadamia nuts, vegetables, citrus fruits, coffee, and ornamental flowers. There are several active cattle ranches in the region (County of Hawai'i 2005). The macadamia nut industry is one of the most prominent in the district with Mac Farms of Hawai'i in Nā'ālehu being the largest employer in the area. Residents also commute to the labor markets in Hilo, Kona, and the Kohala coast. Tourism is a growth industry in the region with its proximity to Hawai'i Volcanoes National Park (Ka'ū to South Kona Water Master Plan 2004).

The Ka'ū Listening Project, conducted in response to community concerns about large-scale resort development proposed for the area, found that residents generally believe that economic development needs to be balanced with conservation of the environment and the local community. This study also found that the subsistence economy of fishing, gathering, hunting, and gardening remains important today for many families (Kent 2007).

It is unknown how many people use the Reserve for hunting or gathering. Hunter use data is not available as there are no hunter check stations for Ka'ū Forest Reserve. There were approximately 139 licensed hunters in the Ka'ū District in 2010 out of 3,265 licensed hunters on Hawai'i island, approximately 1.6% of the population of the Ka'ū District (DOFAW internal data). However, additional residents that are not registered as licensed hunters may also be hunting in the Forest Reserve. DOFAW has no records of any permits issued for gathering of forest resources in the Reserve. It may be inconvenient for residents to obtain permits because they are issued through the DOFAW office in Hilo.

### 3. Regional Partnerships

The Ka'ū Forest Reserve is part of the TMA, a voluntary public-private watershed partnership of landowners and agencies with a management interest in the landscape and a goal to coordinate conservation management on a landscape level. The overall management goal of the TMA is to sustain the multiple ecosystem benefits, provided by the three mountains of Kīlauea, Mauna Loa, and Hualālai, by responsibly managing its watershed areas, native habitat and species, historical, cultural, and socio-economic resources for all who benefit from the continued health of the three mountains. TMA lands in the vicinity of Ka'ū Forest Reserve are shown in Figure 1.

TMA lands include the 116,000 ac (46,944 ha) Kahuku section of Hawai'i Volcanoes National Park, which was formerly used as a ranch and was then sold by Damon Estate to the park in 2003 (Figure 1). NPS is currently developing a General Management Plan (GMP) for the park, which will provide a framework to use in making decisions about how to protect resources, what levels and types of uses are appropriate, what facilities should be developed, and how people should access the park. Other ongoing resource management actions at Kahuku include replacing the boundary fence with Ka'ū Forest Reserve, removing feral ungulates, reforestation of pasture and non-native invasive plant control (NPS 2011; Rhonda Loh personal communication). NPS management of Kahuku provides new opportunities for cooperative management with adjacent DOFAW lands in Ka'ū (e.g. public access to the Reserve through Kahuku, recreational opportunities, fire protection, invasive species control etc).

TNC purchased the 3,511 ac (1,421 ha) Ka'ū Preserve in 2002 to protect biologically rich and intact native forest found there. TNC's Ka'ū Preserve consists of four separate sections that are adjacent to the Ka'ū Forest Reserve (Figure 1). The TNC Ka'ū Preserve is included in the state's Natural Area Partnerships Program, which provides state-matching funds on a 2:1 basis with private funds for the management of natural resources on private lands permanently dedicated to conservation. TNC has constructed a fence around a 1,200 ac (486 ha) portion of the preserve at Kaiholena and removed feral ungulates from within the fenced unit. Other management activities include: non-native invasive plant control and education and outreach. TNC has also worked to enhance public hunting in the Ka'ū Forest Reserve by coordinating access through the TNC preserve, maintaining roads and providing fence step-overs.

KS lands include two parcels of approximately 2,883 ac (1,167 ha) of conservation land (Figure 1). KS seeks to *mālama i ka ʻāina*: practice ethical, prudent and culturally appropriate stewardship of lands and resources (KS 2000-2015 Strategic Plan). KS intends to integrate Hawaiian cultural values and knowledge into resource stewardship practices, incorporate ahupuaʻa management principles, and promote a broad understanding of stewardship efforts and, as appropriate, cultural resource management programs.

#### 4. Related Land Use Planning Efforts

There are numerous completed and ongoing planning efforts that may have implications for the management of the Kaʻū Forest Reserve (Table 3). These include plans for adjacent conservation areas as well as plans that may identify goals, objectives and proposed actions for the management of various resources in Kaʻū Forest Reserve.

**Table 3. Related Plans and Cooperative Efforts.**

| Plan/Cooperative Effort   | Description   |
|---|---|
| Ka'ū Community Development Plan (CDP) - Under Development<br><a href="http://www.hawaiicountycdp.info/kau-cdp">http://www.hawaiicountycdp.info/kau-cdp</a>  | The CDP was mandated by the Hawai'i County General Plan to translate goals, objectives, and policies into implementation actions as they apply to specific geographical areas. CDP's are "intended to be a forum for community input into managing growth and coordinating the delivery of government services."  |
| Hawai'i Volcanoes National Park General Management Plan (GMP) - Under Development (Draft scheduled to be completed in 2012-2013)<br><a href="http://www.nps.gov/havo/parkmgmt/gmp.htm">http://www.nps.gov/havo/parkmgmt/gmp.htm</a>   | A GMP is the broadest level of planning for the future management of national parks. The GMP will describe the general path for managing Hawai'i Volcanoes National Park over the next 15 to 20 years. Alternatives will be developed and analyzed before a preferred direction is selected. The Draft GMP is scheduled to be finalized in 2014.  |
| DOFAW Statewide Assessment and Resource Strategy (SWARS) 2010<br><a href="http://www.hawaiistateassessment.info/SWARS/">http://www.hawaiistateassessment.info/SWARS/</a>  | Identifies areas of greatest need/opportunity for forests in Hawai'i and develops a long-term strategy. Objectives include: 1.1. Identify and conserve high-priority forest ecosystems; 2.2. Identify, manage and reduce threats to forest and ecosystem health; 3. 3. Enhance public benefits from trees and forests; 3.1. Protect and enhance water quality and quantity; 3.5. Protect, conserve and enhance wildlife and fish habitat; 3.7. Manage and restore forests to mitigate and adapt to global climate change. |
| Three Mountain Alliance (TMA) Management Plan (2008) and TMA Weed Management Plan (2009)<br><a href="http://hawp.org/library/documents/three-mountain-alliance/tma%20mgmt%20plan.final.2.pdf">http://hawp.org/library/documents/three-mountain-alliance/tma%20mgmt%20plan.final.2.pdf</a>   | TMA watershed partnership and TMA weed management plans identify the importance of natural resources in Ka'ū Forest Reserve and propose management activities.  |
| TNC Ka'ū Preserve Long Range Management Plan: Fiscal Years 2006-2018 (2012) and Final Environmental Assessment<br><a href="http://oegc.doh.hawaii.gov/Shared%20Documents/E A and EIS Online Library/Hawaii/2000s/2006-09-23-HA-FEA-KAU-PRESERVE-NATURAL-AREA-PARTNERSHIP.pdf">http://oegc.doh.hawaii.gov/Shared%20Documents/E A and EIS Online Library/Hawaii/2000s/2006-09-23-HA-FEA-KAU-PRESERVE-NATURAL-AREA-PARTNERSHIP.pdf</a> | This plan documents long-range goals and strategies for TNC's Ka'ū Preserve including the following activities: ungulate control, invasive plant control, resource monitoring, rare species protection and research, community outreach, and watershed partnership.<br><br>TNC is currently preparing an updated plan to cover Fiscal years 2013 - 2018.  |
| Hawai'i Comprehensive Wildlife Conservation Strategy (2005)<br><a href="http://www.state.hi.us/dlnr/dofaw/cwcs/index.html">http://www.state.hi.us/dlnr/dofaw/cwcs/index.html</a>  | Identifies species of greatest conservation need and their affiliated habitats. It includes strategies for addressing those needs and the conservation of the diversity of wildlife species. Ka'u Forest Reserve is identified as a priority area for the enhanced conservation management for the long-term conservation of native wildlife  |
| County of Hawai'i General Plan (2005)<br><a href="http://www.co.hawaii.hi.us/la/gp/2005/main.html">http://www.co.hawaii.hi.us/la/gp/2005/main.html</a>  | 8.2(c) Protect/promote the prudent use of Hawaii's unique, fragile, and significant environmental and natural resources. 8.2 (d) Protect rare or endangered species and habitats native to Hawai'i. 8.3 (b) Encourage collection/dissemination of basic data concerning natural resources. 8.3 (e) Encourage an overall conservation ethic in the use of Hawai'i resources by protecting, preserving, and conserving the critical and significant natural resources of the County.  |

## **D. Forest Ecosystems**

### 1. Native Forest Communities

The Ka'ū Forest Reserve is one of the largest native forests remaining in the Hawaiian Islands. The forests of the Reserve currently consist almost entirely of native ecosystems. According to DOFAW's Draft Management Guidelines, most of the Reserve falls into highest quality native ecosystem vegetation classification, with minimal disturbance and low levels (less than 10%) of non-native plants (State of Hawai'i 2001). Also, TNC's Ecoregional Plan rates the condition of most of the Reserve as good or very good with regard to their overall ecosystem viability ranking (TNC 2006b).

Although much of the native forest upper canopy (large trees) is intact, DOFAW and TMA staff has observed serious degradation of large portions of the Reserve from feral ungulates and non-native weeds, threatening the long-term survival of high quality native forest. Upper elevation portions of the Reserve have widespread disturbance from feral ungulates resulting in a ground layer with exposed soil and leaf litter instead of native ferns, small plants and tree seedlings. These openings in the forest floor enhance erosion as soil washes away during storms. Large upper canopy trees may not be replaced as they die due to lack of regeneration of younger generations of native trees in the middle and lower forest layers. Lower portions of the Reserve have severe infestations of weeds that are spreading into the middle and upper areas of the Reserve due to openings in the forest created by feral ungulates. The long-term survival of the forest is threatened by the gradual disappearance of the native trees and plants and conversion to non-native weedy species. Management is needed to address these threats, slow the decline of this unique forest ecosystem and restore areas that have been severely impacted.

There are five major native-dominated natural communities in the Ka'ū Forest Reserve (Figure 7) (UH 2005; Jacobi 1989; Price unpublished data). The wet forest types typically receive > 75 in (1900 mm) average annual precipitation while the mesic forest types receive 50 - 75 in (1300 - 1900 mm).

- (1) Wet 'Ōhi'a Forest
- (2) Wet Koa Forest
- (3) Mesic Koa Forest
- (4) Mesic 'Ōhi'a Forest
- (5) Montane and Subalpine Shrubland and Woodland

**Wet 'Ōhi'a Forest** is one of the most widespread wet forest types in the Hawaiian islands and covers a large portion of the the southwest portion of the Reserve in both lowland and montane areas. This forest type is generally dominated by 'ōhi'a, with a dense hāpu'u (*Cibotium* spp.) tree fern layer. Some areas, particularly steep slopes contain more open/stunted 'ōhi'a forest with an uluhe (*Dicranopteris linearis*) understory. An 'ōhi'a-dominated forest belt with more open canopy and shrub layer of kanawao

(*Broussaisia arguta*) occurs between 5,315 ft (1,620 m) and 5,724 ft (1,740 m) (Jacobi and Price 2007). This community type contains many rare and endangered plants, birds and invertebrates.

**Wet Koa Forest** occurs in the center of the Reserve and extends to the northeast. 'Ōhi'a and koa (*Acacia koa*) form the canopy with subcanopy layers rich in endemic trees, shrubs, sedges, and ferns such as 'ōlapa (*Cheirodendron trigynum*), kāwa'u (*Ilex anomala*), kōlea (*Myrsine lessertiana*), pilo (*Coprosma* spp.), manono (*Hedyotis terminalis*), and ālani (*Melicope* spp.). Native ferns, shrubs, and sedges such as 'uki (*Carex alligata*) are found beneath the hāpu'u layer. This forest type has older substrates than elsewhere in the area and supports many native forest birds and invertebrates (TNC 2006b, Jacobi and Price 2007).

**Mesic Koa Forest** is found at the highest elevation in the northeast and into the Kapāpala Forest Reserve. This forest type has a good representation of 'ōhi'a and koa forming the canopy layer, with native trees forming the subcanopy layer. Hāpu'u tree ferns typical of wet forests are scarce or lacking. In addition, plants more characteristic of drier areas, such as manena (*Melicope hawaiiensis*), 'aiea (*Nothocestrum breviflorum*), and pūkiawe (*Styphyelia tameiameia*) may be present. Where it has not been greatly disturbed, the ground cover is dominated by native ferns, often including large laukahi (*Dryopteris wallichiana*). The groundcover in portions of this forest is dominated by non-native grasses, primarily meadow ricegrass, which is not considered a habitat modifying weed in this area. A number of rare plants, including members of *Clermontia*, *Cyanea*, *Phyllostegia*, and *Stenogyne* occur here (TNC 2006b). This community provides important habitat for forest birds as well as specialized plants and animals such as 'Alalā (TMA 2007).

**Mesic 'Ōhi'a Forest** occurs near the upper Reserve boundary. This community is a transitional vegetation type between wet and mesic montane habitats and drier subalpine shrublands (Hawai'i Natural Heritage Program 1995). This forest type is dominated by an 'ohi'a canopy with native trees and shrubs in the subcanopy. Similarly to mesic koa forests described above, there is a lack of large tree ferns and a ground cover of native ferns.

**Montane and Subalpine Shrubland and Woodland** occurs at the upper boundary of the Reserve and into Kahuku at the drier upper elevations. This forest type is generally more open canopy with scattered, shorter stature native trees and shrubs. Native grasses such as *Deschampsia nubigena* are found in the understory. This area also contains younger lava flows with less well-developed forests.

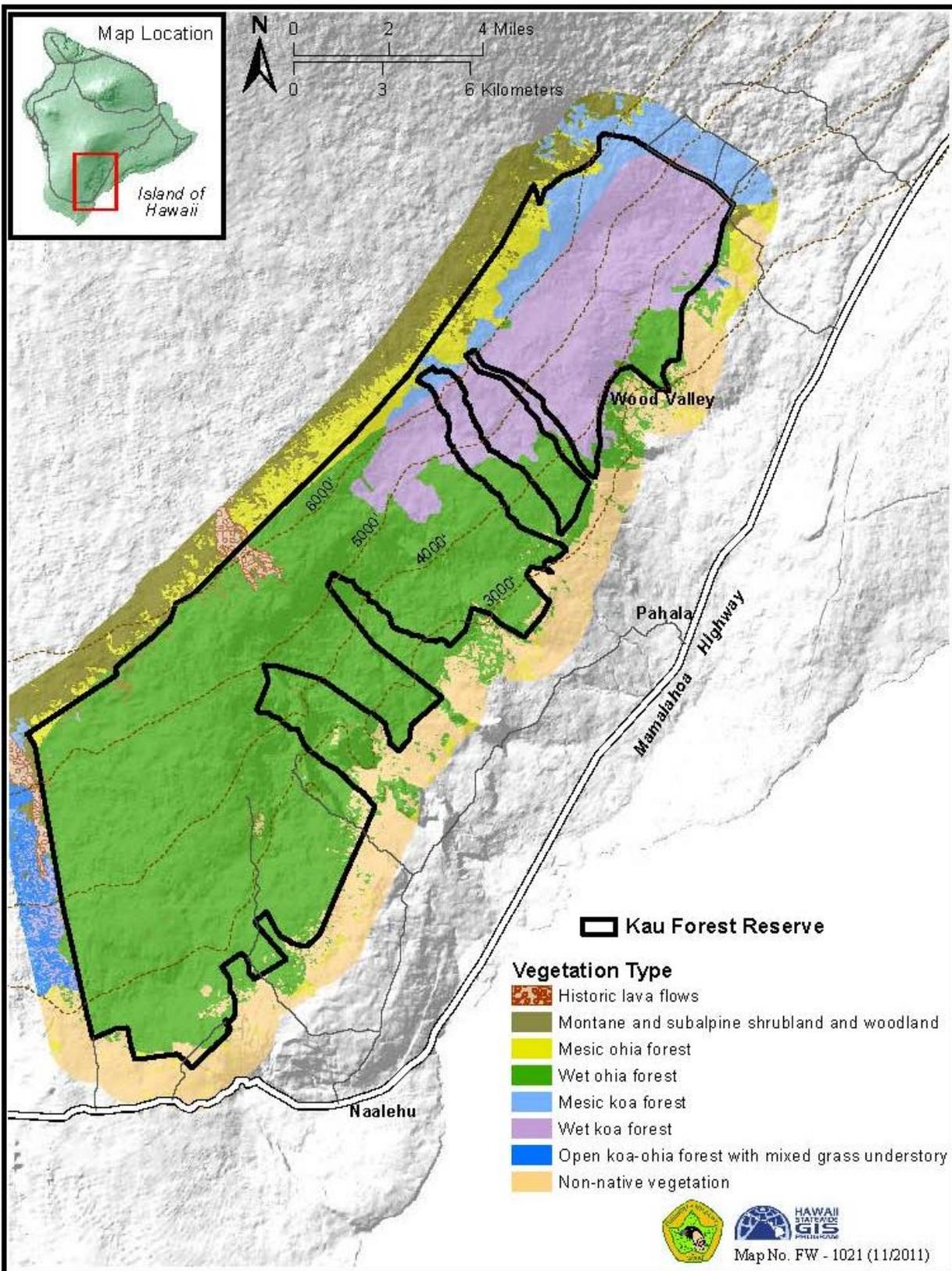
**Open Koa-'Ōhi'a Forest with a Mixed Grass Understory** is present adjacent to the Reserve, at Kahuku. Long-term use of these lands as pasture has resulted in open forest and with a non-native grass understory.

**Non-Native Vegetation** occurs just outside of the Reserve. The agricultural land along the lower boundary of the Reserve, adjacent to the forest, was cleared for sugar cane

production and is now mainly used for pasture. Serious infestations of habitat-modifying invasive weeds including strawberry guava (*Psidium cattleianum*), Koster's curse (*Clidemia hirta*) and night-blooming jasmine (*Cestrum nocturnum*) occur along the lower forest edge and into some sections of the lower Reserve.

In addition to the communities described above, intermittent streams provide habitat for aquatic insects and other stream-associated organisms. Lava tubes and caves are associated with pāhoehoe lava flows and most likely contain subterranean invertebrate communities, especially in forested portions of the area (Hawai'i Natural Heritage Program 1995).

**Figure 7. Vegetation Communities of Ka'ū Forest Reserve**



## 2. Native Flora

The mesic and wet forest ecosystems in the southeast portion of Mauna Loa (eastern side of the Southwest Rift Zone) support 153 endemic plant species and provide habitat for at least 32 known species of rare plants (Table 5). These species are known currently or historically from the Reserve or adjacent areas. Fourteen of these are listed as endangered by the U.S. Fish and Wildlife Service.

The U.S. Endangered Species Act defines Critical Habitat as areas that may or may not be occupied by a threatened or endangered species, but are essential to the conservation of the species. These areas may require special management considerations or protection (16 U.S.C. § 1532 (5)). The Reserve is Critical Habitat for three species of Hawaiian plants: *Phyllostegia velutina*, *Cyanea stictophylla*, and *Melicope zahlbruckneri* (U.S. Fish and Wildlife 2003) (Table 5, Figure 8).

**Table 5. Rare Plants found in or near Ka‘ū Forest Reserve**

| Species   | Common Name           | Federal Status* | Critical Habitat |
|---|-----------------------|-----------------|------------------|
| <i>Argyroxiphum kauense</i>                     | Mauna Loa silversword | LE              |                  |
| <i>Asplenium peruvianum</i> var <i>insulare</i> |                       | LE              |                  |
| <i>Asplenium schizophyllum</i>                  |                       | -               |                  |
| <i>Clermontia lindseyana</i>                    | ‘oha wai              | LE              |                  |
| <i>Cyrtandra menziesii</i>                      |                       | SOC             |                  |
| <i>Cyanea platyphylla</i>                       | ‘āku‘āku              | LE              |                  |
| <i>Cyanea shipmanii</i>                         | hāhā                  | LE              |                  |
| <i>Cyanea stictophylla</i>                      | hāhā                  | LE              | X                |
| <i>Cyanea tritomantha</i>                       |                       | C               |                  |
| <i>Eurya sandwicensis</i>                       |                       | SOC             |                  |
| <i>Fragaria chiloensis</i>                      | ‘ōhelo papa           | SOC             |                  |
| <i>Lobelia hypoleuca</i>                        |                       | -               |                  |
| <i>Marattia douglasii</i>                       | pala, kapua‘ilio      | -               |                  |
| <i>Melicope zahlbruckneri</i>                   |                       | LE              | X                |
| <i>Neraudia ovata</i>                           |                       | LE              |                  |
| <i>Nothocestrum breviflorum</i>                 |                       | LE              |                  |
| <i>Pittosporum hawaiiense</i>                   |                       | SOC             |                  |
| <i>Phyllostegia ambigua</i>                     |                       | SOC             |                  |
| <i>Phyllostegia floribunda</i>                  |                       | C               |                  |
| <i>Phyllostegia velutina</i>                    |                       | LE              | X                |
| <i>Phyllostegia vestita</i>                     |                       | -               |                  |
| <i>Plantago hawaiiensis</i>                     |                       | LE              |                  |
| <i>Pritchardia lanigera</i>                     | loulu                 | SOC             |                  |
| <i>Ranunculus hawaiiensis</i>                   | makou                 | C               |                  |
| <i>Rubus macraei</i>                            |                       | SOC             |                  |
| <i>Sanicula sandwicensis</i>                    |                       | SOC             |                  |

|                               |              |     |  |
|-------------------------------|--------------|-----|--|
| <i>Silene hawaiiensis</i>     |              | LE  |  |
| <i>Sisyrinchium acre</i>      | mau'u lā'ili | SOC |  |
| <i>Stenogyne angustifolia</i> |              | LE  |  |
| <i>Strongylodon ruber</i>     | nuku 'i'iwi  | SOC |  |
| <i>Trematolobelia wimmeri</i> | koli'i       | SOC |  |
| <i>Vicia menziesii</i>        |              | LE  |  |

\* Key to Federal Status:

Listed Endangered (LE) = Taxa listed as endangered.

Candidate (C) = Taxa for which substantial information on biological vulnerability and threat(s) support proposals to list them as threatened or endangered.

Species of Concern (SOC) = Taxa for which available information meets the criteria for concern and the possibility to recommend as candidate.

## **E. Wildlife**

Ka`ū Forest Reserve contains a variety of wildlife resources including both endemic species of birds and invertebrates as well as the 'Ōpe'ape'a, or the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*). Non-native species include birds, mammals and invertebrates.

The Hawai'i Comprehensive Wildlife Conservation Strategy identifies the Reserve as a priority area for management for the long-term conservation of native wildlife on the island of Hawai'i. The area is a priority because it is one of the most diverse and intact forests on the island with high densities of common and rare forest birds and great potential habitat for restoration of some endangered forest bird populations. Lower portions of the Reserve harbor a diverse native insect fauna. As part of a broader landscape that includes Kapāpala Forest Reserve and Hawai'i Volcanoes National Park, the Reserve provides a range of elevations and rainfall that would allow wildlife populations to move in response to changing climate or weather conditions (Mitchell *et al.* 2005). Ka'ū Forest Reserve has also been identified as an important bird area by the National Audubon Society (National Audubon Society 2011).

### 1. Native Wildlife

#### *Birds*

The Ka'ū Forest Reserve is very important for the survival and recovery of native Hawaiian forest birds because it contains large tracts of upper elevation native forest. The Reserve provides habitat for eight native forest birds including five of the six birds that are endemic to Hawai'i Island, four of which are federally endangered. An additional five endemic or indigenous species likely use small areas of the Reserve (Table 6). In addition to supporting a diverse avifauna, the area provides habitat for the second largest concentration of native birds on Hawai'i Island and some of the highest densities in the State (Gorresen *et al.* 2007).

Populations of native Hawaiian forest birds in the Reserve and across the state have declined due to habitat loss and the ecological impacts of introduced species (threats are discussed in more detail in Section J. of this plan). Of the 46 historically known

forest bird species in Hawai'i, only 24 species still survive, and of these 13 species are listed as endangered. Ten species of endemic Hawaiian birds have likely gone extinct over the past 25 years - an average of one extinction every two years (Pratt *et al.* 2009).

The Reserve provides habitat for six honeycreepers (Subfamily Drepanidinae) endemic to the Hawaiian Islands (occur nowhere else in the world). These include three federally listed endangered species: 'Akiapōlā'au (*Hemignathus munroi*), Hawai'i Creeper (*Oreomystis mana*), and Hawai'i 'Ākepa (*Loxops coccineus*). The non-endangered honeycreepers found in the area include: Hawai'i 'Amakihi (*Hemignathus virens*), 'I'iwi (*Vestiaria coccinea*) and 'Apapane (*Himatione sanguinea*). Other native birds reported from the project area include the federally endangered 'Io or Hawaiian Hawk (*Buteo solitarius*), the Hawai'i 'Elepaio (*Chasiempis sandwichensis*), and the 'Ōma'o or Hawaiian thrush (*Myadestes obscurus*).

Native forest birds are primarily found in the upper elevations (above 4,000 ft (1,219 m)) where colder temperatures minimize the number of mosquitoes and limit avian malaria, a non-native disease carried by mosquitoes. The distributions of 'Akiapōlā'au, Hawai'i Creeper, and Hawai'i 'Ākepa within the Reserve are even more narrowly restricted to a narrow band of forest and adjacent woodland above 5,000 ft (1,524 m) (Figures 8-10). These species have been extirpated from habitat below this elevation at least since 1976 due to the prevalence of mosquito-borne avian malaria (Scott *et al.* 1986). Figures 8 - 10 show the observed density (bird counts are the number of individuals detected along monitoring transects) and ranges of these endangered species in Ka'ū Forest Reserve. Lower elevations are not generally habitat for endangered forest birds on Hawai'i Island due to the presence of mosquitoes but may be important for native forest birds that have developed resistance to avian malaria (Pratt *et al.* 2009).

The Akiapōlā'au, the rarest of the honeycreepers in the Reserve, forage preferentially on koa, but nest almost exclusively in 'ōhi'a. This species is concentrated in the northeastern portion of the Reserve, which supports a large percentage (approximately 56%) of the species' total population (Tweed *et al.* 2007, Table 7). Hawai'i Creeper and Hawai'i 'Ākepa densities are highest in mature 'ōhi'a and koa-'ōhi'a forests in the upper central portion of the Reserve and these two species have a larger distribution and population compared to the Akiapōlā'au. Populations of these three species in the Reserve are separated from other populations on Hawai'i Island. The 'Io, 'Ōma'o, and the other three honeycreeper species are broadly distributed across the Reserve, although the 'I'iwi is restricted to habitats mostly above 5,000 ft (1,524 m) in elevation.

The endemic Nēnē or Hawaiian Goose (*Branta sandvicensis*), 'Ua'u or Hawaiian Petrel (*Pterodroma sandwichensis*) as well as the indigenous 'Akē'akē or Band-Rumped Storm-Petrel (*Oceanodroma castro*), Kōlea or Pacific Golden Plover (*Pluvialis fulva*) and Pueo or Short-eared Owl (*Asio flammeus sandwichensis*) may use small portions of the Reserve; the importance of the Reserve to these species is unknown or low.

Finally, in recent years (1970's) the Ka'ū Forest Reserve also supported the 'Alalā or Hawaiian Crow (*Corvus hawaiiensis*). The 'Alalā is listed as endangered and the

species is extinct in the wild. The entire population, approximately 95 birds, is housed in two captive breeding facilities, making the 'Alalā one of the rarest birds in existence. Known from the island of Hawai'i (and from fossils on the island of Maui), the 'Alalā was restricted to the dry and mesic forests in the western and southern portions of the island. The species was associated with 'ōhi'a and 'ōhi'a-koa forests with an understory of native fruit-bearing trees and shrubs. This understory is essential to the survival the 'Alalā in the wild, providing food as well as cover from natural predators such as 'Io. Threats to wild 'Alalā include predation by non-native mammals, non-native diseases (avian malaria and toxoplasmosis), habitat degradation, fragmentation, and loss, and direct human impacts (e.g. shooting and harassment).

Although they are insulated from these threats in captivity, their small population size makes them vulnerable to inbreeding problems, which has resulted in genetic-related egg and chick death as well as to demographic problems (e.g. uneven sex ratio). Recently, this problem has been minimized and production of young in captivity has dramatically increased during the last three years. In addition, unpredictable environmental events such as hurricanes, droughts and volcanic activity will further complicate the restoration of this species to the wild. All of these threats will challenge the species for many years post-release.

The current captive population of 'Alalā is at the point where restoration of a wild population can proceed. Several potential release sites have been identified in the Ka'ū Forest Reserve and elsewhere. The Reserve is a high priority site to restore this wide ranging species to the wild due to the large size and elevational range of the forest, as well as the fact that the area recently supported 'Alalā. The restoration of a wild population of 'Alalā will require minimizing threats, including predator control, and protecting significant areas of forest protected from ungulates. In addition to the restoring 'Alalā, these efforts will benefit the watershed resources of the Reserve as well as native plants, invertebrates, and other birds. Restoring the 'Alalā to the wild will require human assistance, including providing supplemental food, a semi-permanent infrastructure and a constant, long-term human presence. Planning for initial releases is underway, although, the Reserve may not be the first release site.

**Table 6. Native Birds with Habitat in Ka'ū Forest Reserve.**

| Species                              | Scientific Name                    | Island Distribution | Federal Status* | State Status* |
|--------------------------------------|------------------------------------|---------------------|-----------------|---------------|
| Nēnē or Hawaiian Goose               | <i>Branta sandvicensis</i>         | H, K, M, Mo         | LE              | LE            |
| 'Ua'u or Hawaiian Petrel             | <i>Pterodroma sandwichensis</i>    | H, L, K, M          | T               | LE            |
| `Akē`akē or Band-rumped Storm Petrel | <i>Oceanodroma castro</i>          | H, K                | C               | LE            |
| Kōlea or Pacific Golden Plover       | <i>Pluvialis fulva</i>             | Throughout Hawai'i  | MBTA            | Indigenous    |
| 'Io or Hawaiian Hawk                 | <i>Buteo solitarius</i>            | H                   | LE              | LE            |
| Pueo or Hawaiian Short-eared Owl     | <i>Asio flammeus sandwichensis</i> | Throughout Hawai'i  | MBTA            | Endemic       |
| Ālalā or Hawaiian Crow               | <i>Corvus hawaiiensis</i>          | Captivity           | LE              | LE            |
| Hawai'i 'Elepaio                     | <i>Chasiempis sandwichensis</i>    | H                   | -               | Endemic       |
| 'Ōma'o                               | <i>Myadestes obscurus</i>          | H                   | MBTA            | Endemic       |
| Hawai'i 'Amakihi                     | <i>Hemignathus virens</i>          | H, M, Mo            | MBTA            | Endemic       |
| 'Akiapōlā'au                         | <i>Hemignathus munroi</i>          | H                   | LE              | LE            |
| Hawai'i Creeper                      | <i>Oreomystis mana</i>             | H                   | LE              | LE            |
| Hawai'i 'Ākepa                       | <i>Loxops coccineus</i>            | H                   | LE              | LE            |
| 'I'iwi                               | <i>Vestiaria coccinea</i>          | H, K, O, M, Mo      | MBTA**          | Endemic       |
| 'Apapane                             | <i>Himatione sanguinea</i>         | Throughout Hawai'i  | MBTA            | Endemic       |

\* Key to Federal and State Status:

Listed Endangered (LE) = Taxa listed as endangered.

Threatened (T) - Taxa listed as threatened

Candidate (C) = Taxa for which substantial information on biological vulnerability and threat(s) support proposals to list them as threatened or endangered.

Migratory Bird Treaty Act (MBTA) = It is illegal to harass or kill birds listed under the MBTA

Endemic and Indigenous species are protected under Hawai'i Revised Statutes 183D and 195D

\*\* USFWS is reviewing the status of this species and will decide within a year whether it should be LE.

**Table 7. Estimated Population Status of Endangered Forest Birds in Ka'ū Forest Reserve (Gorresen et al. 2007)**

| Species         | Total Population | Ka'ū Population       |
|-----------------|------------------|-----------------------|
| Ālalā           | ~95              | 0                     |
| 'Akiapōlā'au    | 1,900            | 1,073 (616 - 1,869)   |
| Hawai'i Creeper | 14,000           | 2,268 (1,159 - 4,438) |
| Hawai'i 'Ākepa  | 12,000           | 2,556 (1,340 - 4,876) |

Figure 8. Hawai'i 'Ākepa - Observed Density in Ka'ū Forest Reserve

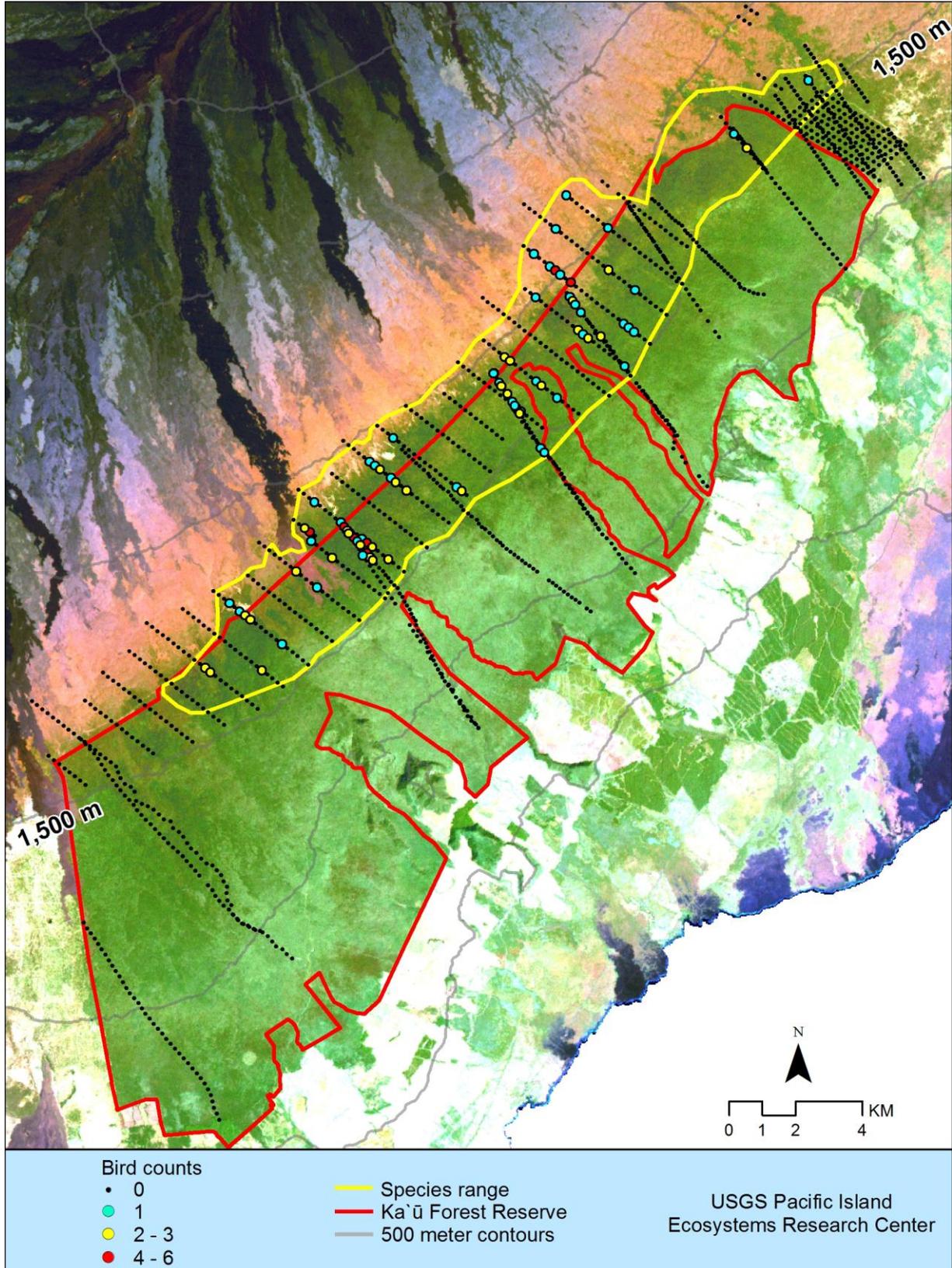


Figure 9. Hawai'i Creeper - Observed Density in Ka'ū Forest Reserve

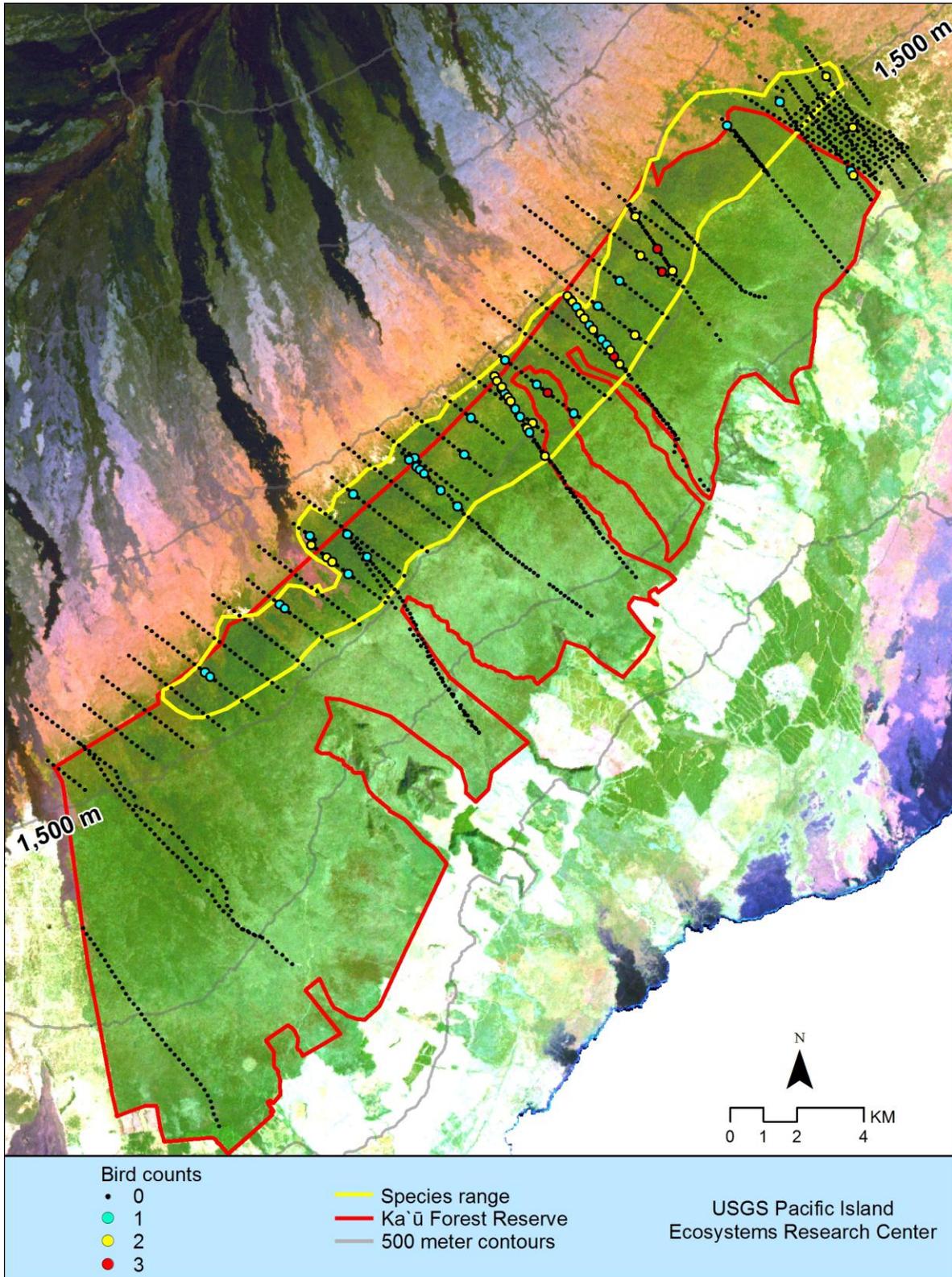


Figure 10. 'Akiapōlā'au - Observed Density in Ka'ū Forest Reserve

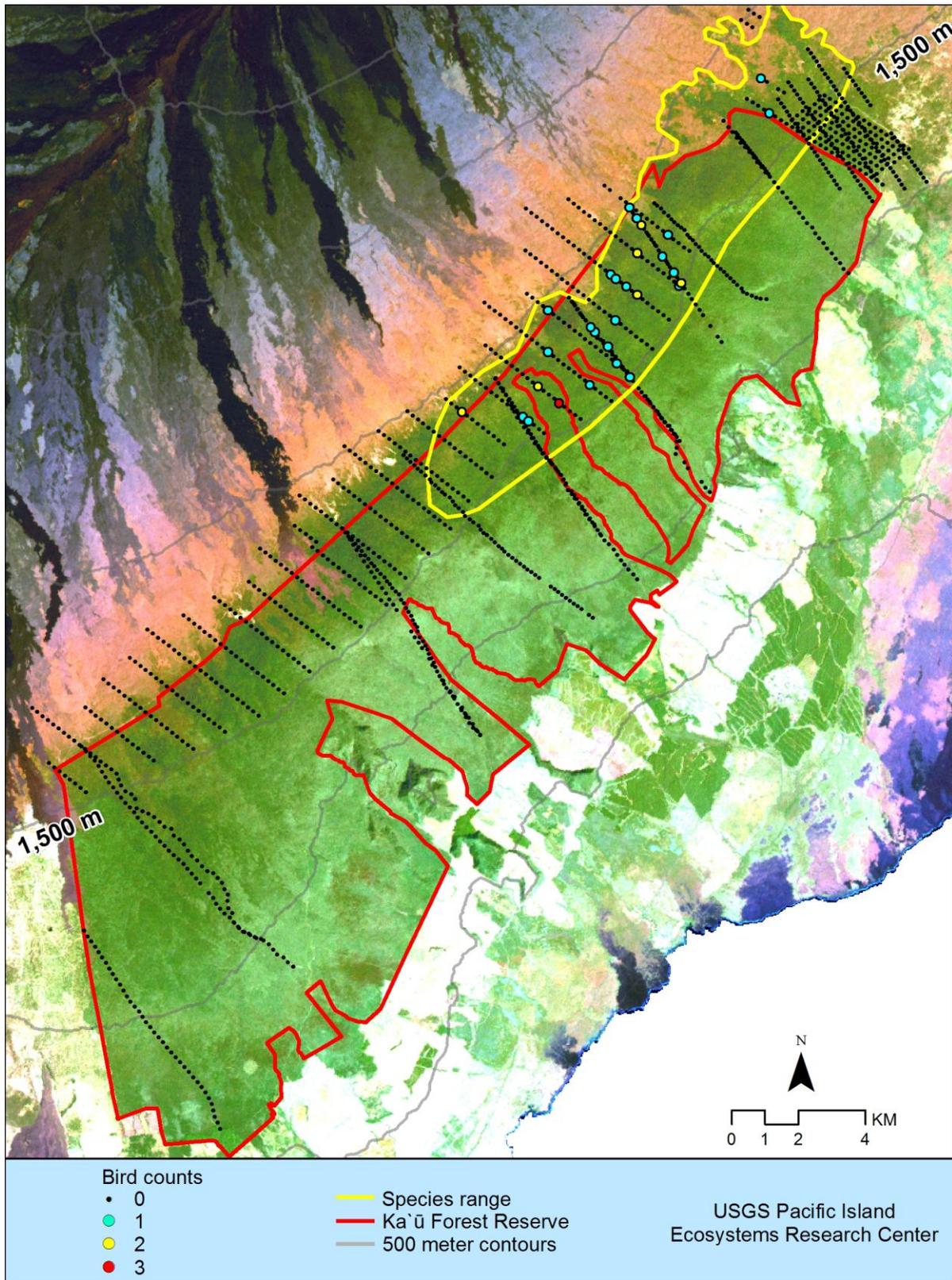
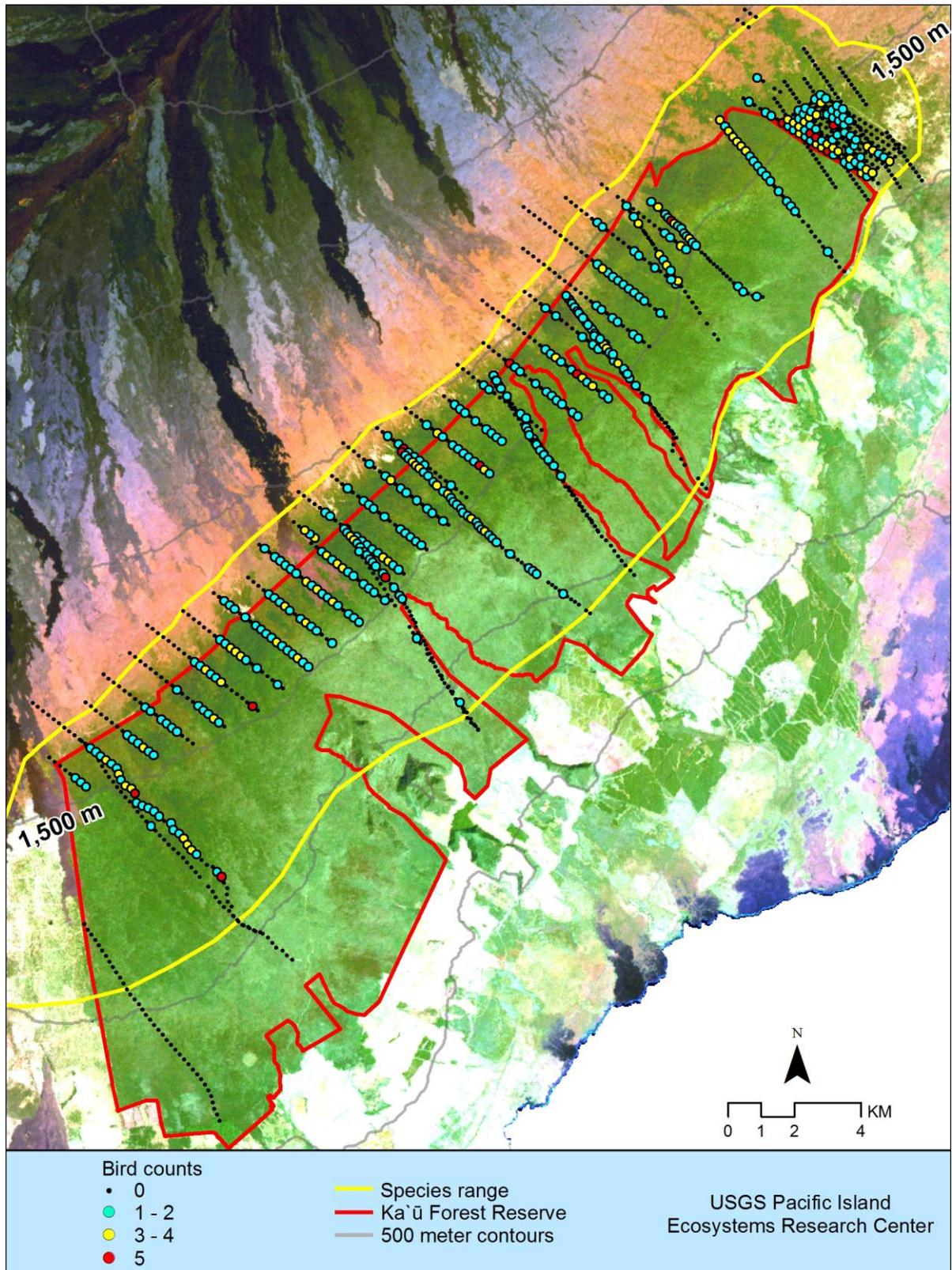


Figure 11. 'I'iwi - Observed Density in Ka'ū Forest Reserve



## *Mammals*

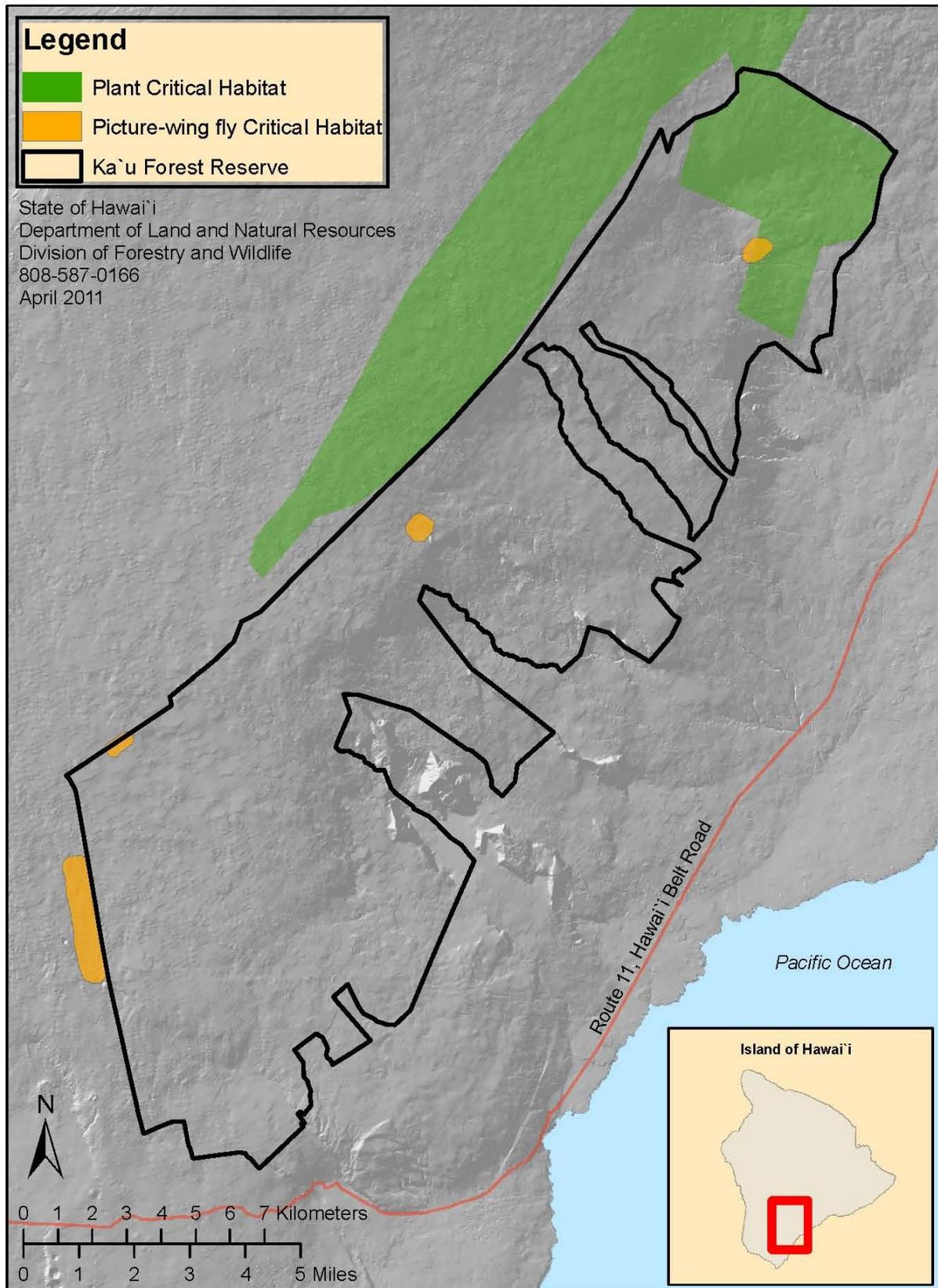
The 'Ōpe'ape'a, or the Hawaiian Hoary Bat (*Lasiurus cinereus semotus*), is the only endemic terrestrial mammal in Hawai'i (Hawai'i Natural Heritage Program 1995). The 'Ōpe'ape'a is listed as endangered under the U.S. Endangered Species Act. Recent surveys of TNC lands below the Reserve at Kaiholena and on NPS lands at Kahuku have noted the presence of the 'Ōpe'ape'a, and it is presumed that the species also uses the Reserve, as they use similar forested areas at that elevation across the island.

## *Invertebrates*

Ka'ū Forest Reserve contains 245 ac (99 ha) of designated critical habitat in two separate areas for one endangered species of Picture Wing Fly (*Drosophila heteroneura*) (U.S. Fish and Wildlife 2008) (Figure 8). Habitat for this species is in wet, montane, 'ōhia and 'ōhia/koa forest and larval stage host plants include 'ōlapa, and *Clermontia* sp. (U.S. Fish and Wildlife Service 2006b). The Hawaiian Picture-Wing Fly group consists of 106 known species, most of which are relatively large with elaborate markings on their wings. The picture-wing *Drosophila* have been referred to as the "birds of paradise" of the insect world because of their relatively large size, colorful wing patterns, elaborate courtship displays and territorial defense behaviors. Each species is found only on a single island, and the larvae of each are dependent upon only a single or a few related species of native host plants.

Ka'ū Forest Reserve also contains habitat for three endemic species of Pinao or Hawaiian Damselfly: *Megalagrion blackburni*, *Megalagrion calliphya* and *Megalagrion xanthomelas*. *Megalagrion xanthomelas* is a candidate for listing as an endangered species and is known from Hilea gulch (Parham *et al.* 2008).

Figure 12. Ka'ū Forest Reserve Critical Habitat



## 2. Non-Native Wildlife

### *Birds*

A large variety of introduced birds inhabit the Ka'ū Forest Reserve. The most common species include the Japanese White-eye (*Zosterops japonicus*), Northern Cardinal (*Cardinalis cardinalis*), and Red-billed Leiothrix (*Leiothrix lutea*). The densities of these species appear stable and relatively low in the upper elevations. Japanese White-eye was the most abundant non-native species recorded in Ka'ū and occurs in forest and open habitat. Red-billed Leiothrix were widespread throughout the Reserve and most abundant at lower elevations (Gorreson *et al.* 2007).

Other species present in Ka'ū include the Japanese Bush-Warbler (*Cettia diaphone*), Hwamei (*Garrulax canorus*), Common Myna (*Acridotheres tristis*), House Finch (*Carpodacus mexicanus*), Erckel's Francolin (*Francolinus erckelii*), Kalij Pheasant (*Lophura leucomelanos*), Spotted Dove (*Streptopelia chinensis*), and Barn Owl (*Tyto alba*). Bush-Warblers are rapidly expanding their range on Hawai'i Island and are expected to be a common species on the island in the future (Tweed *et al.* 2007). Other species present along the open, grassy patches at the edge of the Reserve and in adjacent areas (Kahuku and Kāpapala) include Yellow-fronted Canary (*Serinus mozambicus*), Saffron Finch (*Sicalis flaveola*), Japanese Quail (*Coturnix japonica*), Chukar (*Alectoris chukar*), Zebra Dove (*Geopelia striata*), Wild Turkey (*Meleagris gallopavo*), and (Eurasian) Sky Lark (*Alauda arvensis*)

### *Mammals*

A variety of non-native mammals such as feral pigs (*Sus scrofa*), feral cattle (*Bos taurus*), mouflon sheep (*Ovis musimon*), feral sheep-mouflon hybrids (*Ovis aries-Ovis musimon*), rats (*Rattus spp.*), mice (*Mus musculus*), cats (*Felis catus*), and small Indian mongoose (*Herpestes auropunctatus*) are present in the Reserve. Other ungulates including sheep (*Ovis aries*), feral goats (*Capra hircus*) and Axis deer (*Axis axis*) are not known from the Reserve, but may be present in adjoining areas.

## **F. Cultural Resources**

DOFAW contracted Keala Pono Archaeological Consulting to prepare a comprehensive Cultural Impact Assessment for the project. This Assessment includes information on archaeological and historic sites as well as traditional and cultural practices. The Assessment consisted of archival research as well as community consultation with knowledgeable parties recognized as having a cultural, historical, genealogical, or managerial connection to the project area in Ka'ū. Sources included historic maps and photos, accounts from early visitors, Hawaiian language newspaper articles, mele, oli, 'ōlelo no'eau, collections of mo'olelo, and archaeological reports obtained from individuals and institutions across the State of Hawai'i and ethnographic surveys consisting of oral history interviews.

## 1. Archaeological and Historical Sites

Archaeological and historic sites are protected by state law and will not be impacted by management actions proposed in this plan.

Most of this dense forest area has not been surveyed for sites. Trails, small forest shrines, burial caves and lava tube shelters are the types of features that may be present, as the greater area was used historically by Hawaiians for activities such as bird hunting, harvesting timber for canoe-making and gathering forest plants for medicinal uses.

Other historical sites include ranching era walls along the Reserve boundary, tunnels and infrastructure from old water systems and historic trails.

The Ainapo Trail, a historic trail nominated to the National Register of Historic places, is located in Kapāpala, adjacent to Ka'ū Forest Reserve. This trail is currently used by the public to access the eastern side of the Reserve as well as used as a route up Mauna Loa. This trail was used by ancient Hawaiians as well as foreigners (beginning from as early as 1790). An undeveloped historic trail, the Kahuku- Ainapo Trail, connects to the Ainapo trail. This historic trail is primarily above the Reserve in the Kahuku section of Hawai'i Volcanoes National Park; however portions of the trail are within the Reserve. Old maps also show a trail from Mountain House to Kahuku as well as numerous trails from the bottom of the Reserve boundary leading to tunnel systems within the Reserve.

## 2. Cultural Practices

The Reserve's native Hawaiian ecosystems and species are an essential part of the overall cultural-historical landscape. Today, both traditional and more contemporary cultural practices continue to be perpetuated within the Reserve. Notably, the Reserve is used for gathering plants, such as maile, māmaki, palapalai, 'a'ali'i, and'olonā. Wai is also collected from springs up mauka, which is used for ceremonial purposes. Additionally, hunters continue to use this area as a means of subsistence. The Cultural Impact Assessment discusses consulted individuals' knowledge and opinions regarding places that have special associations and resources that have ongoing cultural uses.

### **G. Public Access and Recreation**

Public access is allowed in the Reserve for recreational and cultural uses, including hunting, hiking and gathering of plant material (with a permit).

**Vehicular Access:** Access to Ka'ū Forest Reserve is via public roads including Lorenzo Rd, Kiolaka'a Rd, Mountain House Rd., Waterfall Rd. (known as Galimba access at Pu'u One), Honanui Rd. and Ainapo Rd. Ainapo and Honanui roads have locked gates and permission for access is through Kāpapala Ranch (call 982-8403 for combination for lock on gate between the hours of 7:30 and 8:30 p.m. Check-in is at 6:00 a.m. and check-out is at 6:00 p.m.

**Trails:** There are no officially designated state-managed trails in Ka'ū Forest Reserve.

**Hunting:** DOFAW manages public hunting on all Forest Reserve System lands, and hunting is allowed in Ka'ū Forest Reserve, which lies within Hunting Unit B. DLNR's Division of Conservation and Resource Enforcement (DOCARE) carries out enforcement of hunting regulations (Chapter 122 Rules Regulating Game Bird Hunting, and Chapter 123 Rules Regulating Game Mammal Hunting). General hunting regulations can be found in Hawai'i Revised Statutes Title 13 Chapter 121. Current information regarding hunting rules, seasons and bag limits for all game species can be obtained by contacting the DOFAW Hilo office at 19 East Kawili Ave. Hilo, Hawai'i, (808) 974-4221.

All persons are required to have a valid Hawai'i hunting license on their person to hunt or have a bagged game mammal in their possession. Hunting licenses may be purchased online from <http://www.ehawaii.gov/DLNR/hunting/>, from any DOFAW office or from any registered hunting license vendor. All hunting license applicants must show proof of having successfully completed a hunter education course that is recognized by the National Hunter Education Association.

**Camping:** No camping is currently allowed in the Ka'ū Forest Reserve.

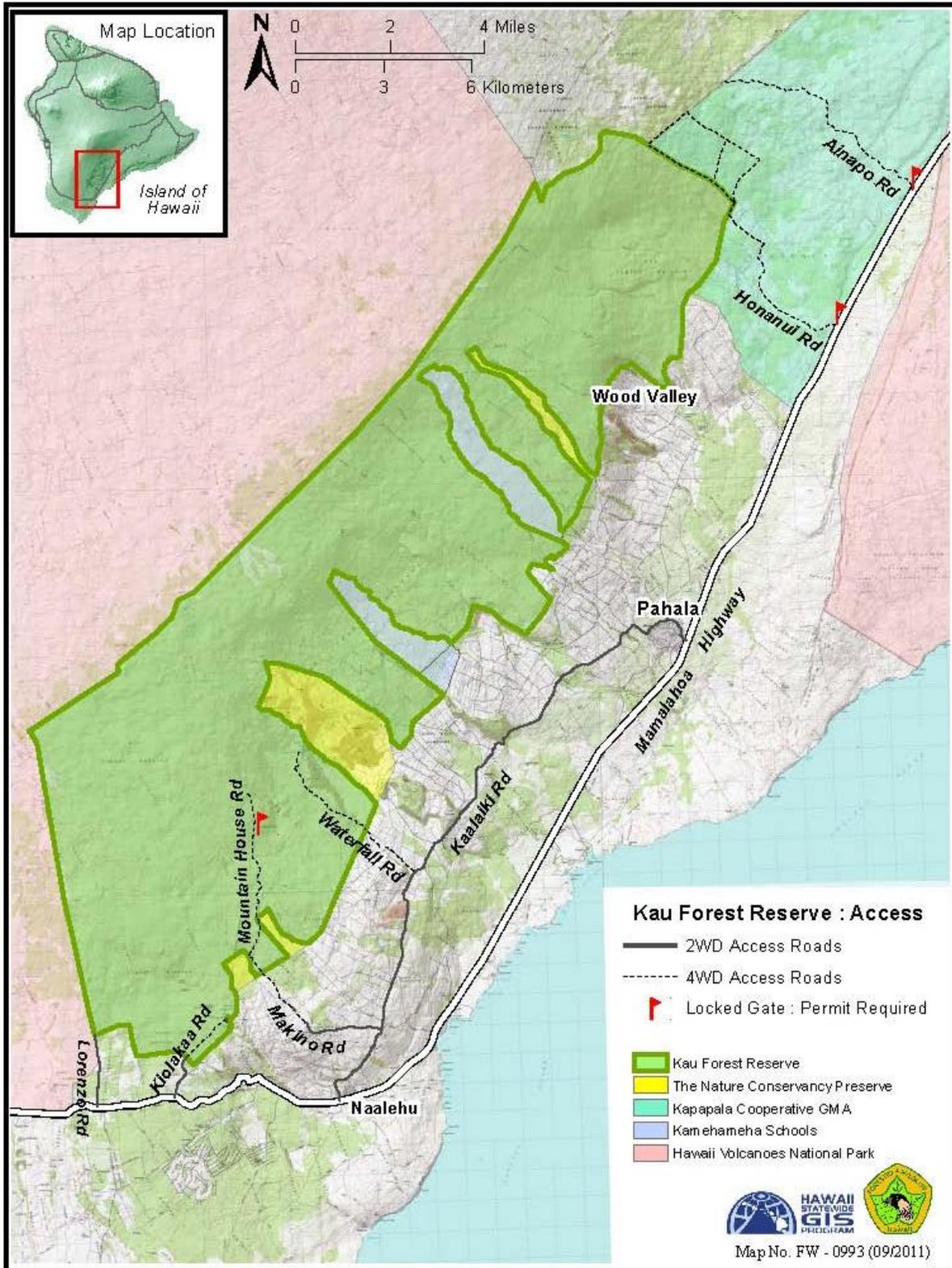
**Forest Products:** Small-scale non-commercial harvesting or salvage is allowed, such as materials for cultural uses. Non-timber forest products such as ferns, maile (*Alyxia oliviformis*), flowers, fruits, and lei-making materials etc for cultural or personal use may be collected from within the Reserve. Gathering of forest products is permitted and regulated by DOFAW through Forest Reserve System permit procedures. Permit applications for gathering plant material can be obtained from the DOFAW Hilo office at 19 East Kawili Ave. Hilo, Hawai'i, (808) 974-4221. These permits are available, upon approval, free of charge (for common, personal use items) or for a fee, depending on the purpose. Gathering of materials from listed species is not permitted.

## **H. Infrastructure**

Infrastructure within the Reserve consists of unimproved trails and four wheel-drive roads. No recreational facilities (e.g. bathrooms, freshwater sources, improved campsites) exist within the Reserve.

The Reserve contains water system infrastructure including 30 water tunnels.

Figure 13. Ka'ū Forest Reserve Public Access



## ***I. Revenue***

According to HRS §183.5 (5), the department shall: Devise and carry into operation, ways and means by which forests and forest reserves can, with due regard to the main objectives of title 12, be made self-supporting on whole or in part.

There is not currently any revenue collected for DOFAW from the Ka'ū Forest Reserve.

## ***J. Threats***

The major threats to the Reserve integrity in this area include introduced plants, animals, diseases, climate change and volcanic activity (vog).

### 1. Ungulates

Ungulates are hoofed animals such as pigs, sheep, goats and cattle. The primary ungulates of concern in the Reserve are feral (wild) pigs, feral cattle and mouflon sheep. Feral ungulates are a threat to native ecosystems, species and watershed because they eat and trample native plants and cause increased erosion and soil runoff. Hawaiian plants evolved without such animals and have no defenses to protect themselves from browsing animals (e.g. thorns and chemicals). Feral ungulates are one source of watershed pollutants, (i.e. animal waste) and increase turbidity in streams due to soil erosion.

Feral cattle are one of the greatest threats to forests in Hawai'i. Small populations of feral cattle are currently located in the upper, northeastern portion of Ka'ū Forest Reserve. Grazing and trampling by feral cattle is extremely destructive to native forest, and removing cattle has been a management focus (through fencing and/or cattle control) since the Reserve was originally established in 1906.

Pigs were originally brought to Hawai'i with the first Polynesian settlers as a domesticated species (Tomich 1986). After the arrival of Captain Cook, the larger European wild boar was intentionally introduced and quickly became feral. Feral pigs in Hawai'i today are generally smaller in size to their mainland cousins as a result of over 200 years of interbreeding between the smaller Polynesian pig and the larger European boar (Tomich 1986).

Feral pigs are present throughout the Reserve. Pigs pose a significant threat to native biodiversity and watershed integrity of Hawaiian forests by damaging native vegetation and exposing soil to erosion (Stone 1985). In montane wet forests, there is a direct correlation between pig-induced soil disturbance and the increase of weeds (Aplet et al. 1991). In addition, feral pigs have been shown to spread root-rot fungi (Baker 1979), create muddy areas that provide mosquito breeding habitat that helps transmit avian diseases spread such as avian pox and malaria (Baker 1979, USGS 2005; USGS 2006c), eat native plants (Cooray and Mueller-Dombois 1981), and carry parasites and diseases transmittable to humans and dogs, such as leptospirosis (Warner 1959 –

1969) and tuberculosis (Giffin 1978). Decades of feral pig control in Hawai'i verify that the only successful method currently available to adequately protect an area from feral pigs is to use physical barriers such as fencing to exclude the animals (Stone 1985).

Mouflon sheep were introduced to Kahuku in 1968 and by 2008 the Kahuku population was estimated at approximately 1,500 individuals (Hess et al. 2006; Hess, personal communication). Mouflon are primarily present in the Kahuku section of Hawai'i Volcanoes National Park, Kapāpala Forest Reserve and the Kapāpala Cooperative Game Management Area, but their range has been expanding and mouflon have been documented throughout the Reserve.

Axis deer, a species introduced to Hawai'i from India, have recently been observed below the Ka'ū Forest Reserve. This species is not yet established on the island of Hawai'i and it is unknown how and when these deer were introduced to the Ka'ū area. Axis deer are established on Maui, where they cause major damage to native forest, agricultural crops and resort areas. They also pose a human health and safety concern due to vehicle collisions (Anderson 1999).

## 2. Invasive Non-Native Plant Species

Invasive non-native plants, or weeds, constitute a severe threat to the native ecosystems in the Reserve. Certain weeds are a problem because they can establish and survive in undisturbed native forest, disperse long distances via wind or birds, affect large portions of land, displace native vegetation, grow and reproduce rapidly, convert a diverse native forest plants to a monoculture of alien species, and encourage fire by increasing fuels. Invasive weeds can displace distinctive native flora, resulting in a loss of species diversity and eventually in changes to ecosystem function such as nutrient cycling. Many invasive weeds completely replace native vegetation resulting in total loss of native habitats thereby negatively affecting native birds and invertebrates (Cuddihy and Stone 1990; Vitousek 1992). In addition, forests that have been severely invaded by weeds such as strawberry guava show increased evaporation of water to the atmosphere, which reduces water available for human use (Giambelluca, unpublished research).

Invasive weeds with great potential for spreading and causing habitat modification are identified in this plan as high priority for control. Weed species were prioritized based on observed invasiveness and other criteria including growth form, dispersal mechanisms, ability to displace native vegetation and ability to alter ecosystem cycles (water, nutrients and succession) (Table 8).

Only a small portion of the Reserve has had systematic surveys for weeds. In general, the upper elevations and interior portions do not appear to be heavily infested with weeds. However, there are some localized areas, particularly in the lower elevations, that are heavily infested with high priority weeds and these are spreading into the interior portions of the forest.

Currently known locations for priority weeds include glory bush at Mountain House Road, strawberry guava on the southwest end of the Reserve, isolated patches of cat's claw and palm grass at Mauna Kea Springs Pipeline Road, cane tibouchina at Waterfall Road, and kahili ginger along the lower forest edge. The lower elevation forest edge, which is adjacent to lands originally cleared for sugarcane plantations and now are mainly used for pasture and cattle grazing, contains abundant priority weeds, particularly strawberry guava. Night-blooming jasmine is present along the forest edge on the east side of Pu'u Enuhe, and dominates the understory of the eastern portion of the forest, northeast of Wood Valley, and it is spreading. DOFAW staff have collected incidental location points of night-blooming jasmine at the far eastern extent of this population. *Bocconia* has been spreading into the Reserve from eucalyptus plantations in the Wood Valley area.

**Table 8. High priority invasive weeds present in Ka'ū Forest Reserve**

| Species                       | Common Name                |
|-------------------------------|----------------------------|
| <i>Bocconia frutescens</i>    | bocconia, plume poppy      |
| <i>Caesalpinia decapetala</i> | cat's claw                 |
| <i>Cestrum nocturnum</i>      | night blooming jasmine     |
| <i>Clidemia hirta</i>         | clidemia, Koster's curse   |
| <i>Hedychium gardnerianum</i> | kahili ginger              |
| <i>Morella faya</i>           | faya                       |
| <i>Psidium cattleianum</i>    | strawberry guava, waiawi   |
| <i>Rubus ellipticus</i>       | yellow Himalayan raspberry |
| <i>Setaria palmifolia</i>     | palm grass                 |
| <i>Sphaeropteris cooperi</i>  | Australian tree fern       |
| <i>Tibouchina herbacea</i>    | cane tibouchina            |
| <i>Tibouchina urvilleana</i>  | glory bush                 |

### 3. Introduced Species - Other Animals

A variety of non-native mammalian predators are serious pests to the biodiversity found in Ka'ū Forest Reserve. Mongoose, feral cats, dogs, rats, and mice prey upon native species and have a severe impact on native birds in the Reserve. In addition, small mammals serve as vectors of diseases and can affect the water quality and cause human and wildlife diseases. Leptospirosis and Cryptosporidiosis are potentially fatal illnesses caused by water-borne microorganisms spread by pigs, dogs, mongooses and rats.

Feral cats kill forest birds as well as native sea birds and other species that nest on the ground or in burrows (USGS 2006a). Cats are the host of a potentially fatal disease called toxoplasmosis. In Hawai'i, toxoplasmosis has killed native Hawaiian birds such as the 'Alalā, the endangered Nēnē and even seabirds such as the Red-Footed Booby (*Sula sula*). Because the organism that causes toxoplasmosis (*Toxoplasma gondii*) can complete an important part of its life cycle in seawater, this disease also poses a threat to marine mammals such as the endangered Hawaiian monk seal (*Monachus*

*schauinslandi*) and spinner dolphin (*Stenella longirostris*). In addition to threatening wildlife, toxoplasmosis poses a significant health risk to pregnant women (USGS 2006a).

Rats prey on native bird eggs, nestlings, native land snails and also eat the fruits and/or strip the bark of native plants. Similarly, mice consume the seeds of native plants; seed predation can be a major factor contributing to species decline.

The Reserve has been invaded by non-native forest birds; however their impacts on native species have not been determined. Non-native birds may compete with native forest birds for food and other resources and act as vectors for avian diseases. Non-native birds may also contribute to the spread of weeds by eating the fruits of weedy species and spreading seeds.

Non-native invertebrates are present, but largely undocumented, and can consume native plants, interfere with plant reproduction, predate or act as parasites on native species, transmit disease, affect food availability for native birds, and disrupt ecosystem processes. The invasion of the yellowjacket wasp (*Vespula pennsylvanica*), voracious predators of numerous species of native invertebrates, is of concern. Other non-native parasitoids adversely impact native moth species, and ants are a significant mortality factor for native invertebrates. Slugs (*Milax gagates*, *Limax maximus*, *Veronicella* spp.) consume fruit from native plants and prey on seedlings and mature plants. The two-spotted leafhopper (*Sophonia rufofascia*) is a major concern for the *uluhe* fern, which is particularly sensitive to leafhopper feeding. Mosquitoes (*Aedes albopictus* and *Culex quinquefasciatus*) transmit deadly diseases to native birds and humans.

Both Jackson's chameleon (*Chamaeleo jacksonii*) and Coqui frog (*Eleutherodactylus coqui*) have growing populations on the island, and these species can consume native invertebrates, such as insects, spiders, and small snails.

#### 4. Wildfire

Fire poses a threat to the Reserve, particularly during times of drought and in areas adjacent to human activity. Hawaii's flora evolved with infrequent, naturally-occurring fire, so most native species are not fire-adapted and are unable to recover quickly after wildfires. Wildfires leave the landscape bare and vulnerable to erosion and non-native weed invasions. Continued feral ungulate damage to native ecosystems can convert native forest to non-native grasses and shrubs, which provide more fuel for fires. Weeds, particularly grasses, are often more fire-adapted than native species and will quickly exploit suitable habitat after a fire. The principal human-caused ignition threats are from catalytic converters and other hot surfaces of vehicles or heavy equipment and illegal campfires. The principal natural ignition sources are lightning and lava flows.

## 5. Disease

Introduced diseases and pathogens threaten native animals and plants. Given the lack of biosecurity in Hawai'i, the introduction of new diseases and pathogens is highly likely. Avian pox and avian malaria are mosquito-transmitted diseases that currently kill or weaken many native Hawaiian birds and are thought to be responsible for the extinction of numerous forest bird species. In the extreme isolation of the Hawaiian Islands, birds evolved in the absence of these diseases and lost their natural immunity. Avian pox is caused by a virus (*Avipoxvirus*) and avian malaria by a single-celled parasite (*Plasmodium relictum*). For many native forest bird species, infection with these diseases is almost always fatal (USGS 2005; USGS 2006c).

Introduced plant diseases such as 'ōhi'a rust (*Puccinia psidii*) and koa wilt (caused by the fungus *Fusarium sp.*) have the potential to impact the major components of the forest throughout the Reserve. 'Ōhi'a rust affects 'ōhi'a as well as other plants in the same family (Myrtaceae) (HEAR 2010). In severe infections, growing tips wither and die back. Koa wilt is a serious, often fatal disease of the native tree, koa. Trees affected with the disease rapidly lose their canopies and may die within a few months (UH-CTAR 2010).

## 6. Climate Change, Volcanic Activity and Hurricanes

Climate change may affect the Reserve by altering rainfall patterns and amounts. Changing climate may affect the abundance and seasonality of precipitation, thereby altering forest composition, growth and structure. Rare ecosystems and species may be negatively affected by relatively rapid changes in precipitation, temperature, and humidity that result from a rapid and drastic change in regional or local climate patterns (e.g. prolonged drought, higher temperatures). Detrimental invasive species may change their distribution and abundance due to changes in the climate (e.g. mosquitoes may be more frequently found at higher elevations due to warming temperatures).

Volcanic activity has the potential to impact the Reserve. Mauna Loa flows reached the top portions of Ka'ū Forest Reserve in 1950. The Ka'ū Forest Reserve is located within Volcanic Hazard Zones 3 and 6 for Mauna Loa (USGS). During the past 750 years, lava flows have covered about 15 to 20 percent of Zone 3 on Mauna Loa. The portion of the Reserve above Nā'alehu is classified as Zone 6 because it is currently protected from lava flows by the local topography. Kīlauea Volcano is also currently active. Volcanic gases or vog from nearby vents can cause high concentrations of gases that affect native plants, animals and people.

Although natural disturbances such as hurricanes and lava flows are regular occurrences in Hawai'i, native species and ecosystems may not be able to recover from these disturbances as readily due to small populations and/or invasion of non-native weed species.

## 7. Illegal Human Activity

Illegal human activity occurs on a small scale, primarily in the form of illegal camping, off-road all-terrain vehicle use, dumping, unpermitted harvesting (maile, hāpu'u, and other native trees and plants), marijuana cultivation, and vandalizing signs and fences. These activities destroy infrastructure and native species. Some illegal activities create openings in the forest that can be invaded by weeds.

### **III. KA'Ū FOREST RESERVE MANAGEMENT**

#### **A. Summary of Existing Management and Research Activities**

##### 1. Watershed Values and Native Ecosystems

DOFAW has been conducting feral cattle control to protect the watershed and native ecosystems in the Reserve. Hundreds of feral cattle have been removed since the 1980's, particularly from the northern and central portions of the Reserve. Currently, there are low numbers of feral cattle in the Reserve, and DOFAW staff are continuing to remove the remaining cattle. Adjoining ranchers have primary responsibility for maintaining and constructing fences to prevent additional cattle from entering the Reserve.

##### 2. Threatened and Endangered Species Management

Seven forest bird surveys were conducted between 1976 and 2008 by DOFAW and other cooperating agencies and organizations. These surveys, generally conducted every five years, provide information on bird populations in the Reserve. The Hawai'i Forest Bird Interagency Database Project analyzes the monitoring data every five years and produces reports on forest bird densities and population trends. A summary of survey results is available at: <http://pubs.usgs.gov/of/2007/1076/of2007-1076.pdf> (Gorreson *et al.* 2007).

In 1995, DOFAW contracted TNC to inventory plant and animal species and prepare a report on the biological resources on the Waihaka portion of Ka'ū Forest Reserve, an area that had been proposed as a potential Natural Area Reserve (TNC 1995). This area was found to have important biological resources, including rare species of plants and birds.

Two sites in Ka'ū Forest Reserve (southwest and central) were included in a rapid assessment of vegetation at six potential 'Alalā release sites on the island of Hawai'i to rank sites for suitability as reintroduction sites for this species (Jacobi and Price 2007). Out of the six sites examined, the two Ka'ū study sites ranked first and second overall.

Several small fenced areas have been constructed for protection and/or outplanting of rare plant species.

### 3. Invasive Species Control and Resource Protection

DOFAW and Big Island Invasive Species Committee (BIISC) staff have controlled populations of priority weeds in Ka'ū Forest Reserve including cats claw, bocconia, palm grass, ginger, strawberry guava and night blooming jasmine.

Limited portions of the Reserve have been surveyed for weeds. Surveys have been conducted along the lower boundary and on Hawai'i forest bird survey transects. BIISC also surveyed portions of the Reserve for bocconia.

In 2010, TNC contracted with Resource Mapping Hawai'i to collect high resolution aerial imagery with a fixed wing aircraft in TNC's Ka'ū Preserve and also along the lower edge of the Ka'ū Forest Reserve, where the forest meets the pasture. These aerial images will help identify patches of priority weeds in the forest so they can be controlled. TNC and Resource Mapping Hawai'i have been analyzing, compiling and checking the accuracy of the imagery data which will allow resource managers to view the imagery and obtain information about priority weed locations. Three weed species are a focus of these efforts: strawberry guava, kahili ginger, and night blooming jasmine.

### 4. Public Activity

DOFAW staff maintain roads used for public access to the Ka'ū Forest Reserve.

## ***B. Management Goals and Objectives***

Forest Reserves are multi-use areas that encompass and incorporate a variety of public uses and benefits, from fresh water supply to recreation. Each Forest Reserve within the system has differing goals depending on the nature of the resources found within it. DOFAW manages the Forest Reserves individually for their unique resources as well as provides an overall management philosophy for the entire Forest Reserve System, in keeping with the rules it must abide by. Broad management action categories within the Forest Reserve System include:

- Watershed Values (aquifer recharge and erosion control)
- Native Ecosystems (landscape level protection)
- Invasive Species Control (incipient and established plants and animals)
- Threatened and Endangered (T&E) Species Management (Federally listed, State listed, and rare plants and animals)
- Public Activity (non-income generating uses, such as recreation, cultural activities, personal gathering, educational or research activities, and events, among others)
- Resource Protection (fire, insects, and disease)
- Game Animal Management (areas managed to enhance public access for hunting game birds and mammals)
- Commercial Activity (income generating activities such as timber, tours, etc.)

From within these broad management action categories, specific management goals for Ka'ū Forest Reserve were determined from the unique resources and management needs for the area, mandates that regulate DOFAW activities, including Draft Management Guidelines (Appendix C), past planning efforts and Administrative Rules, as well as input from DOFAW Staff. Goals for Ka'ū Forest Reserve include the following, in priority order.

1. Watershed Values: Protecting and managing the forested watersheds for production of fresh water supply for public uses now and into the future
2. Native Ecosystems: Maintaining native ecosystems and rare and endangered species
3. Public Activity: Providing public access, recreational and hunting opportunities

### ***C. Proposed Management***

Management objectives and proposed actions for each of the broad management action categories are discussed below. Proposed actions have been prioritized based on the three specific management goals for Ka'ū Forest Reserve. The highest priority actions proposed have multiple benefits and accomplish numerous management objectives.

#### 1. Watershed Values and Native Ecosystems

Management Objective: Protect and manage forested watersheds to produce fresh water for public use, reduce land-based pollutants (e.g. soil erosion, animal waste), improve coastal water quality and maintain native ecosystems.

Actions:

1. Prevent damage to watershed and native ecosystems by removing all feral cattle from within the Reserve and controlling livestock trespass through maintenance of existing boundary fencing.
2. Protect watershed and native ecosystems from feral ungulate damage by construction of approximately 12,000 ac (4,856 ha) of new fenced management units in the upper elevation central portions of the Reserve.
3. Remove feral ungulates from within fenced management units using a variety of approved methods including special public hunts, trapping, and staff control.
4. Inspect, maintain and replace fences.
5. Monitor fenced management units for ungulate presence following complete removal and control ingress ungulates, if necessary.
6. Protect and maintain biological diversity of the Reserve's ecosystems.
7. Monitor watershed function.
8. Participate in collaborative initiatives such as the Three Mountain Alliance Watershed Partnerships with other public and private forest landowners.
9. Protect important forested lands through addition to the Forest Reserve System.

It is important to protect the Reserve's native ecosystems because this forested watershed impacts the quantity and quality of water in the wells and tunnels used for the District's domestic and agricultural water supply. While many people are familiar with the water cycle and how rainfall ends up in groundwater that is used by humans, fewer people are aware of the forest's role in producing and filtering our drinking and fresh water. Forests are critical for accumulating fresh water. Fog condensing on trees is an important source of moisture and can increase measurable precipitation by 20% (Juvik and Perreira 1973; Juvik and Nullet 1995). Forests collect and filter water into the ground water and streams. A healthy native forest without soil disturbance limits aquatic pollutants (e.g. siltation, suspended solids, turbidity, nutrients, organic enrichment, toxins and pathogens) due to erosion and runoff. Forests may also reduce the impacts of flooding and erosion by slowing down water as it flows down the mountain.

Feral cattle have long been a threat to the watersheds of Ka'ū Forest Reserve, and continued work is needed to remove feral cattle from the Reserve and prevent the ingress of additional cattle from adjacent lands. Adjacent ranchers are responsible for maintaining boundary fences. DOFAW staff are planning on continuing their efforts to remove all feral cattle from the Reserve, through staff hunting and other approved animal removal methods. Additional boundary fencing may be required to prevent the ingress of cattle into Ka'ū Forest Reserve.

To protect the water resources of the Reserve and limit damage to native Hawaiian ecosystems, a combination of fencing and feral ungulate removal from fenced units is needed. Without fencing, ungulate control is not effective, due to reproduction of existing populations and continued ingress from adjacent areas. The construction of fenced management units is proposed for approximately 12,000 ac (4,856 ha) in the upper elevation (4,000 - 5,000 ft (1,219 - 1,524 m)) central portions of the Reserve.

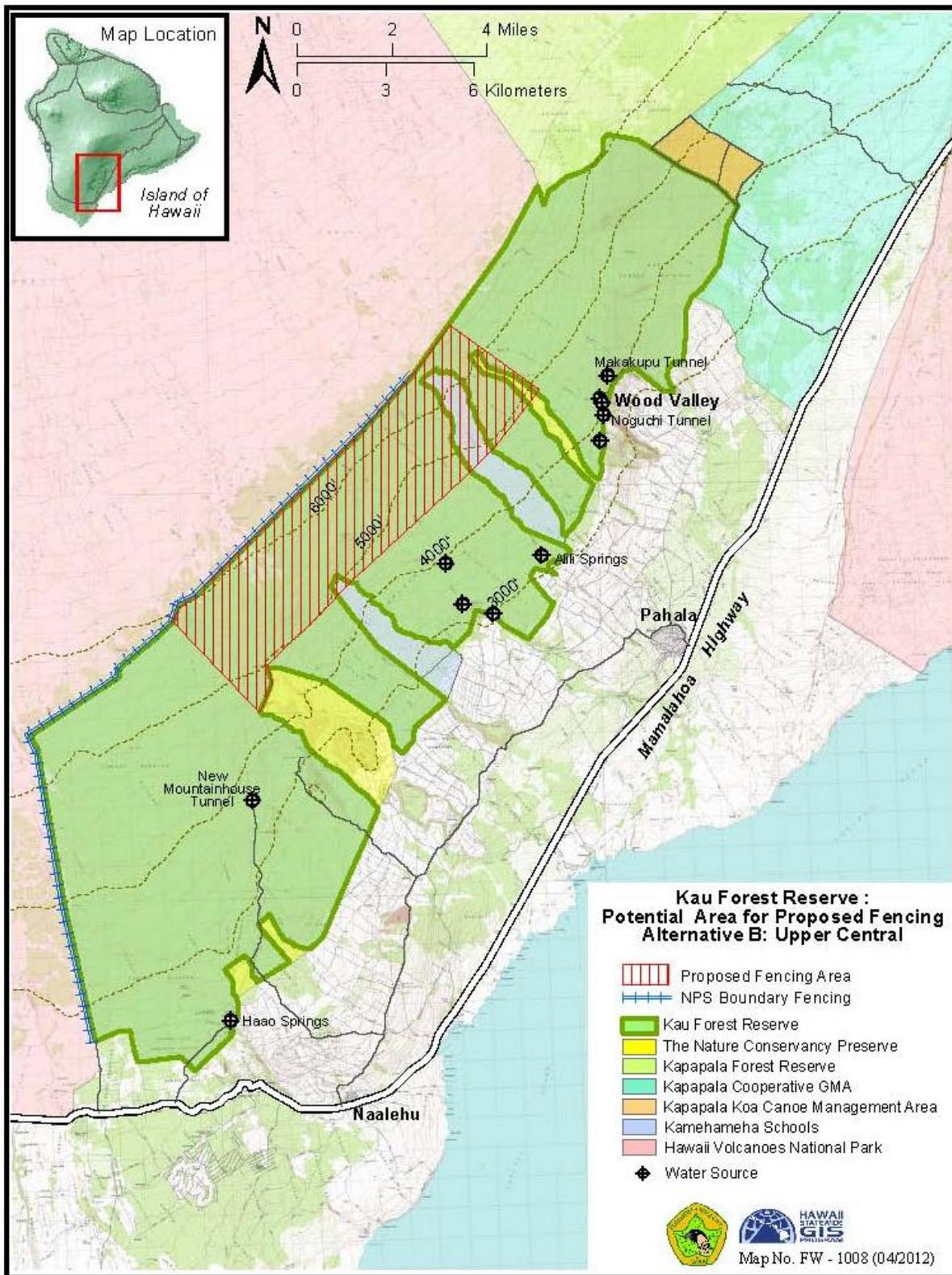
Fencing will be constructed in the upper central portion of the Reserve, shown in Figure 14. We have prioritized this area because the proposed fencing and feral ungulate removal would protect a large portion of the Ka'ū Forest Reserve landscape, including important watershed and existing native species habitat, particularly habitat for the three endangered forest bird species. This area is also a priority for restoration for release of the 'Alalā. Monitoring data from forest bird transects shows this area is the portion of the Reserve that has the most feral ungulate damage. Although there is currently an intact canopy of tall native trees, in many areas much of the ground and understory layers of ferns, small plants and young tree seedlings have been damaged by feral ungulates, leaving the ground bare and exposed. Without management, the native forest will continue to decline because young trees will not be able to grow and become established to replace the older canopy trees as they die. Fencing and feral ungulate removal will benefit native ecosystems by limiting the browsing and trampling of native plants. Other benefits include reduction of soil erosion/exposed soil and subsequent invasion of non-native plants.

We are still determining the location, size design and number of the fenced units that would be constructed within the fenced area. The area would be subdivided into separate fenced subunits of 2,000 - 4,000 ac (809 - 1,619 ha) in size that would be fenced over time, as funding becomes available. The final configuration and number of fenced unit(s) will consider factors such as water resources, quality of native ecosystems and habitat for native species, level of damage from ungulates, public use of area, cooperation with adjacent landowners, terrain, logistics, accessibility, and feasibility for effective feral ungulate removal. Field surveys will be conducted to identify locations for the planned fence alignments, and final fence alignments will be sited to avoid any impacts to botanical, faunal, and archaeological resources. Fences are not meant to restrict public access into management units, and walkovers and gates will be installed in order for people to access fenced areas. Fencing costs are estimated at approximately \$150,000 per mile (labor, materials and helicopter), and will be completed based upon the availability of funding for labor and materials. DOFAW staff and/or contractors will need to implement construction of fenced units in phases.

As fence construction is completed, DOFAW staff will use various approved methods to remove ungulates from within the fenced units (State of Hawai'i 2007). Public hunting will be encouraged during the first phase of ungulate removal where safe, feasible and effective, but additional control methods including drives, trapping, staff control with dogs, and snaring, may be needed to remove all the ungulates.

Regular fence inspection and maintenance will be needed once fence construction is complete. Fences will also need to be replaced as they deteriorate and costs for fence replacement will need to be taken into account in future management plans.

Figure 14. Ka'ū Forest Reserve Fencing (Central Portion of the Reserve)



## 2. Invasive Species Control

Management Objective: Protect intact native forest by removing high priority non-native, invasive weeds and other invasive species.

Actions:

1. Monitor and map the distribution of high priority weeds and develop a control strategy.
2. Identify highest priority areas for intensive weed control.
3. Control weeds along invasion corridors (e.g., roads, trails, fences) and within fenced management units using approved methods.
4. Maintain procedures to prevent introduction of new weeds.
5. Monitor weeds to determine whether weed control measures are effective and to detect changes in long term distribution and abundance.
6. Monitor and map the distribution of other invasive species and develop a control strategy, as needed.

Weed mapping is essential to developing a comprehensive control strategy. Distribution mapping includes compiling transect monitoring data, incidental observations and reconnaissance surveys to map the distribution and abundance of weeds. Results from surveys will then be used to better delineate the weed populations core extent and outlying individuals, and permit the development of an effective control strategy. DOFAW staff will monitor weed control areas to evaluate the effectiveness of control efforts. Ka'ū Forest Reserve is also targeted for additional weed mapping using new mapping technologies (high resolution aerial imagery). Analysis of the aerial imagery will assist DOFAW staff in locating priority weeds for control purposes.

Weed control priorities include suppression and containment of priority weeds (night blooming jasmine, kahili ginger, bocconia, clidemia, and strawberry guava) along the lower Reserve boundaries to prevent and reduce the spread of these weeds into more intact native forest areas in the higher elevations. Regular surveys along the lower boundary and along forest bird survey transects should be continued to detect new incipient weeds and increased spread of priority weeds into the upper Reserve. DOFAW will develop cooperative weed control projects with adjacent private landowners and lessees to benefit ranching, forestry and agriculture as well as suppress priority weeds in critical native forest buffer areas.

Other weed control priorities include the following: reducing the spread of bocconia from Wood Valley into the Reserve; develop a containment strategy for night-blooming jasmine (e.g. keep Waihaka gulch population farthest to the east from spreading further east); eliminate kahili ginger from Mauna Kea Springs Hunter Trail vicinity west of Waihaka gulch; and control glory bush on Mountain House Road.

Priority areas for weed management will also include fenced, ungulate-free management units. Removal of ungulates from fenced units is a critical first step in weed control because it allows for the recovery of native vegetation by minimizing

ground disturbance and reducing the spread of weeds by ungulates. Certain incipient weeds (high priority weeds that are just beginning to invade the area) may be targeted in unfenced areas to prevent their establishment and spread.

Weed control goals include early detection and preventing the establishment of incipient, habitat modifying weeds that are not currently present (e.g. miconia) or are still localized. For priority weeds already present, the goal is to eliminate all known occurrences within targeted control areas and/or to contain the spread of priority species. Due to limited resources for monitoring and control throughout these dense rainforest areas, DOFAW staff will focus control efforts in disturbed areas such as roads, trails, and fence lines as these often serve as corridors for weed establishment and spread. Prevention is a critical component of the weed management program, and it is important to avoid and/or reduce the inadvertent introduction and spread of weeds by people working in and visiting the area. DOFAW staff and volunteers will follow protocols for cleaning of boots, equipment and vehicles.

A combination of control techniques including staff control using manual, mechanical and approved herbicides will be used to remove weeds. The technique used is based on the characteristics of the target species, the sensitivity of the area in which the species is found, and the effectiveness of the control technique. Due to widespread and heavy infestations of certain weeds and limited resources, DOFAW will use approved biocontrol agents within the Reserve, when available, and if shown to be effective.

### 3. Threatened and Endangered Species Management

Management Objective: Protect occurrences of threatened and endangered species and restore populations of these species in appropriate habitat to assist with the overall recovery of these species.

Actions:

1. Fencing and feral ungulate removal (discussed above in section on Watershed Values - actions #1 - 4).
2. Weed management and preventing the introduction of new habitat-modifying species are discussed above (Invasive Species Control - actions #1-5).

General actions to protect watershed values and native ecosystems discussed above (e.g. fencing, ungulate removal and weed control etc) are critical to the long-term health and recovery of native ecosystems which provides habitat for threatened and endangered plants and animals. These management actions are the most critical actions needed to protect existing native habitat, biological diversity and rare species. These actions, as well as other actions specific to individual species, are recommended in U.S. Fish and Wildlife Service Recovery Plans (Appendix C). The areas proposed for fencing and ungulate removal are a high priority because they contain existing populations of forest birds as well as rare and endangered plant species.

In some instances, the implementation of actions described above is not enough to recover certain threatened and endangered plants and animals. These species may have wild populations that are so low that the species cannot survive and recover without additional management. These species may require additional management actions to maintain the persistence of wild populations or re-establish new populations. Additional specific actions for forest birds, 'Alala and rare plants are discussed below.

#### *a) Forest Birds*

Actions:

1. Predator control
2. Continue long-term forest bird monitoring program in cooperation with the Hawai'i Forest Bird Interagency Database Project to assess changes in the population and distribution.

The native birds of Ka'ū will benefit from previously discussed management actions in all alternative areas proposed including fencing and ungulate removal and invasive species control. Although there is still a forest canopy in the areas proposed for fencing, removal of feral ungulates will allow native understory plants and trees to regenerate, providing additional areas for birds to forage for fruit and nectar resources as well as ensuring the long-term presence of the forest into the future. Further, removing pigs would reduce the number of mosquito breeding sites, which would reduce the transmission of avian diseases, and reduce the spread of non-native plants. The former is critically important as climate change increases the area over which mosquitoes and the avian malaria parasite will be able to survive reduces the overall area of disease free forest available for native forest bird habitat.

Native forest birds will benefit from management actions directed at 'Alalā described below, such as predator control of non-native mammals. Non-native mammals eat native birds and eggs as well as seeds/fruit and arthropods that are critical foods to sustain native birds. Thus any reduction in their numbers would likely benefit native birds. Small mammalian predator removal is extremely difficult and costly to implement on a large-scale using currently existing methods. DOFAW staff may implement predator removal in certain high priority areas (e.g. upper elevation, fenced management units, 'Alala release sites, bird nesting sites) using existing, approved methods (trapping and application of rodenticides using bait stations). New methods for widespread control of these species across large conservation areas are currently being developed and may be implemented if they are approved and offer a cost-effective way to remove predators.

#### *b) 'Alalā Restoration*

The restoration of 'Alalā to the wild will require significant management actions, including the construction of holding aviaries, and a constant human presence at

release sites. The following management actions are recommended by the Revised Recovery Plan for the 'Alalā (2009):

Actions:

- 1) Fencing and ungulate control - a minimum area of approximately 2,500 ac (1,012 ha) is required for initial releases.
- 2) Remove predators from the release area (all feral cats and 80% of other non-native predators (mongoose, rats).
- 3) Restore native food plants through planting, as needed
- 4) Construct release cages
- 5) Determine 'lo density and the relationship between 'lo density and the availability of rodents and game birds, and vegetation density.

Fencing a management unit of 2,500 ac (1,012 ha) is the minimum area needed for initial releases to start the restoration of a small wild population of 'Alalā. 'Alalā may use both unfenced and fenced areas in the Ka'ū Forest Reserve as well as adjoining lands. The size area needed to sustain a large wild population of 'Alalā is not known at this time. In previous releases of 'Alalā in Kona, the released birds used an area of about 10,000 ac (4,047 ha), but there were, at the most, 12 birds in the field at any one time, and none had set up breeding territories.

Holding or release aviaries will be erected at release sites. These will most likely be placed on scaffolding to minimize predator access. DOFAW will attempt to place aviaries in natural openings in the forest; however, some clearing of native vegetation may be necessary. Given the need to have staff on site at all times, the construction of a remote cabin or weatherport will be needed. The release and monitoring team will need to maintain a constant presence at the release site for an undetermined length of time to care for, feed, monitor, and track released birds. It is difficult to estimate the length of time that the release and monitoring team will have to remain on site. Much will depend on the availability and use of wild foods by the 'Alalā, their dependence on supplementary food, their health, and how they adjust to their new environment.

Other management actions involved with 'Alalā release will require additional staff. The predator control team will track the abundance of predators and trap and bait as needed. The ungulate and vegetation team will track the abundance of ungulates, remove ungulates from fenced areas, monitor 'lo abundance, restore food plants, monitor vegetation recovery, track and control invasive species and check and repair fence. The latter two teams do not need to maintain a constant presence at the site.

### *c) Rare Plants*

Actions:

1. Survey, map and monitor existing populations and individual rare plants and collect propagation material.
2. Propagate and re-introduce certain species of rare and endangered plants in appropriate protected habitat through outplanting, in coordination with other agencies and organizations working on rare plant recovery.

3. Monitor growth and survival of reintroduced plants.
4. Protect rare plants in areas outside fenced management units through the construction of small fenced exclosures
5. Conduct other management, as required (control of damaging weeds, insects, slugs, plant disease and/or mammalian predators).

Over the past decade, numerous species of rare plants have been propagated and reintroduced into fenced, ungulate-free areas to contribute to their overall recovery in the wild. Species listed in Table 5 will be the focus for the DOFAW rare plant program in Ka'ū Forest Reserve. The goal of rare plant management is to remove threats to these species and ensure their long-term survival in secure and self-sustaining wild populations.

DOFAW staff will work cooperatively with other organizations and agencies on rare plant recovery including the Hawai'i State Plant Extinction Prevention Program (PEPP) and the Volcano Rare Plant Facility (VRPF) of the University of Hawai'i. Management actions specific to rare plant recovery includes rare plant surveys to locate wild individuals, collection of propagation and genetic storage materials, propagation, and reintroduction through outplanting. PEPP is focused on preventing the extinction of taxa with fewer than 50 individuals in the wild. The VRPF and/or other state permitted facilities will propagate all rare plants used in the DOFAW program.

DOFAW staff will follow rare plant collection and reintroduction guidelines recommended by the Hawai'i Rare Plant Restoration Group (interagency group of rare plant experts) <http://www.hear.org/hrprg/>. DOFAW staff will tag and map the locations of all outplanted plants and monitor their survival and growth. They will do additional management of wild and/or reintroduced populations if needed (e.g. small fences around wild plants that are not within fenced management units, control of damaging weeds, insects, slugs, plant disease and/or mammalian predators).

#### *d) Rare Invertebrates*

Specific management actions to protect invertebrates are not proposed at this time. Little is known about native invertebrates in Ka'ū Forest Reserve so additional surveys are needed to inventory species and identify important habitat for rare species. Previously discussed management actions to benefit watershed and native ecosystems and other rare species will also benefit rare native invertebrates, as native invertebrates are generally dependent on native plants for food and as host plants.

#### 4. Public Activity

Management Objective: Provide for continued public use of Ka'ū Forest Reserve including hunting, recreational opportunities, cultural uses, personal gathering, educational programs and activities.

Actions:

- 1) Maintain existing public access roads.

- 2) Develop new access routes to increase access, particularly across private and state-leased lands below the Reserve.
- 3) Continue to facilitate public hunting in the Reserve.
- 4) Develop trails and recreational amenities (e.g. picnic and/or camping areas).
- 5) Hire outreach staff and work with partners to provide community outreach and education (e.g. volunteer service trips, student internships, school programs etc) to build public understanding and support for Ka'ū Forest Reserve's unique native resources.
- 6) Develop more effective and user-friendly methods to issue DOFAW permits for gathering and other activities.
- 7) Hire additional staff to implement proposed actions, establish a regular DOFAW presence in the area and continue consultation with the community.

Public activity and recreational uses of the Reserve are a high priority as long as these activities are compatible with the protection of watershed and natural resources. DOFAW Draft Management Guidelines (Appendix C) classify the Reserve as "light use" for recreation. Recreational uses will be limited to certain areas to minimize impacts on natural resources and trails would be the main recreational feature for this type of classification. DOFAW management of recreational uses of the Reserve will emphasize low-impact activities and minimal improvements that are consistent with the remote, wilderness nature of the Reserve.

The transition of lands from sugar production to numerous private landowners and state-leases has reduced public access to the Reserve. DOFAW needs to ensure continued public access for recreational uses, hunting, and traditional and cultural practices as private lands adjacent to the Reserve get sold and developed. Additional forest access routes to Ka'ū Forest Reserve are currently being assessed by DOFAW, and community input will be sought on priority access routes. DOFAW will implement increased public access to the Reserve through various methods including developing easements, land acquisition or public access agreements with adjacent landowners.

There are not currently any designated trails or camping areas within the Reserve; however, these types of recreational amenities may be appropriate for certain areas within the Reserve. DOFAW will seek community input and recommendations on the potential development of and locations for additional recreational amenities for Ka'ū Forest Reserve such as picnic and camping areas, trail development and public cabins/shelters.

DOFAW management will seek to ensure the long-term availability and sustainability of native plant resources for traditional resource gatherers in Ka'ū Forest Reserve. The current extent of use of the Reserve for traditional and cultural gathering is not currently known. DOFAW will explore more effective and user-friendly ways to issue permits to the public for gathering including potentially establishing a satellite office with a more regular staff presence in Ka'ū and/or implementing a on-line computerized permitting system. The sustainability of these resources will be enhanced by protection of native

forest ecosystems through fencing, feral ungulate control and weed control as well as a greater staff presence in the region.

NPS is currently developing a general management plan for the Kahuku section of Hawai'i Volcanoes National Park. This plan may increase access to and recreational uses of Ka'ū Forest Reserve as this section of the park surrounds Ka'ū on two sides. DOFAW will work cooperatively with NPS on the development of additional trails and access routes through the park. Trails through the Reserve could potentially connect to other trails in the park, including historic trails such as the Kahuku - Ainapo trail across the top of Ka'ū Forest Reserve as part of a larger trail system. For example, historic maps depict a trail from Mountain House through the Reserve to Kahuku (connecting with the Kahuku-Ainapo trail), which may be a good trail to reestablish for public use.

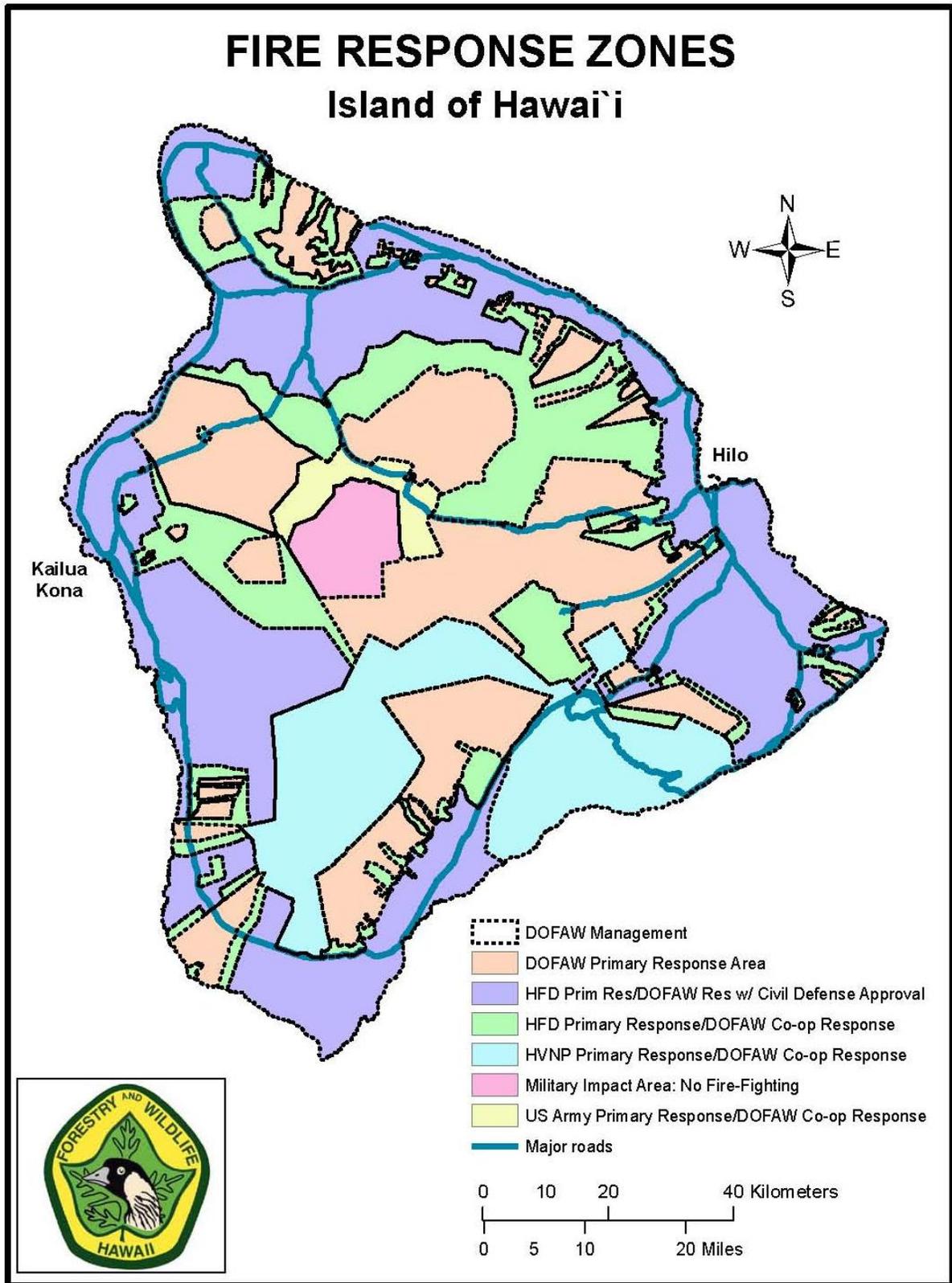
#### 5. Resource Protection

Management Objective: Reduce the threats of fire, insects, and disease to the Ka'ū Forest Reserve.

1. Install a remote automatic weather station to monitor fire weather in the Reserve and/or adjacent areas (specific location to be determined).
2. Respond to fires, as needed.
3. Monitor forest for insects and disease.

Management actions to protect watershed values and native ecosystems will maintain the overall health of the forest, which will make the forest more resistant to threats from fire, insects and disease. DOFAW is the primary responder to fires within the Ka'ū Forest Reserve (Figure17). DOFAW is responsible for fire protection within DOFAW lands and is also required to cooperate with Hawai'i County Fire Department and fire control agencies of the Federal Government in developing plans, programs and mutual aid agreements for assistance for prevention on other lands.

Figure 15. Fire Response Zones, Island of Hawai'i



## 6. Game Animal Management

Management Objective: Continue to provide public hunting opportunities in Ka'ū Forest Reserve.

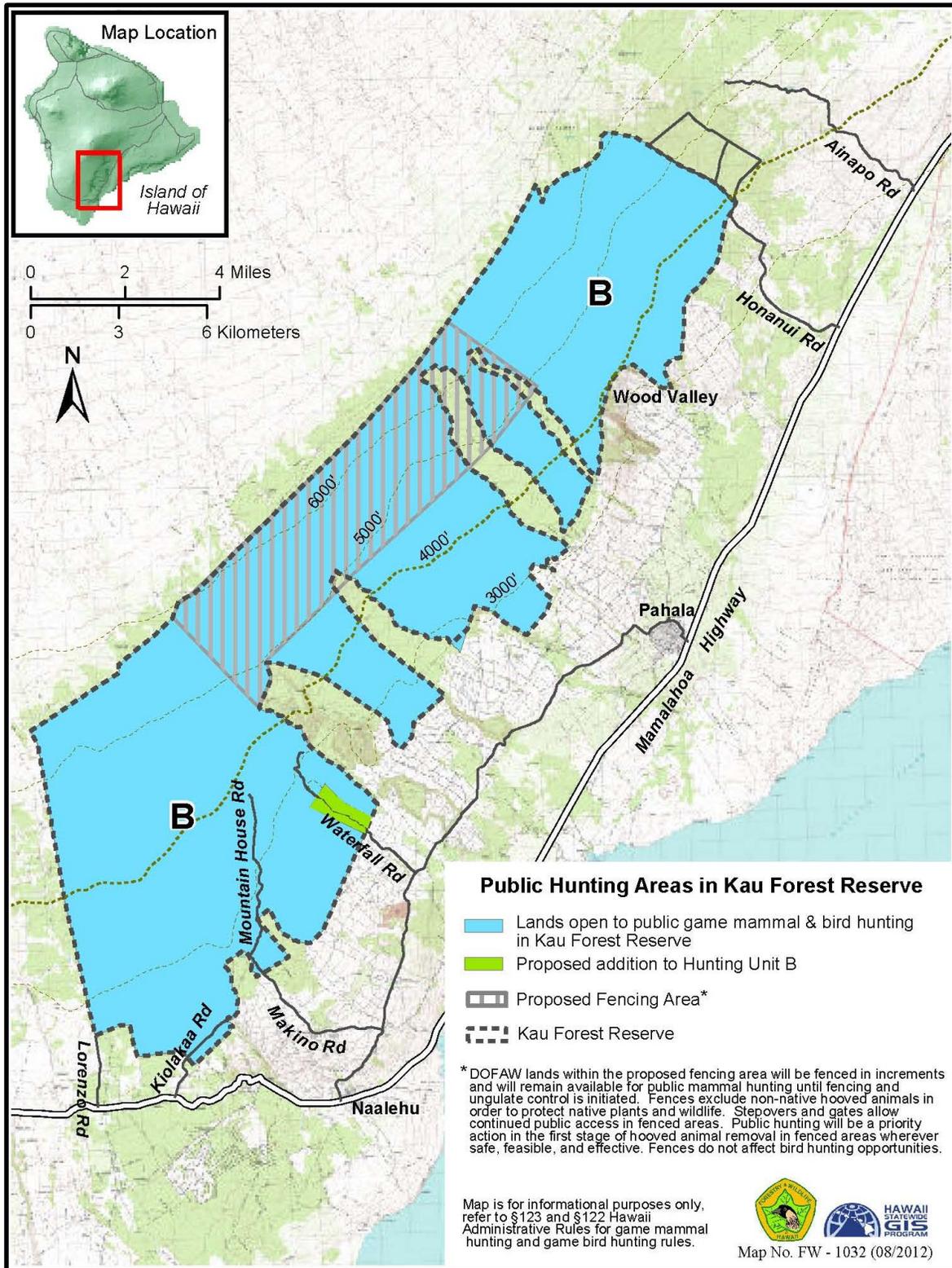
Actions:

- 1) Continue to provide public hunting in the Reserve as part of Hunting Unit B.
- 2) Maintain existing public access roads for use by the public.
- 3) Develop new access routes to increase public access, particularly across private and state-leased lands below the Reserve.
- 4) Use public hunters to assist with the removal of feral pig and sheep removal in fenced, management units prior to staff control whenever safe, feasible and effective.
- 5) Investigate opportunities to increase hunting in other less environmentally sensitive lands outside of the Reserve.

Ka'ū Forest Reserve is currently part of Hunting Unit B, and the Reserve is used by local residents for hunting, particularly for feral pigs. Game mammal management for the Reserve includes continuing to provide public hunting in the Reserve and enhancing public hunting opportunities whenever safe, feasible, and effective. This is accomplished through the establishment of liberal hunting conditions and measures designed to increase access to the hunting areas, particularly across lands below the Reserve. Figure 18 depicts areas that will be available for public hunting (approximately 49,000 ac or 80% of the Reserve) following establishment of the planned, fenced management units. DOFAW lands within the proposed fencing area will be fenced in increments and will remain available for public mammal hunting as part of Hunting Unit B until fencing and ungulate control is initiated. Public hunting will be used in the initial stages of feral ungulate removal from fenced management areas wherever safe, feasible, and effective.

DOFAW seeks to balance the objective of continuing to provide public hunting opportunities in the Reserve with the protection of native ecosystems and watersheds. The Ka'ū Forest Reserve is very large (61,641 ac (24,945 ha) of public land) and will be able to accommodate both management objectives. The Reserve is not designated as an area where habitat will be manipulated to enhance game populations due to the high quality of the native ecosystems and watersheds. This plan emphasizes increasing access to lower portions of the Reserve to allow for public hunting while increasing watershed and native ecosystem protection in more remote, inaccessible upper portions of the Reserve through fencing of management units and removal of feral ungulates.

Figure 16. Public Hunting Areas in Ka'ū Forest Reserve



## 7. Commercial Activity

Management Objective: Develop means to make Ka'ū Forest Reserve economically self-supporting, in whole or in part, as has been done with other forest reserves across the state.

Actions:

1. Determine environmentally compatible means for generation of revenue to support proposed management activities.

According to HRS §183.5 (5), the department shall: Devise and carry into operation, ways and means by which forests and forest reserves can, with due regard to the main objectives of title 12, be made self-supporting on whole or in part.

Commercial activity is not a priority management activity for Ka'ū Forest Reserve. DOFAW will only develop commercial activities in the Reserve that are compatible with the highest priorities - protection of watershed values and native ecosystems, and that do not interfere with public activity.

Water is one of the most important sustainable resources generated by the Reserve. One potential source of funding for watershed management is a long-term agreement with ADC for the use of water and water infrastructure in Ka'ū Forest Reserve. ADC is interested in developing such an agreement to benefit agricultural water users in Ka'ū. Funds generated from an agreement with ADC could be used for the implementation of watershed protection projects, which would improve the quantity and quality of water generated from the Reserve.

### ***D. Management Plan Implementation***

#### 1. Management Plan Cost

The estimated costs of proposed management actions are outlined in Table 9. The management actions proposed in this plan will require a greatly increased level of funding in order to implement over the next ten or more years.

There are currently limited financial resources to manage the Forest Reserve System, and DOFAW has estimated there is approximately \$0.25/acre funding available for forest reserve management statewide. Increased funding for high cost projects outlined in this plan will be obtained through outside grants as well as funding from partners, including federal and private organizations. High profile actions such as the reintroduction of 'Alalā to the wild will provide an opportunity for increased funding for management that will provide multiple benefits (e.g. funding for fencing and ungulate removal will benefit watershed values, native ecosystems and native forest birds, including the 'Alalā). Ka'ū Forest Reserve is a high priority for increased management for conservation agencies and organizations across the state and nationwide. The

completion of management planning and compliance for actions proposed in the plan will likely generate increased financial resources to manage the area.

## 2. Staffing

Current staffing levels are not adequate to implement the projects proposed in this plan. DOFAW anticipates obtaining outside funding through federal and private grants to increase staff levels to implement projects. Major actions such as fencing may be contracted to outside entities; however, a DOFAW team of 5-10 people (wildlife biologists and field personnel) will be needed to implement other projects proposed in this plan. Similar ongoing DOFAW and watershed management projects elsewhere in the state hire personnel through the University of Hawai'i Pacific Cooperative Studies Unit. Additional funding and staff support will also be available from partners such as the TMA.

## 3. Timetable

To be determined based on available funding.

### ***E. Overall Measures of Success***

Indicators that may be used to gauge the success of the various management actions proposed for Ka'ū Forest Reserve include:

- Number of cattle removed from forest
- Miles of fence, or number (acres) of fenced management units constructed
- Miles of fence, or number (acres) of fenced management units maintained
- Numbers of feral ungulates removed from fenced management units
- Area and percent of forest land with significant soil erosion
- Levels of nutrients, dissolved oxygen, suspended sediment, turbidity, siltation or temperature change in water
- Ground-water recharge rates and aquifer sustainable yields
- Level of rainfall gauging
- Improved public access by roads and trails
- Reintroduction of extirpated species
- Native forest bird populations stable or increasing
- Percent cover by forest type
- Acres of invasive plants controlled
- Miles of unpaved access road maintenance
- Number and extent of fires in the area
- Level of forest disease incidence or pest infestation
- Number of special use permits issued
- Amount of revenue generated

#### **IV. FUTURE RECOMMENDATIONS**

Forest Reserves encompass and incorporate a variety of public uses and benefits. DOFAW will continue to seek to balance these uses to accomplish overall goals for Ka'ū Forest Reserve including protecting watershed values and native ecosystems and providing public recreational opportunities. This plan is intended to cover a fifteen-year time frame and will be revised, as necessary, as actions proposed in the plan are successfully implemented.

Future plans will address management of additional areas which are currently in the process of being added to the Ka'ū Forest Reserve (Kapāpala Koa Canoe Management Area and Kamilo). These areas contain different resources (e.g. koa canoe logs, coastal ecosystems), and DOFAW will have different priorities for the management of these areas.

Ka'ū Forest Reserve will continue to be a major water resource for future generations. Watersheds services include providing humans with a fresh water supply, providing habitat for native plants and animals, allowing better flood control, mitigating climate change impacts, and providing economic, social, recreational and educational opportunities for the human communities in the area. Economic and agricultural development in the Ka'ū District and an increasing population will require the fresh water produced and filtered by the forested watershed.

Future management will need to benefit watershed, native forest ecosystems and unique native species and people who use the area for recreation and cultural practices. Future plans may propose additional fencing and ungulate removal, particularly in areas critical to protect the watershed and native plants and animals.

**Table 9. Ka‘ū Forest Reserve Management Summary (15 years)**

| <b>Management Goal</b>                       | <b>Management Objectives</b>  | <b>Recommended Major Actions</b>  | <b>Estimated Cost</b>   |
|--|---|---|---|
| Watershed Values and Native Ecosystems       | <p>Maintain native forest for production of fresh water for public use, reduction of land-based pollutants and improvements in coastal water quality.</p> <p>Maintain the long-term presence of native ecosystems</p> | <p>Remove all feral cattle from within the Reserve and control livestock trespass through continued DOFAW staff cattle control and maintenance of existing fencing</p> <p>Protect forested watershed from feral ungulate damage by constructing fenced management units for approximately 12,000 acres, removing feral ungulates from within fenced management units, and inspecting and maintaining fences.</p>  | <p>\$250,000</p> <p>\$3,300,000 (22 miles fencing)<br/>\$1,350,000 (ungulate control)<br/>\$ 200,000 (inspect/maintain)</p> |
| Invasive Species Control                     | Protect intact native forest from non-native, invasive weeds  | <p>Monitor and map the distribution of high priority weeds and develop a control strategy.</p> <p>Control weeds and prevent the introduction of new habitat-modifying species</p> <p>Identify highest priority areas for intensive weed control.</p> <p>Control weeds along invasion corridors (e.g., roads, trails, fences) and within fenced management units.</p> <p>Monitor weeds to determine whether weed control measures are effective and to detect changes in long term distribution and abundance.</p> | <p>\$350,000 (aerial imagery)</p> <p>\$1,000,000 (control)</p> <p>\$300,000 (map/monitor)</p>                               |
| Threatened and Endangered Species Management | Assist with the recovery of threatened and endangered species by protecting occurrences of these species and restoring them in appropriate habitat  | <p>Forest Birds</p> <ul style="list-style-type: none"> <li>• Monitor to assess changes in the population and distribution.</li> </ul> <p>‘Alalā</p> <ul style="list-style-type: none"> <li>• Predator control</li> <li>• Restore native food plants</li> </ul>  | <p>\$150,000</p> <p>\$2,500,000</p>   |

|                        |  |   |  |
|------------------------|--|---|--|
|                        |  | <ul style="list-style-type: none"> <li>• Construct release cages, release birds</li> </ul> Plants <ul style="list-style-type: none"> <li>• Survey, map and collect propagation material.</li> <li>• Propagate and re-introduce plants through outplanting.</li> <li>• Monitor growth/survival of reintroduced plants.</li> <li>• Protect rare plants outside fenced management units through the construction of small fenced exclosures</li> </ul> | \$100,000  |
| Public Activity        | Provide for continued public use including hunting, recreational opportunities, cultural uses, personal gathering, and educational programs. | Maintain existing public access roads.<br><br>Develop new access routes to increase access, particularly across private and state-leased lands below the Reserve.<br><br>Continue to facilitate public hunting in the Reserve.<br><br>Develop trails and recreational amenities<br><br>Hire outreach staff and work with partners to provide community outreach and education   | \$300,000<br><br>\$500,000<br><br>\$500,000<br><br>\$500,000                                       |
| Resource Protection    | Reduce the threats of fire, insects, and disease to the Ka'ū Forest Reserve  | Respond to fires, as needed.<br><br>Monitor forest for invasive insects and disease.  | 100,000<br><br>\$50,000  |
| Game Animal Management | Continue to provide public hunting opportunities in Ka'ū Forest Reserve.   | Maintain existing public access roads for use by hunters.<br><br>Develop new access routes to increase access, particularly across private and state-leased lands below the Reserve.<br><br>Provide opportunities for public hunters to   | Costs under public activity<br><br>Costs under public activity<br><br>Costs under ungulate control |

|                     |  |   |              |
|---------------------|--|---|--------------|
|                     |  | assist with the removal of feral pigs and sheep in fenced, management units prior to staff control.             |              |
| Commercial Activity | Develop means to make Reserve economically self-supporting, in whole or in part, as has been done with other forest reserves across the state. | Determine environmentally compatible means for generation of revenue to support proposed management activities. |              |
| <b>TOTAL</b>        |  |   | \$11,450,000 |

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## VI. APPENDICES

**A. Ka'ū Forest Reserve Additions and Withdrawals**

| <b>Action</b>           | <b>Date</b>      | <b>A/W</b> | <b>Description</b>   | <b>Acres</b>  | <b>Copy of Survey Furnished (CSF)</b> | <b>Tax Map Key</b>   |
|-------------------------|------------------|------------|--|---------------|---------------------------------------|--|
| Governor's Proclamation | August 2, 1906   | A          | Set aside to continue protection of the forest on the lower slope of Mauna Loa | 65,850<br>*/1 | 1722                                  | 397001001 (por.)<br>398001004 (por.)<br>397001022<br>397001007 (por.)<br>397001006<br>397001018<br>397001013<br>397001005<br>397001012<br>397001014<br>397001008<br>397001004<br>397001016<br>39700102397001020<br>397001015<br>397001003<br>397001017<br>397001002<br>397001019 |
| Governor's Proclamation | February 4, 1911 | A          | Addition of lands at Ka'ala'ala-Makakupu, Keaīwa, Ka'auhuuula and Pālima       | 216.2<br>*/2  | 2213                                  | 397001001 (por.)<br>397001007 (por.)   |
| Governor's Proclamation | October 17, 1930 | W          | Modify - boundary revision/revised description of Ka'ū Forest Reserve          | 67,078<br>*/3 | 5652                                  | 397001001 (por.)<br>397001022<br>397001007<br>397001006<br>397001018<br>397001013<br>397001005<br>397001012<br>397001014<br>397001008<br>397001004<br>397001016<br>397001021<br>397001020<br>397001015<br>397001003<br>397001017<br>397001002<br>397001019                       |

|                         |                |   |   |              |                         |  |
|-------------------------|----------------|---|---|--------------|-------------------------|--|
| Governor's Proclamation | April 13, 1932 | A | Addition (portion of the lands of Wai'ōhinu in the vicinity of Hā'ao Springs) as land important for the conservation of water | 266.80       | 5842                    | 397001001 (por.)<br>397001009  |
| Executive Order 1560    | May 1, 1953    | W | Withdraw from Governor's proclamations of August 2, 1906, February 4, 1911, October 17, 1930 and April 13, 1932               | 5,955        | 11599                   | 397001013<br>397001012<br>397001014<br>397001008<br>397001004 (por.)<br>397001016<br>397001021<br>397001020<br>397001015<br>397001003<br>397001017<br>397001002 (por.) |
| Executive Order 4156    | April 24, 2006 | A | Land set aside for public purpose, for addition to Ka'ū Forest Reserve  | 4,744.9<br>0 | 24187<br>24188<br>24189 | 396006018<br>396006015<br>396006010<br>396006009<br>397001014<br>397001016<br>397001021<br>397001020<br>397001015<br>397001017   |

\*/1 Includes private lands at Kāhilipalinui (165 ac.), Hīlea Nui (2620 ac.), Hīlea Iki (37 ac.), Punalu'u (1275 ac.), Pā'au'au 2 (1675 ac.), and Keaīwa (460 ac.).

\*/2 Includes private lands at Keaīwa (23 ac.).

\*/3 Includes private lands at Kāhilipalinui (169 ac.), Kī'olokū (211 ac.), Hīlea Nui (2620 ac.), Hīlea Iki (37 ac.), Punalu'u (1378 ac.), Pā'au'au 2 (1598 ac.), and Keaīwa (511 ac.).

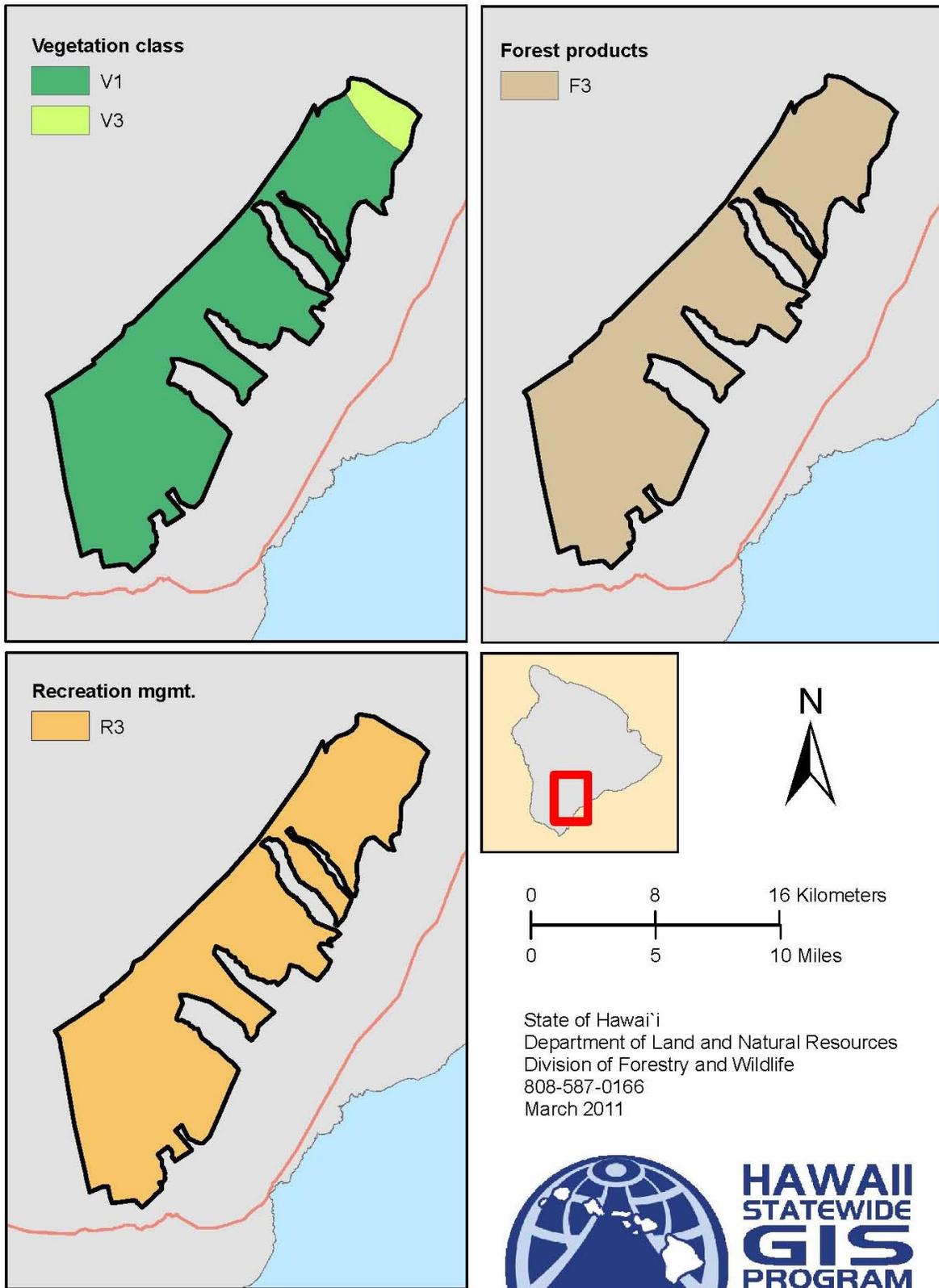
## B. DOFAW DRAFT Management Guidelines for Ka'ū FR

DOFAW prepared DRAFT Management Guidelines in 2001 to balance desired levels of activities (human use) on DOFAW managed lands. DOFAW is currently in the process of updating these draft management guidelines. The guidelines emphasize three program areas with conflicting resource demands or user groups. Current management guideline maps show classification of native vegetation according to its relative intactness and habitat quality and recommended levels of human use within these vegetation classifications for the following activities: Outdoor Recreation, Forest Products, Game Management and Hunting.

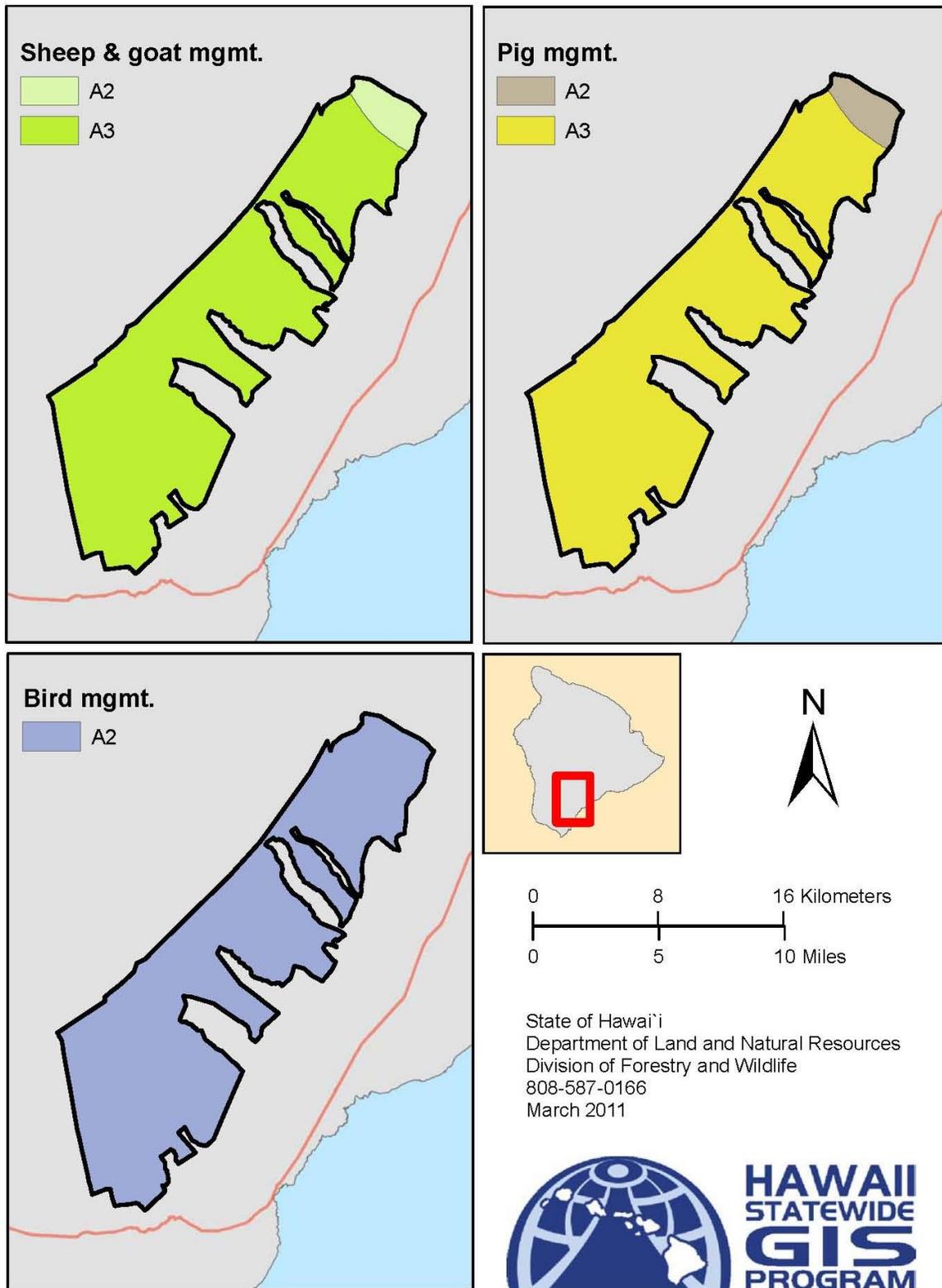
| Management Guideline        | Classification                        | Objective   | Permitted activities  |
|-----------------------------|---------------------------------------|---|---|
| Vegetation                  | V-1 Highest Quality Native Ecosystems | Protect and perpetuate these areas, by preventing non-sustainable activities or intensities of use  | Permitted activities are minimally disruptive, and would be focused on ecosystem preservation   |
|                             | V-3 - Considerably Disturbed Areas*   | Prevent activities or intensities of use that result in degradation of unique native species and secondary forest resources (water supply, erosion control & aesthetic values). | Permitted activities may have high levels of disturbance, as long as they don't negatively impact remaining native plant populations and have an eventual net benefit to other resources like water, or an improved vegetative cover for other activities. Native plant conservation may be focused at a species, rather than an ecosystem level. |
| Game Management and Hunting | A3 - Game Control (public)            | Resource protection is the primary objective, with emphasis on native plant communities and watersheds.   | Seasons and bag limits are designed for public hunting to reduce impacts to native resources  |
|                             | A2 - Mixed Game and Other Uses        | Game management is an objective integrated with other uses.   | Habitat may be manipulated for game enhancement. Game populations are managed to acceptable levels using public hunting.  |
| Outdoor Recreation          | R3 Light Use                          | Recreation would be limited to certain areas, or occasional levels of use due to impacts on resources or programs.  | Trails would be the main recreational feature, and their use may be restricted.   |
| Forest Products             | F3 Personal                           |   | Small-scale non-commercial harvesting or salvage is allowed, such as materials for cultural uses. Permit and/or license required with appropriate restrictions.   |

\* According to DOFAW staff, Ka'ū FR areas classified as V-3 in 2001 are not currently distinctive from adjacent V-1 areas. V-3 areas may have been classified due to disturbance due to feral cattle that have since recovered due to feral cattle removal.

DOFAW DRAFT Management Guidelines for Ka'ū FR (Vegetation Class, Forest Products and Recreation Management)



DOFAW DRAFT Management Guidelines for Ka'ū FR (Vegetation Class, Forest Products and Recreation Management)



**C. U.S. Fish and Wildlife Service Recovery Plans/Critical Habitat Designations for Ka'ū Species of Plants and Animals**

| Recovery Plan/Critical Habitat Designation   | Comment  |
|--|--|
| Revised Recovery Plan for the 'Alalā ( <i>Corvus hawaiiensis</i> ) (2009)  | <p>Recommendations for management actions for the benefit and recovery of the 'Alalā.</p> <p><a href="http://www.fws.gov/pacific/ecoservices/angered/recovery/documents/AlalaDraftRevisedRecoveryPlan.pdf">http://www.fws.gov/pacific/ecoservices/angered/recovery/documents/AlalaDraftRevisedRecoveryPlan.pdf</a></p> |
| U.S. Fish and Wildlife Designation of Critical Habitat for 12 Species of Picture-Wing Flies From the Hawaiian Islands (2008)               | <p>Provides recommendations for habitat management for <i>Drosophila heteroneura</i></p> <p><a href="http://www.gpo.gov/fdsys/pkg/FR-2008-12-04/pdf/E8-27664.pdf#page=2">http://www.gpo.gov/fdsys/pkg/FR-2008-12-04/pdf/E8-27664.pdf#page=2</a></p>  |
| U.S. Fish and Wildlife Revised Recovery Plan for Hawaiian Forest Birds (2006)  | <p>Recommendations for management actions for the benefit and recovery of native forest birds.</p> <p><a href="http://ecos.fws.gov/docs/recovery_plan/060922a.pdf">http://ecos.fws.gov/docs/recovery_plan/060922a.pdf</a></p>  |
| U.S. Fish and Wildlife Final Designation and Nondesignation of Critical Habitat for 46 Plant Species From the Island of Hawai'i, HI (2003) | <p>Discusses management actions for the benefit and recovery of <i>Cyanea stictophylla</i>, <i>Melicope zahlbruckneri</i>, and <i>Phyllostegia velutina</i></p> <p><a href="http://www.fws.gov/policy/library/2003/03-14143.pdf">http://www.fws.gov/policy/library/2003/03-14143.pdf</a></p>                           |
| U.S. Fish and Wildlife Big Island II: Addendum to the Recovery Plan for the Big Island Plant Cluster (1998a)                               | <p>Provides recommendations for management of <i>Phyllostegia velutina</i> and <i>Melicope zahlbruckneri</i></p> <p><a href="http://ecos.fws.gov/docs/recovery_plan/980511a.pdf">http://ecos.fws.gov/docs/recovery_plan/980511a.pdf</a></p>  |
| U.S. Fish and Wildlife Recovery Plan for the Hawaiian Hoary Bat (1998b)  | <p>Supports objective 2: protect and manage current populations and identify and manage threats</p> <p><a href="http://ecos.fws.gov/docs/recovery_plan/980511b.pdf">http://ecos.fws.gov/docs/recovery_plan/980511b.pdf</a></p>   |
| U.S. Fish and Wildlife Recovery Plan for Four Species of Hawaiian Ferns (1998c)  | <p>Provides recommendations for management of <i>Asplenium peruvianum</i> var <i>insulare</i></p> <p><a href="http://ecos.fws.gov/docs/recovery_plan/980410e.pdf">http://ecos.fws.gov/docs/recovery_plan/980410e.pdf</a></p>   |
| U.S. Fish and Wildlife Recovery Plan for the Big Island Plant Cluster (1996)   | <p>Provides recommendations for management of <i>Clermontia lindseyana</i>, <i>Cyanea stictophylla</i>, and <i>Nothocestrum breviflorum</i></p> <p><a href="http://ecos.fws.gov/docs/recovery_plan/960926a.pdf">http://ecos.fws.gov/docs/recovery_plan/960926a.pdf</a></p>   |