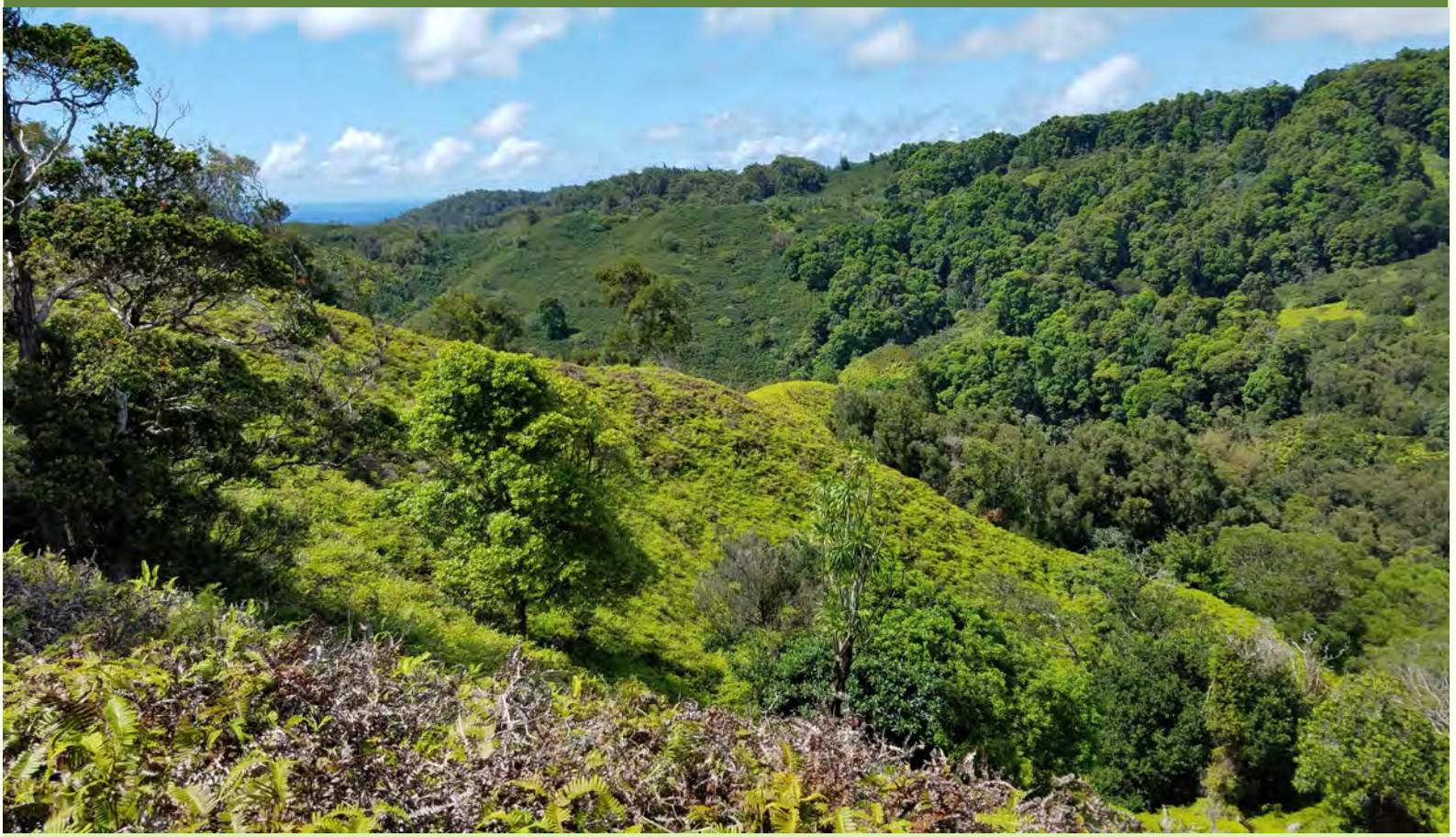
Pūpūkea Forest Reserve

Management Plan - 2017



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

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EXECUTIVE SUMMARY

This management plan for Pūpūkea Forest Reserve on Oʻahu is one in a series of site-specific natural resource management 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 Hawaiʻi. These plans present a brief history of the specific forest reserve, a complete record of land transactions and boundary changes over time, a description of cultural and natural resources, as well as an account of infrastructure and intended use(s) of the area. These plans serve to: (1) assist in preparation of regulatory compliance documents required to implement management actions outlined in the plan; (2) support DOFAW efforts to secure funding for plan objectives; (3) prioritize implementation of management objectives; (4) solicit requests for proposals or bids to implement plan objectives; and (5) inform the public of short and long-term goals.

Pūpūkea Forest Reserve (FR) was established by Governor's Proclamation in 1910 to conserve and protect the remaining forest and increase local water supply. The reserve consists of approximately 782 acres of state land located on the northwestern portion of the Koʻolau Mountain Range in the Koʻolauloa District on Oʻahu. Vegetation is dominated by non-native forest, but some ʻōhiʻa forest, open koa ʻōhiʻa forest, and scattered native shrublands still exist in the southeast portion of the reserve. There are several plantation stands composed of non-native commercial timber species that were planted as part of a reforestation effort that happened in the early 1900's. A previous management plan was drafted for Pūpūkea Forest Reserve in the early 1960's; this plan was never completed and much of the information it contains is now outdated.

DOFAW's current management activities within Pūpūkea FR include maintenance of infrastructure such as fences, picnic tables, gates, locks, a shelter, bridge, and one Nā Ala Hele (NAH) trail.

Forest reserve management priorities were divided into eight categories and ranked on a qualitative basis. Summaries of management priorities and goals for the Pūpūkea Forest Reserve are as follows:

1. Watershed Values - Erosion reduction and prevention; increase lands under Forest Reserve status.
2. Resource Protection - Wildfire prevention and mitigation.
3. Public Activity - Maintain and enhance public use opportunities; improve educational and informational signage.
4. Invasive Species Control - Manage incipient and established invasive plants and animals.
5. Game Animal Management - Promote public hunting through amendments to Hawaiʻi Administrative Rules (HAR) Chapter 122 and 123.
6. Native Ecosystems - Native ecosystem restoration; expand native forest ecosystems/cover.
7. Threatened and Endangered (T&E) Species Management - Protect occurrences of rare and endangered plants and animals.
8. Commercial Activity - Generate income from commercial use activities in the reserve; provide opportunities for sustainable commercial forest product collection.

Details of specific strategic goals and action items can be found in Table 9 on page 35 of this plan. This plan is intended to describe short-term resource management planning and implementation strategies, as well to serve as a basis for future updates and modifications to accommodate evolving or additional objectives for Pūpūkea Forest Reserve.

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PŪPŪKEA FOREST RESERVE

MANAGEMENT PLAN SIGNATURE PAGE

O'ahu Branch certification: This plan was prepared by a team of Division of Forestry and Wildlife (DOFAW) staff to provide a management framework for Pūpūkea Forest Reserve.

Marigold S. Zoll, DOFAW O'ahu Branch Manager — Date: 10-16-17

DOFAW Administrator's approval: I have reviewed the enclosed Forest Reserve Management Plan and concur with the recommendations herein. I agree that resource management implementation will follow those specified in the Management Plan for Pūpūkea Forest Reserve.

David G. Smith – DOFAW Administrator — Date: 11/14/17

Department of Land and Natural Resources Board approval: This plan is in accordance with the mandates of the State Forest Reserve System which includes Chapter 183, Hawai'i Revised Statues, and Chapter 13-104, Hawai'i Administrative Rules.

Suzanne D. Case - BLNR Chairperson

Approved by the Board of Land and Natural Resources at its meeting held Oct. 13, 2017

DEVELOPMENT PROCESS TIMELINE

Pūpūkea Forest Reserve, O‘ahu

Stage of Development	**Date Achieved**	**Comments**
Branch review	August 2015	Incorporated
DOFAW review	October 2016	Incorporated
Partner agency consultation	March 2017	Incorporated
Public consultation	June 2017	Incorporated
DOFAW approval	September 2017	None
BLNR approval	October 2017	None

I. INTRODUCTION

The Division of Forestry and Wildlife conducts on-going planning efforts to develop and update management plans for all forest reserves across the state. The format and content of the respective reserve plans are generally consistent across the state and serve to guide field management, assist in budgeting and funding concerns, and involve partner organizations and the public in the intended management of the forest reserve. These plans also help to fulfill certain recommendations made in the Hawai‘i Tropical Forest Recovery Action Plan, including updating or completing and implementing management plans for all publicly owned and managed forests. The recovery action plan came about as a result of the 1992 Federal Hawai‘i Tropical Forest Recovery Act.

Each Branch office of the Division will have a comprehensive management plan that addresses overall Forest Reserve System issues, goals and objectives for that Branch. In addition, management plans will be developed for each individual forest reserve, which will in part reflect the Division's management guidelines specific to that area. This document represents the management plan for the Pūpūkea Forest Reserve, in which concerns and strategies are addressed for the public lands within the reserve.

This management plan for the Pūpūkea Forest Reserve was developed using a variety of methods. Initial development consisted of reviewing and analyzing DOFAW historic and current files (both at the administrative and O‘ahu Branch office), and documents obtained from other state agencies including the Department of Land and Natural Resources Land Division and Bureau of Conveyances, the Department of Accounting and General Services Survey Division, as well as the State Archives. State of Hawai‘i Geographic Information Systems (GIS) map layers relating to biological, historical, and environmental resources were referenced extensively to develop this plan.

Additional resources utilized for the development of this plan (including other plans that identified the Forest Reserves or the general area), were the Hawaiian Forester and Agriculturalist, Hawai‘i Biodiversity and Mapping Program, Hawai‘i Comprehensive Wildlife Conservation Strategy, Hawai‘i Forest Action Plan, U.S. Fish and Wildlife Service Recovery Plans, biological surveys, among others. The plan evolved into its final iteration through discussions with Division staff from all program areas, both at the O‘ahu Branch and administrative offices, other divisions and state agencies, DOFAW partners, and the public.

Once finalized by DOFAW, this management plan for Pūpūkea Forest Reserve will be submitted for review and approval by the Board of Land and Natural Resources (Board). If approved by the Board, the following actions may be triggered:

1. Preparation of regulatory compliance documents as required for implementation of management actions as outlined in the plan.
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 as necessary.

II. PŪPŪKEA FOREST RESERVE DESCRIPTION

A. Location and Description: Pūpūkea FR is located on the northern slopes of the Koʻolau Mountains on the island of Oʻahu (Figure 1) and is comprised of approximately 782 acres of public land (Table 1). Pūpūkea FR is within the ahupuaʻa of Paumalū, and is surrounded by the ahupuaʻa of Waimea to the south, Kaunala to the northeast, and Pūpūkea to the west. Principal adjacent landowners and lessees include the Boy Scouts of America (on former public FR lands) to the west, Pūpūkea Homesteads to the northwest, Girl Scouts of Hawaiʻi to the north, Pūpūkea-Paumalū State Park Reserve to the northeast, federal lands used as the Kahuku Training Area to the east, private lands owned by Dole Food Co. Inc. leased to the U.S. Military as components of the Kawailoa Training Area to the south, and Waimea Valley owned by the Office of Hawaiian Affairs to the southwest. Pūpūkea FR is dominated by non-native vegetation, with some areas of ʻōhiʻa forest, open koa ʻōhiʻa forest, and scattered native shrublands in the southeast portion of the FR.

Table 1: Government Tax Map Key (TMK) parcels currently comprising public lands of Pūpūkea Forest Reserve (Figure 1).

TMK Number	Owner	Tax Acres (entire TMK)	GIS Acres (entire TMK)	GIS Forest Reserve Acres
159006026	State of Hawaiʻi	700	720.1	720.1
159006006	State of Hawaiʻi	72.9	61.86	61.86
			TOTAL	**781.97**

B. Geographic Site Data: The island of Oʻahu is the third largest of the Hawaiian Islands. Oʻahu consists of two extinct volcanoes: Koʻolau in the east and Waiʻanae in the west. These mountains form parallel ranges which are the eroded remnants of two shelf volcanoes that erupted 1.3 and 2.2 million years ago. The broad plain that extends from Diamond Head across Pearl Harbor to ʻEwa and Barbers Point is partly the result of upward seafloor warping or tilting as caused by weight pressure from Maui and Hawaiʻi Island (Juvik and Juvik, 1998). Pūpūkea FR is a part of the Koʻolau mountain range and is the northernmost forest reserve on Oʻahu.

C. Physical Site Data: The elevation of Pūpūkea FR ranges from 500 feet along the northern boundary to 1,300 feet at the southeast corner of the reserve at a peak called Puʻu Moa. There is another peak, Puʻu Aimuʻu, located in the northern portion of the reserve. The reserve encompasses three gulches and adjacent ridge systems. Each gulch contains one perennial tributary that feed into Paumalū Stream. The stream supplies water for users downstream and is ranked as a substantial cultural and recreational resource in the Hawaiʻi Stream Assessment Report (State of Hawaiʻi and National Park Service, 1990).

Average annual rainfall ranges from 62 to 90 inches (Figure 2). The United States Department of Agriculture's Natural Resource Conservation Service has mapped Kapaʻa silty clay as the dominant soil type in Pūpūkea FR. Other soils present include Paumalū-Badland complex, Paʻaloa silty clay, and Paumalū silty clay as shown in Figure 3. This agency provides online soil maps and data at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

D. Pre-Reserve History and Forest Reserve History:

Pre-Reserve History: According to the Atlas of Hawaiʻi, 3rd Edition, the area of Pūpūkea FR was most likely mesic forest and shrubland prior to human settlement. The topography of Paumalū was not suitable for wet taro cultivation, so it is likely that the gulches and streams were never terraced or planted (Handy and Handy, 1991). Following European contact, Pūpūkea FR was primarily used for cattle grazing.

Figure 1: Current extent of public lands of Pūpūkea Forest Reserve

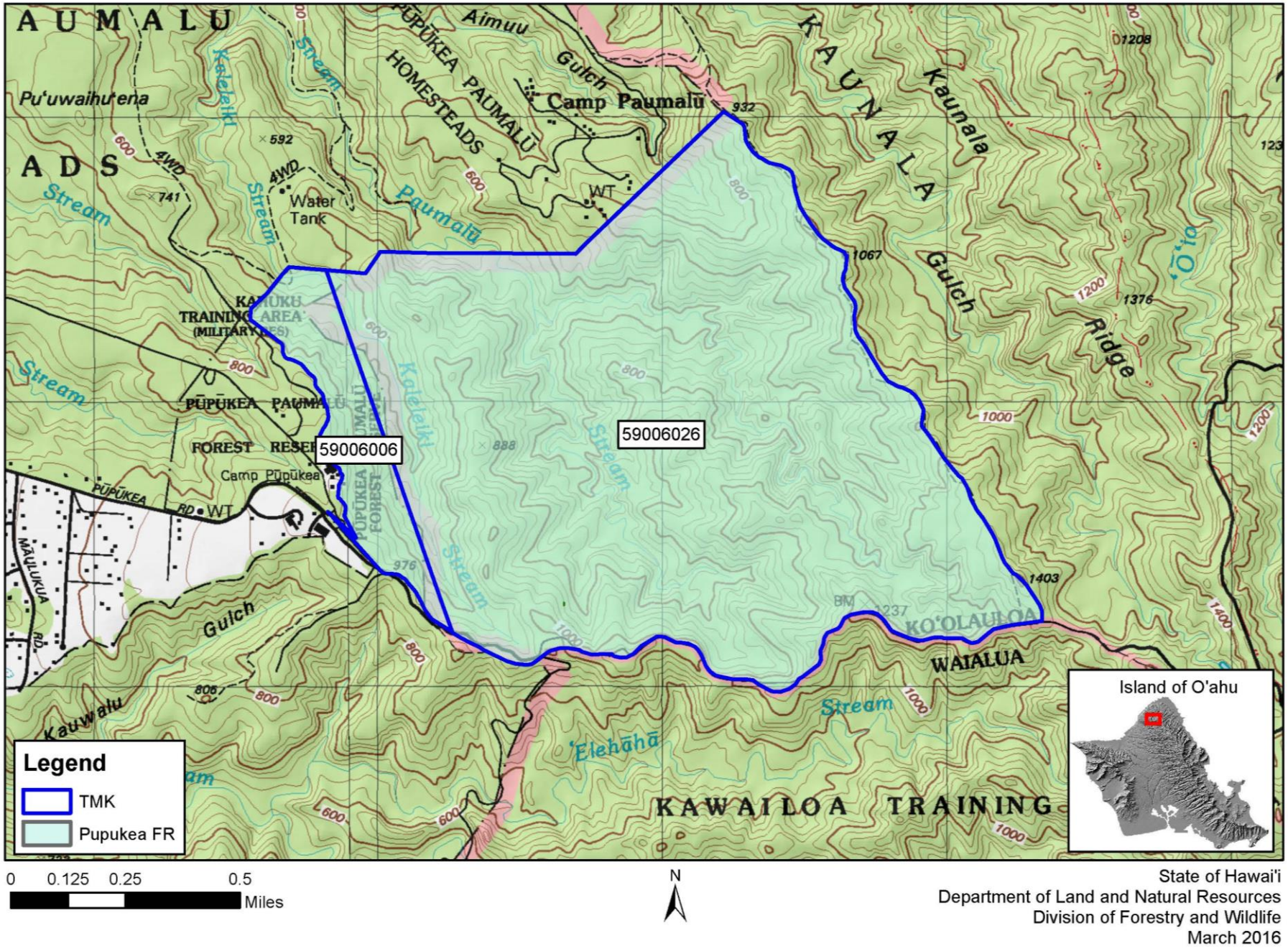


Figure 2: Hydrological features of Pūpūkea Forest Reserve

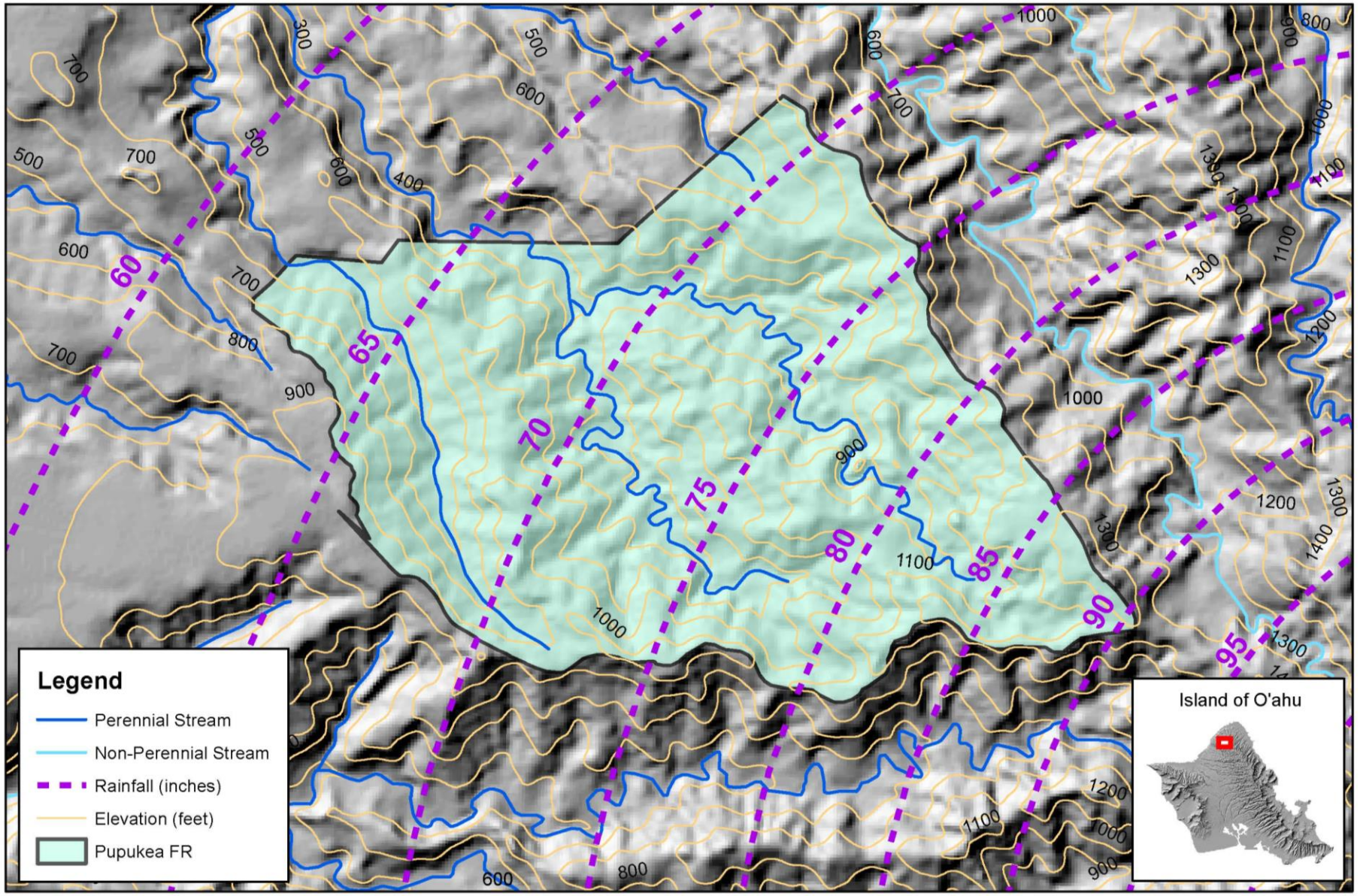
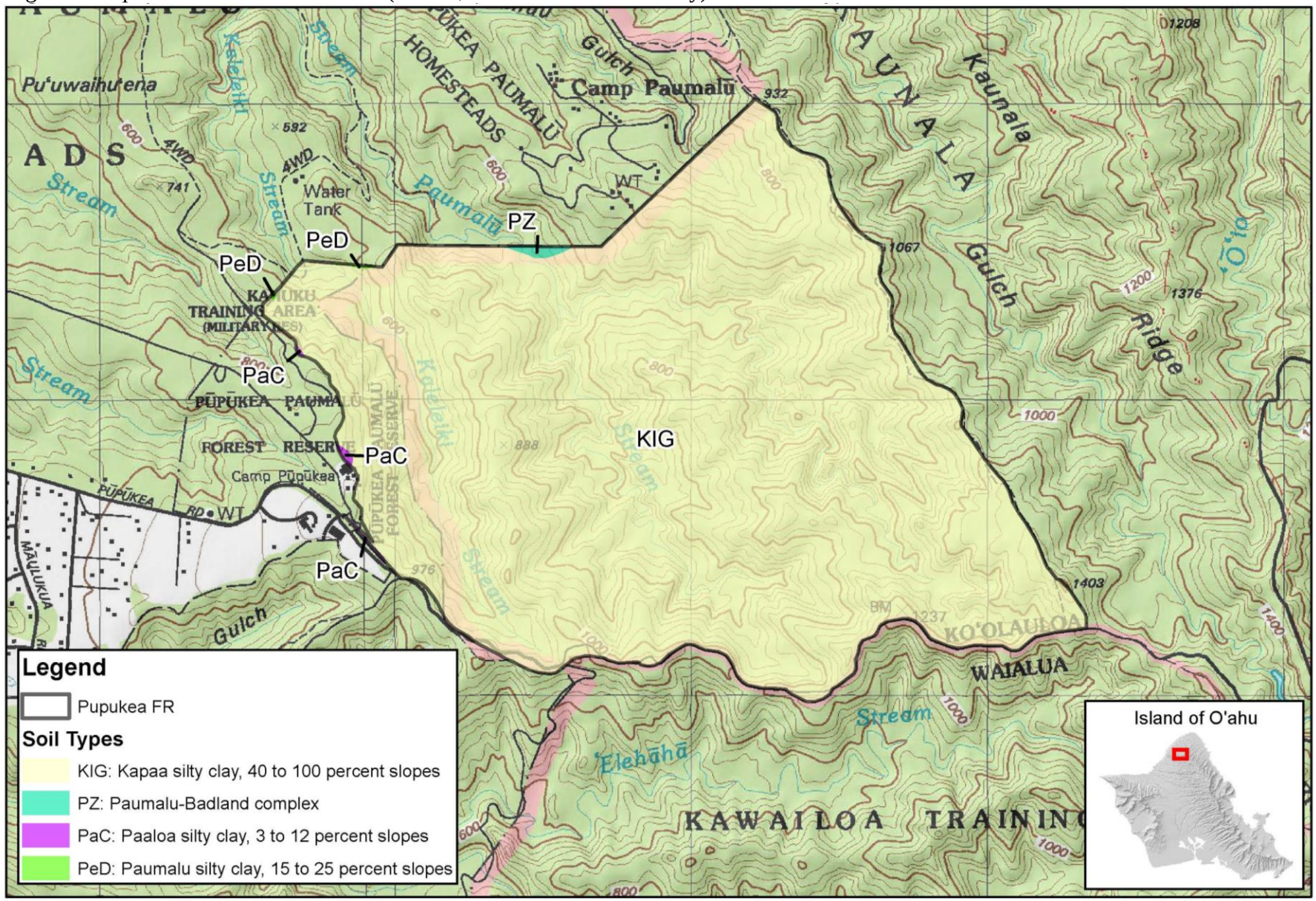


Figure 3: Pūpūkea Forest Reserve Soils (USDA, NRCS Web Soil Survey)



Since 1903, the Division of Forestry has planted millions of trees statewide to replace forests that were lost due to fire, cattle grazing, and harvesting for fence posts and fuel wood for whaling ships and sugar mills. Non-native tree species were primarily used because early foresters concluded that they were more suitable to rapidly revegetate denuded sites than native species. Native species were also used, but in much smaller numbers (Skolmen, 1980). See Appendix B for more information on the specific plantings done in Pūpūkea FR.

Forest Reserve History: Pūpūkea FR was established by Governor's Proclamation on May 10, 1910, to protect the forest and increase the flow from several small springs and waterholes. According to a report that preceded the 1910 proclamation, the forest consisted of "ohia lehua and koa, with considerable lauhala in the lower part and a scattering of other trees, including some iliahi," (Hosmer 1910, p. 129). Pūpūkea FR was comprised of four main units: Water Reserves A (13.33 acres), Water Reserve B (13.4 acres), Water Reserve C (47.1 acres) and the main FR unit (790 acres). The water reserves were included in the forest reserve to provide additional protection to the existing water and natural resources in the area.

Water use:

Residents of the Pūpūkea-Paumalū Homestead Tract were interested in utilizing the surface water flowing from the forest reserve onto their lots. In 1910, they formed two water users associations, the Pūpūkea Water Users Association and the Paumalū Water Users Association. The Pūpūkea Water Users Association was issued a water license (GL741-A) in 1911 that allowed for utilization of 11/20ths of all natural running waters for a term of 50 years. The Paumalū Water Users Association was issued a similar license (GL1701) in 1925 for a term of 21 years. Both licenses covered the main forest reserve unit and Water Reserve C.

In 1943, the Attorney General issued an opinion stating that the license issued to the Pūpūkea Water Users Association in 1911 was nothing more than a revocable permit because it was not sold at public auction. As a result of the Attorney General's opinion, both associations were issued revocable permits (RP330 and RP338) in 1949 to continue to take water from the FR. The revocable permits were canceled in the 1960's as both associations had dissolved by this point.

In 1949, the Board of Commissioners of Agriculture and Forestry approved the removal of Water Reserves A and B from the FR. The water reserves were removed because most of the Homestead area was acquired by the Hawaiian Avocado Company, and the surrounding areas had been converted to pastureland. In 2007, both parcels were acquired by the DLNR to be set aside to the Division of State Parks for state park purposes. It was found that the parcels had not been formally withdrawn from the FR however, so EO 4437 was issued in 2013 to remove the parcels from the FR and set them aside to the Division of State Parks (Table 2). The parcels were added to the Pūpūkea-Paumalū State Park Reserve to increase public access and recreational opportunities. In 1964, a one-acre portion of Water Reserve C was withdrawn by EO 2155 for a reservoir site.

United States Army:

The United States Army (Army) has a long history of land use in Pūpūkea FR, using the area for training purposes prior to, during, and after World War II. In 1944, the Army was granted a permit that allowed them to use and occupy Water Reserve C for military purposes. The terms of the permit were retroactive and effective from December 7, 1941 to 6 months after the end of

the war. The permit allowed the Army to establish temporary structures for training purposes. In 1945, BSA expressed interest in using the buildings and camping facilities constructed by the Army in Water Reserve C for a summer camp. The Army had no objections and canceled their permit to allow BSA to obtain their own permit to use the area.

In 1964, the Army was issued General Lease No. S-3850 for military purposes in the main forest reserve area (TMK (1) 5-9-006:026). The lease is valid for a term of 65 years, and entitles entrance, construction activities, and sign posting in the FR. The Army is responsible for taking precautions to prevent forest fires and unnecessary damage to the natural resources in the reserve. Firing of weapons is allowed as long as they are not larger than .50 caliber, and 3.5-inch rockets or weapons of similar size are allowed as long as no forest fires are created. The lease also stipulates that the FR will be open to the public and under the control of the State of Hawai‘i from dusk on Friday to midnight on Sunday, and from dawn to midnight on national holidays. The Army may obtain an exemption from this clause by notifying the public about training activities that must be conducted during specific weekends and holidays.

Figure 4: Drum Road in Pūpūkea FR

In 2006, the Board approved the issuance of a perpetual, non-exclusive easement to the Army for road right-of-way purposes over Drum Road in Pūpūkea FR. The U.S Army Engineer District was subsequently granted an interim construction right-of-entry onto Government lands for repairs to Drum Road while the easement documents were completed. The perpetual non-exclusive easement was never finalized.

In 2009, the Army paved the portion of Drum Road within the FR in support of Striker Brigade training. O‘ahu Branch staff met with the Army to discourage the project, preferring the dirt road because it would be more manageable to maintain. The Army ultimately paved the road, classifying it as “road maintenance” which is an allowed activity under their lease agreement. In late 2014, early 2015, heavy rainfall resulted in soil erosion that undercut a portion of the paved road. The road was deemed impassable and has been closed since. DOFAW does not have the current resources to repair the road.

<u>Boy Scouts of America:</u>
The Boy Scouts of America also have a history of land use in Pūpūkea FR. In 1946, BSA was issued a 10-year use permit to use buildings and camping facilities built by the Army in Water Reserve C for a summer camp. Rights to the facilities and campsite were transferred to BSA from the Army. The permit allowed BSA to use the area as a campsite, occupy a portion of the main FR, perform tree planting, trail cleaning, and other maintenance work as authorized by the Board. The facility is now called Camp Pūpūkea. To secure long term interest in Camp Pūpūkea, BSA requested a long-term lease in 1964. BSA was granted a lease (S-3951) in 1966 for use of Water Reserve C for the duration of 55 years. BSA sought to acquire fee title of the two parcels that comprise Water Reserve C, so a land exchange with DLNR was executed in 2004. The parcels were formally withdrawn from the FR in 2011 by EO 4395.

Other notable items:

- 1946 - A truck from Fort Shafter was found cutting down Norfolk pines for Christmas trees without a permit.
- 1946 - Live ammunition was found along the roadsides, which was not permitted under the original lease.
- 1950 - One of the old army cabins under the Division's control was found to be used and locked by hunters. The cabins were open for use by hikers, but no exclusive use or locking was permitted.
- 1952 - The Hawaiian Electric Company was granted permission to construct a power line over a portion of the FR to serve the Mutual Telephone Company's Relay Service.
- 1952 - Harold Nakasone was issued a one-year revocable use permit to place one hundred colonies of bees in the FR for one year.
- 1953 - The Hawai'i Meat Co. and the Division of Forestry handled the repair of a deteriorated fence line discovered during an inspection as a 50-50 divide of materials and labor.
- 1954 - The Sunset Beach Community complained to the Board about a gate erected across the access road into the FR saying it limited public use. Construction of the gate was approved by the Board to stop pleasure rides and fence destruction.
- 2001 - Waimea Valley was given a key to the gate on the Pūpūkea access road to assist bikers involved in accidents related to their activities. There was one instance of misuse of that key by hunters who claimed they received the key from Waimea Valley.
- 2014 - Sunset Ranch proposed to build a parking lot on their property for the public who use the FR. Branch staff did not have any objections. To date however, construction has not begun.

Table 2: Summary of public land additions and withdrawals (A/W) for Pūpūkea Forest Reserve See Figure 6 for map descriptions. Data relating to these items are filed at the DOFAW Administrative Office and the State Survey Office.

Action	Date	A/W	Description	Acres	Copy of Survey Furnished (CSF)	Tax Map Key
Governor's Proclamation	10-May-1910	A	Establishment of Pūpūkea Forest Reserve	864	2137	5-9-006:026, 5-9-006:007, 5-9-005:071, 5-9-:005:002
Executive Order 2155	28-Jun-1964	W	Removal of section of land within Water Reserve C for the purpose of a reservoir site	0.942	13939, 13940	5-9-005:071
Executive Order 4395	15-Dec-2011	W	Removal of lands, Parts 1 and 2 of remainder of Water Reserve C, Pūpūkea	64.80	25132	5-9-005: 002 & 077
Executive Order 4437	23-Sep-2013	W	Removal of Water Reserve A and Water Reserve B, Paumalū	27.50	25298	5-9-006: 003 & 007

Kuleana Parcels: None.

Documented Activities/Leases/Deeds/Permits: Documentation has been found for land use agreements involving lands of the Pūpūkea FR (Table 3).

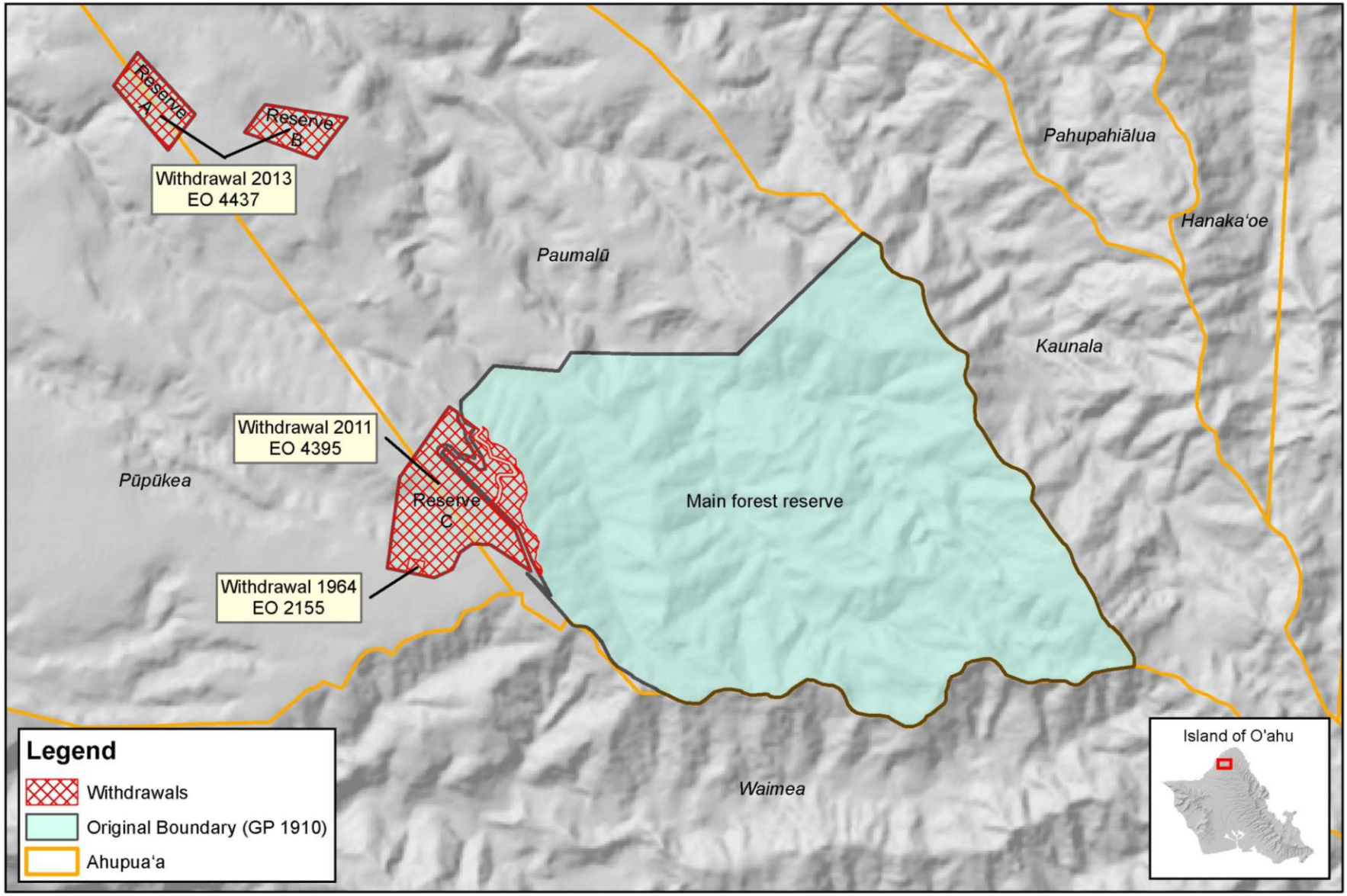
Table 3: Historical and current land use agreements in Pūpūkea Forest Reserve

Type of Action	Action Number	Duration	Description	Acres	Copy of Survey Furnished (CSF)	Tax Map Key
Lease	GL-741A	16-Feb-1911 to 1-Feb-1961	Pūpūkea Water Users Association, Limited	837.1	n/a	Not specified
Lease	GL-1701	30-Mar-1925 to 30-Mar-1946	Paumalū Water Users Association, Limited	837.1	n/a	Not specified
Use Permit	n/a	19-Mar-1946 to 31-Dec-1956	Boy Scouts of America (BSA)	n/a	n/a	Not specified
Revocable Permit	n/a	19-Mar-1946	Boy Scouts of America (BSA) – rights transferred to BSA from Army	n/a	n/a	Not specified
Revocable Permit	328	19-Apr-1949 to Jun-1960	Paumalū Water Users Association, Limited (under terms and condition of GL-1701)	837.1	n/a	Not specified
Revocable Permit	330	6-Jun-1949 to Apr-1965	Pūpūkea Water Users Association, Limited (under terms and condition of GL741A)	837.1	n/a	Not specified
Lease	Gl3850	17-Aug-1964 to 16-Aug-2029	USA: Army Training Area	700	n/a	5-9-006:026
Lease	S-3951	11-Mar-1966 to 11-Mar-2012	Boy Scouts of America (BSA)	64.8	n/a	5-9-005: 002 & 077
Perpetual Easement	LOD 28536	28-Jun-2005	Hawaiian Electric Co, Inc.	11.02	Govt. Survey Registered Map H.S.S. Plat2034A	5-9-006:026

E. Vegetation: According to the Hawai‘i Gap Analysis Program (2005), the vegetation of Pūpūkea FR is highly degraded and dominated by non-native forest cover (80% of total land cover, Figure 8). Much of this area consists of invasive species such as satin leaf (*Chrysophyllum oliviforme*), strawberry guava (*Psidium cattleianum*), and Guinea grass (*Urochloa maxima*). However, native stands of closed ‘ōhi‘a lehua (*Metrosideros polymorpha*) forest, open ‘ōhi‘a lehua/koa (Acacia koa) forest, and patches of ‘uluhe (*Dicranopteris linearis*) shrubland are present in the southeast

Figure 5: Mixed native and non-native forest in Pūpūkea FR

Figure 6: Historical changes to public lands in Pūpūkea Forest Reserve. Year of addition/withdrawal and ahupua‘a indicated.



portion of the FR. Other less dominant native plant species include ʻiliahi (sandalwood, *Santalum freycinetianum*), halapepe (*Chrysodracon halapepe*), (*Wikstroemia oahuensis*), and others. For a more detailed list of plant species found in the reserve, see Appendix A.

DOFAW's Draft Management Guidelines for the island of Oʻahu consist of four vegetation classifications (see Appendix D for descriptions). The vegetation in Pūpūkea FR is classified as V-3 (Considerable Disturbed Area) (Figure 9). Management objectives for V-3 areas are to 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. Native plant conservation may be focused at a species, rather than an ecosystem level. There are approximately 782 acres of V-3 in the reserve. DOFAW is in the process of updating its Management Guidelines.

Rare and Endangered Plants:
Rare and endangered species in Hawaiʻi are listed under the Federal Endangered Species Act (ESA) and the State Endangered Species Law, Chapter 195D, HRS. There are six plant species currently known to exist in Pūpūkea FR (Table 9, Figure **10**) that have been placed on the endangered species list. These species include nīoi (*Eugenia koolauensis),* ʻakoko *(Euphorbia rockii),* nanu (*Gardenia mannii*), ʻohe ʻohe (*Polyscias gymnocarpa*), kaulu (*Pteralyxia macrocarpa*), and pilo kea *(Platydesma cornuta var cornuta*.) Koʻokoʻolau (*Bidens campylotheca ssp. campylotheca)* is recognized as a species of concern (SOC) by DOFAW. A SOC is a species for which there is concern or uncertainty about its status. SOC are not listed under the ESA, therefore they do not afford any protections under the Act.

Pilo kea is managed by the Plant Extinction Prevention Program (PEPP) of Hawaiʻi. The mission of PEPP is to protect the rarest native Hawaiian plants from extinction. PEPP works to reverse the trend toward extinction by managing existing populations, collecting seeds and establishing new populations with a focus on species that have fewer than 50 plants remaining in the wild. Members of the Hawaiʻi Rare Plant Restoration Group, of which DOFAW is a founding member, provides oversight to PEPP and provides botanical expertise when necessary. PEPP regularly collaborates with over 60 conservation partners and landowners to protect PEPP species under their jurisdiction.

Figure 7: Rust damage on Eugenia koolauensis

The Oʻahu Army Natural Resource Program (OANRP) manages two of the endangered species in the reserve. The main goal of OANRP is to effectively balance the requirements of the U.S. Army training mission with its natural resource responsibilities. OANRP is responsible for overseeing compliance of various environmental laws, and is required to protect federally listed species that may be impacted due to the Army's training operations. OANRP maintains a rare plant exclosure fence built for the endangered *Eugenia koolauensis* by DOFAW. Given that the population of *Eugenia koolauensis* has been severely affected by *Puccinia psidii*, a pathogenic rust, OANRP's immediate strategy is to establish a living collection in their nursery by collecting cuttings. All plants within the exclosure have been

Figure 8: Vegetation cover of Pūpūkea Forest Reserve. (Hawai‘i GAP Analysis Program 2005)

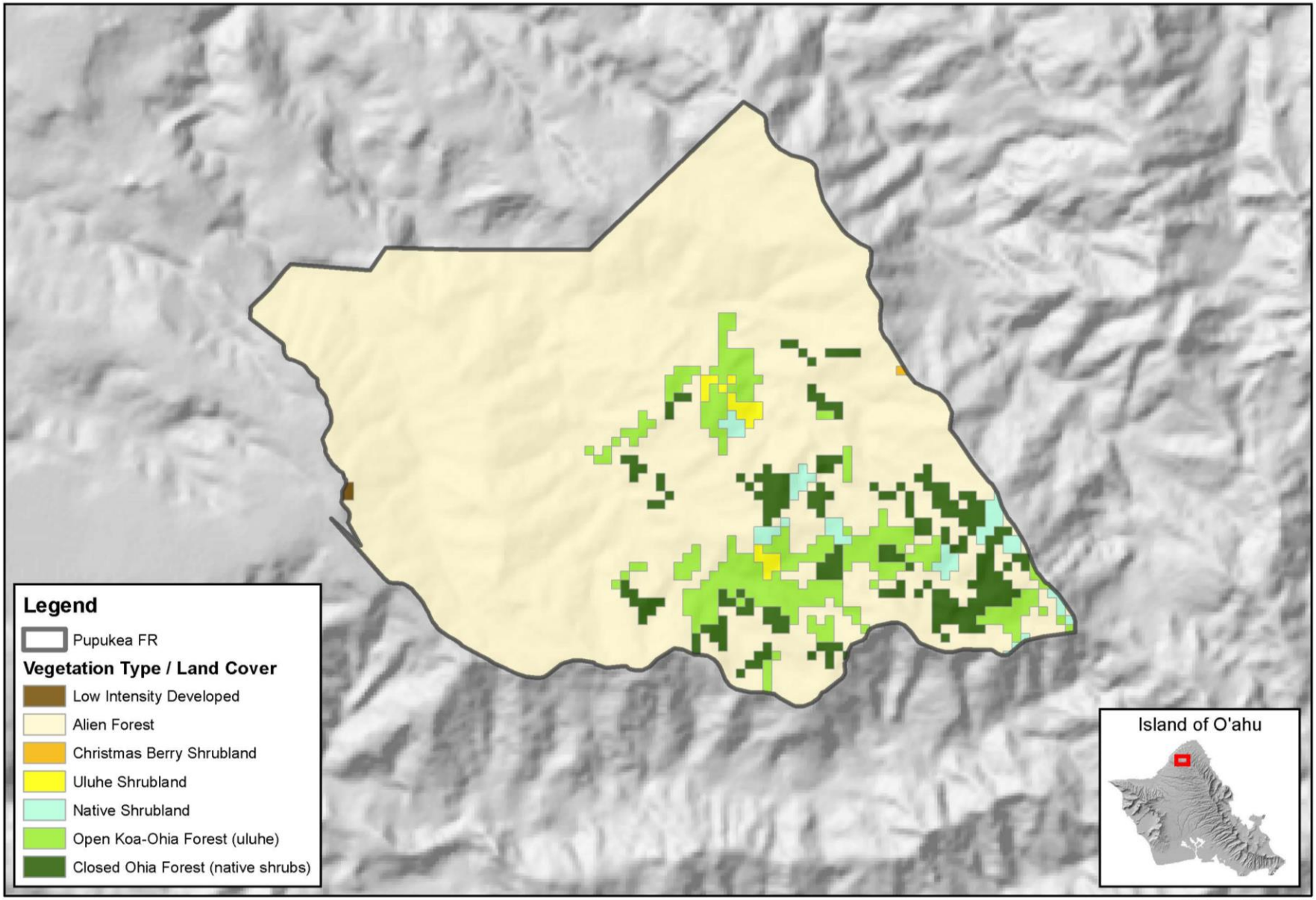
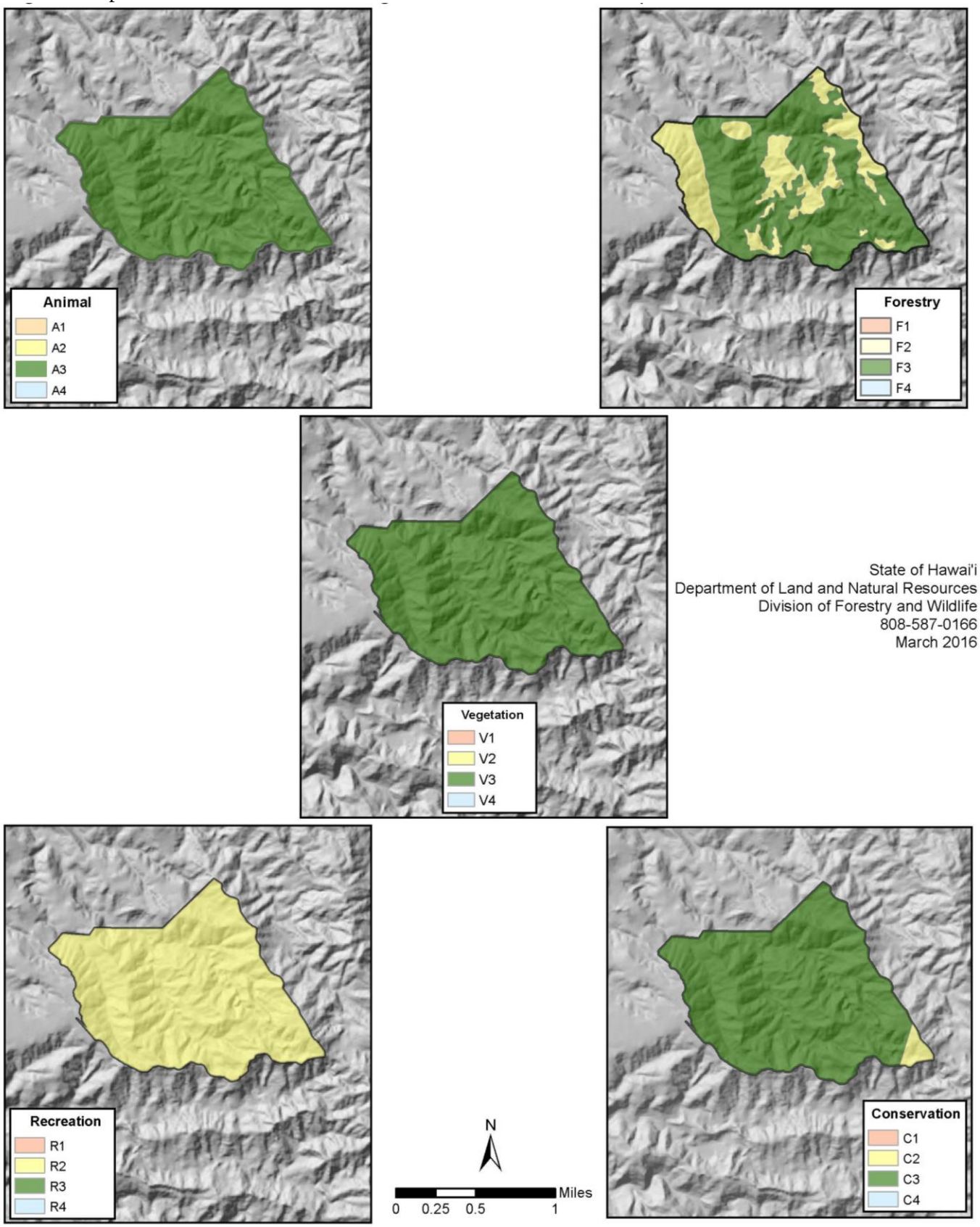


Figure 9: DOFAW's 2015 Draft Management Guidelines for Pūpūkea Forest Reserve. See Appendix D for class descriptions.



accounted for during census monitoring in 2015 and 2016. The fence is checked and maintained quarterly, but other habitat protection and management have been discontinued until the wild plants and outplants can be protected from infection of *Puccinia psidii* or be sufficiently controlled with legal application of fungicide chemicals. No outplanting is planned for the next 5 years. Work done by OANRP to manage *Eugenia koolauensis* in the Pūpūkea FR vicinity is outlined by their five-year rare plant plan (http://manoa.hawaii.edu/hpicesu/DPW/2014_YER/default.htm).

To minimize potential adverse effects to listed plants, the following actions will be considered should any proposed activities occur outside existing disturbed areas: a botanical survey of the proposed activity area including a 200 foot buffer, flagging of all listed plants within the survey area, avoidance of cutting or removing vegetation within 200 feet of listed plants. Additional information on state and federally listed endangered species can be viewed on the USFWS website (http://www.fws.gov/endangered/). USFWS also provides recovery plans for select species which can also be found on their website (http://www.fws.gov/endangered/species/recovery-plans.html).

Table 4: Rare and endangered plants that have been observed within Pūpūkea FR (Hawai‘i Biodiversity and Mapping Program 2008). Species listed may have more than one observation. An observation is considered historical if it occurred more than 30 years ago. Also see Figure 10.

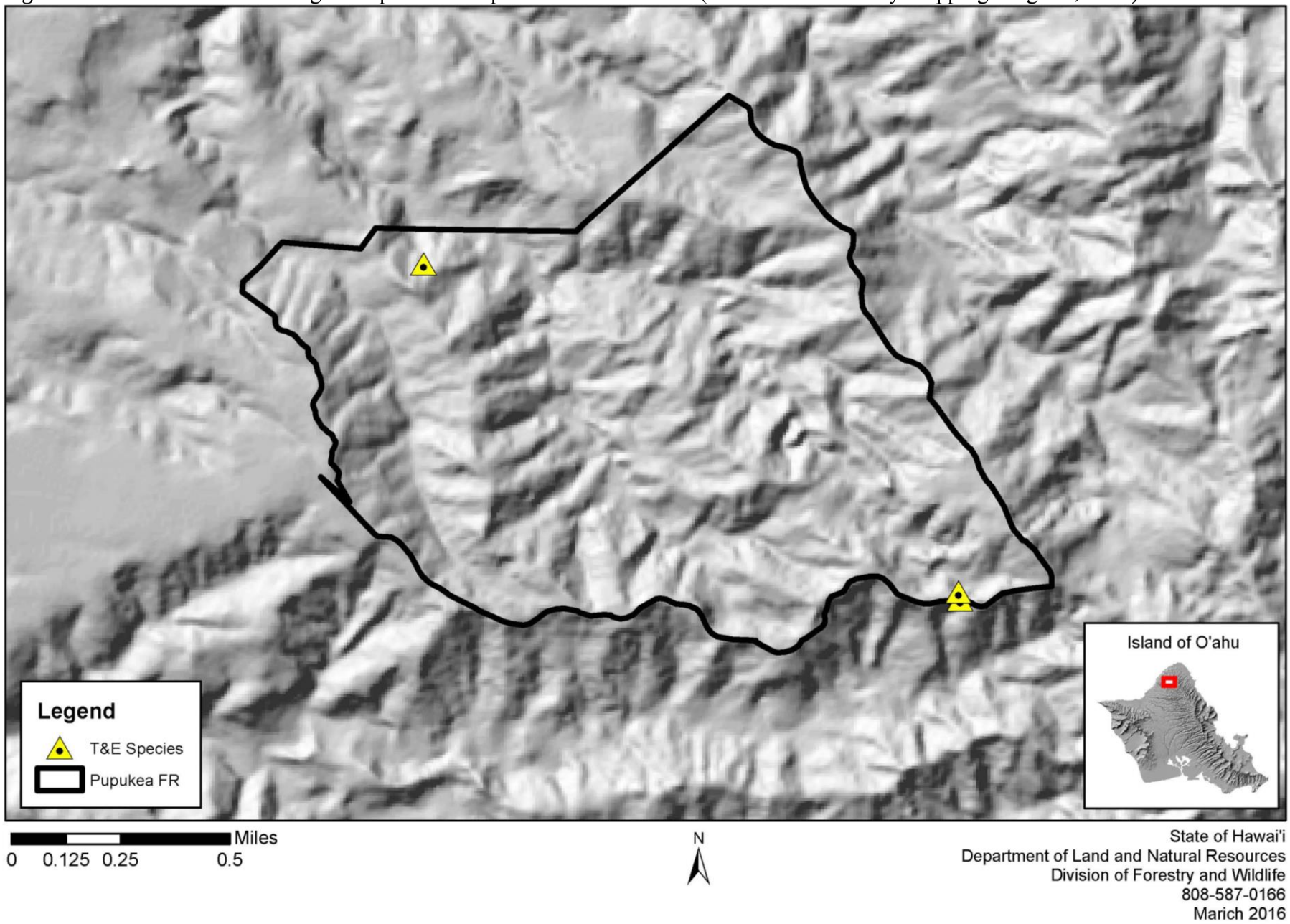
	Species	Current/ Historical	ESA Listing Status	Mgmt Program
Plants	*Euphorbia rockii* (‘Akoko)	Current	Endangered	DOFAW
	Eugenia koolauensis (Nīoi)	Current	Endangered	OANRP
	Gardenia mannii (Nanu)	Current	Endangered	OANRP
	Polyscias gymnocarpa (‘Ohe ‘ohe)	Current	Endangered	DOFAW
	Pteralyxia macrocarpa (Kaulu)	Current	Endangered	DOFAW
	Bidens campylotheca ssp. campylotheca (Ko‘oko‘olau)	Current	Not listed, but recognized as a species of concern	DOFAW
	Platydesma cornuta var cornuta (Pilo kea)	Historical	Endangered	PEPP

Plant Critical Habitat: As outlined by the US-ESA, critical habitat is defined as “specific geographic areas, whether occupied by a listed species or not, that are determined to be essential for the conservation and management of listed species, and that have been formally described in the Federal Register,” (U.S. Fish and Wildlife Service, 2014). There is no designated plant critical habitat located within Pūpūkea FR (Figure **10**).

Timber Species: The first commercial forest product industry in Hawai‘i started in 1791, with the harvesting of sandalwood, or ‘iliahi. Sandalwood is prized for its fragrant wood and is a valuable commodity in national and international trade. By the late 1830’s, the six endemic species of sandalwood were largely exhausted from the forests of Hawai‘i (Merlin and Van Ravenswaay, 1990). Since the sandalwood trade, a sustainable export market for Hawai‘i grown wood has not developed in Hawai‘i due to less expensive wood-based building materials that are available from the Pacific Northwest and Southeast Asia.

There are a number of mid to large-scale timber plantations both on public and private lands throughout the state. In the late 1800’s, ranchers and sugar plantations began replanting efforts to replace the forests that were lost due to fire, cattle grazing, and harvesting for fence posts and

Figure 10: Threatened and Endangered Species in Pūpūkea Forest Reserve. (Hawai‘i Biodiversity Mapping Program, 2008)



fuel wood for whaling ships and sugar mills. The Territorial government also had a tree planting program in which they utilized both introduced and native trees species. Reforestation was primarily done to protect and replenish the fresh water resources, but was also done to conduct trials with commercially valuable timber species.

According to a list of the recorded plantings made by the Division between 1910 and 1960, over 283,000 trees were planted in Pūpūkea FR on government and privately owned lands (Skolmen, 1980). The largest majority of trees planted were silk-oak (*Grevillea robusta*, 46%), paperbark (*Melaleuca quinquenervia*, 13%), and koa (*Acacia koa*, 12%) (see Appendix B). This list does not indicate which species survived.

Figure 11: Paperbark trees in Pūpūkea FR

Mylar maps of tree plantations made from aerial photography show that 25 plantation plots were established in Pūpūkea FR by 1967 (Klingensmith, 1967). These plots were planted with 6 species: ironwood (*Casuarina equisetifolia*), blackbutt eucalyptus (*Eucalyptus pilularis*), brushbox (*Lophostemon confertus*), paperbark (*Melaleuca quinquenervia*), swamp mahagony (*Eucalyptus robusta*), and lemon-gum eucalyptus (*Eucalyptus citriodora*) (Nelson et al., 1966). These stands were established prior to 1950 and encompass approximately 166 acres (Figure **12**) (Klingensmith, 1967).

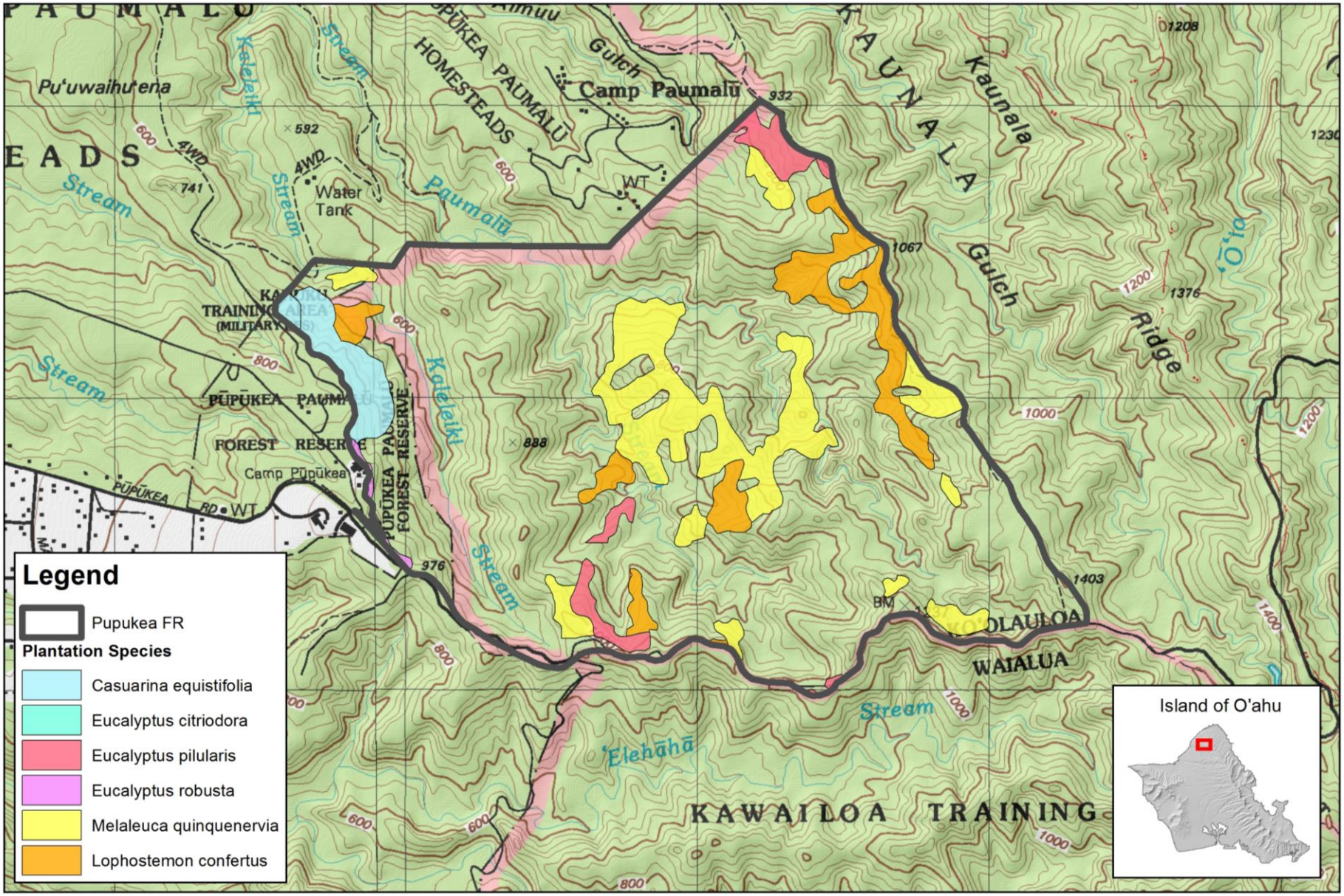
DOFAW's Draft Management Guidelines separate forestry management into four categories (see Appendix D for classes and class descriptions). Pūpūkea FR contains two of four possible Forest Management categories: F2 and F3 (Figure 9). Approximately 157.74 acres are classified as F2, where limited small-scale (no more than 5% of the total F2 acreage for each forest reserve, annually) commercial timber harvesting or salvage is allowed . Harvesting of non-timber forest products is also allowed. Approximately 696.57 acres are classified as F3, where limited non-commercial timber harvesting and commercial timber salvage is allowed. Harvesting of non-timber forest products is generally not allowed and will be considered on a case by case basis for improving forest health, watershed protection, cultural uses and conservation efforts. All classification levels have restrictions regulated by DOFAW and require appropriate permits and/or licenses. DOFAW is in the process of updating its Management Guidelines.

The Division does not have any current plans for large scale timber harvesting in Pūpūkea FR, but may issue commercial salvage permits for the purpose of purchasing and removing dead or hazardous trees. Each application for a commercial salvage permit shall be considered on its own merits, including its effect on the premises and the public's use and enjoyment of the forest reserve. Permits will not be issued for harvesting forest products for direct resale and the value of the raw material to be harvested cannot exceed $10,000.

F. Wildlife:

Native Wildlife: The occurrence of native animal species in Pūpūkea FR is limited to small populations of common species. During a comprehensive bird survey of Pūpūkea FR conducted

Figure 12: Plantation timber stands in in Pūpūkea Forest Reserve. (Aerial photo interpretations Klingensmith, 1967)



in 2015 (Table 5, Appendix C), the Oʻahu ʻamakihi (*Hemignathus flavus*) and ʻapapane (*Himatione sanguinea*) were found to be uncommonly present (VanderWerf, 2015). Pūpūkea FR contains valuable native montane forest habitat for both native forest birds. One endangered bird species, the Oʻahu ʻelepaio (*Chasiempis ibidis*), was observed in the FR in 1965 (Hawaiʻi Biodiversity and Mapping Program, 2005) but was not detected in the most recent survey.

In May 2015, a survey for the Hawaiian hoary bat, ʻopeʻapeʻa, was also conducted. Although the presence of the native bat was not detected during the survey (VanderWerf, 2015), the amount of time spent (7 nights) was short. The native bat has been regularly detected in nearby areas, including the Kawailoa Wind Farm, and is likely to occur or transit near Pūpūkea FR. Additional surveys need to be conducted to determine if the hoary bat is present in the FR. The endangered Oceanic Hawaiian damselfly (*Megalagrion oceanicum*) was last observed in Pūpūkea FR in 1928. A damselfly was recently observed near Opaeula summit in a pristine reach of stream. A survey for invertebrate present in the FR should be considered.

Figure 13: View of the Kawailoa Wind Farm from Pūpūkea FR

Non-native wildlife: A wide variety of introduced birds exist across the island of Oʻahu. Eighteen species of non-native birds (Table 6, Appendix C), including a mix of birds usually found in the forest and others more typical of urban or open habitats, were documented during the bird survey (VanderWerf, 2015). Invasive species such as mosquitos, rats, pigs, and mongoose are also present in Pūpūkea FR. Non-native wildlife competes with native species for resources and serve as reservoirs for diseases that affect native bird populations.

Table 5: Rare and endangered animals that have been observed within Pūpūkea FR (Hawaiʻi Biodiversity and Mapping Program 2008). Species listed may have more than one observation. An observation is considered historical if it occurred more than 30 years ago. Also see Figure 9.

	Species	Current/ Historical	US-ESA Listing Status	Mgmt Program
Animals	*Chasiempis ibidis* (Oʻahu ʻelepaio)	Historical	Endangered	DOFAW
	Megalagrion oceanicum (Oceanic Hawaiian damselfly)	Historical	Endangered	DOFAW

Animal Critical Habitat:
There is no animal critical habitat located in Pūpūkea FR.

Table 6: Wildlife found in Pūpūkea FR.

Species	Common name	Native/Non-native	Game species
Birds			
Acridotheres tristis	common myna	Non-native	No
Amazona viridigenalis	red-crowned parrot	Non-native	No
Cardinalis	northern cardinal	Non-native	No
Copsychus malabaricus	white-rumped shama	Non-native	No
Estrilda astrild	common waxbill	Non-native	No
Garrulax canorus	melodious laughing thrush	Non-native	No
Haemorhous mexicanus	house finch	Non-native	No
Hemignathus flavus	Oʻahu ʻamakihi	Native	No
Himatione sanguinea	ʻapapane	Native	No
Horornis diphone	Japanese bush warbler	Non-native	No
Leiothrix lutea	red-billed leiothrix	Non-native	No
Lonchura punctulata	nutmeg mannikin	Non-native	No
Paroaria coronata	red-crested cardinal	Non-native	No
Pycnonotus cafer	red-vented bulbul	Non-native	No
Pycnonotus jocosus	red-whiskered bulbul	Non-native	No
Spilopelia chinensis	spotted dove	Non-native	Yes
Thectocercus acuticaudatus	blue-crowned parakeet	Non-native	No
Zosterops japonicus	Japanese white-eye	Non-native	No
Mammals			
Sus scrofa	pig	Non-native	Yes
Rattus spp.	rat	Non-native	No
Felis catus	cat	Non-native	No
Herpestes auropunctatus	mongoose	Non-native	No
Mus musculus	house mouse	Non-native	No

G: Access: There is public access to Pūpūkea FR via Pūpūkea Road (Figure 17).

Figure 14: Entrance gate to Camp Pūpūkea on left; public trail access to Pūpūkea FR on right

Vehicular Access: Pūpūkea FR is located at the end of Pūpūkea Road, which terminates at the gated entrance to the FR. Beyond the gate, the road continues as a dirt road along the southern boundary of the FR, providing principal vehicular access for management purposes. The dirt access road meets up with the paved military training road called Drum Road, which runs along the southern boundary of the FR and continues onto the military owned land adjacent to the FR. Upon reaching the eastern boundary of the FR, a four-wheel drive jeep road follows the northeastern boundary of the FR until it reaches Camp Paumalū (Girl Scout camp). The military has gate keys to utilize the jeep road. Public vehicular access is not permitted in the reserve; vehicular access is for management purposes only.

Trails: Nā Ala Hele, the State of Hawaiʻi trail and access system (https://hawaiitrails.org/trails/#/) oversees 38 trails on Oʻahu including the Kaunala trail, the only trail within Pūpūkea FR

(Figure 17). The trail is 2.5 miles (4.0 km) long and its use is restricted to hikers and mountain bikers. Commercial trail tour activities are not permitted. The trail begins 0.6 miles from the gated entrance and traverses the gulches between the primary FR access road and the jeep road leading to Camp Paumalū. The current lease with the U.S. Army allows for hiking on weekends and state and national holidays unless otherwise posted. The purpose of the limited public access days was to allow the Army to train during the week. Although the FR is only open to the public on weekends, the area is used by members of the public for recreation seven days a week. As of yet, a conflict between training and public recreation has not surfaced.

Figure 15: Na Ala Hele - Kaunala Trail

Designated Helicopter Landing Zone: A helicopter landing zone is located approximately 250 yards northwest of Fox Gate up the jeep road (Figure 18).

Restricted Watershed: Pūpūkea Forest Reserve is not designated as restricted watershed.

H: Infrastructure: A 12'x12' shelter with a picnic table can be found along Drum Road, approximately 1.65 miles mauka of the FR entrance gate (Figure **18**). This structure provides hikers with a destination and rest stop while hiking. There is one 0.5 acre *Eugenia Koolauensis* exclosure in the FR, and one bridge along the Kaunala trail. Other infrastructure includes 4 gates, 1 landing zone, and a hunter check in station. A Hawaiian Electric Company easement also runs north to south through the western portion of the FR.

Figure 16: Shelter and picnic table in Pūpūkea FR

I: Archaeological and Historical Sites: An archaeological inventory survey has not been conducted in Pūpūkea FR, but adjacent land surveys have shown there to be numerous pre and post-contact archaeological resources. Considering the FR's active freshwater streams and proximity to Puʻu O Mahuka Heiau (makai of the area) and the ahupuaʻa of Waimea, an archaeological inventory survey should be carried out in the region prior to any management activities conducted in the FR. There are no known historic burial sites within Pūpūkea FR. In the event any surface and/or subsurface evidence of historic properties, including cultural deposits or features, human remains, lava tubes, structural remnants or concentrations of artifacts are uncovered during any management activities, DOFAW will immediately cease activity in the area, protect the discovery from further disturbance, and contact SHPD for further advisement.

If significant historical sites are present and require mitigation, a mitigation or preservation plan will need to be developed and submitted to SHPD for review and acceptance prior to initiation of project work.

Figure 17: Public Access Routes to Pūpūkea Forest Reserve.

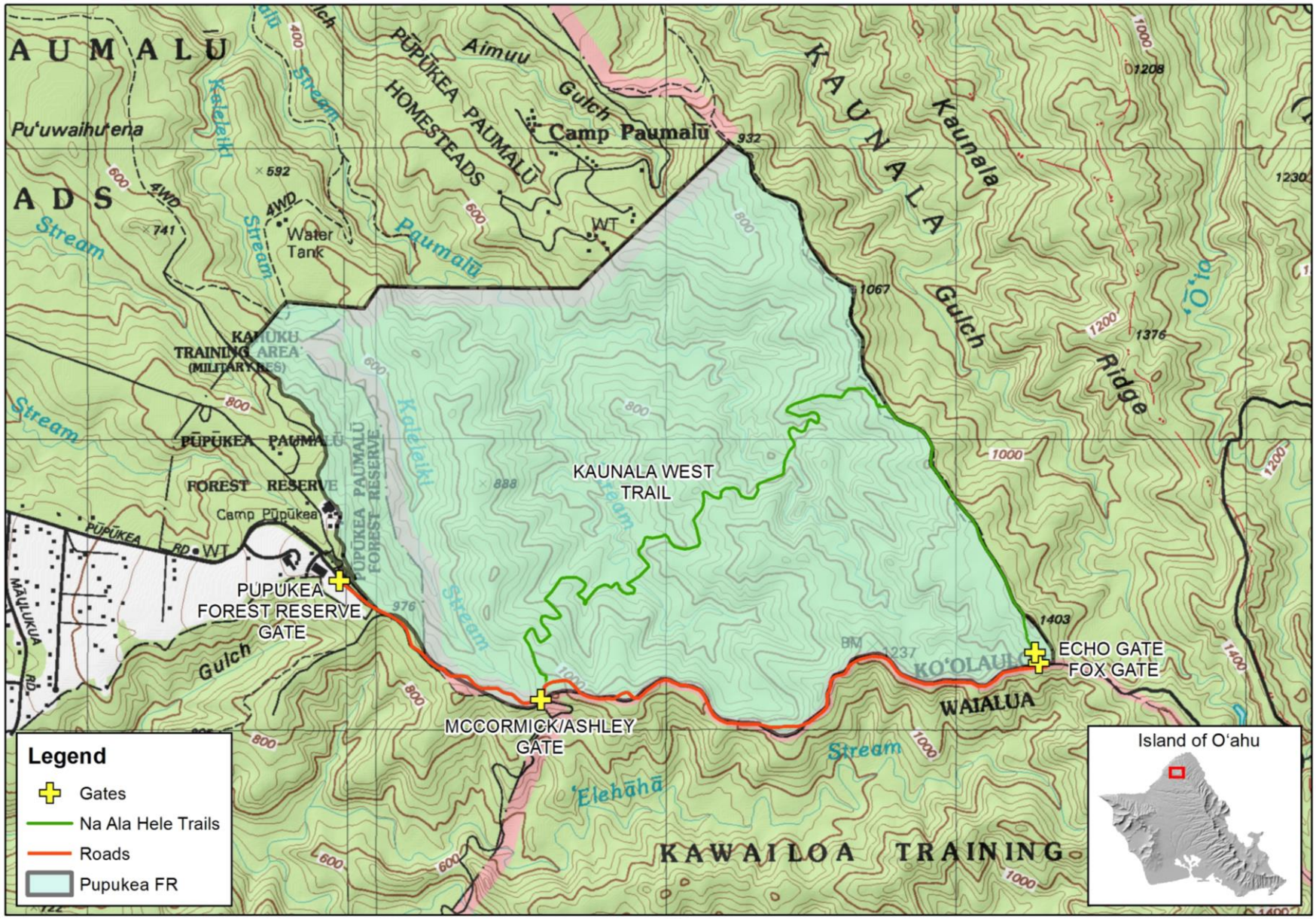
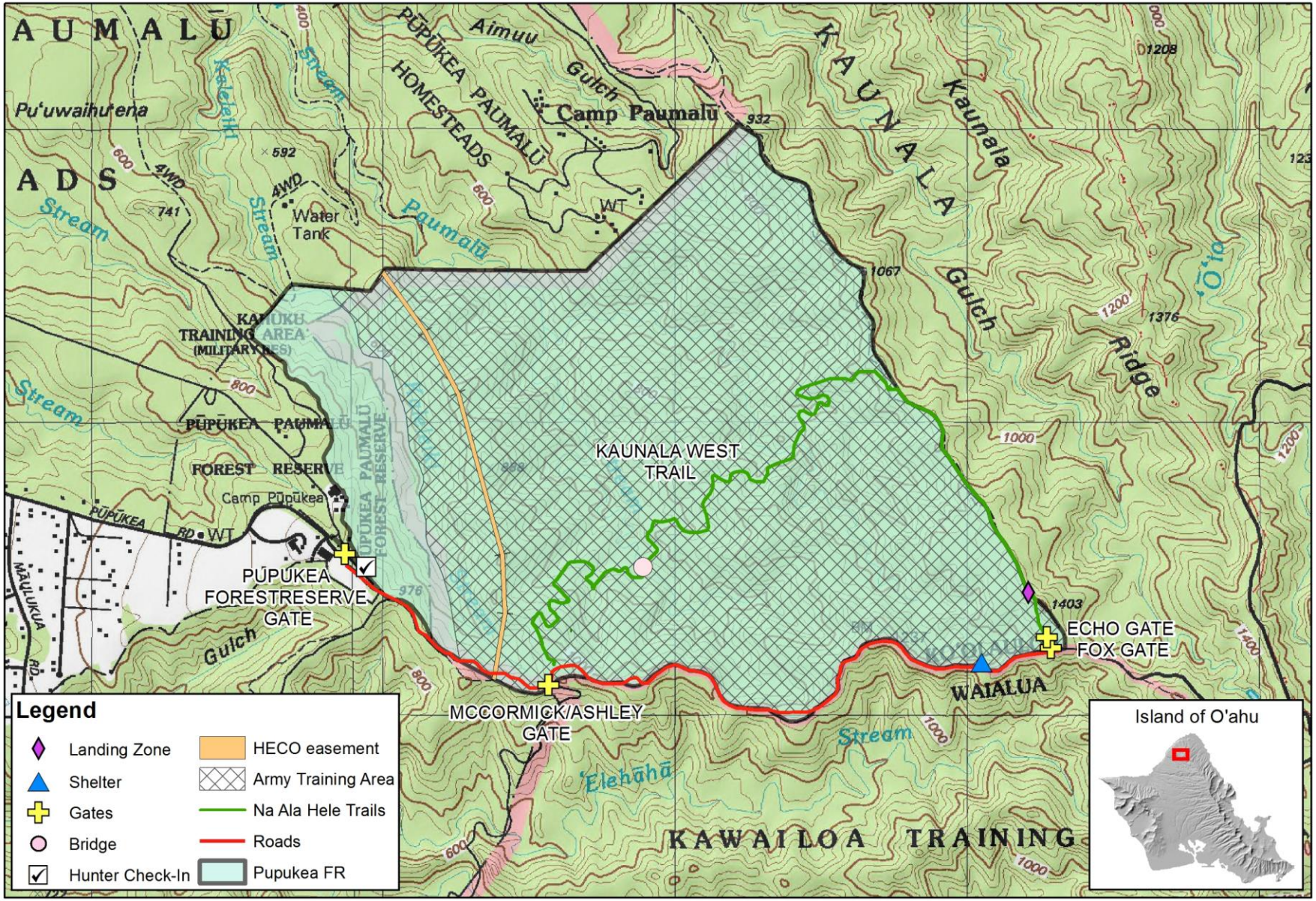


Figure 18: Infrastructure of Pūpūkea Forest Reserve.



J. Public Use:

General Recreation: DOFAW's Draft Management Guidelines consist of four categories for Recreation Management (see Appendix D for descriptions). Pūpūkea FR is designated as R2 (781.97 acres); these are areas where outdoor recreation is limited or controlled, or where it may be integrated with other uses. Facilities are not highly developed and include trails and trail shelters (Figure 9). DOFAW is currently in the process of updating its Management Guidelines.

Hunting: DOFAW manages public hunting on FR lands on Oʻahu by regulation of hunting days, seasons, bag limits, and hunting methods. The Division of Conservation and Resources Enforcement enforces hunting regulations found in Chapter 121, HAR Rules Regulating the Hunting of Wildlife on Public Lands and Other Lands, Chapter 122, HAR Rules Regulating Game Bird Hunting, and Chapter 123, HAR Rules Regulating Game Mammal Hunting. Pūpūkea FR comprises 759 acres of the Division's Game Mammal Hunting Area C for the island of Oʻahu (Figure 20). A hunter check-in station is located just inside the Pūpūkea FR Gate (Figure **18**). Hunters are required to check in before hunting and check out after hunting at this check-in station. There is no hunting allowed within 100 yards of the BSA camp. Hunting is allowed for feral pigs and feral goats using rifles, shotguns, handguns, knives, spears, bow & arrows, and dogs. Dogs must be kept under physical restraint and control at all times except when actively pursuing game. There is a bag limit of two pigs and two goats of either sex per hunter per day but there is no season limit. Hunting Area C is open year round but only on weekends and state holidays. There is no game bird hunting permitted within the FR.

Figure 19: Hunter check-in station in Pūpūkea FR

DOFAW's Draft Management Guidelines separate Game Animal Management into four categories (see Appendix D for descriptions). Lands within Pūpūkea FR (781.97 acres) are classified as A-3, where game control is managed through public hunting to protect native plant communities and watersheds (Figure 9). DOFAW is currently in the process of updating its Management Guidelines.

Camping: Camping along Kaunala trail within 10 feet of the center of the trail is allowed with a permit. Campsites are not designated. Camping permits are available for weekends and holidays at a fee. These permits are available online at https://camping.ehawaii.gov/.

Fishing: No fishing opportunities are available in this forest reserve.

Hiking: Hiking opportunities include the paved and unpaved access roads and the Nā Ala Hele Kaunala trail. See section G above for more details.

Horseback Riding: Horseback riding is not allowed in Pūpūkea FR. **Motorized Vehicles:** Dirt bikes and ATVs are not allowed in Pūpūkea FR.

Non-motorized Vehicles: Non-motorized mountain bikes may be used on access roads and Kaunala Trail.

Non-Timber Forest Product Collection: Non-timber forest products may be collected within the forest reserves. Examples include, but are not limited to:

a. Ferns
b. Flowers
c. Fruits
d. Guava *(Psidium* spp.) poles

Gathering of material from plant species that are not on federal or state threatened and endangered species lists is permitted and regulated by DOFAW through standard Forest Reserve System permit procedures as described in Chapter 104, HAR. Gathering of non-listed species or common materials requested in quantities that are determined by DLNR as representing personal use, is regulated through issuance of a Collection Permit free of charge. If quantities are determined to represent commercial use, a Commercial Harvest Permit may be issued at a fee. Consult the Forest Products Fee Schedule for information on personal versus commercial use quantities, as well as current commercial use pricing.
http://dlnr.hawaii.gov/forestry/files/2013/09/Forest-Product-Fee-Schedule.pdf

Collection of:

1. Listed threatened, endangered, or other rare species;
2. Common invertebrate species; or
3. Any migratory bird species,

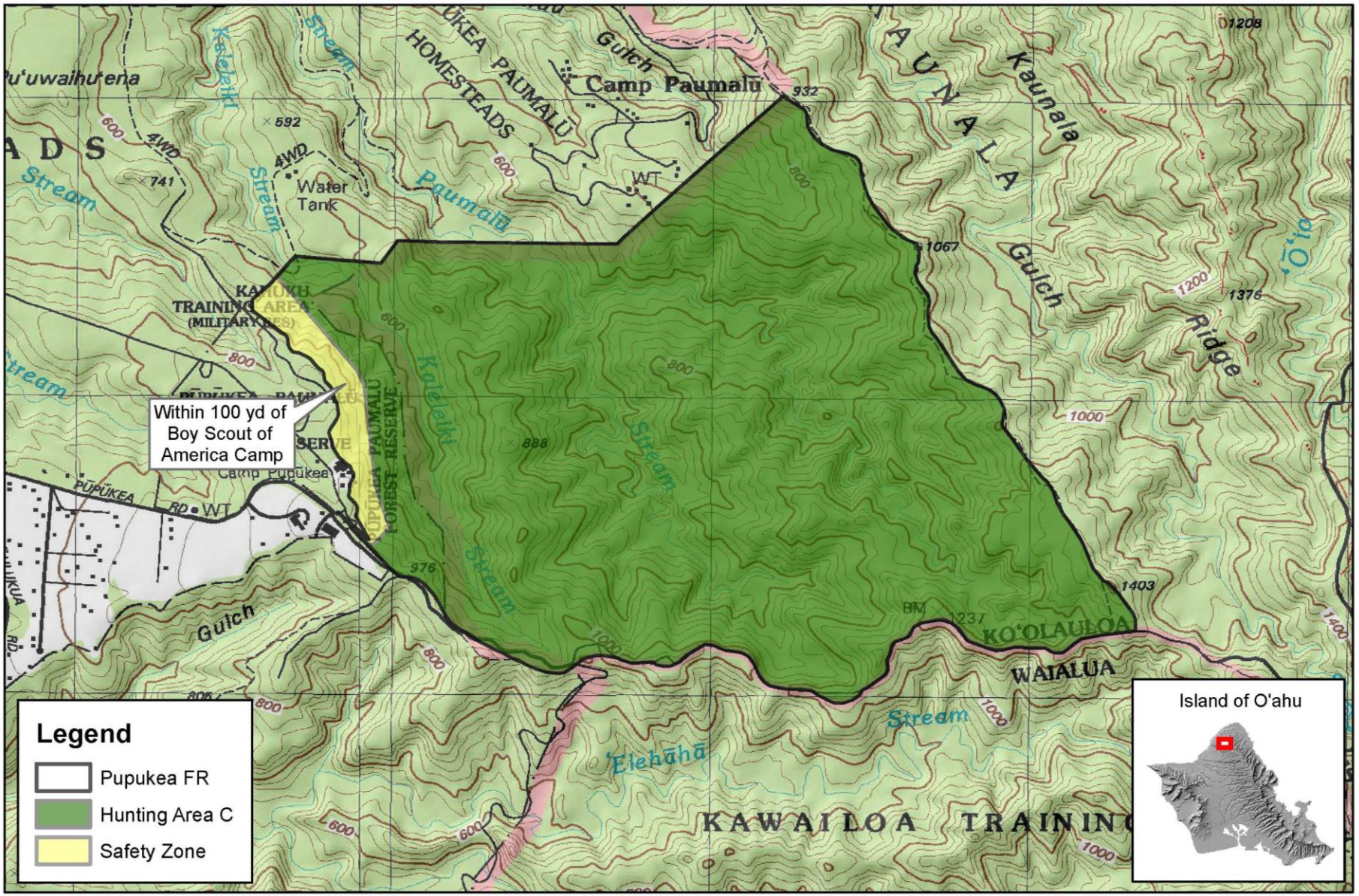
are prohibited under state laws Chapter 183D and 195D, HRS and subject to regulation under applicable HAR. Applications for permits for such activities may be submitted to the "Administrator," at the DOFAW Honolulu office. In these cases, a separate Access Permit may be required which is obtained through the Branch Manager at the DOFAW O'ahu office. Both addresses follow:

Administrator
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, HI 96813
Phone (808) 587-0166
O'ahu Branch Manager
Division of Forestry & Wildlife
2135 Makiki Hts. Drive
Honolulu, HI 96822
Phone: (808) 973-9784

The collection of any federally listed or migratory bird species is also subject to federal permits. Contact the USFWS for additional information.

Traditional and Customary Rights: Traditional and customary rights of the native Hawaiian people are protected under Hawai'i law. In the Constitution of the State of Hawai'i, Article XII, Section 7, "The State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupua'a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights." Any inquiries regard traditional and customary rights, please contact Forestry Manager at the DOFAW O'ahu Office:

Figure 20: Game mammal public hunting area in Pūpūkea Forest Reserve.



Forestry Manager
Division of Forestry and Wildlife
2135 Makiki Hts. Drive
Honolulu, HI 96822
Phone: (808) 973-9784

K. Threats:

Plants: Invasive plants are non-native species that can invade natural areas, grow and reproduce rapidly, reduce biodiversity and alter ecosystem functions. Invasive plants presently found in Pūpūkea FR or adjacent areas that have some of the greatest potential to impact, disrupt, and alter the ecosystem are listed in the table below. These species have been identified by Hawai‘i Pacific Weed Risk Assessment (HPWRA) as having a high risk of causing ecological or economic harm. For more information on the HPWR, please visit https://sites.google.com/site/weedriskassessment/assessments.

Some of these species are also designated as a noxious weed by the Hawai‘i Department of Agriculture. A noxious weed is defined as a plant species which is, or likely may become, injurious, harmful, or deleterious to the agricultural industry or natural resources of the state. Selling or transporting noxious weeds, their seeds or vegetative reproductive parts is prohibited under state law Chapter 152, HRS and subject to regulation under Chapter 4-68, HAR.

Table 7: Invasive plant species that occur in or near Pūpūkea FR

Potential impact	Species	Common name	HPWRA Score	Risk Rating	Official State or Federal Listing
Ecosystem altering	*Chromolaena odorata*	Devil weed	28	High	Hawai‘i Noxious Weed List
	Falcataria moluccana	Albizia	8	High	none
High impact	*Angiopteris evecta*	Mule’s foot fern	8	High	none
	Ardisia elliptica	Shoebutton ardisa	11	High	Hawai‘i Noxious Weed List
	Chrysophyllum oliviforme	Satin leaf	7	High	none
	Casuarina equisitifolia	Ironwood	21	High	none
	Heliocarpus popayanensis	Moho	7	High	none
	Melochia umbellata	Melochia	7	High	none
	Psidium cattleianum	Strawberry guava	18	High	none
	Schefflera actinophylla	Octopus tree	13	High	none
	Urochloa maxima	Guinea grass	17	High	none

Many of these invasive plants have the potential to spread or be introduced from adjacent areas via animals, military training vehicles, and recreational activities such as hiking, biking, and motocross. For example, OANRP has observed that illegal motocross activity fosters the spread of devil weed in the Kahuku Training Area. One immature plant was found within the *Eugenia koolauensis* fence in February 2017. For more information on these invasive species, please visit http://dlnr.hawaii.gov/hisc/info/invasive-species-profiles/

Animals: Non-native animals that have the potential to disrupt the ecosystem in Pūpūkea FR include:

- *Felis catus* (cats) - Prey on native and game birds and can be vectors of disease
- *Sus scrofa scrofa* (pigs) - Cause vegetation damage and erosion
- *Rattus* spp. (rats) - Predate on native plant fruits/seeds and birds
- *Mus musculus* (mice) - Predate on native plant fruits/seeds
- *Herpestes javanicus* (mongoose*)* - Predate on native and game birds
- *Aedes* spp., *Culex quinquefasciatus, Wyeomyia mitchelli* (Mosquitoes) - Vectors of disease
- *Trioceros jacksonii* (Jackson's chameleon) - Predate on native insects

Transport and release of any injurious wildlife is restricted by Chapter 124, HAR Rules Regulating Indigenous Wildlife, Endangered and Threatened Wildlife, Injurious Wildlife, Introduced Wild Birds, and Introduced Wildlife. Any non-native has the potential to pose a threat to native flora and fauna.

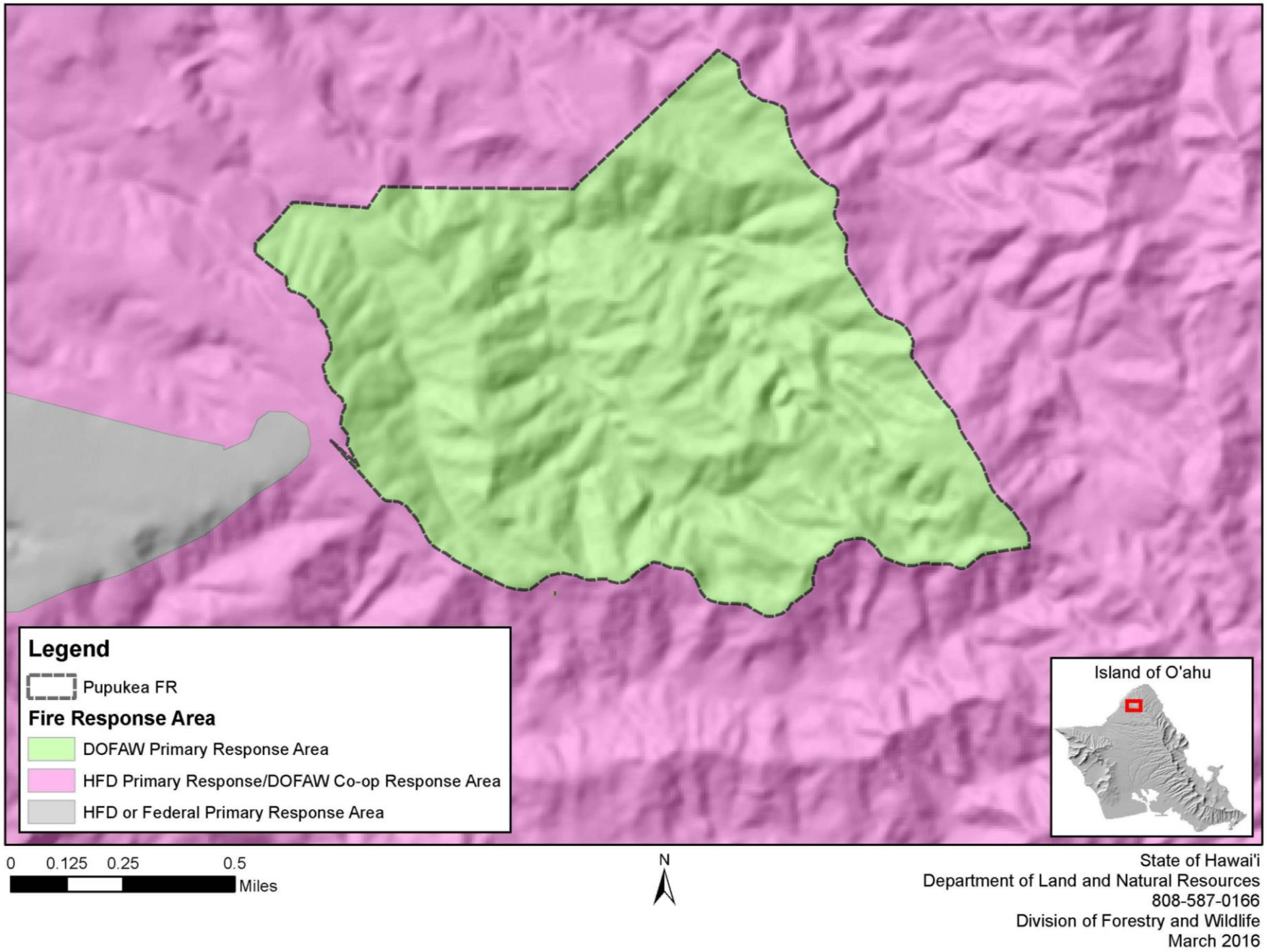
Fire: Native ecosystems in Hawai‘i are not adapted to wildfire with the majority of plant species not being able to regenerate after a fire. Introduced fire adapted grasses and shrubs now cover 25 percent of the total land mass in Hawai‘i (Trauernicht, 2014). This in combination with an increase in human caused ignition has resulted in a fourfold increase of area burned annually by wildfires in Hawai‘i (Trauernicht and Pickett, 2016). Wildfires are a serious threat to human safety and property, and impact native ecosystems, watersheds, and near shore coastal resources statewide. Pūpūkea FR is a DOFAW Primary Response area, and the areas surrounding the FR are DOFAW-HFD Co-op Response areas (Figure 21). Fire pre-suppression activities, including road and trail maintenance, are needed for effective fire suppression in Pūpūkea FR.

Insects and Diseases: Introduction of insects and disease are a serious threat to the natural areas of Hawai‘i. Of particular concern are pest and diseases that could cause widespread dieback of predominant forest canopy species such as koa and ‘ōhi‘a. With globalization and an increased dependence on imports, approximately 20 insect species become established in Hawai'i every year (DOFAW 2010).

Recent notable introductions of insects and diseases include a Puccinia rust (*Puccinia psidii*), and koa wilt (*Fusarium oxysporum* f.sp *koae*). Puccinia rust has severely impacted nīoi (*Eugenia koolauensis*), including individuals in Pūpūkea FR, as well as rose apple (*Sygyzium jambos*). It can also damage ‘ōhi‘a seedlings and saplings. Koa wilt is a soil born disease that is causing dieback and decline of koa primarily in lowland plantation stands on former agricultural land.

The most recent epidemic that has caused major concern across the state is rapid ‘ōhi‘a death (ROD), which is caused by a fungus (*Ceratocystis fimbriata*). Currently, it has only been confirmed to occur on Hawai‘i island where hundreds of thousands of ‘ōhi‘a trees have been killed by this disease spanning across approximately 75,000 acres of forest. Aerial surveys for ROD have been completed for the neighboring islands. Based on the results of the aerial surveys, the Division collected samples from targeted areas to determine if ROD is present. Thus far, ROD has not been detected on O‘ahu or any of the other islands given that samples tested have not been shown to be ROD.

Figure 21: Fire response zones in Pūpūkea FR



Climate Change: According to the 2012 Pacific Islands Regional Climate Assessment (PIRCA), documented indicators of climate change in the region include an increase in air temperature (more significant at higher elevation), decrease in rainfall across much of the region, decrease in ground water discharge to streams, changes to frequency and intensity of climatic extremes, mean sea level rise (Western Pacific), changes in species distributions, increasing ocean surface temperature and changing ocean chemistry. However, there is no level of certainty as to how these changes will specifically affect Pūpūkea FR.

Potential impacts to communities and natural environments include shifts in rainfall patterns, a decrease in freshwater supplies, increase in extreme weather events, flooding and erosion, increase in prevalence and transmission of disease (e.g. avian malaria), increase in non-native biological invasions, increase in frequency and size of wildfires, and an increased risk of species extinction.

The primary mitigation for climate change involves actions to reduce emissions and enhance sinks of greenhouse gases. Tropical forests are important for carbon sequestration because compared to other biomes they have a high carbon content and productivity. Maintaining and ideally increasing carbon storage within forests will help decrease atmospheric carbon. In terms of reducing emissions, Governor David Ige signed into law the most aggressive clean energy goal in the nation. The goal set in 2015, is to achieve energy self sufficiency utilizing 100 percent renewable sources of energy by the year 2045.

Even with the above mitigation actions, forest ecosystems in Hawai‘i will face new climatic conditions associated with climate change. Individual species and ecosystems types may be more vulnerable to climate change if they are not able to adapt to these new conditions or migrate to suitable habitats. The Pacific Island Climate Change Cooperative (PICCC) has started climate vulnerability assessment for Hawai‘i species, but additional information is needed at local scales to determine impacts within individual watersheds and forest reserves.

Flooding: The Kaunala Trail crosses multiple streams. Flash floods may occur posing a threat to public safety.

Other Issues: The current lease with the Army only allows for public access on weekends and holidays. However, public recreation is continuous seven days a week. The purpose of the limited public access days was to allow the Army to train during the week. As of yet, a conflict between training and public recreation has not surfaced.

Figure 22: Bridge crossing the Paumalū Stream

Since the Army paved the road, the cost to maintain and repair the road has risen dramatically. In 2015, there was a small landslide that undermined the road. Historically, DOFAW could task a bulldozer and an equipment operator to fix the road but the repair of a paved road has caused a rise in cost and difficulty in comparison to a dirt road. DOFAW currently does not have funds to repair the road.

L. Revenue:
According to Section 183-1.5, HRS, 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."

Camping fees are the only source of revenue coming from Pūpūkea FR. The Division may issue commercial permits for non-timber forest products and small scale salvaging of dead, down, or hazardous trees if the opportunity arises. Each application for a commercial salvage permit shall be considered on its own merits, including its effect on the premises and the public's use and enjoyment of the forest reserve. Permits will not be issued for harvesting forest products for direct resale and the value of the raw material to be harvested cannot exceed $10,000.

III. MANAGEMENT

A. Past Planning: A previous management plan was created for Pūpūkea FR during the early 1960's. Pūpūkea FR is also included in the Koʻolau Mountain Watershed Partnership Management Plan.

B. Related Plans: Plans that contain relevant information on the resources and management strategies pertinent to the management of Pūpūkea FR are listed below.

- Koʻolau Mountain Watershed Partnership Management Plan
- Hawaiʻi's State Wildlife Action Plan
- DOFAW Forest Action Plan
- Nā Ala Hele Program Plan
- DOFAW Draft Management Guidelines
- Oʻahu Invasive Species Committee Strategic Plan
- USFWS Endangered Species Recovery Plans

C. Summary of Existing Management Activities: Current management activities include:

- Hiking trails: Nā Ala Hele maintains the Kaunala Trail in Pūpūkea FR. The trail requires maintenance three times a year (four days each), equivalent to 12 person-days per year. The objectives for the trail system include the maintenance of trails through weed and brush clearing, removal of downed trees, repairing washout areas, and installation and maintenance of regulatory and directional signage. Additional improvements are needed including ground maintenance of graveling, re-establishing, or re-routing of the trail.
- Fences: The rare plant exclosure fence for endangered nīoi (*Eugenia koolauensis*) is maintained by OANRP.
- Other infrastructure: Additional infrastructure currently maintained includes the entry gate, locks, picnic table, bridge, and shelter.
- Public hunting: The area is managed as a public hunting area, allowing for public access for hunting purposes and includes a hunter check-in station.
- Resource monitoring: Intermittent resource monitoring for wildlife and plants is conducted in the FR.
- Sandalwood research: The ʻiliahi (*Santalum frecynatium)* stand in Pūpūkea FR is healthy with relatively large trees that could be a resource for genetic conservation and

commercial use. In 2015, sandalwood in the FR was measured to begin the process of determining the economic potential of Hawaiian sandalwood oil and wood. Oil from individuals in Pūpūkea FR will be sampled and tested to determine oil content and potential commercial opportunities.

D. Management Objectives and Goals:

Broad management categories for each FR were derived from the mandates that regulate DOFAW activities including the Draft Management Guidelines and Administrative Rules, as well as input from Branch staff. These management priorities were divided into eight categories:

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

Each category has been ranked on a qualitative scale of 1 to 8, with 1 as higher priority and 8 as lower priority. Table 7 lists qualitative rankings of the management priority categories for Pūpūkea FR.

Table 8: Pūpūkea Forest Reserve and associated management priority categories

Forest Reserve Name	Resource Protection	Watershed Values	Invasive Species Control	T&E Species Mgmt.	Native Ecosystems	Game Animal Mgmt.	Commercial Activity	Public Activity
Pūpūkea	2	1	4	7	6	5	8	3

Table 9 expands on these management priority categories, listing general management actions to address the objectives, along with tactical goals, action items, and estimated cost associated with these actions.

Table 9: Management objectives and associated plans for Pūpūkea Forest Reserve. Estimated cost refers to state funds.

Management Priority	General Management Action	Tactical Goals	Action Items	Estimated Cost
Watershed Values (1)	Increase amount of lands under Forest Reserve status	Addition of adjacent Dole land TMK: 6-3-1:2 (approximately 3,700 acres)	Secure state/grant funding to acquire TMK 6-3-1:2. Follow procedures to establish as forest reserve.	$3,734,600.00
	Reduce the threat and impact of erosion on reserve resources	Maintain diverse forest cover on watershed lands to provide high quality water for residents	Periodic ground and aerial surveys of the area to maintain vigilance on forest health status	$5K/year

Management Priority	General Management Action	Tactical Goals	Action Items	Estimated Cost
		Maintain ground cover	Collect and store seed stock for various native plant species to be used for erosion mitigation	$5K/year
			Outplant as needed	
Resource Protection (2)	Fire Mitigation	Maintain ground cover post fire	Collect and store seed stock for various native plant species to be used for post-fire mitigation work	Costs under watershed values
			Outplant as needed	
		Maintain access for fire crews	Road and trail maintenance	Staff & mgmt costs only
		Fire prevention campaign at campsites	Post Smokey Bear signs at picnic and camping shelter and trail head	$300
		Maintain fire suppression force readiness	Train, equip and supply staff for fire suppression	Staff & mgmt costs only
Public Activity (3)	Increase amount of lands under Forest Reserve status for recreation	Addition of adjacent Dole land TMK: 6-3-1:2 (approximately 3,700 acres)	Secure state/grant funding to acquire TMK 6-3-1:2. Follow procedures to establish as forest reserve.	Costs under watershed values
	Sustain public recreation enjoyment	Maintain public recreation infrastructure	Trail and picnic table and shelter maintenance	$1K/year
			Weed and brush clearing	$3.2K/year
	Public information	Update informational signage	Sign installation and replacement as needed	$800
Invasive Species Control (4)	Manage incipient and established invasive plants and animals	Invasive species monitoring and control	Chemical, mechanical, and/or biological control in high priority areas	TBD
			Periodic weed surveys	
		Invasive species outreach	Provide surrounding landowners with educational outreach programs; Educate botanical gardens, commercial nurseries, and residential landscaping projects on the risks of using potential invasive species and in Weed Risk Assessment	$5K/year
		Invasive species prevention	Encourage cleaning of gear via informational signage and boot brushes at the trailhead	$2K

Management Priority	General Management Action	Tactical Goals	Action Items	Estimated Cost
Game Animal Management (5)	Promote public hunting through Chapter 122 & 123	Amendments to HAR Chapter 122 & 123	Add to Chapter 122 & 123	$22.5K
	Increase land area for public hunting	Addition of adjacent Dole land TMK: 6-3-1:2 (appx. 3,700 acres)	Purchase property	Costs under watershed values
Native Ecosystems (6)	Native ecosystem restoration	Determine landscape level needs	Common native outplanting (low priority action)	$50K/acre
	Expand ʻiliahi forest	Increase footprint of ʻiliahi by 10%/year	Map ʻiliahi forest	$40K/year
			Collect and store ʻiliahi seed for potential outplanting	
T&E Species Management (7)	Protection and recovery of listed rare plants and animals	Determine specific areas and species of interest	Research historical presence of T&E species and conduct field surveys	$15K
		Identify and address threats to identified species	Address threats to species, fence, predator control, hand pollinate, etc	$15K/year
		Increase number of individuals	Collect plant material for potential outplanting	$10K
Commercial Activity (8)	Generate income from commercial use activities in the Forest Reserve	Determine future income possibilities – commercial tour permits and film industry.	Determine protocol to manage fee collection	Staff & mgmt costs only
			Evaluate potential of doing commercial tours on jeep road	
	Provide opportunities for sustainable commercial forest product collection	Identify potential locations and species	Issue commercial harvest permits for harvest of forest products	Staff & mgmt costs only
		Collect revenue from timber salvage sales	Issue commercial timber harvest permits on an as needed basis	Staff & mgmt costs only
		Manage commercial harvest permits for non-timber forest products	Issue commercial harvest permits on an as needed basis	Staff & mgmt costs only

E. Overall Measures of Success

Measures of success for individual forest reserve management plans can be derived from the State of Hawaiʻi annual variance reports. Initial measures of success that may be applicable to Pūpūkea FR include:

- Number of volunteer service projects
- Acres of noxious plants controlled
- Acres of fire protection area
- Acres of exclosure developed
- Acres of exclosure maintained
- Acres of native forest protected
- Number of rare, threatened, or endangered plant/animal species protected

- Number of cultural resources protected
- Number of commercial leases/licenses/permits issued
- Number of signs replaced
- Number of appurtenant features maintained
- Number of miles of trails maintained
- Number of game species harvested (game birds, game mammals)
- Number of common native species outplanted

IV. FUTURE RECOMMENDATIONS

A. Desired Outcome for the Forest Reserve: Protection of watershed quality and quantity provided by the lands of Pūpūkea FR is essential. Another important goal is to maintain and enhance public access and activity in Pūpūkea FR.

B. Future Recommendations:

- Amend Army lease to allow more public access
- Increase public parking areas
- Increase recreational opportunities (developed camping site, horseback riding, and additional trails)
- Conduct further surveys for the Hawaiian hoary bat and other biological resources
- Expand the FR by pursuing acquisition of adjacent land
- Explore potential for commercial bike tours
- Collect seeds for potential outplanting projects for fire mitigation, ground cover, maintenance, and native species protection and expansion
- Update/upgrade informational signage
- Survey for early detection and rapid response of high priority invasive species targets
- Introduce biocontrol for strawberry guava
- Investigate potential to research and discuss the carrying capacity of the FR for recreation, hunting, collection, and harvesting activities

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VI. APPENDIX

Appendix A: Pūpūkea Forest Reserve Plant Species List

Appendix B: Historic Tree Plantings in Pūpūkea Forest Reserve

Appendix C: Pūpūkea Forest Reserve Bird and Bat Survey Report

Appendix D: DOFAW Draft Management Guidelines (2014)

Appendix A: Pupukea Forest Reserve Plant Species List

Compiled by Lara Reynolds, O'ahu Botanist

This species list (native and non-native flowering plants and ferns and fern allies) was complied by updating the plant species list from the previous draft management plan (2005), consulting records of the Hawaii Biodiversity and Mapping Program, conducting a botanical inventory of Kaunala Trail and Kaunala Trail West, consulting with the O'ahu Army Natural Resources staff, and checking available literature sources to update taxonomic names.

*Inclusion of indicated species comes from referencing data from the Hawaii Biodiversity and Mapping Program

Affinity:
End = Endemic
Ind = Indigenous
Non = Non-native
Pol = Polynesian

Satus: Federal and State endgangered species list
E = Endangered
T = Threatened
C = Candidate species
SOC = Species of concern (unofficial)

Scientific Name	Common Name	Family	Affinity	Status
Flowering Plants				
Acacia confusa	Formosa koa	Fabaceae	Non	
Acacia koa	Koa	Fabaceae	End	
Ageratum conyzoides	Billy goat weed	Asteraceae	Non	
Aleurites moluccana	Kukui	Euphorbiaceae	Non	
Alyxia stellata	Maile	Apocynaceae	End	
Andropogon virginicus	Broomsedge	Poaceae	Non	
Antidesma platyphyllum	Hame	Euphorbiaceae	End	
Araucaria heterophylla	Norfolk pine	Araucariaceae	Non	
Ardisia elliptica	Shoebutton	Primulaceae	Non	
Arundina graminifolia	Bamboo orchid	Orchidaceae	Non	
Bidens alba	Beggar's tick	Asteraceae	Non	
Bidens campylotheca spp. campylotheca *	Koʻokoʻolau	Asteraceae	End	SOC
Bobea elatior	Ahakea	Rubiaceae	End	
Buddleja asiatica	Buddleia	Buddlejaceae	Non	
Carex meyenii	Kaluhalua	Cyperaceae	Ind	
Carex wahuensis	Carex	Cyperaceae	End	
Casuarina equisetifolia	Ironwood	Casuarinaceae	Non	

Appendix A: Pupukea Forest Reserve Plant Species List

Compiled by Lara Reynolds, O'ahu Botanist

Scientific Name	Common Name	Family	Affinity	Status
Casuarina glauca	Swamp mahogany	Casuarinaceae	Non	
Cecropia obtusifolia	Trumpet tree	Urticaceae	Non	
Centella asiatica	Gotu kola	Apiaceae	Non	
Chamaechrista nictitans	Partridge pea	Fabaceae	Non	
Chrysodracon halapepe	Halapepe	Asparagaceae	End	
Chrysophyllum oliviforme	Satin leaf	Sapotaceae	Non	
Cinnamomum burmanii	Padang Cassia	Lauraceae	Non	
Clidemia hirta	Koster's curse	Melastomataceae	Non	
Cocculus orbiculatus	Huehue	Menispermaceae	Ind	
Conyza bonariensis	Hairy horseweed	Asteraceae	Non	
Cordyline fruticosa	TĪ leaf	Asparagaceae	Pol	
Cyanea sessilifolia *	Oha Haha/Wai	Campanulaceae	End	E
Cyanthilium cinereum	Little ironweed	Asteraceae	Non	
Desmodium incanum	Desmodium	Fabaceae	Non	
Desmodium intortum		Fabaceae	Non	
Dianella sandwicensis	Ukiuki	Xanthorrhoeaceae	End	
Diospyros sandwicensis	Lama	Ebenaceae	End	
Emilia sp.		Asteraceae	Non	
Epipremnum pinnatum	Pothos	Araceae	Non	
Erechtites sp.	Fireweed	Asteraceae	Non	
Eucalyptus globulus	Bluegum	Myrtaceae	Non	
Eucalyptus robusta	Swamp mahogany	Myrtaceae	Non	
Eugenia koolauensis	Nioi	Myrtaceae	End	E
Euphorbia rockii *	ʻAkoko	Euphorbiaceae	End	E
Falcataria moluccana	Albizia	Fabaceae	Non	
Ficus sp.	Ficus	Moraceae	Non	
Freycinetia arborea	ʻIeʻie	Pandanaceae	Ind	
Gahnia beecheyi	Uki	Cyperaceae	End	
Gardenia mannii *	Nanu	Rubiaceae	End	E

Appendix A: Pupukea Forest Reserve Plant Species List

Compiled by Lara Reynolds, O'ahu Botanist

Scientific Name	Common Name	Family	Affinity	Status
Grevillea robusta	Silk oak	Proteaceae	Non	
Heliocarpus popayanensis	Moho	Malvaceae	Non	
Hibiscus tiliaceus	Hau	Malvaceae	Pol	
Lantana sp.	Lantana	Verbenaceae	Non	
Leptecophylla tameiameiae	Pukiawe	Ericaceae	Ind	
Leucaena leucocephala	Koa haole	Fabaceae	Non	
Lophostemon confertus	Brush box	Myrtaceae	Non	
Machaerina mariscoides subsp. *meyenii*	Uki	Cyperaceae	End	
Mangifera indica	Mango	Anacardiaceae	Non	
Melaleuca quinquenervia	Paperbark	Myrtaceae	Non	
Melochia umbellata	Melochia	Malvaceae	Non	
Melinis minutiflora P. Beauv.	Molasses grass	Poaceae	Non	
Metrosideros polymorpha	ʻŌhiʻa	Myrtaceae	End	
Mimosa pudica	Sleeping grass	Fabaceae	Non	
Mimusops elengi	Bullet wood	Sapotaceae	Non	
Nestegis sandwicensis	Olopua	Oleaceae	End	
Oplismenus hirtellus	Basketgrass	Poaceae	Non	
Pandanus tectorius	Hala	Pandanaceae	Ind	
Paspalum conjugatum	Hilo grass	Poaceae	Non	
Passiflora edulis	Passion fruit, lilikoi	Passifloraceae	Non	
Passiflora suberosa	Corky passion vine	Passifloraceae	Non	
Persea americana	Avocado	Lauraceae	Non	
Phaius tankarvillae	Nun's cap	Orchidaceae	Non	
Planchonella sandwicensis	Alaʻa	Sapotaceae	End	
Plantago major	Plantain	Plantaginaceae	Non	
Platydesma cornuta var. cornuta *		Rutaceae	End	E
Pluchea carolinensis	Sourbush	Asteraceae	Non	
Polygala paniculata	Island snakeroot	Polygalaceae	Non	

Appendix A: Pupukea Forest Reserve Plant Species List

Compiled by Lara Reynolds, O'ahu Botanist

Scientific Name	Common Name	Family	Affinity	Status
Polyscias gymnocarpa	ʻOhe	Araliaceae	End	E
Pouteria sandwicensis	ʻAlaʻa	Sapotaceae	End	
Psidium cattleianum	Strawberry guava	Myrtaceae	Non	
Psidium guajava	Common guava	Myrtaceae	Non	
Psychotria fauriei	Kopiko	Rubiaceae	End	
Psychotria mariniana	Kōpiko	Rubiaceae	End	
Psydrax odorata	Alaheʻe	Rubiaceae	End	
Pteralyxia macrocarpa *	Kaulu	Apocynaceae	End	C
Pterolepis glomerata		Melastomataceae	Non	
Rauvolfia sandwicensis	Hao	Apocynaceae	End	
Rubus rosifolius	Thimbleberry	Rosaceae	Non	
Sacciolepis indica	Glenwood grass	Poaceae	Non	
Santalum freycinetianum	Iliahi	Santalaceae	End	
Scaevola gaudichaudiana	Naupaka kuahiwi	Goodeniaceae	End	
Schinus terebinthifolius	Christmas berry	Anacardiaceae	Non	
Setaria palmifolia	Palm grass	Poaceae	Non	
Spathodea campanulata	African tulip	Bignoniaceae	Non	
Spathoglottis plicata	Philippine ground orchid	Orchidaceae	Non	
Spermacoce assurgens	Buttonweed	Rubiaceae	Non	
Stachytarpheta cayennensis	Vervain	Verbenaceae	Non	
Syzygium cumini	Java Plum	Myrtaceae	Non	
Urochloa maxima	Guinea grass	Poaceae	Non	
Vitex parviflora	Molave	Verbenaceae	Non	
Waltheria indica	ʻUhaloa	Malvaceae	Ind	
Wikstroemia oahuensis var. *oahuensis*	ʻĀkia	Thymelaeaceae	End	

Appendix A: Pupukea Forest Reserve Plant Species List

Compiled by Lara Reynolds, O'ahu Botanist

Scientific Name	Common Name	Family	Affinity	Status
Ferns and fern allies:				
Angiopteris evecta	Mule's foot fern	Marattiaceae	Non	
Blechnum appendiculatum	Blechnum	Blechnaceae	Non	
Cibotium chamissoi	Hapuʻu	Cibotiaceae	End	
Cyclosorus dentatus	Downy wood fern	Thelypteridaceae	Non	
Cyclosorus parasiticus	Christella	Thelypteridaceae	Non	
Dicranopteris linearis	ʻUluhe	Gleicheneaceae	Ind	
Lepisorus thunbergianus	ʻEkaha	Polypodiaceae	Ind	
Nephrolepis multiflora	Nephrolepis	Lomariopsidaceae	Non	
Odontosoria chinensis	Palaʻā	Lindsaceae	Ind	
Ophioglossum pendulum	Puapuamoa	Ophioglossaceae	Ind	
Phlebodium aureum	Rabbit foot's fern	Polypodiaceae	Non	
Phymatosorus grossus	Lauaʻe, maile-scented fern	Polypodiaceae	Non	
Psilotum nudum	Moa	Psilotaceae	Ind	
Pteridium aquilinum subsp. *decompositum*	Kilau, bracken fern	Dennstaedtiaceae	End	

Appendix B: Historic Tree Plantings in Pūpūkea Forest Reserve (Skolmen, 1980)

Species	Year	Number planted	Total planted per species	% of all trees planted
Acacia confusa	1936	8,707	8,707	3.65%
Acacia koa	1920	283	29,525	12.37%
	1921	630		
	1921	913		
	1922	5310		
	1922	2430		
	1922	2880		
	1923	5206		
	1923	450		
	1923	1410		
	1923	3001		
	1924	2800		
	1924	300		
	1924	2500		
	1938	1412		
Albizia coriaria	1938	1000	1,000	0.42%
Allocasuarina verticillata	1924	250	370	0.16%
	1926	120		
Araucaria columnaris	1926	306	346	0.15%
	1927	40		
Araucaria heterophylla	1938	803	849	0.36%
	1941	46		
Barringtinia asiatica	1928	20	20	0.01%
Bauhinia variegata	1928	15	15	0.01%
Bischofia Javanica	1926	20	20	0.01%
Calophyllum inophyllum	1928	25	25	0.01%
Casimiroa edulis	1933	250	250	0.10%
Casuarina cunninghamiana	1924	800	800	0.34%
Casuarina glauca	1933	500	700	0.29%
	1936	200		
Casuarina sp	1924	800	800	0.34%
Chionanthus macrophylla	1933	528	528	0.22%
Cordia alliodora	1926	600	1,200	0.50%
	1926	600		
Cordyline fruticosa	1933	1080	1,080	0.45%
Corymbia citriodora	1921	252	2,941	1.23%
	1922	152		
	1922	152		
	1926	326		
	1927	1000		
	1938	31		
	1949	1028		

	1950	1232		
Cryptomeria japonica	1923	800	2,200	0.92%
	1923	800		
	1924	300		
	1924	300		
Dovyalis hebecarpa	1939	75	75	0.03%
Enterolobium cyclocarpum	1928	25	25	0.01%
Eucalyptus bridgesiana	1936	1960	2,114	0.89%
	1938	154		
Eucalyptus camaldulensis	1924	947	4,544	1.91%
	1924	947		
	1926	2300		
	1939	350		
Eucalyptus paniculata	1939	664	664	0.28%
Eucalyptus pilularis	1929	250	1,477	0.62%
	1938	1227		
Eucalyptus robusta	1933	107	107	0.04%
Eucalyptus rubida	1928	60	60	0.03%
Eucalyptus rudis	1938	284	284	0.12%
Eucalyptus sideroxylon	1938	105	105	0.04%
Falcataria moluccana	1928	50	50	0.02%
Ficus sp.	1920	129	129	0.05%
Ficus altissima	1921	91	91	0.04%
Ficus rubiginosa	1923	405	835	0.35%
	1923	225		
	1923	180		
	1926	25		
Faraxinus americana	1928	15	1,015	0.43%
	1929	1000		
Fraxinus uhdei	1957	10	10	0.00%
Grevillea robusta	1926	954	110,279	46.21%
	1928	15		
	1929	600		
	1933	14331		
	1934	3754		
	1936	46889		
	1938	14472		
	1938	4757		
	1939	24507		
Guaiacum officinale	1923	200	400	0.17%
	1923	200		
Harpullia hillii	1933	432	432	0.18%
Kigelia pinnata	1938	50	50	0.02%
Lophostemon confertus	1929	1000	18,505	7.77%

	1938	5889		
	1939	11616		
Lysiloma latisiliquum	1957	100	1,000	0.42%
Macadamia integrifolia	1929	100	100	0.04%
Melaleuca quinquenervia	1926	150	30,755	12.89%
	1927	1050		
	1928	40		
	1929	150		
	1933	3637		
	1934	1448		
	1936	7880		
	1939	16400		
Mimusops elengi	1933	118	118	0.05%
Morella fiya	1956	2	2	0.00%
Morus nigra	1938	50	454	0.19%
	1939	404		
Nesoluma polynesicum	1933	118	118	0.05%
Persea americana	1938	2897	2,897	1.22%
Pritchardia sp.	1928	25	25	0.01%
Santalum album	1936	1430	1430	0.60%
Scheflerra actinophylla	1928	15	15	0.01%
Swietenia mahagoni	1921	250	1,100	0.46%
	1923	300		
	1923	300		
	1926	250		
Syncarpia glomulifera	1938	508	508	0.21%
Syzygium cumini	1923	200	200	0.08%
Syzygium jambos	1923	200	392	0.16%
	1933	192		
Syzygium malaccense	1938	650	650	0.27%
Taxodium distichum	1927	350	350	0.15%
Tipuana tipu	1938	2038	2,038	0.85%
Toona ciliata	1920	88	3,374	1.41%
	1921	538		
	1921	450		
	1923	550		
	1923	550		
	1924	594		
	1924	594		
	1957	10		
Trema orientalis	1926	150	150	0.06%
		238,635		

Appendix C
Pupukea Bird and Bat Survey Report

Prepared by: Dr. Eric VanderWerf, Pacific Rim Conservation, 3038 Oahu Avenue, Honolulu, HI 96822

Prepared for: The Hawaii Division of Forestry and Wildlife, 2135 Makiki Heights Drive, Honolulu, HI 96822

Introduction and Background

The 782-acre Pupukea-Paumalu Forest Reserve is located in the northern Koolau Mountains of Oahu and contains the northernmost native forest on the island. The lower portions of the reserve are dominated by a variety of non-native plant species, but the higher portions, adjacent to the U.S. Army Kawailoa and Kahuku training areas, support remnants of native montane forest including koa (*Acacia koa*) and ohia (*Metrosideros polymorpha*) trees, with extensive ground cover of the mat-forming uluhe fern (*Dicranopteris linearis*).

There is limited information about the distribution and abundance of forest birds on Oahu, except for the Oahu Elepaio (*Chasiempis ibidis*), which has been the subject of intensive survey effort (VanderWerf et al. 2001, 2013). Oahu was not included in the original forest bird surveys conducted on most other islands in the 1970s and 1980s (Scott et al. 1986), or in the annual surveys that currently rotate among islands (Gorreson et al. 2009). A forest bird survey was conducted on Oahu by the Hawaii Division of Forestry and Wildlife (DOFAW) in 1991, but the results were never published and it has not been repeated since. The only previous quantitative data available for most forest bird species on Oahu are from Shallenberger (1977), who surveyed military bases on Oahu, including the Kawailoa Training Area, and from Shallenberger and Vaughn (1978), who surveyed several valleys in the leeward Koolau Mountains as part of an environmental assessment for the construction of the H-3 Freeway. There have been no previous quantitative surveys for birds in the Pupukea area.

The Hawaiian hoary bat (*Lasiurus cinereus semotus*) is the only land mammal native to Hawai'i. It is considered a subspecies of the North American hoary bat, but additional research would help to confirm this status (Tomich 1986, Bonaccorso 2010). Unlike many bats, it roosts solitarily in large trees rather than in caves. Recent research has begun to shed light on its ecology, behavior, and movements, but it still relatively little-known and more information is needed. It is found on most of the larger islands, but its population size and trend are unknown because of the difficulty in detecting this nocturnal species. Important conservation actions are to minimize lethal collisions with wind turbines, barbed wire fences, and other structures, while identifying and conserving habitat.

Pacific Rim Conservation (PRC) was contracted in 2015 by the Hawaii Division of Forestry and Wildlife to survey the Pupukea-Paumalu Forest Reserve for birds and the Hawaiian hoary bat. The purposes of these surveys were to provide data on the presence and abundance of these natural resources that can be used to monitor their abundance and help inform management decisions.

Methods

Birds. Birds were surveyed using the variable circular plot (VCP) method, which has been the standard method used for forest birds in the Hawaiian Islands for over 30 years (Shallenberger and Vaughn 1978, Scott et al. 1986, Gorreson et al. 2009). Twenty-six survey points were

located at 200 meter intervals along two transects (Figure 1). The first transect followed Pupukea Road along the southern edge of the reserve and consisted of 12 stations. The second transect followed the mauka boundary road along the eastern edge of the reserve and then the Kaunala Trail through the center of the reserve and consisted of 14 points. Survey points were located with a hand-held GPS unit. Surveys were conducted on 7 and 14 May 2015.

At each point, an 8-minute count of all birds was conducted, during which the species of each bird and its horizontal distance from the observer were recorded. A laser range-finder was used to help estimate distance to each bird. Two measures of abundance were calculated for each species: 1) relative abundance, which was the number of detections divided by the number of points surveyed; 2) frequency, which was the number of points at which the species was detected divided by the number of points surveyed. The data collected during these surveys eventually can be used to estimate the absolute abundance (# of individuals per hectare) of each bird species using distance-based methods, but larger sample sizes are needed for reliable estimates and this will be done after surveys are completed in additional areas on Oahu.

Bats. Surveys for the Hawaiian hoary bat were conducted using a Wildlife Acoustics SM2Bat+ detector (Wildlife Acoustics Inc., Concord, Massachusetts). This device detects and records sounds in the frequency range of bat calls, which are generally inaudible to humans. The recorded sounds were examined by Corinna Pinzari of the U.S. Geological Survey, Biological Resources Discipline, Kilauea Field Station, to determine if they were made by bats. The bat detector was deployed in two locations (Figure 1). The first deployment was from 7-14 May 2015 (7 nights) at the junction of Pupukea Road and the mauka boundary road. The second deployment was from 14-26 May 2015 (12 nights) at the start of the Kaunala Trail on Pupukea Road. In both cases the detector was attached to a tree about two meters off the ground. Both locations where the bat detector was deployed encompassed a corridor along the road overhung by large trees and a small clearing. The bat detector was programmed to automatically turn on at sunset and turn off at sunrise each day. This method provides information about the presence of bats and their activity patterns over time, but it does not provide information about the number of bats using the area.

Results

Birds. A total of 397 birds of 18 species were detected at the 26 points surveyed (Table 1). The Red-billed Leiothrix (*Leiothrix lutea*) was the most abundant species, followed by Red-vented Bulbul (*Pycnonotus cafer*), House Finch (*Haemorhous mexicanus*), and Japanese White-eye (*Zosterops japonicus*). Those four species, all of which were introduced to Hawaii, also were the most frequently detected, each being observed at 25 of the 26 points. Two species of native Hawaiian honeycreepers were observed, the Apapane (*Himatione sanguinea*) and Oahu Amakihi (*Hemignathus flavus*), both of which were uncommon. A total of five Apapane were observed at three points, and a single amakihi was observed. The Amakihi and four of the five Apapane were observed in the highest portion of the reserve along the mauka boundary road at survey points 2-2 and 2-3, and the fifth Apapane was observed in the interior of the reserve at survey point 2-8 (see Figure 1). Two species of introduced parrots were observed; 1-3 Blue-crowned Parakeets (*Aratinga acuticauda*) were seen or heard at points 2-8, 2-11, and 2-12, and two larger parrots, likely Red-crowned Parrots (*Amazona viridigenalis*) were heard at point 1-9. The Red-crowned Parrot identification was based on their distinctive calls. No Oahu Elepaio, Iiwi (*Vestiaria coccinea*), or Oahu Creeper (*Paroreomyza maculata*) were detected during the surveys.

Bats. No bats were detected at the first location where the bat detector was deployed, indicating no bats used the area during those dates. Unfortunately the bat detector malfunctioned during the second deployment and no data were recorded.

Discussion

The Pupukea-Paumalu Forest Reserve, though small, contains native montaine forest habitat that is valuable to two species native Hawaiian forest birds, the Apapane and the Oahu Amakihi. Both of these species were uncommon in the reserve, but Pupukea is the northern-most location where they occur and it thus represents an important part of their range. No Oahu Elepaio were observed during the surveys, which was expected. The last observation of elepaio in the northern Koolau Mountains was in 1977, when a single bird was observed in the Kawailoa Training Area (Shallenberger 1977), but none have been detected since despite numerous visits to the area.

A variety of non-native bird species also were found in the Pupukea-Paumalu Forest Reserve. These species included a mix of birds usually found in forest and other species more typical of urban or open habitats, reflecting the proximity of Pupukea to suburban and agricultural areas. Pupukea Road in particular appeared to serve as a corridor that allowed species usually found in suburban areas, such as Common Myna (*Acridotheres tristis*) and Red-crested Cardinal (*Paroaria coronata*), to penetrate farther than usual into forest habitat.

The observations of the two parrot species in Pupukea are noteworthy. Red-crowned Parrots were first sighted on Oahu in about 1969 in Kapiolani Park, and an additional 3-4 pairs escaped from an aviary in Aiea during hurricane Iwa in 1982 (Pyle and Pyle 2009). More recently, a flock of about 40 Red-crowned Parrots has become established in central Oahu, and is known to roost and nest near Waimano, and to disperse widely in central Oahu while foraging (Kalodimas 2013). The observation of two Red-crowned Parrots in Pupukea indicates their range extends to the northern Koolaus. Blue-crowned Parakeets are much less common on Oahu and less is known about their range or behavior. Single birds have been observed in Honolulu in 1986-1988 (with a flock of Red-crowned Parrots) and in 1999, and one was observed nesting with a Red-masked Parakeet (*Aratinga erythrogenys*) and producing hybrid offspring in Honolulu in 2004 (Pyle and Pyle 2004-2006). A single bird was observed at Turtle Bay in February 2012 (E. VanderWerf pers. obs.). The bird observed at Turtle Bay and the birds seen at Pupukea had only a small amount of dull blue coloration on the head, which is characteristic of the *haemorrhous* subspecies of the Blue-crowned Parakeet, which is native to northeastern Brazil (del Hoyo et al. 1997), though it is also possible they were hybrids. The presence of multiple individuals in Pupukea suggests this species may be established in the northern Koolaus.

Although no bats were detected during the surveys, the amount of time surveyed was short in duration (7 nights total), and it is desirable to conduct additional surveys to confirm whether bats may use the area seasonally or sporadically in low numbers. Bats have been detected regularly in nearby areas, including the Kawailoa wind farm.

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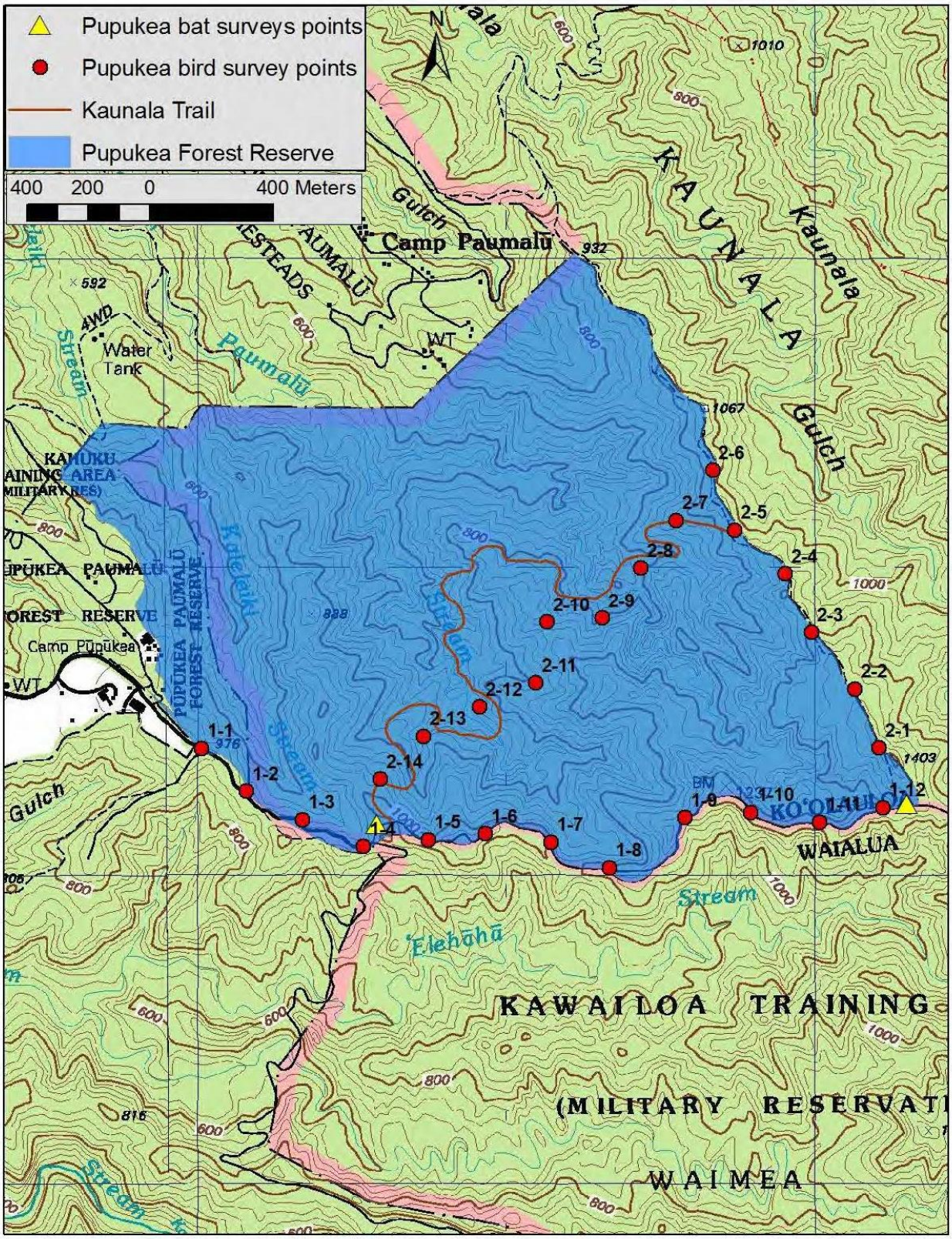
Table 1. Abundance of birds in the Pupukea-Paumalu Forest Reserve on Oahu based on surveys conducted from 7-14 May 2015.

Species	# points occupied	Frequency (% points occupied)	Total detections	Relative abundance (birds per point)
Red-billed Leiothrix	25	96%	83	3.19
Red-vented Bulbul	25	96%	75	2.88
House Finch	25	96%	65	2.50
Japanese White-eye	25	96%	50	1.92
Red-whiskered Bulbul	13	50%	28	1.08
Japanese Bush-warbler	11	42%	22	0.85
White-rumped Shama	15	58%	20	0.77
Common Waxbill	7	27%	17	0.65
Red-crested Cardinal	9	35%	10	0.38
Common Myna	4	15%	8	0.31
Blue-crowned Parakeet	3	12%	6	0.23
Apapane	3	12%	5	0.19
Spotted Dove	2	8%	3	0.12
Red-crowned Parrot	1	4%	2	0.08
Melodious Laughing-thrush	1	4%	1	0.04
Northern Cardinal	1	4%	1	0.04
Nutmeg Mannikin	1	4%	1	0.04
Oahu Amakihi	1	4%	1	0.04
All	26		397	15.27

Figure 1. Map showing the locations of Pupukea-Paumalu Forest Reserve, bird and bat survey points, and the Kaunala Trail.



Appendix D

DRAFT MANGEMENT GUIDELINES (2014)

Vegetation Management		
Class Name	Class Definition	Management Goal
V-1 Highest Quality Native Ecosystems	These units consist of the highest quality native ecosystems and communities. They have minimal disturbance, with low levels (less than 10%) of non-native plants in any vegetative layer. Examples are portions of the Alakai Wilderness Preserve (Kauai), Eke Crater (Maui), Wright Road section of Puu Makaala NAR (Hawaii). 90-100% Native Plant Cover	To protect and perpetuate these areas, by preventing non-sustainable activities or intensities of use. Permitted activities in these areas are minimally disruptive, and would be focused on ecosystem preservation.
V-2 Predominantly Native Areas:	Areas in which native plants predominate in communities that are relatively intact. They have a significant component of non-native plants (>10% in any layer). Examples are the most native portions of some NARs and Forest Reserves. 50-90% Native Plant Cover	To prevent activities or intensities of use that create further significant degradation of native plant or animal communities, and encourage activities or intensities of use that are beneficial to those communities. Permitted activities may have a higher level of disturbance than in V-1 areas, provided they remain within sustainable levels.
V-3 Considerably Disturbed Areas:	Units consist of areas that had a considerable amount of disturbance. The vegetation in the area does not reflect a naturally evolved species composition, but rather a mixture of small remnant patches dominated by native plants, patches of largely invasive weedy alien plants, and areas of mixed native and non-native plants. Examples are portions of Puu Ka Pele Forest Reserve (Kauai), Puu Waawaa public hunting area (Big Island). 10-50% Native Plant Cover	To 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.
V-4 Badly Degraded Areas:	Units are areas that are severely degraded or highly altered from their natural state. They may be areas of severe erosion, former pasture or crop lands, forest plantations, areas of non-native grass or brush resulting from fires or intensive grazing. Examples are portions of the Kakaha Game Management Area (Kauai), and Puu Anahulu Game Management Area (Hawaii). 0-10% Native Plant Cover	To prevent activities or intensities of use that result in degradation of watershed cover or soils. These areas are where the most disruptive activities would be allowed, such as large-scale commercial forestry, game habitat manipulation, etc. Native plant conservation is mainly focused at the species level.

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Conservation Management		
Class Name	Class Definition	Management Goal
C-1: High Conservation Value (High)	Area has two or more of the following factors: 1. Area has a high degree of regulatory encumbrances (i.e., critical habitat, conservation district, T&E species occurrences, court orders, deed restrictions, etc); 2. Is important to the conservation and/or recovery of native species (i.e., forest bird recovery habitat, essential plant habitat, etc); 3. High level of native biological diversity and/or native ecosystem intactness (e.g. V-1)	1. Protect and restore native species and ecosystems (collect genetic material, reintroduce species, protect areas from degradation, restore damaged resources); 2. Reduce the threat of alien species or other factors to the greatest extent possible (fence, intensive animal and weed control, etc); 3. All other uses are secondary to the protection and restoration of native species and ecosystems; 4. Funding and management rules support conservation efforts above all other uses.
C-2: Medium Conservation Value (Medium)	Area has two or more of the following factors: 1. Area has a medium degree of regulatory encumbrances (i.e., critical habitat, conservation district, T&E species occurrences, court orders, deed restrictions, etc); 2. Contributes to the conservation and/or recovery of native species (i.e., forest bird recovery habitat, essential plant habitat, etc); 3. Medium level of native biological diversity and/or native ecosystem intactness	1. Provide ecological buffer from threats to C1, areas; 2. Maintain & improve native ecosystem processes; 3. Conservation of native resources is balanced with other public uses.
C-3: Low Conservation Value (Low)	Area has two or more of the following factors: 1. Area has a low degree of regulatory encumbrances (i.e., critical habitat, conservation district, T&E species occurrences, recovery habitat, etc); 2. Contributes to the conservation of native species (i.e., genetic collection); 3. Low level of native biological diversity and/or native ecosystem intactness	1. Control invasive dispersal corridors, incipient populations of invasive species, localized mammal control; 2. Activities are focused on erosion & fuel control; 3. May provide for ecological corridors or emergency conservation actions for individual species; 4. Other uses may have a higher priority than conservation.
C-4: Very Low Conservation Value (None)	Area has two or more of the following factors: 1. Area has a very low or no regulatory encumbrances (i.e., critical habitat, conservation district, T&E species occurrences, recovery habitat, etc); 2. Little to no contribution to the conservation of native species (i.e., genetic collection); 3. Low to no level of native biological diversity and/or native ecosystem intactness	1. Areas where non conservation dominated uses are encouraged. For example: commercial forestry, sustained game yield, commercial tourism;. 2. All other uses have a higher priority than conservation. 3. Conservation activities are focused on localized threat abatement and emergency response.

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Game Animal Management		
Class Name	Class Definition	Management Goal
A1 Game Production:	Game is a primary objective. Hunting seasons and bag limits provide maximal sustained public hunting opportunities and benefits. Areas include Game Management Areas (GMA).	Game is a primary objective. Oahu: Game birds are the only game in this category
A2 Mixed Game and Other Uses:	Areas where 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.	Areas where game management is an objective integrated with other uses. Oahu: Only PHAs impacted by bird seasons are in this category
A3 Liberal Public Hunting:	Areas where native 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 (e.g. liberal hunting rules).	Areas where resource protection is the primary objective, with emphasis on native plant communities and watersheds. Oahu: most PHAs are in this category. Goal is to maximize public access, game take, and public hunting opportunities in general in order to reduce non-native animal impact on native resources.
A4 Game Control (Staff):	Areas designated for animal removal by staff or agency designees because of environmental sensitivity, remoteness, or public safety.	Areas designated for animal removal. Oahu: areas that are fenced or are targeted for aerial hunting.
Forestry Management		
Class Name	Class Definition	Management Goal
F1 Large Scale Commercial	Forest products are a primary objective and large scale commercial timber harvesting or salvage is allowed. Permits and/or licenses are required with appropriate restrictions. Harvesting of non-timber forest products is allowed. All Timber Management Areas are designated as F1 areas.	To produce timber while allowing other uses such as recreation, hunting and gathering. Activities may include, but are not limited to pre-commercial thinning, commercial thinning, and forest stand improvement. Harvesting activities should follow Best Management Practices for maintaining water quality. Sustained yield management is encouraged and planting or revegetation must follow harvesting to ensure sustainability.
F2 Small Scale Commercial	Areas where limited small-scale (no more than 5% of the total F2 acreage for each forest reserve, annually) commercial timber harvesting or salvage is allowed. Harvesting of non-timber forest products is allowed. Permits and/or licenses are required with appropriate restrictions.	To ensure sustainability of forest product resources while minimizing impacts to non-target native species. Activities may include, but are not limited to pre-commercial thinning and forest stand improvement thinning. To distribute impacts of harvesting over the resource area through controlled seasons and harvest. Depending on the scale and impact of harvesting, planting or revegetation may be required, if deemed necessary by land managers. To encourage active management of culturally and economically significant forest products.

F3 Personal Use	Areas where limited non-commercial timber harvesting and commercial timber salvage is allowed. Harvesting of non-timber products will be considered on a case by case basis. Permits are required with appropriate restrictions.	To minimize human impacts to native species and native ecosystems. To encourage active management of culturally and economically significant forest products for sustainable personal use.
F4 Restricted	Forest Products are not a primary objective. Harvesting of timber products is not allowed. Harvesting of non-timber forest products is generally not allowed and will be considered on a case by case basis for improving forest health, watershed protection, cultural uses and conservation efforts. Permits are required with appropriate restrictions.	To ensure protection of native species and native ecosystems. Permitted activities in these areas are minimally disruptive, and would be focused on improving forest health, watershed protection, and conservation efforts.
Recreation Management		
Class Name	Class Definition	Management Goal
R1 Heavy Use Areas:	Areas where outdoor recreation is a primary objective. Areas may have highly developed recreational facilities such as checking stations, camp sites with utilities and parking lots. Generally restricted to Considerably Disturbed Areas (V-3) and Badly Degraded Areas (V-4).	Areas where outdoor recreation is a primary objective.
R2 Medium Use:	Areas where outdoor recreation is limited or controlled, or where it may be integrated with other uses. Facilities are not highly developed and include trails, rustic shelters, or unimproved campsites.	Areas where outdoor recreation is limited or controlled, or where it may be integrated with other uses.
R3 Light Use:	Areas where 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.	Areas where recreation would be limited to certain areas, or occasional levels of use due to impacts on resources or programs.
R4 Restricted:	Areas where outdoor recreation is heavily restricted or controlled, if permitted at all. Trails would be the main feature considered. Areas may be classified "restricted" due to hazardous conditions, fragile ecosystems, limited accessibility or other management practices incompatible with recreational activities.	Areas where outdoor recreation is heavily restricted or controlled