LAUPĀHOEHOE FOREST

MANAGEMENT PLAN

2016

DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE

UNITED STATES DEPARTMENT OF AGRICULTURE
UNITED STATES FOREST SERVICE

The Laupāhoehoe Forest Management Plan has adopted the pepeʻe as its logo. Pepeʻe is the Hawaiian word for a fern frond that is starting to unravel (see cover). The pepeʻe's circular shape conveys a sense of perpetual forward motion; while its inward curl suggests a return to the point of origin. The pepeʻe begins its life in the shadows of the forest floor, unfurling as it grows. It must overcome the elements to successfully pierce the darkness as it reaches for light and sky. The Laupāhoehoe Forest Management Plan's pepeʻe logo symbolizes new beginnings, overcoming obstacles, positive change, and empowerment through cultural understanding.

- Contributed by Pua Ishibashi

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TABLE OF CONTENTS

TABLE OF CONTENTS i
ACRONYMS iii
SIGNATURE PAGE 1
FORWARD 2
ACKNOWLEDGEMENTS 3
EXECUTIVE SUMMARY 4
INTRODUCTION 5
Background 5
Guiding Principles 5
General Information 6
Location 6
Management Focal Areas 9
Natural Resources 9
Research 10
Education and Outreach 10
Public Access and Recreation 11
Infrastructure 11
DESCRIPTION AND CURRENT CONDITION 12
Land Use 12
Land Designation and Management 12
Land Use History 16
Public Access and Recreation 19
Existing Infrastructure and Facilities 21
Regional Partnerships 24
Site Description (Physical and Biological Resources) 24
Topography, Climate, Geology, and Soils 24
Water Resources 28
Forest Ecosystems 30
Wildlife 36
Cultural Resources and Traditional Practices 39
THREATS TO NATURAL AND CULTURAL RESOURCES 43
Non-Native Plants and Animals 43
Disease 46
Climate Change and Natural Disturbances 46
Wildfire 47
Threats to Cultural Resources 48

OVERVIEW OF EXISTING MANAGEMENT 49
Natural Resources 49
Forest Protection and Management 49
Invasive Non-Native Plant Control 49
Rare Species Restoration 49
Monitoring 50
Research 50
Education and Outreach 52
Public Access and Recreation 52
Infrastructure 52
PROPOSED MANAGEMENT PROGRAM 53
Natural Resources 53
Forest Protection and Management 54
Invasive Non-Native Plant Control 57
Rare Species Restoration 58
Monitoring 59
Wildfire Prevention and Response 60
Research 61
Education and Outreach 63
Public Access and Recreation 65
Infrastructure 70
CULTURAL RESOURCES 70
ADMINISTRATION 73
Coordination 73
Permitting 73
Biosecurity 73
Safety 74
Budget and Staffing 74
REFERENCES 79
Appendix A – Other Available Resources 86
Appendix B – Biosecurity Protocols 87
Appendix C - List of Research Projects to Date 91

ACRONYMS

BLNR	Board of Land and Natural Resources
DAR	Division of Aquatic Resources
DLNR	Hawai‘i Department of Land and Natural Resources
DOCARE	Division of Conservation and Resource Enforcement
DOFAW	Division of Forestry and Wildlife
EA	Environmental Assessment
FIA	Forest Inventory and Analysis Program
FR	Forest Reserve
HIPPNET	Hawai‘i Permanent Plot Network
IPIF	Institute of Pacific Islands Forestry
LAC	Laupāhoehoe Advisory Committee
NAGPRA	Native American Graves Protection and Repatriation Act
NAR	Natural Area Reserve
NARS	Natural Area Reserves System
OCCL	Office of Conservation and Coastal Lands
PEPP	Plant Extinction Prevention Program
PIPES	Pacific Internship Programs for Exploring Science
PSW	Pacific Southwest Research Station
SHPD	State Historic Preservation Division
UH	University of Hawai‘i
USFS	USDA Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VRPF	Volcano Rare Plant Facility
YCC	Youth Conservation Corps

LAUPĀHOEHOE FOREST MANAGEMENT PLAN SIGNATURE PAGE

Hawai'i District: This plan was prepared by the Division of Forestry and Wildlife (DOFAW), U.S. Forest Service (USFS) and the Laupāhoehoe Advisory Council (LAC) to provide a management framework for Laupāhoehoe Forest.

Steve Bergfeld - DOFAW Hawai'i District Manager — Date: 6/6/16

DOFAW Administrator: I have reviewed the Laupāhoehoe Forest Management Plan and agree it will serve as a guiding document for the management of Laupāhoehoe Forest.

David Smith - DOFAW Administrator — Date: 6/9/16

USDA Forest Service: This plan is consistent with the vision for the Hawai'i Experimental Tropical Forest as an important research, education, and demonstration forest where globally relevant activities are conducted to benefit the people and ecosystems of Hawai'i, all Pacific islands and the tropical world.

Ricardo D. Lopez, Director, Institute of Pacific Islands Forestry, USDA Forest Service, Pacific Southwest Research Station — Date: 6/1/16

Board of Land and Natural Resources: This plan conforms with the purpose of the Natural Area Reserve System as stated in Hawai'i Revised Statutes (HRS § 195-1) and associated Hawai'i Administrative Rules (HAR§ 13-209) and the mandates of the State Forest Reserve System which includes HRS § 183 and HAR § 13-104.

for Suzanne D. Case - BLNR Chairperson — Date: 6/9/16

Approved by the Board of Land and Natural Resources at its meeting held June 9, 2016

FORWARD

In 1994 the Hawai‘i Tropical Forest Recovery Task Force, comprised of a cross-section of the people of Hawai‘i, completed their work on an Action Plan that outlines the specific elements necessary to, ‘develop strategies for the long-term management, protection, and utilization of the existing and potential forest resources of the State of Hawai‘i.’ The promise of the Action Plan is even more relevant today and is borne out in part by the completion of the Laupāhoehoe Forest Management Plan, as expressed in the Foreword to the Action Plan, over two decades ago:

> We of Hawai‘i, in the most fundamental of ways, call ourselves ***“kama‘āina,”*** “children of the land.” Ours is a way fragile and vulnerable, even as are the forests, wet and dry, the water ways, on the surface and beneath it, and the oceans, near shore and pelagic.
>
> We are filled with wonder, when we learn a new lesson from a venerated ***kumu*** or a cherished ***kupuna***. We are filled with wonder when we go into the forest and learn something for ourselves that the elders knew all along. We are filled with wonder by what we see of the natural order around us.
>
> We are not always filled with wonder in the marvelous sense, however. There are those among us who have become hurt and cynical when, directly or indirectly, we know that our government has strayed from ***pono*** as managers of our natural and cultural resources. And we wonder, “Why?” There are those among us who have become hurt and cynical when, directly or indirectly, we visit a familiar place and the ***ho‘okipa*** no longer embraces us. And we wonder, “Why?”
>
> “Why?” when our land base has long been recognized as a precious and cherished thing. We divide it most fundamentally into the ***wao akua***, the dominion of the gods, and ***wao kānaka***, the dominion of man. For social, economic, and political purposes, the ***ahupua‘a*** was devised and serves us still. The ***ahupua‘a*** offers us a marvelous interpretive and management tool. We can learn of the history of cultures, natural resources, economies, and management through our study of ***ahupua'a***. The classical lesson is that resources management is nothing new and that the interconnectedness of the clouds, the forests, the fishponds, the seas, and ***kānaka*** has long been recognized.
>
> As the interconnectedness of the natural order was recognized, so was the interconnectedness of the community of ***kānaka***. The chiefs and the farmers, the healers and the fisher-folk, ***nā kupuna*** and ***nā ‘ōpio***, lofty born--lowly born, men--women, every individual was a meaningful component of the whole. Protocol governed divisions of labor and the well-being of the whole. ***Pono*** prevailed.
>
> And so, the formation of the Task Force and the work of the working groups causes some of us to be hopeful. We are full of the hope that the ***ahupua‘a*** will take its rightful place as a model for integrated planning and an interpretive tool for sharing the cultural and natural histories of the islands; that a protocol may evolve which shall welcome tenant and landowner, environmentalist and hunter, bureaucrat and citizen, equally to the table or the forest. We are full of hope that ***“E mau ke ea o ka‘āina i ka pono.”***
>
> - Hannah Kihalani Springer
> Ka‘ūpūlehu, Hawai‘i

Through respect and an attentiveness to the wisdom of the past, along with a solid vision for the future, the Laupāhoehoe Forest Management Plan summarizes a pathway for redeeming the hard work of those that have come before us, laying a foundation for future generations to continue to walk through the forest, and continue to appreciate these lands that we all love so dearly.

- Anonymous

ACKNOWLEDGEMENTS

The DOFAW and the USFS would like to thank the numerous stakeholders and community members that provided input and guidance during the writing of this plan. Special thanks in particular to the LAC members who participated in many meetings and field trips during plan writing and contributed a great deal of time and energy to the process.

Aerial view of Laupāhoehoe Forest

EXECUTIVE SUMMARY

The Laupāhoehoe Forest Management Plan seeks to comprehensively protect and preserve Laupāhoehoe Forest while enhancing public use and benefits through education, recreation, outreach, demonstration, and research activities. This plan documents the history of the forest, describes its current condition, provides an overview of current management activities and agency missions, recognizes the role intact forests play in providing clean freshwater for downstream human and wildlife populations and in supporting healthy coastal marine resources, and recommends management actions. The plan is the management vision for approximately fifteen years and provides:

- Guidance and recommendations to the Hawai‘i Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW) and the U.S. Department of Agriculture (USDA), U.S. Forest Service (USFS) from stakeholders including the Laupāhoehoe Advisory Council (LAC)
- Prioritized recommendations on how to protect and preserve the area, as well as continue and enhance human use
- A compilation of natural and cultural history, resources, and research
- Documentation of current forest conditions and threats
- A planning and management tool for the DOFAW and the USFS to use to determine priorities, work plans, staffing requirements, budget requests, and more
- Funding guidance and a document that enables the DOFAW and the USFS to ask for resources necessary to protect Laupāhoehoe Forest

The plan was jointly developed by DOFAW, the USFS, and the Laupāhoehoe Advisory Council (LAC) through a collaborative planning process. Formed in December 2010, the LAC is a community-based advisory council that provides guidance and consultation to DOFAW and USFS on issues of management, research, and education in Laupāhoehoe Forest.

This draft plan includes proposed management actions to protect natural and cultural resources within Laupāhoehoe Forest while also enhancing compatible human uses. Protecting resources includes addressing the threats of invasive non-native species as well as climate change. The plan will be a guiding document for DOFAW and the USFS for management actions, including background information for why those actions were chosen. The management plan identifies objectives and strategic actions related to Natural Resources, Research, Education and Outreach, Public Access and Recreation, and Infrastructure. Objectives include:

- Natural Resources - Protect, manage and restore native ecosystems and species
- Research - Provide lands for conducting research that serves as a basis for the restoration, conservation and management of tropical forest ecosystems
- Education and Outreach - Serve as a center for forest education, training, demonstration, and outreach on tropical forests, conservation biology, and natural resource management for groups ranging from school children to land managers, scientists and the general public
- Public Access and Recreation - Improve appropriate public access and recreational opportunities consistent with maintaining native natural resources, cultural resources and the wilderness character of these lands
- Infrastructure - Provide and maintain infrastructure and facilities to meet forest goals

INTRODUCTION

Background

The 12,343 acre (ac) (5,134 hectare (ha)) Laupāhoehoe Forest area consists of two state-managed parcels of land: 4,449 ac of state land designated as Forest Reserve (FR), and 7,894 ac of land designated as a Natural Area Reserve (NAR) (Figure 1). Both of these programs are under the state of Hawai‘i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW). In addition, the Laupāhoehoe Forest is designated as part of the Hawai‘i Experimental Tropical Forest (HETF).

In 1992, the Hawai‘i Tropical Forest Recovery Act authorized the establishment of the HETF to serve as a center for long-term research and a focal point for developing and transferring knowledge and expertise for the management of tropical forests. Formally established in 2007, the HETF consists of two units, one of which is the Laupāhoehoe Forest; the other unit is the Pu‘u Wa‘awa‘a Forest located on the leeward side of Hawai‘i Island (Figure 2).

USDA Forest Service (USFS), Pacific Southwest (PSW) Research Station’s Institute of Pacific Islands Forestry (IPIF), based in Hilo, works cooperatively with the state of Hawai‘i to coordinate research, management, and educational activities and to jointly develop and implement research and education, and management plans for the experimental forest. Land management and protection responsibilities remain with DLNR-DOFAW and these lands are managed under relevant state laws and regulations.

Guiding Principles

The management plan of Laupāhoehoe Forest is based on the overall vision for the area as part of the HETF, as well as the purpose of the land designations for the two parcels of state lands that are part of the Laupāhoehoe Forest. The plan also incorporates the values and interests of community members and stakeholder groups and attempts to balance the need for increased forest protection and management while enhancing compatible human uses as outlined in the guiding concepts of the Hawai‘i Tropical Forest Recovery Action Plan (1994).

The HETF vision for Laupāhoehoe Forest is as an important research, education, and demonstration forest where globally relevant activities are conducted to benefit the people and ecosystems of Hawai‘i, all Pacific islands and the tropical world. The forest will provide research, demonstration, training and education opportunities for scientists, post-doctoral fellows, graduate and undergraduate students, K-12 school children who are the future generations of land managers/stewards, forest users, landowners, and scientists in Hawai‘i.

DLNR lands within Laupāhoehoe Forest designated as NAR are managed by DOFAW under the state’s Natural Area Reserves System (NARS). The NARS seeks to protect the best remaining examples of the state’s unique ecosystems and strives to actively manage these reserves in order to preserve the unique characteristics that make these areas an integral part of the natural heritage of Hawai‘i. Reflecting this, the mission of the NARS program is, “The NARS exists to ensure the highest level of stewardship for Hawai‘i’s natural resources through acquisition, active management, and other strategies.”

DLNR lands within Laupāhoehoe Forest designated as FR are managed by DOFAW under the state's Forest Reserve System. The Forest Reserve System was created by the Territorial Government of Hawai'i through Act 44 on April 25, 1903 to protect key forested watersheds. In addition, forest reserves are managed to provide recreational opportunities; aesthetic benefits; native; cultural resources; and threatened and endangered species habitat protection among many other things (cultural use and gathering, hunting).

Laupāhoehoe Advisory Council (LAC)

Formed in December 2010, the LAC is a community based advisory council that provides guidance and consultation to DOFAW and USFS relating to management, research, and education activities in the Laupāhoehoe Forest. The LAC's mission statement is, "Within our Hawaiian culture establish community support in the development of strategies for the long-term management, protection and utilization of existing and potential forest resources."

Laupāhoehoe Advisory Council field trip

Management Plan Development Process

The management plan for Laupāhoehoe Forest was jointly developed by DOFAW, USFS and the LAC through a collaborative planning process. The Management Plan is a long-term management vision and covers a time-frame of fifteen years. This plan serves as a DOFAW site-specific plan for the two state-managed parcels of land within Laupāhoehoe Forest and the USFS plan for the Laupāhoehoe Forest Unit of the experimental forest. The plan provides a brief history of the FR and NAR, a description of cultural and natural resources, and proposed management actions for the area. The plan also includes information on Hawaiian history, culture and legends associated with the area (found in textboxes throughout the document) developed through an LAC working group to complement and add depth to the plan narrative.

General Information

Location

Laupāhoehoe Forest is situated on the eastern, windward flanks of Mauna Kea in the North Hilo District on the island of Hawai'i (TMK #'s (3) 3-7-001:002, (3) 3-7-001:012). Laupāhoehoe Forest stretches from about 1,700 to 6,100 feet (ft) (518–1860 meters (m)) elevation and includes several stream drainages (Figure 1). The forest is located on the Hamakua Coast above the town of Laupāhoehoe, which has an estimated total population of 614 (U.S. Census Bureau 2012).

Laupāhoehoe

Lau or leaf, in the sense of the leaf shape created by pāhoehoe lava (smooth, unbroken type of lava).

Laupāhoehoe Point (taken before 1940)

(Pukui et al. 1986)

Figure 1

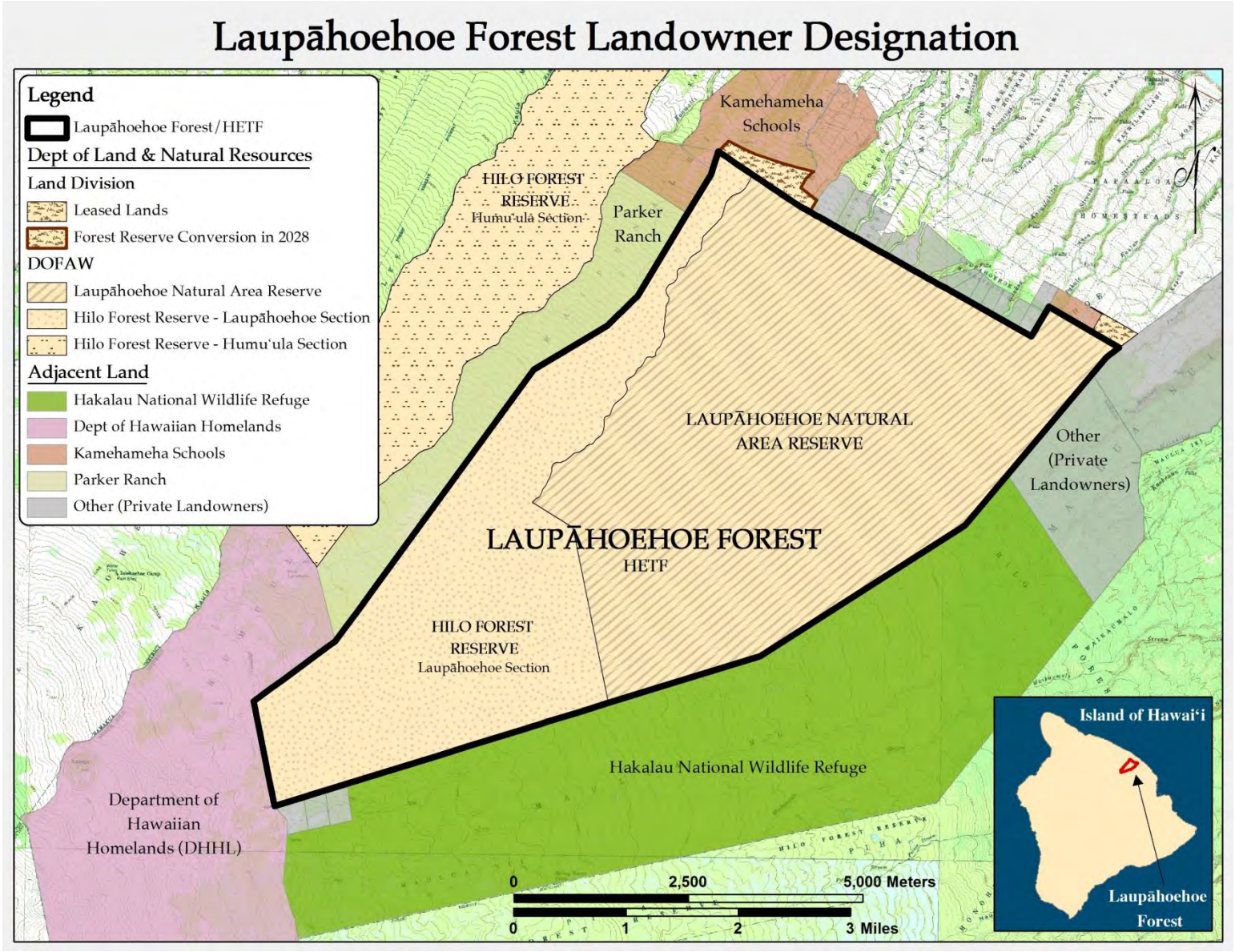
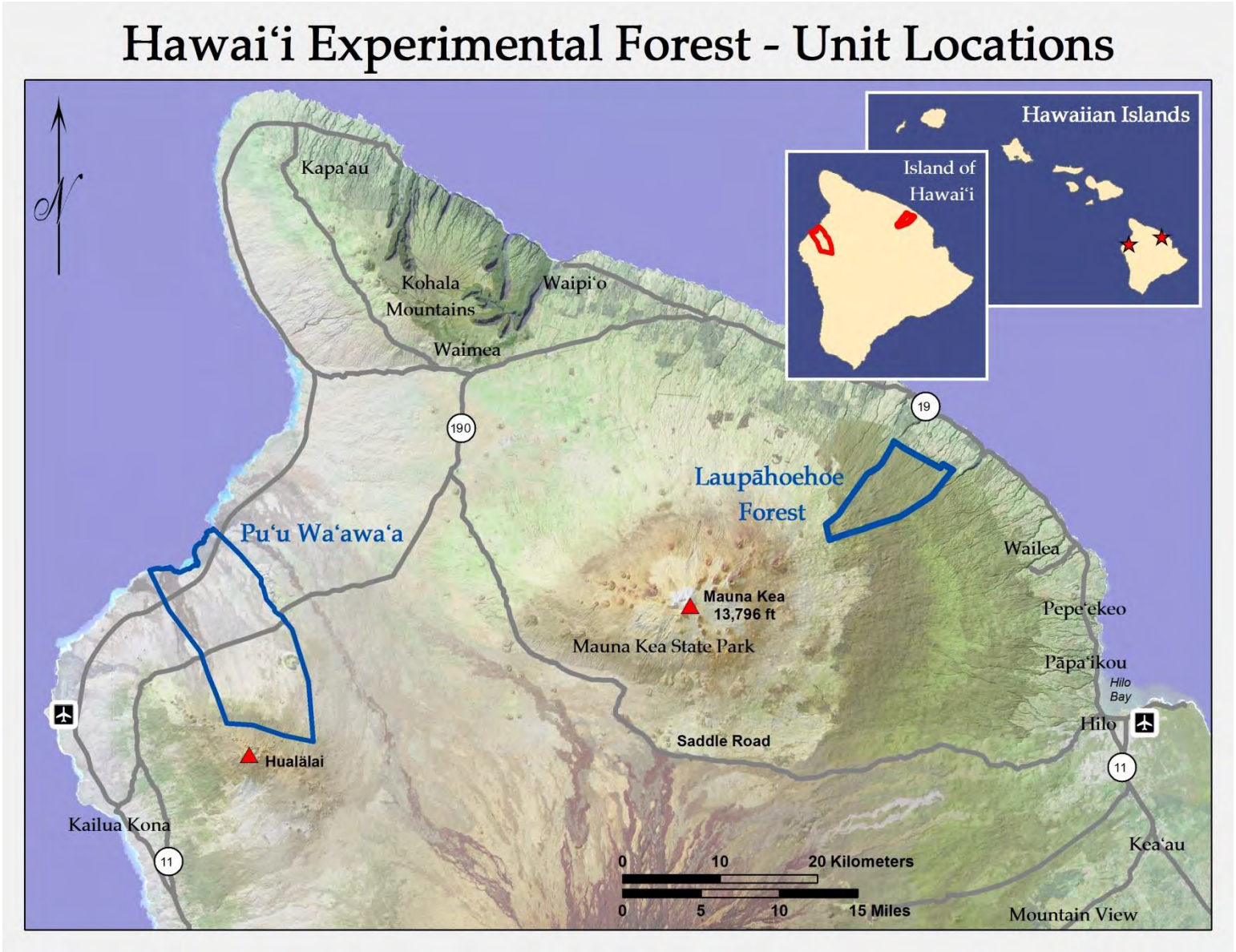

Laupāhoehoe Forest Landowner Designation
Legend
Laupāhoehoe Forest/HETF
Dept of Land & Natural Resources
Land Division
Leased Lands
Forest Reserve Conversion in 2028
DOFAW
Laupāhoehoe Natural Area Reserve
Hilo Forest Reserve - Laupāhoehoe Section
Hilo Forest Reserve - Humu'ula Section
Adjacent Land
Hakalau National Wildlife Refuge
Dept of Hawaiian Homelands
Kamehameha Schools
Parker Ranch
Other (Private Landowners)
Kamehameha Schools
HILO FOREST RESERVE
Humu'ulā Section
Parker Ranch
LAUPĀHOEHOE NATURAL AREA RESERVE
Other (Private Landowners)
LAUPĀHOEHOE FOREST
HETF
HILO FOREST RESERVE
Laupāhoehoe Section
Hakalau National Wildlife Refuge
Department of Hawaiian Homelands (DHHL)
0
2,500
5,000 Meters
0
1
2
3 Miles
Island of Hawai'i
Laupāhoehoe Forest

Figure 2


Hawai‘i Experimental Forest - Unit Locations
Hawaiian Islands
Island of Hawai‘i
Kapa‘au
Kohala Mountains
Waipi‘o
Waimea
190
19
Laupāhoehoe Forest
Pu‘u Wa‘awa‘a
Wailea
Mauna Kea 13,796 ft
Mauna Kea State Park
Pepe‘ekeo
Pāpa‘ikou
Hilo Bay
Hilo
Saddle Road
Hualālai
11
Kailua Kona
Kea‘au
0 10 20 Kilometers
0 5 10 15 Miles
Mountain View

Management Focal Areas

Natural Resources

The protection and effective management of natural resources particularly forested watersheds, unique native Hawaiian ecosystems and threatened and endangered species are a priority for the two parcels of state lands within Laupāhoehoe Forest, and the original purpose for their designations as state NAR and FR. These natural resources require active management in order to persist for the benefit of current and future generations. Key aspects of natural resources management addressed in this plan include:

- Protection and management of watershed and water resources for downstream human and wildlife populations
- Protection of unimpeded surface and/or groundwater flows to the ocean
- Overview of existing natural resources and description of known threats to those resources
- Description of past and current management actions
- Management actions proposed to effectively address threats to natural resources
- Protection and restoration of native Hawaiian ecosystems and species at Laupāhoehoe Forest, including rare and endangered plants and animals
- Linking management to research to develop more effective management techniques
- Monitoring results to assess the effectiveness of management actions, and adjusting management, if necessary, in an adaptive management approach

Natural resources in Laupāhoehoe Forest include numerous streams

Research

Laupāhoehoe Forest is part of a national network of experimental forests and provides researchers with a globally unique opportunity to study wet tropical ecosystems within a larger landscape that stretches across an environmental gradient ranging from sea level to alpine ecosystems. Information from research is critically needed by land managers to help effectively manage the area, particularly the threats posed by invasive species and changing conditions due to climate change impacts. Research can also help us to better understand basic ecological and evolutionary processes, and develop adaptable approaches and effective ways to sustain, enhance and restore the capacity of ecosystems to provide goods and services under changing environmental conditions. Primary areas of research to be promoted and emphasized at Laupāhoehoe Forest include:

- Long-term trends in native montane tropical forest ecosystem conditions and dynamics
- Montane tropical forest ecosystem structure, dynamics, and threats
- Impacts of climate change on wet tropical ecosystems and the services they provide
- Impacts of invasive, non-native plants and animals on montane tropical forest species, communities and ecosystems
- Methods of restoring and maintaining ecosystem function and services in the face of global change
- Methods of restoration that integrate cultural and scientific knowledge
- Methods and approaches that enhance community based collaborative stewardship of natural resources

Education and Outreach

Laupāhoehoe Forest will serve as a center for demonstration, education, training, and outreach on tropical forestry, conservation biology, and natural resources research and management. Education and outreach goals will be accomplished through a strong reliance on partnerships. Education and outreach goals span six focal areas:

- *Formal training for professionals*: Provide work experience and professional development in ecology, conservation, and restoration.
- *Community outreach*: Communicate research findings and management goals, and foster a connection to nature and forest stewardship through engagement activities that involve the public through collaboration with partners including K-12 education program partners.
- *Cultural training*: Exposing researchers, students and managers to cultural knowledge directed at managing forest and coastal resources, including native Hawaiian perspectives and approaches.
- *Demonstration for managers*: Delivery of information, tools and techniques to

Educational programs include hands-on activities such as growing trees for forest restoration projects

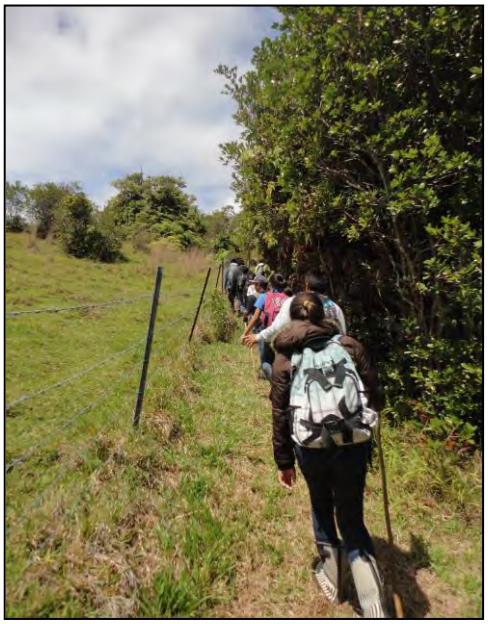
managers through demonstration research, conservation, and restoration projects.

- *Student research*: Foster and support undergraduate and graduate level research opportunities and research internships.
- *Academic education*: Collaborate with universities to integrate college courses and support courses via state and federal facilities.

Public Access and Recreation

Laupāhoehoe Forest is protected and managed by the state for the benefit of the people of Hawai‘i, and is open to the public for various recreational and cultural uses. The use of Laupāhoehoe Forest for activities such as hiking, hunting and traditional and cultural practices, are high priorities for the local community. Management to encourage and enhance public access and recreation includes:

- Encouraging low-impact recreational activities and improvements such as pedestrian trails that are consistent with the remote, wilderness nature of Laupāhoehoe Forest to minimize recreational impacts on natural and cultural resources.
- Improving recreational opportunities by maintaining existing trails and creating new trails to establish a connected trail system.
- Securing new public access routes and appropriate areas for additional forest protection through easements, land acquisition and/or public access agreements with adjacent landowners.
- Continuing to facilitate public hunting in Laupāhoehoe Forest by securing and improving access and trails.
- Providing trails that offer educational and outreach experiences for the public to highlight conservation, restoration and management demonstration sites.



Laupāhoehoe Forest access trail

Infrastructure

Facilities and infrastructure such as roads and trails are essential to facilitate and support the use of HETF for research and education, for natural resources management activities and for public recreation. Goals for the infrastructure and facilities at Laupāhoehoe Forest include:

- Develop and maintain roads, trails, cabins/shelters and campsites for the functions of the HETF and for resources management actions as well as for public recreational use.
- Ensure facilities and infrastructure has minimal impacts on the environment and natural and cultural resources.

DESCRIPTION AND CURRENT CONDITION

Land Use

Land Designation and Management

State lands in the Laupāhoehoe Forest are under overall administration of DLNR. The Board of Land and Natural Resources (BLNR) sets policies for the Department. DOFAW is the Division of DLNR charged with management of the lands which are designated as both NAR and FR. Other relevant planning documents associated with Laupāhoehoe Forest are provided in Table 1.

Both DOFAW and IPIF have responsibilities in the management of the experimental forest. HETF activities are authorized under a 2006 Cooperative Agreement between the BLNR and the USDA Forest Service as well as a permit for use of state lands. Land management and protection responsibilities remain with the state and are managed under relevant state laws and regulations. The IPIF participates in the administration of research and education activities; authority for signing of all permits lies with DOFAW. The IPIF administers the research/education infrastructure.

The Hawai‘i State Constitution Article 11 states: “For the benefit of present and future generations, the state … shall conserve and protect Hawaii's natural beauty and all natural resources, including land, water, air, minerals and energy sources, and shall promote the development and utilization of these resources in a manner consistent with their conservation and in furtherance of the self-sufficiency of the state. All public natural resources are held in trust by the state for the benefit of the people.”

DOFAW has management responsibility for the 4,449 ac (1,800 ha) Laupāhoehoe section of Hilo FR, which is part of the state Forest Reserve System (Figure 1). Hilo FR was originally established in 1905 for the purpose of watershed protection, and various parcels have been added and withdrawn from the FR since it was established. The FR portion of the Laupāhoehoe Forest is approximately 1,700 to 6,100 ft (518–1,860 m) elevation.

Wao akua

The lands of the Laupāhoehoe Forest are part of an ancient region, traditionally known to the Hawaiians as the wao akua (region of the gods), wao ma‘ukele (wet forest zone) and wao nahele (forest zone). In traditional times—pre-western contact in 1778, and in subsequent years through the early 1800s—these forested regions, particularly the wao akua, were considered sacred, the abode of the gods. Travel through the forest lands, undertaking collection of resources—gathering woods and other plant materials, collection of feathers and catching birds, and even travel through the forests, simply to reach another destination beyond the forest—was undertaken with prayer, caution, and respect. Damage to the living forests was often punished by acts of nature—heavy rains might wash the careless traveler from the path; dense mists or sudden growth of such plants as uluhe or ‘ōpiko, might cause the trail to be lost from view, and the traveler to wander aimlessly through the forests.

(Maly and Maly 2006)

The Forest Reserve System was created by the Territorial Government of Hawai'i through Act 44 on April 25, 1903. With Hawaii's increase in population, expanding ranching industry, and extensive agricultural production of sugarcane and later pineapple, early territorial foresters recognized the

need to protect mauka (upland) forests to provide the necessary water for agriculture and surrounding communities. The Forest Reserve System is managed under the guidance of the Hawai‘i Revised Statutes (HRS) (Chapter 183) and associated Hawai‘i Administrative Rules (HAR) (Chapter 104). Through these directives, DOFAW focuses its resources to protect, manage, restore, and monitor the natural resources of the Forest Reserve System. The Forest Reserve System accounts for over 448,000 acres of state managed land on Hawai‘i Island.

Laupāhoehoe Forest includes approximately 7,894 ac (3,195 ha) withdrawn from the FR and designated as a NAR in 1983 by Executive Order 3168 (Figure 1). The NAR was designated to protect wet forests of koa (*Acacia koa*) and ‘ōhia (*Metrosideros polymorpha*), wet grasslands and streams, all of which provide important habitat for plants and animals, including rare species. The NAR portion of Laupāhoehoe Forest includes lands from approximately 1,700 to 4,600 ft (518–1,402 m) on the slopes of windward Mauna Kea. The Natural Area Reserves System (NARS) was created in 1971 by the Hawai‘i State Legislature to “preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawai‘i (HRS § 195-1).” The legislature further found that these unique natural assets should be protected and preserved, both for the enjoyment of future generations and to provide baselines against which changes to Hawaii’s environment can be measured. The NARS is administered by DLNR-DOFAW. NARS Commission members act in an advisory capacity for the Board of Land and Natural Resources, which sets policies for the Department. HAR § 13-209 relate to the management of the NARS.

The NARS presently consists of 20 reserves on five islands, encompassing more than 123,000 ac (49,776 ha) of the state’s most unique ecosystems. The diverse areas found in the NARS range from marine and coastal environments to alpine desert, and from fresh lava flows to wet forests. These areas often serve as habitat for rare native plants and animals, many of which are on the verge of extinction. The NARS also include important watersheds, contributing to Hawai‘i’s sources of drinking water. Finally, the NARS forms an important part of the scenic landscape and contributes to the natural beauty of Hawai‘i, contributing to the islands’ overall appeal to visitors. Some of the most recognizable and visited NARS include Mauna Kea Ice Age NAR (Hawai‘i), Ka‘ena Point NAR (O‘ahu), and ‘Āhihi-Kīna‘u NAR (Maui).

Laupāhoehoe Forest provides a site for long-term research on tropical forests

The DOFAW website located at http://dlnr.hawaii.gov/dofaw/ provides general information on both NAR and FR programs and policies across the state.

Laupāhoehoe Forest is also designated as part of the HETF, which was formally established in 2007. The HETF currently includes two units: the Laupāhoehoe Forest Wet Forest Unit and the Pu‘u Wa‘awa‘a Dry Forest Unit (Figure 2). The USFS works with the state in the management of the experimental forest. The purposes of the HETF are to: (1) understand how to restore, preserve, and sustainably manage

native tropical forests, streams, and watersheds of the Pacific, and to provide information to those managing these landscapes; (2) provide a center for demonstration, education, training, and outreach on tropical forestry, conservation biology, and natural resources research and management; (3) provide sites dedicated to long-term research on tropical forestry, ecology, hydrology, conservation biology, and natural resource management; and (4) foster research cooperation and collaboration between state and federal agencies, and among agencies and other institutions in tropical forestry research.

Other DLNR Divisions and DOFAW Programs also have various responsibilities related to Laupāhoehoe Forest:

- Division of Conservation and Resource Enforcement (DOCARE) - DOCARE has full police powers and is responsible for the enforcement of state laws and rules at Laupāhoehoe Forest, including laws regulating hunting and protection of resources (e.g. illegal harvesting, vandalism etc.).
- Nā Ala Hele - The Hawai‘i Statewide Trail and Access System is a DOFAW Program that has responsibility for trails and access. This program regulates and manages specific trails and accesses; conducts trail and access inventory; investigates potential and needed trails and accesses; examines legal issues; acts as point of contact for trail and access information and issues; and conducts trail and access advisory council meetings.
- Division of Aquatic Resources (DAR) - Manages marine and freshwater resources through programs in commercial fisheries and aquaculture; aquatic resources protection, enhancement and education; and recreational fisheries.
- State Historic Preservation Division (SHPD) - Works to preserve and sustain reminders of earlier times which link the past to the present. SHPD has three branches - History and Culture, Archaeology, and Architecture.
- Office of Conservation and Coastal Lands (OCCL) - Responsible for overseeing private and public lands that lie within the State Conservation District, including designated Conservation District lands in Laupāhoehoe Forest. Conservation District subzones define identified land uses which may be allowed by discretionary permit or some sort of approval from the DLNR or BLNR. NAR portions of Laupāhoehoe Forest are in the Protective Subzone and lands within the FR are in the Resource Subzone.

Table 1. *Related Federal, State and County Planning Documents*

Planning Document	Comment
Hawai‘i State Wildlife Action Plan (DLNR 2015)	Statewide strategy for the conservation of native wildlife and plants. Identifies species of greatest conservation need.
Hamakua Community Development Plan (plan under development)	County of Hawai‘i plan http://www.hawaiicountycdp.info/hamakua-cdp
The Rain Follows the Forest - A Plan to Replenish Hawaii’s Source of Water (DLNR 2011)	Laupāhoehoe Forest is identified as a priority watershed area on the island of Hawai‘i

Planning Document	Comment
DOFAW Statewide Assessment and Resource Strategy (SWARS) (DLNR 2010)	Identifies areas of greatest need and opportunity for forests in Hawai‘i and develops a long-term management strategy. Objectives include: 1.1. Identify and conserve high-priority forest ecosystems and landscapes; 2.2. Identify, manage and reduce threats to forest and ecosystem health; 3.3. Enhance public benefits from trees and forests; 3.1. Protect and enhance water quality and quantity; 3.5. Protect and enhance wildlife and fish habitat; 3.7. Manage and restore trees/forests to mitigate and adapt to global climate change.
Draft Mauna Kea Watershed Alliance Management Plan (Stewart 2010)	DOFAW and USFS are members of the Mauna Kea Watershed Alliance and Laupāhoehoe Forest is included in this partnership area. The Mauna Kea Watershed alliance includes major landowners on Mauna Kea with a shared interest to protect the ‘āina by working together to manage threats that occur across common land ownership boundaries, pooling limited resources to achieve conservation goals, and promoting collaboration in protecting vital resources across large landscapes.
U.S. Fish and Wildlife Revised Recovery Plan for Hawaiian Forest Birds (USFWS 2006)	Supports recovery actions 1 & 2: protect and manage ecosystems for the benefit and recovery of native forest birds.
County of Hawai‘i General Plan (County of Hawai‘i 2005)	8.2 (c) Protect and promote the prudent use of Hawaii’s unique, fragile, and significant environmental and natural resources. 8.2 (d) Protect rare or endangered species and habitats native to Hawai‘i. 8.3 (b) Encourage a program of collection and dissemination of basic data concerning natural resources. 8.3 (e) Encourage an overall conservation ethic in the use of Hawai‘i resources by protecting, preserving, and conserving the critical and significant natural resources of the County. 8.3 (o) Encourage the continued identification and inclusion of unique wildlife habitat areas of native Hawaiian flora and fauna within the NARS.
U.S. Fish and Wildlife Final Designation and Non-designation of Critical Habitat for 46 Plant Species From the Island of Hawai‘i, HI (USFWS 2003)	Provides recommendations for habitat management for *Cyrtandra giffardii*, *Cyanea platyphylla*, *Clermontia peleana, Clermontia pyrularia, Cyrtandra tintinnabula,* and *Phyllostegia warshaueri*
U.S. Fish and Wildlife Service. Big Island II: Addendum to the Recovery Plan for the Big Island Plant Cluster (USFWS 1998a)	Describes recovery actions needed for endangered plant species: *Cyanea platyphylla*, *Phyllostegia racemosa,* and *Phyllostegia warshaueri*
U.S. Fish and Wildlife Recovery Plan for the Hawaiian Hoary Bat (USFWS 1998b)	Describes recovery actions needed for the Hawaiian Hoary Bat including protecting and managing current populations.
U.S. Fish and Wildlife Recovery Plan for the Big Island Plant Cluster (USFWS 1996)	Describes recovery actions needed for *Clermontia lindseyana*, *Clermontia peleana, Cyrtandra giffardii,*and *Cyrtandra tintinnabula*.
Hawai‘i Tropical Forest Recovery Action Plan Hawai‘i Tropical Forest Recovery Task Force (1994)	Plan to develop consensus actions neededto recover, manage, and enhance Hawaii's tropical forests
Laupāhoehoe Natural Area Reserve Draft Management Plan (DLNR 1989)	Previous draft management plan for the NAR

Land Use History

Laupāhoehoe Forest and the surrounding areas have a rich history that has shaped the way the landscape looks today. In 2006, Kumu Pono Associates prepared *Hilo Palikū - Hilo of the Upright Cliffs: A Study of Cultural-Historical Resources of Lands in the Laupāhoehoe Forest Section, Ahupua'a of the Waipunalei-Mauluanui Region, North Hilo District, Island of Hawai'i* (Maly and Maly 2006). This detailed study provides extensive background of the history and cultural resources of the area from ancient Hawaiian uses to the present day and is also discussed further in the Social and Cultural Background portion of this plan. The complete study is available online (see REFERENCES).

In the collection of native and historical accounts, Kumu Pono Associates notes that the lands of the Laupāhoehoe forest region were frequently mentioned in several prominent traditions. Significantly, the importance of the Laupāhoehoe region koa forests, mountain bird habitats, and the traditional trails which connected the lowlands with the mountain lands and neighboring districts, are frequently referenced in traditions and historical accounts. Also, battles fought on the Laupāhoehoe lands were among those which established the kingdoms of chiefs between the early 1500s to the late 1700s.

The Laupāhoehoe Forest region contains at least fourteen ahupua'a or traditional land subdivisions encompassing swaths of land running from the coast to the interior mountains (Figure 3). Ahupua'a names used in Figure 3, encompassed by the Laupāhoehoe ahupua'a border are separate from Laupāhoehoe ahupua'a but do not include boundaries as no surveys are available. The ahupua'a names used on the map are from Maly and Maly (2006). In the mid Nineteenth Century the lower elevation portions of the ahupua'a were sought for sugar plantations. By 1876, the Laupāhoehoe Sugar Company and Mill was developed and lowland forests up to about the 2,000-foot elevation were cleared for sugar cultivation, the development of flumes and water resources and homestead lots (Maly and Maly 2006). By the late Twentieth Century sugar production on Hawai'i was no longer economically competitive with production in other tropical locations and the sugar plantations closed (Maly and Maly 2006).

During the early historic period, the upland section of the Laupāhoehoe forests was impacted by herds of wild sheep and bullocks. By 1825, foreign bullock hunters had established camps on the outer edges of the forest, in the region where Laupāhoehoe and neighboring lands are cut off by the ahupua'a of Humu'ula. By the 1850s, the bullock and sheep hunting activities were giving way to formal ranching operations, with the land of Humu'ula taking in sections of the Laupāhoehoe forests (Maly and Maly 2006).

'Eku ka pua'a ku mai o Hilo Paliku. Ola ka ahupua'a o Laupāhoehoe. Kamapua'a roots up the earth forming the cliffs of Hilo Paliku. Life is given to the lands of Laupāhoehoe.

The pua 'a (pig) was brought with the first Polynesian voyagers to Hawai'i. Associated with Lono, pigs were often used as sacred offerings to the gods. The ahu stone alter, mounted with a pig's head, marked the boundaries of each ahupua'a.

Kamapua'a displays his many kino lau or forms as symbols of fertility and growth.

(Nā Waiwai O Laupāhoehoe)

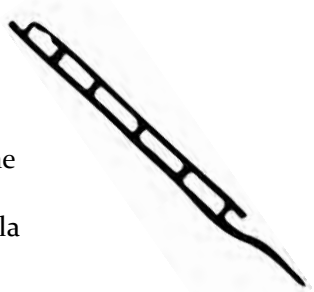
Timber harvesting has also impacted the landscape. Forests in the area were used by traditional canoe makers and others over many centuries, but the pace of harvesting increased by the middle 1800s when sawmills were established in windward Hawai'i Island

and lumber was harvested and milled for growing island communities and businesses. The negative impacts of logging and grazing on the land were noted by the middle to late 1800s, and government leases began to incorporate conditions meant to conserve forest resources. After establishment of the Hilo FR in 1905, almost no collection of lumber occurred in the Laupāhoehoe section, except for that in direct association with management of the ranch lands. Timber harvest again impacted the area in 1969, when Blair, Inc. received a right of entry permit from DLNR and built a road within Laupāhoehoe FR. A license to harvest timber, primarily koa was awarded to Blair, Inc. in 1971. The Blair logging operation impacted approximately 1,000 acres and was terminated by 1979, when Blair went out of business (Maly and Maly 2006). Research after the logging operation indicated that disturbance from logging stimulated koa regeneration but invasion of banana poka (*Passiflora tarminiana*) was also noted (Scowcroft and Nelson 1976). A later study found impacts of the former logging operation including an increase in invasive tropical ash (*Fraxinus uhdei*), which outcompetes native tree species in disturbed areas (Friday et al. 2008).

In 2006, DOFAW prepared a plan and environmental assessment for reforestation of the timber harvest area (state of Hawai‘i 2006) that included scarification to increase koa (*Acacia koa*) regeneration. DOFAW chose not to implement the project as other management actions including removal of feral cattle and introduction of a biocontrol agent to control the invasive non-native banana poka in the area enhanced natural regeneration of the forest. The biocontrol agent proved successful in reducing banana poka (Trujillo et al. 2001). Native species, particularly koa and ‘ākala (*Rubus hawaiiensis*) are recovering in the former timber harvest area although other invasive non-native plants are still a problem.

Mai Maunakea a Paliku, holo i kai, he'e mālie, Hānau ‘o Laupāhoehoe. From Maunakea to Paliku, traveling towards the sea, slipping and sliding, Born is Laupāhoehoe.

Traditionally known as Hilo Paliku, now North Hilo, this favorite playground is where Poli‘ahu and her companions of Maunakea came to compete in the sport of he‘e holua (sledding).

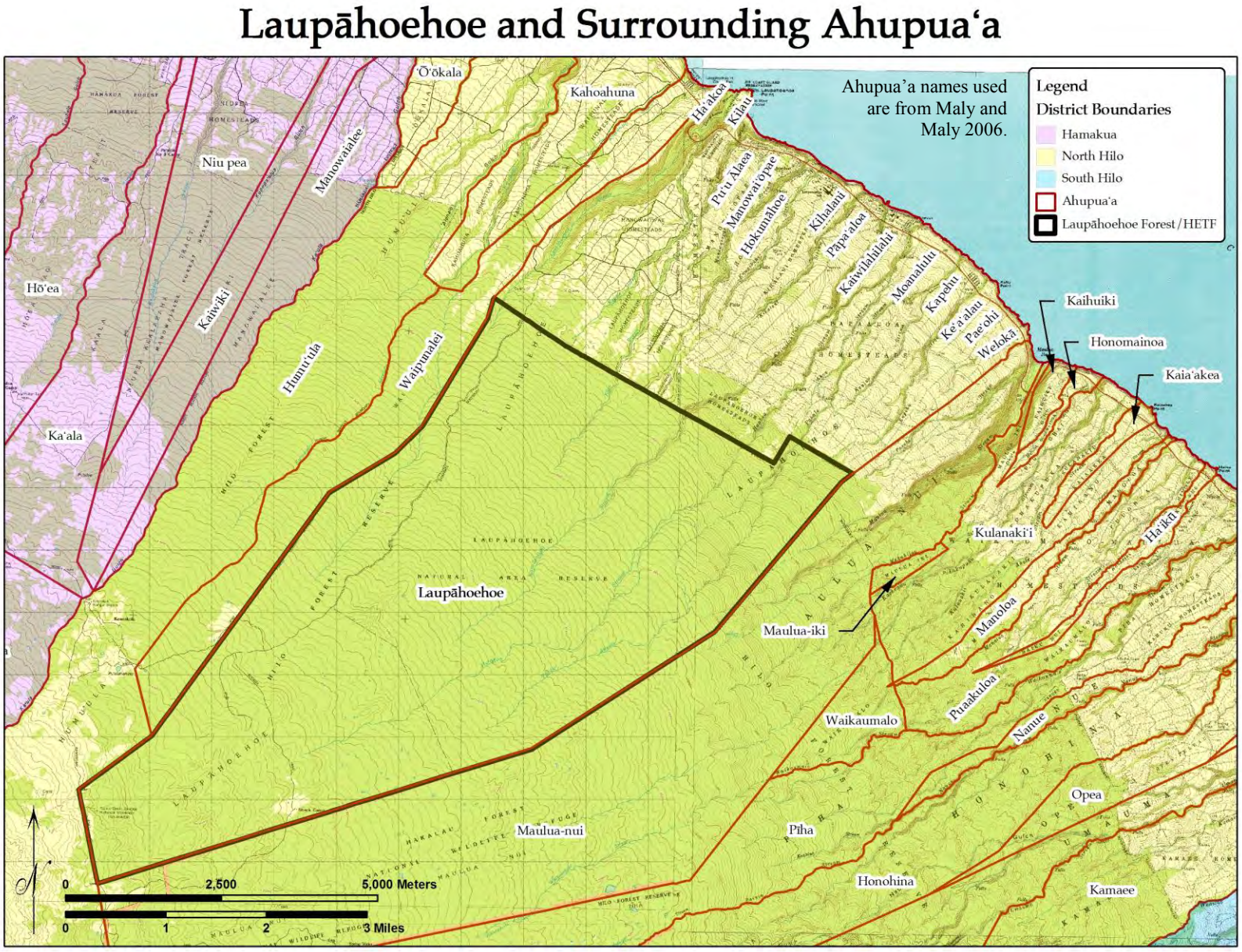


One day a beautiful stranger joined them, but soon after, cast off her disguise as fountains of fire burst out of the subterranean caverns. Narrowly escaping Pele’s fury, Polia‘hu covers the mountain with her snowy mantle. She chills the land and caps the erupting lava, forcing Pele back to her home at Maunaloa. The fire-rivers that rushed to the sea immediately cooled to form the peninsula of Laupāhoehoe.

The conflict of fire and ice is personified with Pele and Poli‘ahu's destructive rivalry but as in nature, harmony and balance prevails giving rise to the creative forces of life..... Hanau 'o Laupāhoehoe.

(Nā Waiwai O Laupāhoehoe)

Figure 3


Laupāhoehoe and Surrounding Ahupua'a
Ahupua'a names used are from Maly and Maly 2006.
Legend
District Boundaries
Hamakua
North Hilo
South Hilo
Ahupua'a
Laupāhoehoe Forest / HETF
Ō'ōkala
Kahoahuna
Ha'akoa
Kilau
Niu pea
Manowaialee
Pu'u Alaea
Manowai'opae
Hokunuihoe
Kihalani
Papa'aloa
Kaiwilahilahi
Moanalulu
Kapehu
Ke'a'alau
Pae'ohi
Welokā
Kaihuiki
Honomainoa
Kaia'akea
Hō'ea
Kaiwiki
Humu'ula
Waipunalei
Ka'ala
Laupāhoehoe
Kulanaki'i
Ha'ikū
Maulua-iki
Manoloa
Puaakuloa
Waikaumalo
Nanue
Opea
Piha
Maulua-nui
Honohina
Kamaee
0 2,500 5,000 Meters
0 1 2 3 Miles

Public Access and Recreation

Laupāhoehoe Forest is open to the public for various recreational and cultural uses. While the public is permitted to access and hike or hunt in any portion of the forest, there are limited legal access points and only a few minimally maintained and marked trails. This area is rough and remote rainforest wilderness and there are currently no amenities for recreational users.

Some recreational uses in the NAR, including hiking or nature study with groups larger than ten require a DOFAW permit. Gathering within the FR or NAR also requires a DOFAW permit (see Gathering).

Vehicle Access

Mauka (inland, towards the mountain) and makai (ocean, towards the ocean) public access to Laupāhoehoe Forest is currently via three main access points off Spencer Road, Mana Road and Uweki Road respectively (Figure 4). These roads provide vehicle access to approximately the forest boundary:

- Spencer Road Access - The state has an easement through private pasture lands at the top of Spencer Road to allow for public pedestrian access to the lower boundary of Laupāhoehoe Forest. Spencer Rd. is a paved County road passable in a two-wheel drive vehicle. There is a small grassy area where vehicles may park mauka of where Spencer Rd. terminates. A primitive, minimally user-maintained trail provides pedestrian access from the parking area to the forest (see description under Trails section below).
- Mana Road Access - Mana Rd. is a 4-wheel drive County road approximately 40 miles long that roughly transverses a contour along Mauna Kea. Mana Rd. is accessed via Mauna Kea Access Rd. (off Saddle Road) on the Hilo side or from the town of Waimea. The first six miles of the road are regularly maintained at both entrances. The road intersects the top of the Laupāhoehoe Forest. A Nā Ala Hele designated trail, Kaluakauka Trail, is accessed via this route (see description under Trails section below).
- Maulua Nui/Uweki Road Access - the County of Hawaii acquired public access to Laupāhoehoe Forest from Uweki Road as a part of a subdivision action. The public access agreement creates a public parking easement to accommodate not less than three vehicles and public pedestrian access to the NAR boundary within a 10-foot wide corridor.

Trails

Trails within Laupāhoehoe Forest include the following:

- Kaluakaukua Trail – The trailhead for this Nā Ala Hele designated trail is on the makai side of the Keanakolu-Mana Rd., 17.7 miles from the junction with Mauna Kea Access Road. The trail is considered moderately difficult and is unmarked and rarely maintained (as described per the official website, http://hawaiitrails.ehawaii.gov/). The trail goes downhill across forested pasture land to a foot gate in the FR boundary fence, then continues to the Dr. David Douglas monument erected in 1934 (approximate death site of Dr. David Douglas, the Scottish botanist for whom the Douglas Fir is named).
- Other Trails – Additional trails can be found within Laupāhoehoe Forest, notably Peneki and Spencer trails (Figure 4) as well as other unnamed trails. These trails are not formally recognized as public access trails and are not marked or maintained. These primitive trails were created by the hunting community from the Spencer Road access point and other access

points. Trail conditions are hazardous, steep and muddy, and lower elevation portions of the trail within the strawberry guava belt may frequently be 'tunneled' in by guava tree windfall.

- Historic Trails:
  - Maulua Trail – A portion of this historic ranching-era trail goes across the upper section of Laupāhoehoe Forest from the boundary near Shack Camp to Waipunalei. Access to this area is via Blair Rd. This trail is a historic route used for moving cattle in the early 1900s, and it is not maintained or easily visible on the ground. Only a few recognizable sections of the historic trail have been identified.
  - Waipunalei Trail – This historic trail (also referred to as the Laupāhoehoe – Waipunalei Trail) is depicted on various maps though the trail is not currently visible on the ground and remnants of the historic trail or associated features have not thus far been identified. Maps depict this trail running inland roughly along the Laupāhoehoe and Waipunalei boundary. This trail may follow an older route referenced in Boundary Commission testimonies recorded in 1875 for Waipunalei Ahupuaʻa.

Waipunalei-Laupāhoehoe Trail

The Waipunalei-Laupāhoehoe Trail, connected with the 'Umikoa Trail, via the Laumaiʻa Trail just in the upper edge of the larger forest zone (where the koa and māmane trees mixed together). The Waipunalei-Laupāhoehoe and 'Umikoa trails also converge in Kaʻohe Ahupuaʻa and run up to the summit of Mauna Kea. It was via this trail that ceremonial pilgrimages were made, that adze makers traveled to the Keanakākoʻi quarries, and that travel to the upper mountain lands was done to accomplish personal family matters—such as the burial of loved ones and the hiding of the piko (umbilical cords) of newborn children.

(Maly and Maly 2006)

Mountain Biking

Mountain biking is legal on FR roads unless otherwise posted. There are no legal public access trails suitable for mountain biking that access Blair Rd. within the FR. Accessing roads or trails across private lands to reach Blair Rd. without landowner permission is illegal.

Hunting

DOFAW manages public hunting on all state lands and hunting in the Laupāhoehoe Forest is regulated by Chapter 13-122,123, Hawaiʻi Administrative Rules (Rules Regulating Game Bird Hunting, Game Mammal Hunting). The Laupāhoehoe Forest includes hunting units B and C in the FR and hunting unit K in the NAR (Figure 5). There is a hunter check station at the Spencer Rd. access. DLNR's Division of Conservation and Resource Enforcement (DOCARE) carries out enforcement of hunting regulations. Current information regarding hunting rules, seasons and bag limits for all game species can be obtained by contacting the DOFAW Hilo office at 19 East Kawili St. Hilo, Hawaiʻi, (808) 974-4221.

All persons are required to have a valid Hawaiʻi hunting license on their person to hunt or have a bagged game mammal in their possession. Hunting licenses may be purchased online from

http://www.ehawaiigov.org/DLNR/hunting/, from any DOFAW office or from any registered hunting license vendor. All hunting license applicants must show proof of having successfully completed a hunter education course that is recognized by the National Hunter Education Association.

Camping

There are no designated camping areas and no camping is currently allowed in the Laupāhoehoe Forest.

Gathering

Gathering is allowed in Laupāhoehoe Forest and there are two different permit procedures, depending on whether gathering is occurring in the FR or the NAR:

- FR - Small-scale non-commercial harvesting or salvage is allowed in the FR section of Laupāhoehoe Forest, such as materials for cultural uses. Non-timber forest products such as ferns, maile (*Alyxia stellata*), flowers, fruits, and lei-making materials etc. for cultural or personal use may be collected from within the FR. Gathering of forest products is permitted and regulated by DOFAW through Forest Reserve System permit procedures.
- NAR - Gathering (including Native Hawaiian religious and customary gathering) within the NAR portion of the forest requires a NAR special use permit.

Permit applications can be obtained from the DOFAW Hilo office at 19 East Kawili Ave. Hilo, Hawai‘i, (808) 974-4221. These permits are available, upon approval, free of charge (for common, personal use items) or for a fee, depending on the purpose. Gathering of materials from listed endangered species is not permitted. DOFAW's permit process is not intended to restrict constitutionally protected cultural practices, but is in place to ensure protection of unique natural resources and avoid over-collection of a particular resource, minimize the potential for user conflict, and to provide safety or resource information.

Existing Infrastructure and Facilities

Roads

Spencer, Mana and Uweki roads provide public access to the Laupāhoehoe Forest boundary (see Public Access and Recreation). There is an existing road located within Laupāhoehoe Forest used for management, research and educational purposes, but this road is not currently available for public vehicular access as private lands/roads must be traversed in order to reach the road, as well as liability issues and maintenance costs.

- Blair Road - Blair Rd. requires 4-wheel drive and is contained within Laupāhoehoe Forest (Figure 4). This road is used for management, research and education purposes by the state and the USFS. Public pedestrian use of the road on state lands is allowed for people who access the road by hiking through the forest from public access points (Spencer Rd., Mana Rd., or Uweki Rd. access). The state has an easement trade with Parker Ranch for use of Blair Rd. in exchange for use of Parker Ranch roads to access other portions of the Hilo FR (Humu‘ula section). Historically, Blair Rd. was built and extended between 1969-1973, and used for logging portions of Laupāhoehoe Forest.

Figure 4

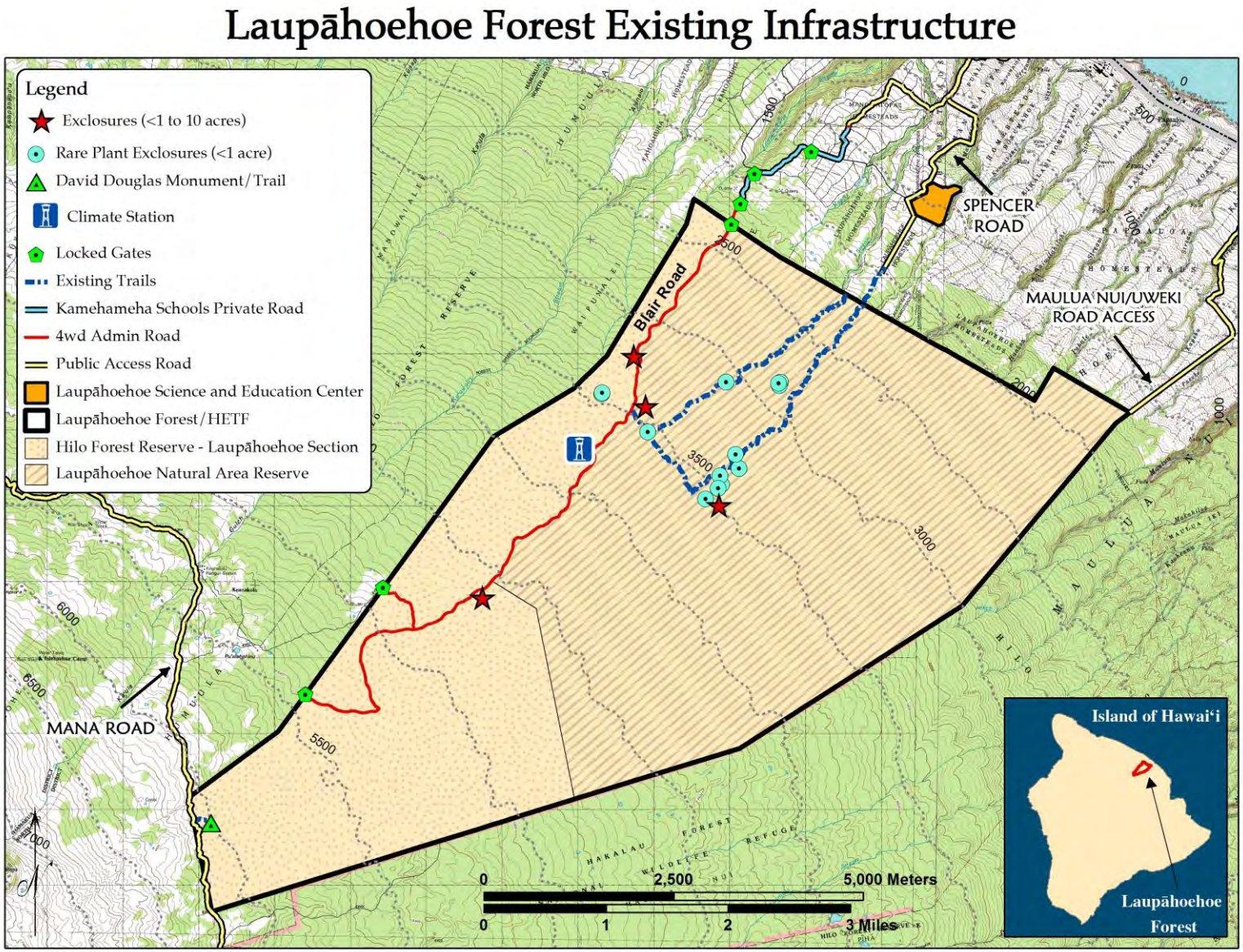
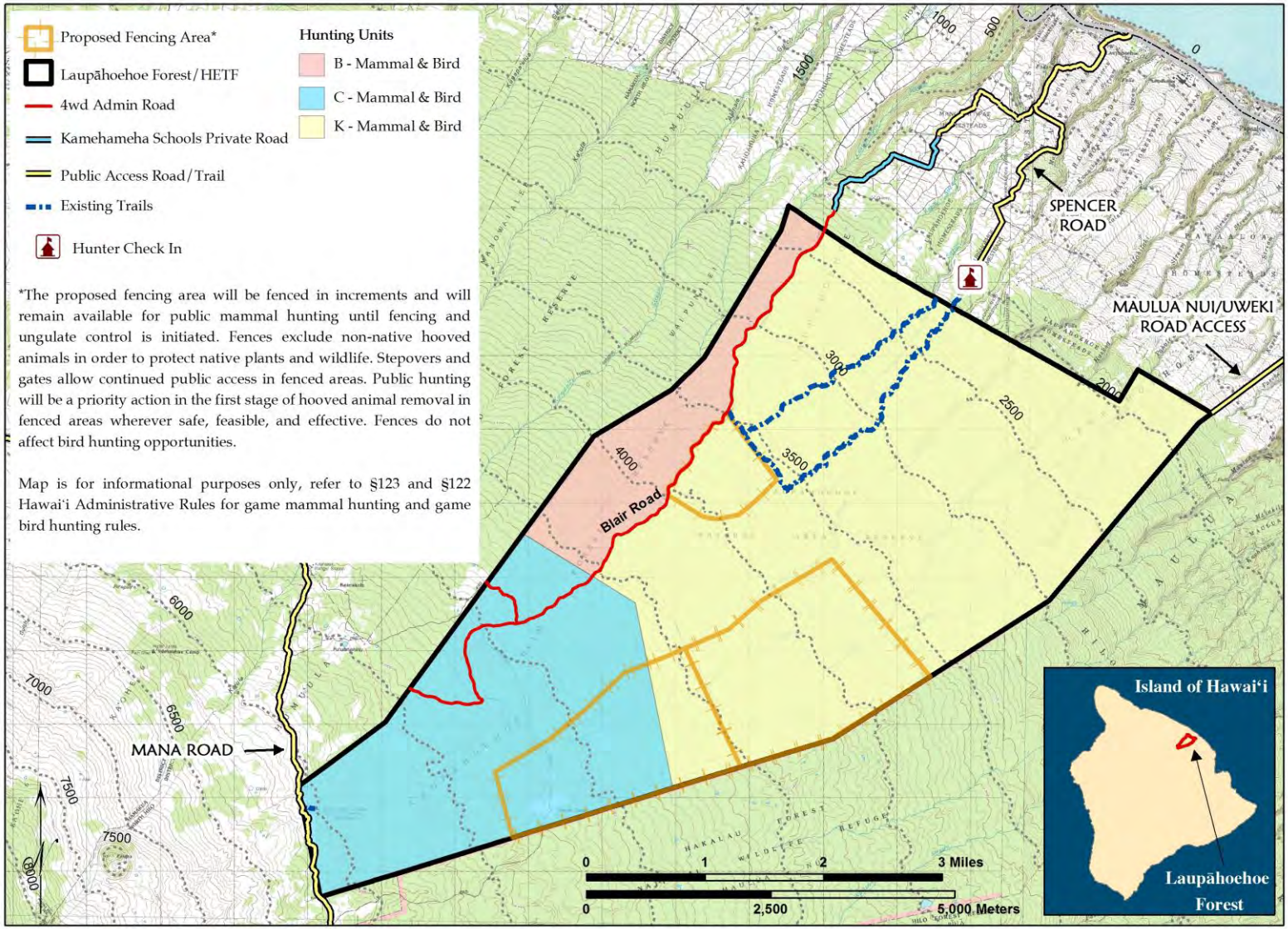

Laupāhoehoe Forest Existing Infrastructure
Legend
Exclosures (<1 to 10 acres)
Rare Plant Exclosures (<1 acre)
David Douglas Monument/Trail
Climate Station
Locked Gates
Existing Trails
Kamehameha Schools Private Road
4wd Admin Road
Public Access Road
Laupāhoehoe Science and Education Center
Laupāhoehoe Forest/HETF
Hilo Forest Reserve - Laupāhoehoe Section
Laupāhoehoe Natural Area Reserve
SPENCER ROAD
MAULUA NUI/UWEKI ROAD ACCESS
Blair Road
MANA ROAD
0
2,500
5,000 Meters
0
1
2
3 Miles
Island of Hawai'i
Laupāhoehoe Forest

Figure 5

Laupāhoehoe Forest Public Hunting Areas



Facilities/Structures

- USFS Facilities - The Laupāhoehoe Science and Learning Center, located approximately 4 miles from the Laupāhoehoe Forest boundary, enhances the ability of the HETF to meet its goals for research, education, and demonstration (Figure 4). This facility serves as the primary support facility for the Laupāhoehoe unit. Facilities support day and overnight use and includes a classroom, workshop, bunkhouse, and laundry facilities.
- Shack Camp - Shack Camp is located at approximately 5,200 ft (1,585 m) elevation near the intersection of the Laupāhoehoe Forest boundary and the historic Maulua Trail. This site contains the ruins of a historic structure associated with Kukaiau Ranch as well as an opening in the forest due to past cattle grazing.

USFS Laupāhoehoe Science and Learning Center

Regional Partnerships

DOFAW and USFS are both members of the Mauna Kea Watershed Alliance and the Laupāhoehoe Forest is included in this partnership area. This partnership includes approximately 484,000 ac (195,868 ha) on the mountain of Mauna Kea. The Mauna Kea Watershed Alliance seeks to manage critical watersheds on a landscape-level by initiating planning for priority areas with the goal of implementing management actions for threats such as feral ungulates, fire, and invasive non-native plants. Coordinated management of these watershed lands is critical to sustain adequate quality and quantity of water and provide important habitat for a wide diversity of native plants and animals, including many that are endangered. The Mauna Kea Watershed Alliance is currently working on several projects related to the HETF including sharing of cultural awareness and protocols for IPIF staff, and participation in planning for HETF programs and facilities.

Site Description (Physical and Biological Resources)

Topography, Climate, Geology, and Soils

Laupāhoehoe Forest is located on the eastern, windward flanks of Mauna Kea from about 1,700 to 6,100 ft (518-1860 m) elevation. As the trade winds off the Pacific Ocean strike the mountain, moist air is elevated and cooled, resulting in cloudy weather, high rainfall rates and afternoon fog and mist in the area. Condensation from ground-level clouds (fog drip) contributes additional moisture at higher elevations. Average annual rainfall in the lower elevations is about 160 inches (in) (418 centimeters (cm)) and ranges from 60 to 100 in (157-261 cm) in the upper elevations (HETF Establishment Record 2007).

Temperatures decrease with elevation. At sea level the average monthly day time temperatures range from 79 to 82 ^{o}F (26-28 ^{o}C) and the night time temperatures range from 62 to 70 ^{o}F (17-21

°C). At highest elevations, the temperature could be more than 20 °F (13 °C) colder than in the lowlands.

There is a climate station (maintained by the USFS) at Laupāhoehoe Forest within the FR recording a variety of information including: air temperature, relative humidity, solar radiation, soil moisture and temperature (Figure 4).

Climate station at Laupāhoehoe Forest

Laupāhoehoe Forest is located on Mauna Kea, a dormant volcano and the second oldest volcano on the island. Figure 6 depicts substrate age, which ranges from 5,000 years before the present to 300,000 years before the present (Sherrod et al. 2007). The terrain and soils varies with the age and type of surface lava flows and the depth of volcanic ash deposited over these flows (Wolf and Morris 1996). The terrain in the highest elevation areas is the youngest and the roughest. Surface flows in this area are grouped with the youngest of Mauna Kea's post-shield formation flow series and are characterized as predominantly a‘a or blocky a‘a flows which are generally free of the wind-blown volcanic ash deposits that cover the older Mauna Kea flows (Wolf and Morris 1996:13; Sheet 2). These younger a‘a flows form a series of pronounced ridges that give the upper areas of Laupāhoehoe Forest a distinct ridge and swale topography. Soils on these flows are described as very stony loam (Sato et al. 1973: 15, Sheet 40).

In the upper mid-elevation of Laupāhoehoe Forest, the surface lava flows are older but are still grouped with those erupted during the younger, post-shield phase of Mauna Kea's development (Wolf and Morris 1996: 13; Sheet 2). These flows are also predominantly a‘a or blocky a‘a flows but are partially mantled by volcanic ash deposits. Soils on these flows are described as silt loam formed from volcanic ash (Sato et. al. 1973: 14 and 50, Sheets 33 and 40). These ash-derived soils are more weathered in the lower elevations where rainfall is slightly greater. Some areas can also be rocky where volcanic ash deposits are discontinuous. Natural Resources Conservation Service Soil Classifications are depicted in Figure 7.

Figure 6

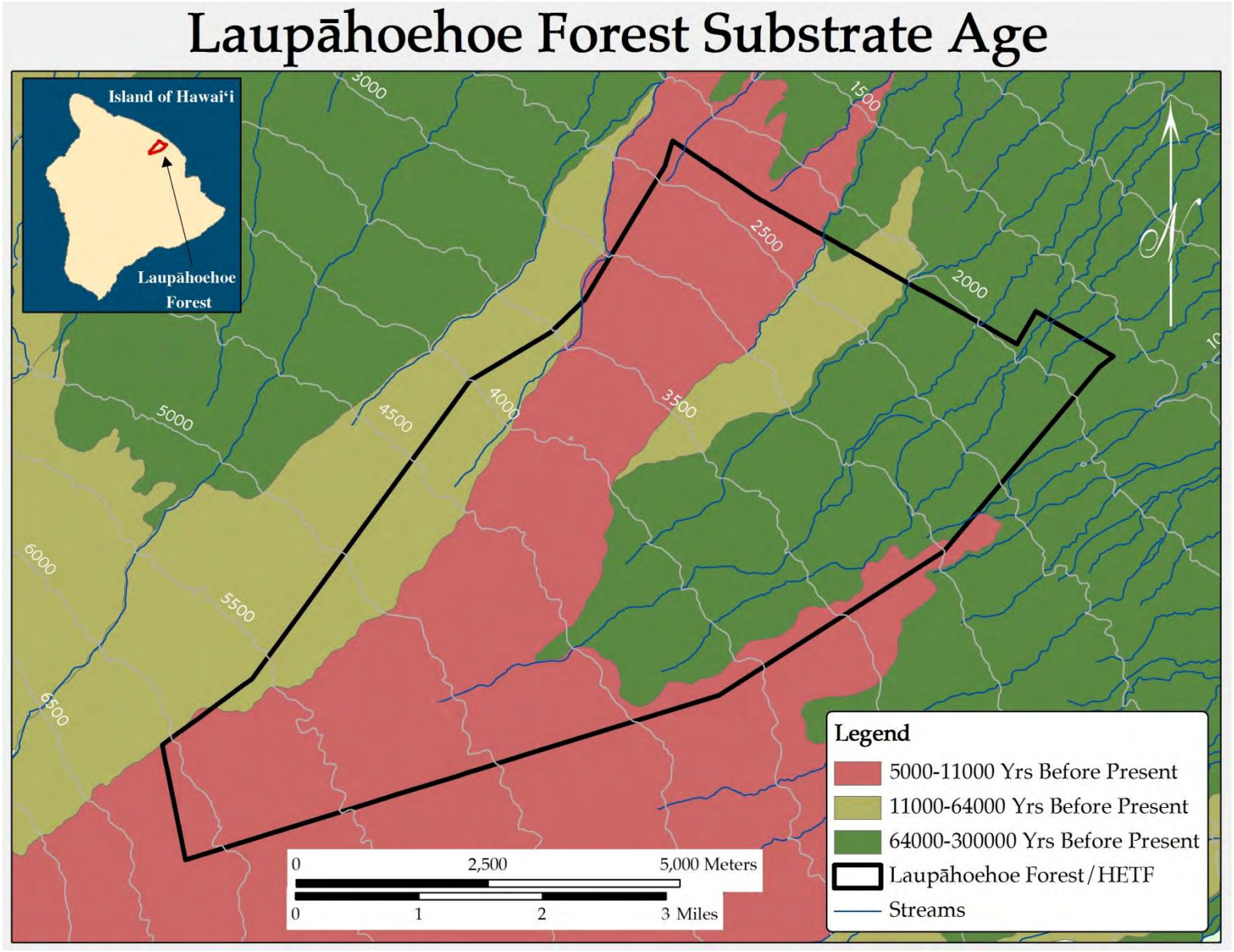
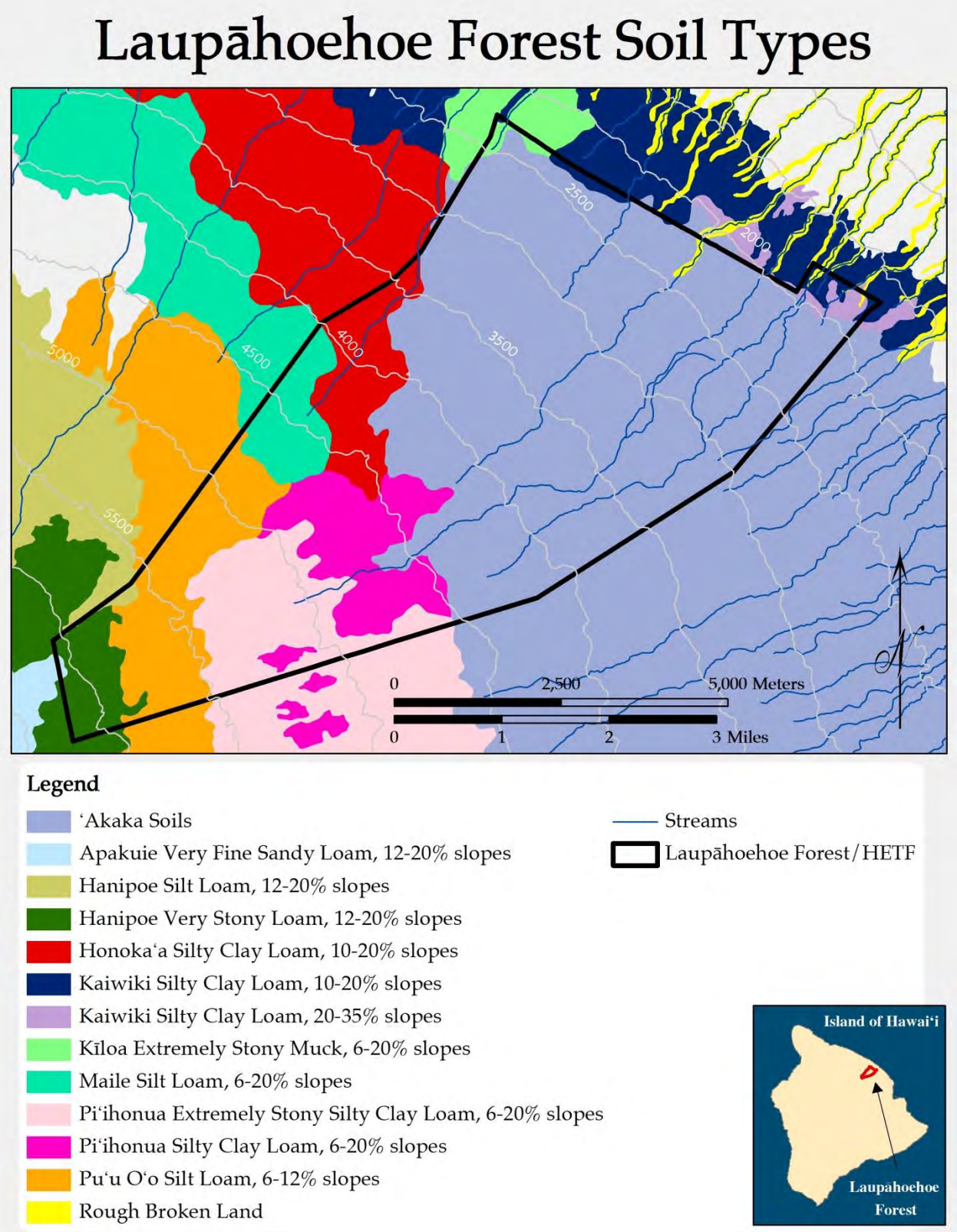

Laupāhoehoe Forest Substrate Age
Island of Hawai'i
Laupāhoehoe Forest
3000
1500
2500
2000
5000
4500
4000
3500
6000
5500
6500
0
2,500
5,000 Meters
0
1
2
3 Miles
Legend
5000-11000 Yrs Before Present
11000-64000 Yrs Before Present
64000-300000 Yrs Before Present
Laupāhoehoe Forest/HETF
Streams

Figure 7


Laupāhoehoe Forest Soil Types
2500
2000
3500
4000
4500
5000
5500
0
2,500
5,000 Meters
0
1
2
3 Miles
Legend
ʻAkaka Soils
Apakuie Very Fine Sandy Loam, 12-20% slopes
Hanipoe Silt Loam, 12-20% slopes
Hanipoe Very Stony Loam, 12-20% slopes
Honokaʻa Silty Clay Loam, 10-20% slopes
Kaiwiki Silty Clay Loam, 10-20% slopes
Kaiwiki Silty Clay Loam, 20-35% slopes
Kīloa Extremely Stony Muck, 6-20% slopes
Maile Silt Loam, 6-20% slopes
Piʻihonua Extremely Stony Silty Clay Loam, 6-20% slopes
Piʻihonua Silty Clay Loam, 6-20% slopes
Puʻu Oʻo Silt Loam, 6-12% slopes
Rough Broken Land
Streams
Laupāhoehoe Forest/HETF
Island of Hawai'i
Laupahoehoe Forest

Water Resources

The Hilo FR (Laupāhoehoe section) was originally established in 1905 to protect the water supply of the district, and Laupāhoehoe Forest continues to provide important watershed services for the community. Native Hawaiians recognized the importance of forests in water production and water quality, as reflected in the Hawaiian proverb, “Haihai ka ua i ka ulu la au” (The rain follows after the forests). Early foresters also recognized the importance of Hawaiian forests as watersheds. Ralph Hosmer, the first Territorial Forester stated, "In Hawai‘i, the most valuable product of the forest is water, rather than wood.”

Laupāhoehoe Forest is an important source of fresh surface and ground water that supports downstream populations of humans and wildlife as well as supports healthy nearshore resources. Other watershed services provided by Laupāhoehoe Forest include: provision stream habitat for native waterbirds, fish, and invertebrates, forest habitat for native plants, birds, and bats, flood control, mitigation of climate change impacts, and economic, social, recreational and educational opportunities for the human communities in the area.

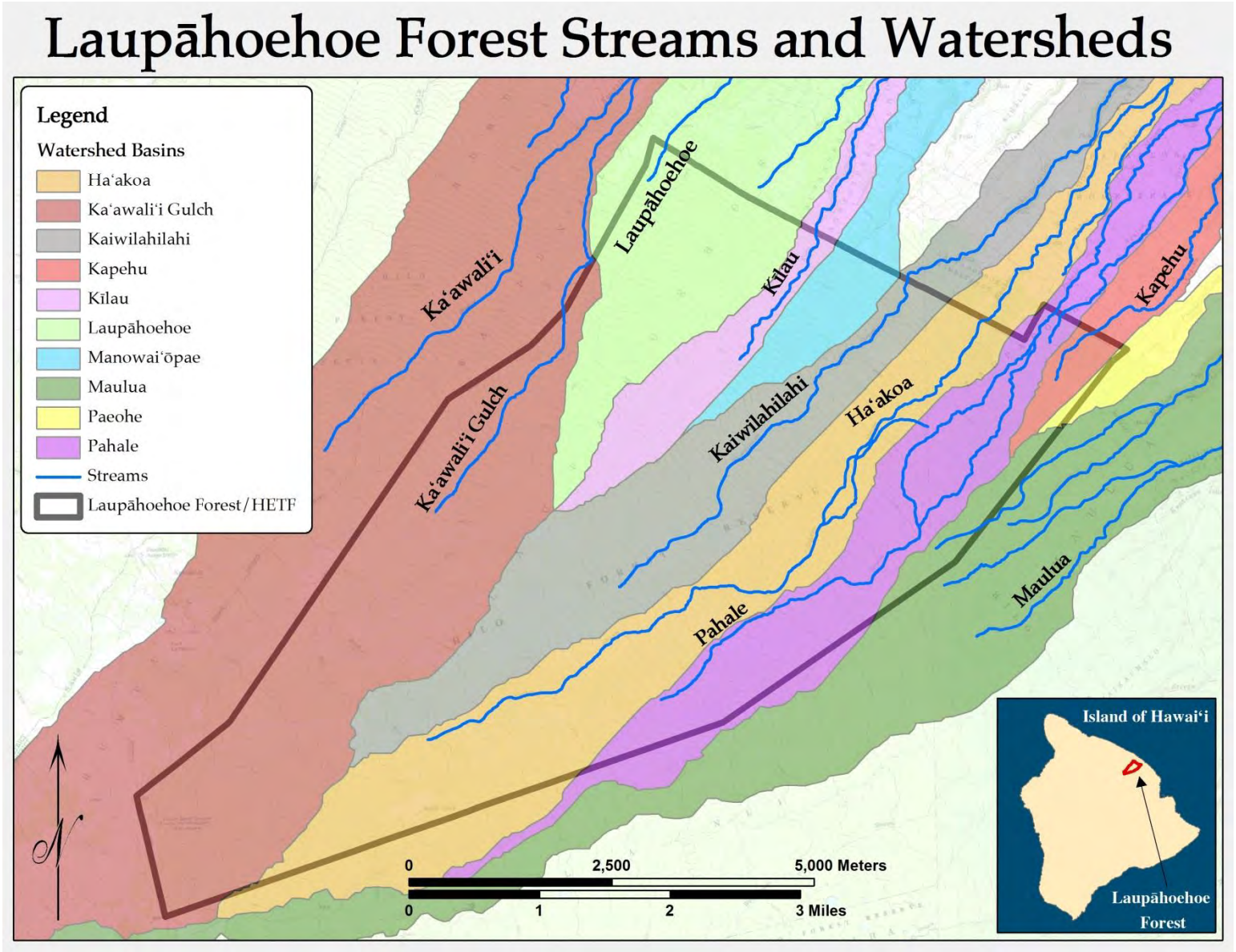
Trees capture moisture from mist which adds to watershed recharge

Numerous streams are found in the Laupāhoehoe Forest, including Ka‘awali‘i Stream, Laupāhoehoe Stream, Kīlau Stream, Kaiwilahilahi Stream, Ha‘akoa Stream, and Pāhale Stream (Figure 8, Table 2). The Atlas of Hawaiian Watersheds and Aquatic Resources (Parham et al. 2008) notes all these streams as perennial. However, the upper portions of these streams within Laupāhoehoe Forest are often intermittent. While the lack of surface water in these upper reaches makes it appear some of these streams within the forest may not necessarily be flowing year-round, subsurface groundwater flows from the forest maintain freshwater inputs to streams below Laupāhoehoe Forest. Stream gauges, used to measure natural stream flows, water quality and sediment in a non-destructive manner, are located in Manowai‘ōpae, Kaiwilahilahi, and Ka‘awali‘i streams below Laupāhoehoe Forest and are maintained by the USFS.

Table 2. Streams and Watershed Basins of Laupāhoehoe Forest (Parham et al. 2008)

Watershed Basin Name	Streams	Watershed Basin Name	Streams
Ka‘awali‘i Gulch	Ka‘awali‘i	Ha‘akoa	Ha‘akoa
Laupāhoehoe	Laupāhoehoe	Ka‘alau	Pāhale
Kīlau	Kīlau	Kapehu	Kapehu
Manowai‘ōpae	Manowai‘ōpae	Paeohe	Paeohe
Kaiwilahilahi	Kaiwilahilahi	Maulua	Maulua

Figure 8


Laupāhoehoe Forest Streams and Watersheds
Legend
Watershed Basins
Haʻakoa
Kaʻawaliʻi Gulch
Kaiwilahilahi
Kapehu
Kīlau
Laupāhoehoe
Manowaiʻōpae
Maulua
Paeohe
Pahale
Streams
Laupāhoehoe Forest/HETF
Kaʻawaliʻi
Laupāhoehoe
Kīlau
Kapehu
Kaʻawaliʻi Gulch
Kaiwilahilahi
Haʻakoa
Maulua
Pahale
N
0
2,500
5,000 Meters
0
1
2
3 Miles
Island of Hawaiʻi
Laupāhoehoe Forest

Kane and Kanaloa Moʻolelo

In old Hawaiʻi, legend tells of the twin gods Kāne and Kanaloa. Kāne who is responsible for the origin of many fresh water springs and Kanaloa who induces Kāne to make these springs flow.

Both Kāne and Kanaloa are needed in an ecosystem to form balance. Legend says that Kanaloa represents death and is the god of sea water and its tides. Kāne represents life as well as fresh water and light. Together they form a whole.

Although Kāne and Kanaloa take the form of water on land and in the sea, they take other body form or kino lau. The āholehole (Hawaiian flag tail fish) and the ʻamaʻama (mullet) are both a kino lau of these gods. The ʻamaʻama and āholehole fish have a status midway between land and sea (found near to freshwater springs in the ocean), this is how they are associated with Kāne and Kanaloa. The āholehole was also called a "sea pig" (puaʻa kai) and used ceremonially as a substitute for pig who is also a kinolau of Kāne.

(Beckwith 1940)

Forest Ecosystems

Laupāhoehoe Forest contains native-dominated forested landscapes from lowland forest at 2,300 ft (701 m) above sea level extending to almost 6,500 ft (1,981 m) in elevation. It is part of the largest remaining native dominated forest in Hawaiʻi and largely dominated by ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*), the two most widespread tree species in native forest remaining in Hawaiʻi.

Laupāhoehoe Forest contains five primary native communities, as well as significant areas between 1,700 ft (518 m) elevation and ~3,000 ft (914 m) of highly altered, non-native dominated vegetation cover (Figure 9). Forestry plantings along the lower boundary and in the lower east corner include non-native trees such as toon (*Toona ciliata*) and *Ficus rubiginosa*, and in the upper north corner, tropical white ash (*Fraxinus uhdei*). The tropical ash has invaded significant portions of higher elevations areas of the Laupāhoehoe Forest.

Koa (Acacia koa)

Other non-native species occupy large areas. Banana poka (*Passiflora tarminiana*), an introduced vine, occurs throughout mid to high elevation areas and forms thickets in the swales. At the lower edge of this community type, below 3,000 ft (914 m) elevation, the understory is heavily invaded by several non-native plants including strawberry guava (*Psidium cattleianum*), thimbleberry (*Rubus rosifolius*), Koster's curse (*Clidemia hirta*), Himalayan ginger (*Hedychium garderianum)*, various grasses, and three species of parasitic strangler fig. A number of these species occur into mid or even high elevation areas of the Laupāhoehoe Forest. Non-native grasses and herbs are primarily pasture species (e.g., kikuyu grass, *Holcus lanatus*, and *Ehrharta stipoides*) and the vine, German ivy (*Delairea odorata*).

The understory has many species in common with the Koa/ʻŌhiʻa Montane Wet Forest community, but the distinct hāpuʻu tree fern layer of the latter is absent. Species more characteristic of drier areas may also be components here. Ground cover is often dominated by native ferns, especially laukahi (*Dryopteris wallichiana*). Species found in this forest type include: ʻōlapa, pilo, manono, kāwaʻu, *Myoporum sandwicense*, kōlea, alani, *Ranunculus hawaiiensis*, *Sophora chrysophylla*, *Styphelia tameiameiae* and ʻōhelo.

ʻŌhelo, māmaki and ʻākolea (from left to right)

ʻĀkala fruits and flower

Rare Plants

A diversity of native plants, including rare species are found within Laupāhoehoe Forest, and there is critical habitat for six species (Table 3). Table 3 also includes species that may not have been found within Laupāhoehoe Forest, but are known from similar habitat in nearby areas. The U.S. Endangered Species Act defines Critical Habitat as areas that may or may not be occupied by a threatened or endangered species, but are essential to the conservation of the species. These areas may require special management considerations or protection (16 U.S.C. § 1532 (5)).

Rare plants include ʻohe, ʻoha wai, and jewel orchid and (left to right)

Figure 9

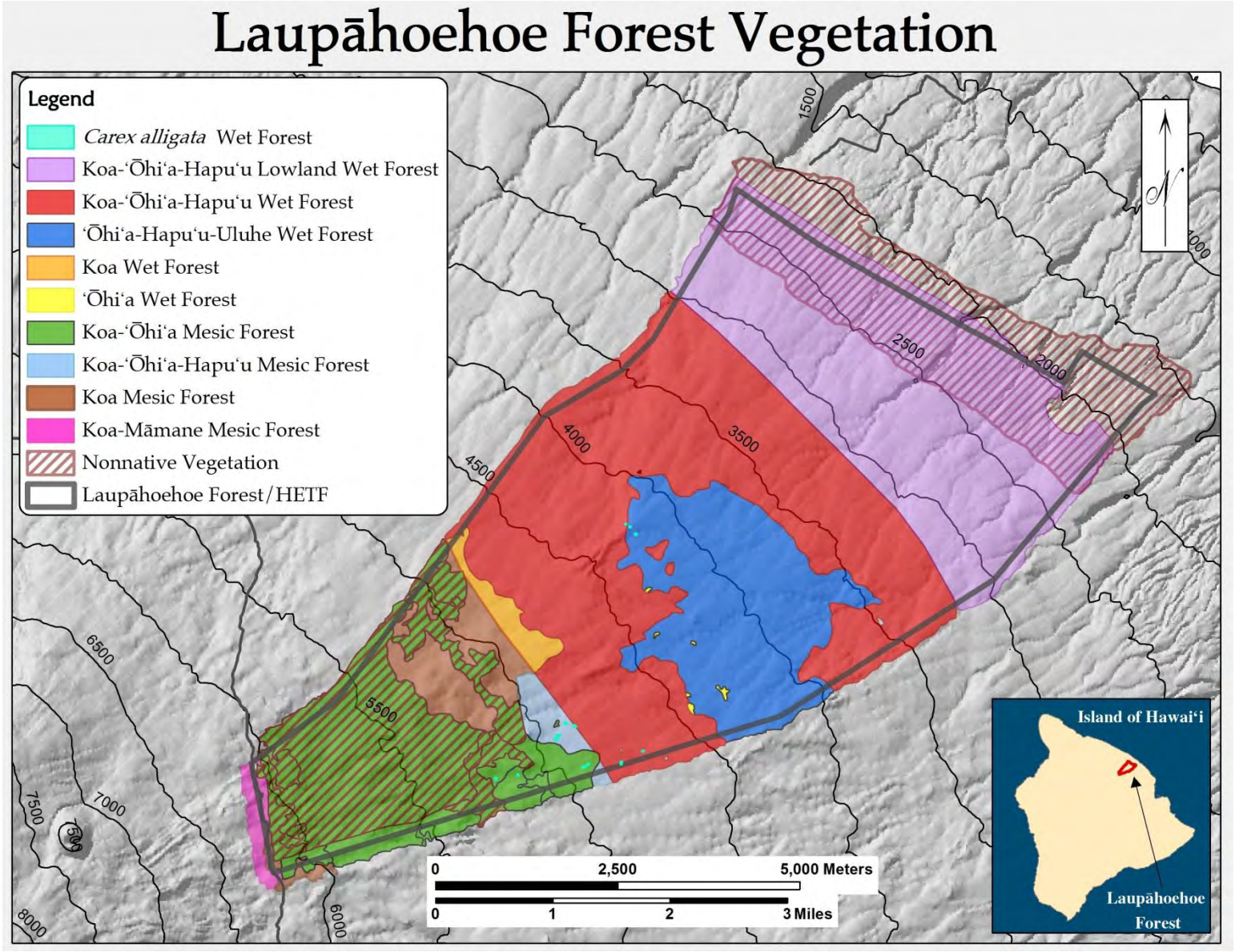

Laupāhoehoe Forest Vegetation
Legend
Carex alligata Wet Forest
Koa-ʻŌhiʻa-Hapuʻu Lowland Wet Forest
Koa-ʻŌhiʻa-Hapuʻu Wet Forest
ʻŌhiʻa-Hapuʻu-Uluhe Wet Forest
Koa Wet Forest
ʻŌhiʻa Wet Forest
Koa-ʻŌhiʻa Mesic Forest
Koa-ʻŌhiʻa-Hapuʻu Mesic Forest
Koa Mesic Forest
Koa-Māmane Mesic Forest
Nonnative Vegetation
Laupāhoehoe Forest/HETF
1500
2000
2500
3500
4000
4500
5500
6500
7000
7500
8000
6000
0 2,500 5,000 Meters
0 1 2 3 Miles
Island of Hawaiʻi
Laupāhoehoe Forest

Table 3. Rare Plants with habitat in or near Laupāhoehoe Forest

Species	*Common Name*	*Federal Status**	*Critical Habitat*	*Known From Laupāhoehoe Forest***	*Known From Adjacent Areas*	*Outplanted in Laupāhoehoe Forest*
Anoectochilus sandvicensis	*jewel orchid*	*SOC*		*X*		
Asplenium schizophyllum	-	*SOC*		*X*		
Clermontia lindseyana	*ʻoha wai*	*LE*		*X*	*X (Piha/Hakalau)*	*X*
Clermontia peleana	*ʻoha wai*	*LE*	*X*		*X (Upper Hilo FR)*	*X*
Clermontia pyrularia	*ʻoha wai*	*LE*	*X*	*X (Historic)*		*X*
Cyanea fernaldii		*No Status****		*X*		
Cyanea platyphylla	*ʻakūʻakū*	*LE*	*X*	*X*		
Cyanea shipmanii	*hāhā*	*LE*			*X*	*X*
Cyanea tritomantha	*ʻakū*	*LE*		*X*		*X*
Cyrtandra giffardii	*haʻiwale*	*LE*	*X*	*X*		
Cyrtandra tintinnabula	*haʻiwale*	*LE*	*X*	*X*	*X (Hakalau)*	
Crytandra wagneri	*haʻiwale*	*LE*		*X*		
Deparia kaalaana	-	*SOC*		*?*		
Gardenia remyi	*nānū*	*C*		*X*		
Huperzia manni	-	*LE*		*X*		
Huperzia stemmermannii	-	*C*		*X*		
Joinvillea ascendens	*ʻohe*	*C*		*X*		
Melicope zahlbruckneri	*alani*	*LE*		*X (Historic)*		*X*
Ochrosia haleakalae	*hōlei*	*C*		*X*		
Phyllostegia brevidens	-	*SOC*		*X (Historic)*		
Phyllostegia floribunda	-	*LE*		*X (Historic)*		*X*
Phyllostegia macrophyllus	-	*SOC*		*X*		
Phyllostegia racemosa	*kīponapona*	*LE*			*X (Hakalau)*	
Phyllostegia warshaueri	-	*LE*	*X*	*X*		*X*
Platydesma remyi	-	*LE*		*X*		*X*
Pritchardia lanigera	*loulu*	*LE*		*X*		
Ranunculus hawaiiensis	*makou*	*C*			*X (Mauna Kea FR)*	
Stenogyne macrantha	*māʻohiʻohi*	*SOC*		*X*		
Strongylodon ruber	*nuku ʻiʻiwi*	*C*		*X historic*	*X*	
Trematolobelia grandifolia	*koliʻi*	*SOC*		*X*		*X*

* Key to Federal Status: Listed Endangered (LE) = Taxa listed as endangered. Candidate (C) = Taxa for which substantial information on biological vulnerability and threat(s) support proposal to LE. Species of Concern (SOC) = Taxa for which available information meets the criteria for concern and the possibility to recommend C.
** Current (wild plants currently present), Historic (historic records describe presence in area); ***newly described or resurrected species

Wildlife

Birds

Laupāhoehoe Forest was surveyed for forest birds as part of the Hamakua Study Area during the Hawai‘i Forest Bird Survey (1976-1983). This survey and several subsequent surveys of the area have provided information on the bird species present and their distribution.

The forest provides habitat for six honeycreepers (Subfamily Drepanidinae) endemic to the Hawaiian Islands. These include three endangered species: Hawai‘i ‘ākepa (*Loxops coccineus*), Hawai‘i creeper (*Oreomystis mana*) and ‘akiapōlā‘au (*Hemignathus munroi*). The non-endangered honeycreepers found in the project area include: ‘apapane (*Himatione sanguinea*), Hawai‘i ‘amakihi (*Hemignathus virens*), and ‘i‘iwi (*Vestiaria coccinea)*. U.S. Fish and Wildlife Service (USFWS) is currently reviewing the status of ‘i’iwi to determine whether it should be listed as endangered or threatened. Other native forest birds reported from the project area include, ‘elepaio (*Chasiempis sandwichensis*), and ‘ōma‘o or Hawaiian thrush (*Myadestes obscurus*). Native forest birds are primarily found in the upper elevations (above 4,000 ft (1,219 m)) where lower numbers of mosquitoes and the effects of cooler temperatures on plasmodium parasite reduce the incidence of diseases such as avian malaria and pox. It is important to note that Hakalau Forest National Wildlife Refuge is adjacent to Laupāhoehoe Forest where these species are seen regularly along with many other native species.

Ua ‘elepaio ‘ia ka wa‘a. The ‘elepaio has [marked] the canoe [log].

Canoe makers of old watched the movements of the ‘elepaio bird whenever a koa tree was hewed down to be made into a canoe. Should the bird peck at the wood, it was useless to work on that log, for it would not prove seaworthy.

‘Elepaio (*Chasiempis sandwichensis*)

(Pukui 1983)

Other native bird species listed as endangered by the USFWS, have been reported from the Laupāhoehoe Forest area including the Hawaiian duck or koloa maoli (*Anas wyvilliana*), and the Hawaiian hawk or ‘io (*Buteo solitarius*). Koloa maoli are generally found in a wide variety of natural and artificial wetland habitats including freshwater marshes, flooded grasslands, streams, montane pools, irrigation ditches, reservoirs, etc. Laupāhoehoe Forest is considered a recovery area for Hawai‘i creeper, Hawai‘i ‘ākepa, and ‘akiapōlā‘au in the USFWS forest bird recovery plan and in the State Comprehensive Wildlife Strategy. Recovery areas are habitat that will allow for the long-term survival and recovery of endangered Hawaiian forest birds.

The most widespread non-native birds observed at Laupāhoehoe Forest include hwamei (*Garrulax canorus*), Japanese white-eye (*Zosterops japonicus*), red-billed leiothrix (*Leiothrix lutea*), northern cardinal (*Cardinalis cardinalis)* and kalij pheasant (*Lophura leucomelana*). Other non-native birds observed in the area are summarized in Table 4 below.

Table 4: Laupāhoehoe Bird Species

Species	Common Name	Status
Acridotheres tristis	Common myna	Non-native
Alauda arvensis	Eurasian skylark	Non-native
Anas wyvilliana	Hawaiian duck, koloa maoli	Endemic (Endangered)
Asio flammeus sanwichensis	Short-eared owl, pueo	Endemic
Buteo solitarius	Hawaiian hawk, 'io	Endemic (Endangered)
Cardinalis cardinalis	Northern cardinal	Non-native
Carpodacus mexicanus	House finch	Non-native
Cettia diphone	Japanese bush warbler	Non-native
Chasiempis sanwichensis sandwichensis	'Elepaio	Endemic
Francolinus erckelli	Erkel's francolin	Non-native
Garrulax canorus	Hwamei	Non-native
Hemignathus munroi	'Akiapola'au	Endemic (Endangered)
Hemignathus virens virens	'Amakihi	Endemic
Himatione sanguinea sanguinea	'Apapane	Endemic
Leiothrix lutea	Red-billed leiothrix	Non-native
Lonchura punctulata	Nutmeg mannikin	Non-native
Lophura leucomelana	Kalij pheasant	Non-native
Loxops coccineus coccineus	Hawai‘i `ākepa	Endemic (Endangered)
Meleagris gallopavo	Wild turkey	Non-native
Myadestes obscurus	Hawai‘i thrush, 'oma'o	Endemic
Nycticorax nycticorax hoactli	Auku‘u or black crowned night heron	Indigenous
Oreomystis mana	Hawai‘i creeper	Endemic (Endangered)
Passer domesticus	House sparrow	Non-native
Phasianus colchicus	Ring-necked pheasant	Non-native
Pluvialis fulva	Kolea or pacific golden plover	Indigenous
Serinus mozambicus	Yellow fronted canary	Non-native
Streptopelia chinensis	Spotted dove	Non-native
Tyto alba	Barn owl	Non-native
Vestiaria coccinea	‘I‘iwi	Endemic
Zosterops japonicus	Japanese white-eye	Non-native

Mammals

Laupāhoehoe Forest is considered very important habitat for the ʻōpeʻapeʻa – the endemic and endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), which uses the area for roosting, reproduction and foraging. U.S. Geological Survey (USGS) Biological Resources Division Hawaiian Hoary Bat Project has monitored bats for five years and has found high levels of bat activity and occupancy. The Hawaiian hoary bat is the only native terrestrial mammal from the Hawaiian archipelago (USFWS 1998). It is a medium-sized, nocturnal, insectivorous bat with short, thick, rounded ears and a furry tail. "Hoary" refers to the white-tinged, frosty appearance of the bat's grayish brown or reddish brown fur.

ʻŌpeʻapeʻa

A variety of non-native mammals such as feral pigs (*Sus scrofa*), rats (*Rattus* spp.), mice (*Mus musculus*), cats (*Felis catus*), wild dogs (*Canis lupus familiaris*) and mongoose (*Herpestes auropunctatus*) are present in Laupāhoehoe Forest.

Invertebrates

Native invertebrates known from Laupāhoehoe Forest include numerous species of *Drosophila.* Species including *D. sproati*, *D. murphyi*, *D. tanythrix*, and *D. yooni* are relatively common. One notable collection was of a female specimen believed to be *D. papala*, taken at 4,800 ft (1,463 m) elevation representing a new location. In 2012, a researcher cataloging *Drosophila* species noted a small patch of *Pisonia brunoniana* at about 4,000 ft (1,219 m) elevation within the FR as the most diverse site sampled. Although too small to support any picture-wing species, this disjunct grove of mesic trees has a community of smaller *Drosophila* species not found elsewhere in Laupāhoehoe Forest. Some of these are associated with *Pisonia* in particular (*D. kambysellisi*, *D. nr. dissita*), while others are associated with other plants but seem to be attracted to the site. This spot is worthy of greater conservation attention, especially since *Pisonia* is relatively rare in the Hamakua area. Table 5 provides a list of *Drosophila* species found during the 2012 survey. Several picture-wing species that breed in *Charpentiera*, *Pisonia*, and *Urera* were formerly known from lower elevations (~2,500 ft (762 m)), but this area now appears to be largely non-native, and no flies were found there.

Table 5. Laupāhoehoe Forest *Drosophila* species found during 2012 Survey

Drosophila basisetae	*Drosophila medialis*	*Drosophila setosimentum*
Drosophila brunneicrus	*Drosophila murphyi*	*Drosophila silvestris*
Drosophila canipolita	*Drosophila neutralis*	*Drosophila sordidapex*
Drosophila cnecopleura	*Drosophila* nr. *ancyla*	*Drosophila sproati*
Drosophila cracens	*Drosophila* nr. *dissita*	*Drosophila tanythrix*
Drosophila dasycnemia	*Drosophila* nr. *medialis #2*	*Drosophila tendomentum*
Drosophila hawaiiensis	*Drosophila* nr. *medialis #3*	*Drosophila trichaetosa*
Drosophila imparisetae	*Drosophila papala*	*Drosophila yooni*
Drosophila kambysellisi	*Drosophila percnosoma*	*Scaptomyza (Elmomyza) tumidula*
Drosophila kikalaeleele	*Drosophila propiofacies*	
Drosophila latigena	*Drosophila seclusa*	

Laupāhoehoe Forest also contains habitat for four endemic species of pinao or Hawaiian damselfly. *Megalagrion calliphya* and *M. hawaiiense* breed in small pools or seeps in the forest, whereas *M. blackburni* breeds in streams. *Megalagrion xanthomelas* is a candidate for listing as an endangered species and is known from Kaiwilahilahi Stream (Parham et al. 2008), below the lower boundary of Laupāhoehoe Forest.

Aquatic Species

Streams provide habitat for endemic waterbirds, four gobies, two crustaceans, one snail, and several aquatic insects (e.g., damselflies, chironomids) that are noted in the Hawai‘i Stream Atlas (Parham et al. 2008). There are also two species of invasive amphibians that have been observed in or near streams in Laupāhoehoe, *Rana catesbeiana* (American bullfrog) and *Rhinella marina* (Cane toad). Both of these species lay eggs in water and have a tadpole stage to their lifecycle.

Surface and groundwater that originate from the Laupāhoehoe Forest also support healthy populations of native nearshore fish assemblages. Many of these fish are an important component of the subsistence-based economy in the region.

Pua ka nenele'au, momona ka wana. When the nenele'au (Hawaiian sumac or *Rhus sandwicensis*) are in blossom, the wana (sea urchin) is fat.

Nenele'au flowers

(Pukui 1983)

Table 6. Native aquatic species known from at least a portion of the 10 Laupāhoehoe streams (Parham et al. 2008)

Native Fish	Native Aquatic Insects	Native waterbirds
Awaous guamensis *Lentipes concolor* *Sicyopterus stimpsoni* *Eleotris sandwicensis* *Kuhlia xenura*	*Megalagrion blackburni* *Megalagrion xanthomelas* *Telmatogeton sp.*	*Anas wyvilliana*
Native Crustaceans	Native Snails	
Atyoida bisulcata	*Neritina granosa*	

Cultural Resources and Traditional Practices

The 2006 cultural historical study prepared by Kumu Pono Associates is an important reference for cultural resources management in the Laupāhoehoe Forest (Maly and Maly 2006). It references the ethnographical and historic uses of the region, and identifies several historic, ethnographic, and archaeological site types and features that may be found in the area. Excerpts from this study are included below, and the complete study is available online (see REFERENCES).

> “In this collection of native and historical accounts we also find that the lands of the Laupāhoehoe forest region are frequently mentioned in several prominent traditions.

> Significantly, the importance of the Laupāhoehoe region koa forests, mountain bird habitats, and the traditional trails which connected the lowlands with the mountain lands and neighboring districts, are frequently referenced in traditions and historical accounts. Also, battles fought on the Laupāhoehoe lands were among those which established the kingdoms of chiefs between the early 1500s to the late 1700s. While many of the accounts cited in the study relate to the lower lands of the Laupāhoehoe vicinity—those lands situated below the 2,000 foot elevation—there are occasional references to travel through the upland forests to the mountain region. There are also specific references to the traditional significance of Laupāhoehoe, and the occurrence of numerous heiau (ceremonial sites) of local and regional significance, though the record is seemingly silent on the location of heiau that might have occurred in the forest region."

Archaeological and Historic Sites

The 2006 cultural historical study also identifies types of archaeological sites that might be found in the Laupāhoehoe Forest (Maly and Maly 2006).

> "These include, but are not limited to—trails extending from the shore to the mountain lands; shelters and resting places along trail sides; shrines used by travelers, bird catchers, canoe makers and other practitioners; battle sites and hiding places; and possible burial sites. Traditional features would include several forms, ranging from stone platforms, terraces, cairns, and walls; and shelter features—called pāpa'i by the ancient Hawaiians—generally made of wood, leafy branches and ferns. Many of the features would naturally deteriorate and evidence of them would return to the earth. Other features of stone might still be visible in the understory, though only found upon careful search. Another feature of importance would be stone filled fractures or crevices, and caves. Such features were sometimes used for shelters over generations, or as burial sites, and as places in which to hide valued cultural artifacts."

The historic resources study prepared for the aforementioned 2006 reforestation project sampled transects in the proposed project area of potential effect (and found no historic properties (e.g. no stone surface features, potential shelter caves or overhangs, subsurface cultural deposits) in the Laupāhoehoe Forest portion of the proposed project (Carpenter et al. 2006).

Kia Manu & Pāpala kēpau

Historically birds were trapped for their feathers which were used to adorn capes, helmets, lei and kāhili (symbols of royalty). Bird catchers used several types of capturing methods one of which was kia manu or catching by gumming. A sticky substance like that found in the fruits of pāpala kēpau (*Pisonia* spp.) was used on a branch where the bird's feet would stick to the substance.

(Abbott 1992, Pukui and Elbert 1986)

'I'iwi (Vestiaria coccinea)

At the request of DOFAW and in accordance with recommendations from Maly and Maly (2006), archaeologists from the Division of State Parks conducted field inspections of selected

areas within Laupāhoehoe Forest that could be affected by project components proposed in the Laupāhoehoe Forest Management Plan. The inspections were conducted to assess the probability of historic properties within these potentially affected areas and to provide a basis for recommending any further steps needed to identify and appropriately manage and protect historic properties within the project area.

Historical sites identified in the region include the following (Carpenter et al. 2006, Maly and Maly 2006, McEldowney et al. 2016) (Figure 10):

- The sheep ranch station at Keanakolu (in the original place of that name, near the Laupāhoehoe-Humuʻula boundary). There remain on the land in the present-day, the ruins of stone shelters, pens, and foundations.
- Noted places such as Keanakolu (not the same location of the present-day cabin of that name), Lahohinu, and Keahua-ai (Douglas Pit), are considered significant features of the historical landscape.
- Waipunalei Trail (also referred to as the Laupāhoehoe – Waipunalei Trail)
- Maulua Trail, established as an old pack trail.
- ʻAuwai or Ditch Feature. This feature at approximately 3,500 ft elevation was determined to be a manmade feature though its purpose and function have not yet been determined.
- Traditional Place at Ahupuaʻa Boundaries. Boundary Commission testimony named Kulanihakoi as the mauka boundary of Waipunalei and Laupāhoehoe. This area is depicted on various historic maps.

Kulanihakoi

The Commission of Boundaries, generally called the Boundary Commission, was established in 1862 to certify the boundaries for ahupuaʻa awarded to the major Aliʻi in the Mahele of 1848. To help verify the traditional boundaries of these lands, the commission heard testimony from those having personal knowledge of these lands, the boundaries, or place names along the boundaries.

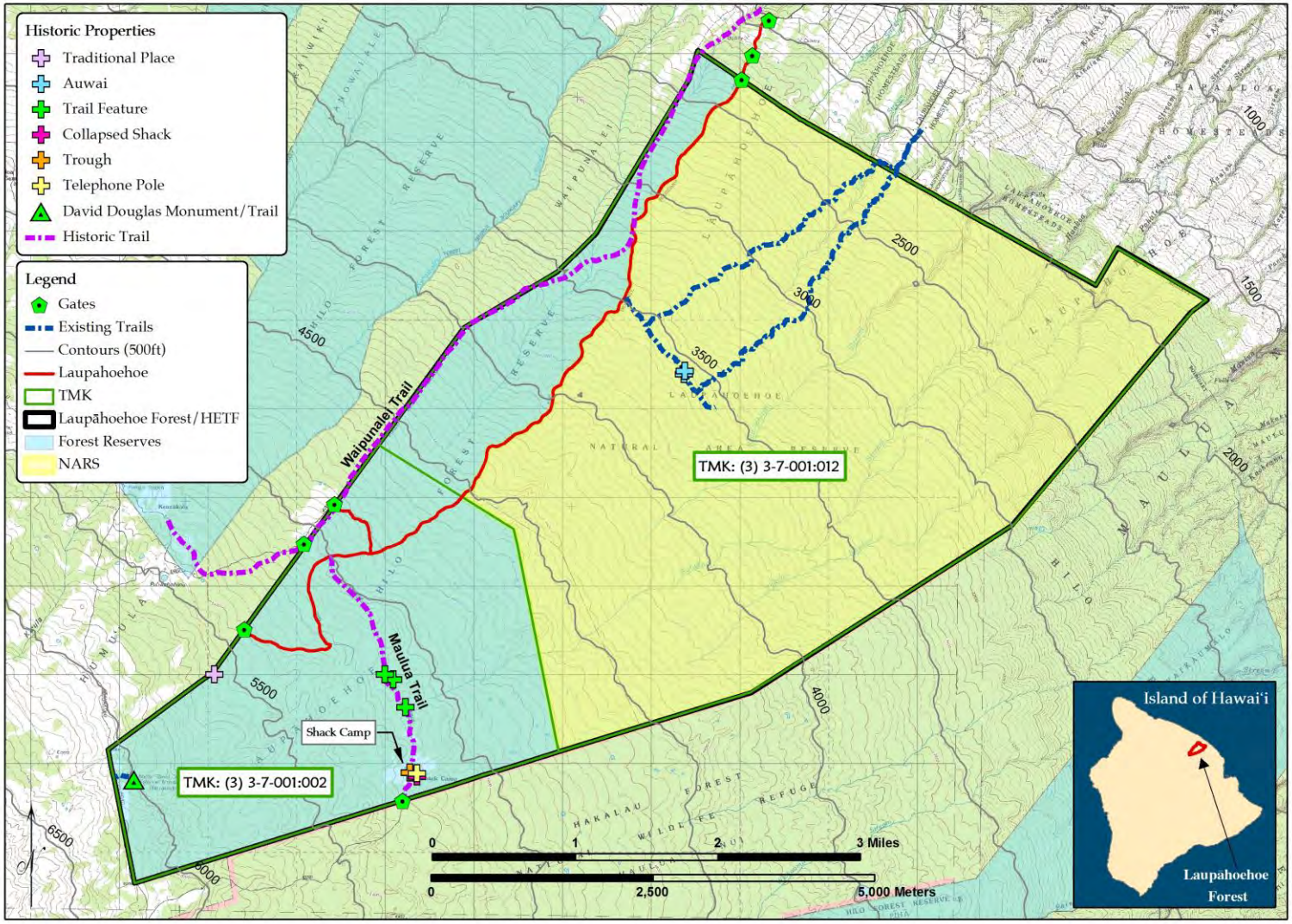
Two native Hawaiians, Paka and Hoahimoa, testified that a place named Kulanihakoi (also transcribed as Kulanikakoi and Kulanikekoi) was the mauka (inland) boundary of Waipunalei and Laupāhoehoe. Paka testifies that there is a water hole at this location and Hoahimoa mentions having lived at Kulanihakoi while shooting bullock on the lands of Humuʻula (Boundary Commission Book B: 367 and 368). The survey map prepared to verify these boundaries in 1875 depicts the location of Kulanihakoi and the waterhole.

The Hawaiian Dictionary (Pukui and Elbert 1977) translates Kū-lani-hā.koʻi as a "Mythical pond or lake in the sky, its overflow comes to the earth as rain." The name can also be used to imply one having been drenched by water. A Dictionary of the Hawaiian Language (Andrews 1922) has the following: "[Ku, the god, Ku, represented in rain and storm, lani, heaven, and hakoi, heavy.] What is above or on high; a supposed place in the heavens from which the waters of rain came; the windows of heaven..."

(McEldowney et al. 2016)

Figure 10

Laupāhoehoe Forest Historic Properties



THREATS TO NATURAL AND CULTURAL RESOURCES

Non-Native Plants and Animals

Invasive Non-Native Plants

Invasive non-native plants constitute a severe threat to the native ecosystems in Laupāhoehoe Forest. Certain non-native plants are considered invasive because they can establish and survive in undisturbed native forest, disperse long distances via wind or birds, affect large portions of land, displace native vegetation, grow and reproduce rapidly, and convert a diverse native forest to a monoculture of alien species. Invasive non-native plants can displace distinctive native flora, resulting in a loss of species diversity and eventually in changes to ecosystem function such as nutrient cycling. Many invasive non-native plants completely replace native vegetation by preventing any regeneration of native species or in the case of strangler figs – direct replacement of native trees, resulting in total loss of native habitats thereby negatively affecting native birds and invertebrates (Cuddihy and Stone 1990, Vitousek 1992). Invasive species can also encourage fire by increasing the amount of available fuels or decrease water input to streams and ground water. For example, forests severely invaded by invasive non-native plants such as strawberry guava show increased evaporation of water to the atmosphere, which reduces the amount of water available for human use (Giambelluca, unpublished research).

Only a small portion of Laupāhoehoe Forest has had systematic surveys for invasive non-native plants. In general, upper forested areas between 3,500-4,500 ft (1,067-1,372 m) elevation contain relatively low densities of invasive non-native plants described below. However, below 3,500 ft (1,067 m) forests become heavily invaded by strawberry guava, clidemia or Koster's curse, yellow Himalayan raspberry, and kahili ginger. Above 4,500 ft (1,372 m) forests are heavily invaded by grasses, banana poka, and tropical ash. Throughout the entire forest Australian tree fern *(Sphaeropteris cooperi)* can be found at low densities, although populations are increasing. *Ficus* spp. is concentrated in the northern portion of the forest, near Blair Rd., at about 2,800 ft (853 m) and is spreading into adjacent areas.

Invasive non-native plants with great potential for spreading and causing habitat modification are identified in this plan as high priority for control. Invasive non-native plant species were prioritized based on observed invasiveness and other criteria including growth form, dispersal mechanisms, ability to displace native vegetation and ability to alter ecosystem cycles (water, nutrients and succession). High priority invasive non-native plants currently present in Laupāhoehoe Forest include:

- Australian tree fern *(Sphaeropteris cooperi)*
- Banana poka (*Passiflora tarminiana*)
- Florida blackberry (*Rubus argutus*)
- Cane tibouchina *(Tibouchina herbacea)*
- Clidemia or Koster's curse (*Clidemia hirta*)
- *Ficus* spp.
- Himalayan ginger *(Hedychium garderianum)*
- Mules foot fern *(Angiopteris evecta)*
- Palm grass *(Setaria palmifolia)*

- Passion fruit (*Passiflora edulis*)
- *Polygonum chinensis*
- Strawberry guava *(Psidium cattleianum*)
- Tropical ash (*Fraxinus uhdei*)
- Yellow Himalayan raspberry (*Rubus ellipticus*)
- German ivy (*Delairea odorata*)

There are additional invasive non-native plants species of serious concern to land managers that are present in adjoining areas but have not yet been detected in Laupāhoehoe Forest. It is a high priority to prevent the establishment of these species, which include but are not limited to miconia (*Miconia calvescens),* faya (*Morella faya)*, gorse (*Ulex europaeus)*, firethorn (*Pyrocantha angustifolia*), *Cotoneaster pannosus*, and New Zealand flax (*Phormium tenax*). Other invasive non-native plant species may be added to the priority invasive non-native plant list if monitoring shows their range and abundance increasing in native ecosystems targeted for management.

Ungulates

Ungulates are hoofed animals such as pigs, sheep, goats and cattle. The primary ungulate in Laupāhoehoe Forest is the wild pig (*Sus scrofa*), which is found throughout the forest except in the small fenced areas (35 total acres) that currently exist. Feral ungulates can pose a threat to native ecosystems, species and watersheds because they eat and trample native plants (Cooray and Mueller-Dombois 1981), and disperse the seed of invasive non-native plants. These changes can cause increased erosion and soil runoff. Hawaiian plants evolved without such animals and so some have lost defenses such as thorns and chemical compounds in leaves. The rooting and wallowing behavior of pigs can increase the inputs of pollutants to streams (i.e. animal waste), stream water turbidity due to soil erosion (Stone 1985, Dunkel 2009, Bruland et al. 2010), and wallows can result in breeding areas for disease carrying mosquitoes (Baker 1979, USGS 2005, USGS 2006c). Pigs also eat some invasive plant fruits, such as strawberry guava, which they can transport and then defecate in new areas (Aplet et al. 1991). In addition, feral pigs have been shown to spread root-rot fungi (Baker 1979), and can carry parasites and diseases transmittable to humans and dogs, such as leptospirosis (Warner 1959-1969, Sasaki et al. 1993) and tuberculosis (Giffin 1978).

Pigs were originally brought to Hawai‘i by the first Polynesian settlers as a domesticated species (Tomich 1986). After the arrival of Captain Cook, the larger European wild boar was introduced as a game species and quickly became feral. Today, feral pigs in Hawai‘i are generally smaller in size than mainland varieties as a result of over 200 years of interbreeding between the smaller Polynesian pig and the larger European boar (Tomich 1986).

Feral cattle have been a problem in Laupāhoehoe Forest in the past; however, all feral cattle were removed from the area by 2003. Feral cattle are still a potential future threat as they are still present in adjoining areas (Waipunalei and Humu‘ula) and occasionally get into the forest.

Other Non-Native Animals

A variety of non-native mammalian predators are serious pests to the biodiversity found in Laupāhoehoe Forest. Mongoose, feral cats, rats, but also mice prey upon native species and have a severe impact on native birds. In addition, small mammals serve as vectors of diseases and can affect the water quality and cause human and wildlife diseases. Leptospirosis and cryptosporidiosis are potentially fatal illnesses caused by water-borne microorganisms spread by non-native mammals (Sasaki et al. 1993).

Feral cats kill forest birds as well as native sea birds and other species that nest on the ground or in burrows (USGS 2006a). Cats are the host of a potentially fatal disease called toxoplasmosis. In Hawai‘i, toxoplasmosis has killed native Hawaiian birds such as the endangered ‘alalā (*Corvus hawaiiensis*) and nēnē (*Branta sandvicensis*) and even seabirds such as the red-footed booby (*Sula sula*). Because the organism that causes toxoplasmosis (*Toxoplasma gondii*) can complete an important part of its life cycle in seawater, this disease also poses a threat to marine mammals such as the endangered Hawaiian monk seal (*Monachus schauinslandi*) and spinner dolphin (*Stenella longirostris*). In addition to threatening wildlife, toxoplasmosis poses a significant health risk to pregnant women (USGS 2006a).

Rats prey on native bird eggs, nestlings, native land snails and also eat the fruits/seeds and strip the bark of native plants. Similarly, mice consume the seeds of native plants; seed predation can be a major factor contributing to species decline (Atkinson 1985, Cole et al. 2000, Cuddihy and Stone 1990, Shiels and Drake 2011).

Laupāhoehoe Forest has been invaded by non-native forest birds; however their impacts on native species have not been determined. The non-native kalij pheasant occur in high densities through the forest and can disturb soils, as well as transport non-native seeds. Non-native birds may compete with native forest birds for food and other resources and act as vectors for avian diseases. Non-native birds also contribute to the spread of invasive non-native plants by eating the fruits and spreading seeds – especially strangler figs, clidemia and ginger.

Non-native invertebrates are present, but largely undocumented, and can consume native plants, interfere with plant reproduction, predate or act as parasites on native species, transmit disease, affect food availability for native birds, and disrupt ecosystem processes. The invasion of the yellow jacket wasp (*Vespula pennsylvanica*), voracious predators of numerous species of native invertebrates, is of concern. Other non-native parasitoids adversely impact native moth species, and ants are a significant mortality factor for native invertebrates. Slugs (*Milax gagates*, *Limax maximus*, and *Veronicella* spp.) consume fruit from native plants and prey on seedlings and mature plants. Black-twig borer (Coleoptera: Scolytidae) is a threat to koa. The two-spotted leafhopper (*Sophonia rufofascia*) is a major concern for the uluhe fern, which is particularly sensitive to leafhopper feeding. Mosquitoes (*Aedes albopictus* and *Culex quinquefasciatus*) transmit deadly diseases to native birds and humans. Little fire ant (*Wasmannia auropunctata*) is known from the community below Laupāhoehoe Forest and could pose a threat to forest resources if it spreads mauka.

Both Jackson’s chameleon (*Chamelaeleo jacksonii*) and coqui frog (*Eleutherodactylus coqui*) have growing populations on the island, and these species can consume native invertebrates,

such as insects, spiders, and small snails. Coqui frogs are known from pastures below Laupāhoehoe Forest as well as from streams within the town of Laupāhoehoe. Cane toads and American bullfrogs, have also been observed in or near streams in Laupāhoehoe Forest. However, it is unclear how these species might be impacting native ecosystems in the forest.

Disease

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

Introduced plant diseases such as rapid ‘ōhia death, ‘ōhi‘a rust (*Puccinia psidii*) and koa wilt (caused by the fungus *Fusarium* sp.) could potentially impact the most common native trees within Laupāhoehoe Forest. Rapid ‘ōhia death is a newly identified disease that has killed large numbers of mature ‘ōhi‘a trees in forests and residential areas of the Puna and Hilo Districts of Hawai‘i Island with the potential to kill ‘ōhi‘a trees statewide. Rapid ‘ōhia death has not been detected in Laupāhoehoe Forest as of March 2016 but is a severe threat to the health of the forest. The USDA Agriculture Research Service has determined that the causal agent of the disease is the vascular wilt fungus, *Ceratocystis fimbriata* (Keith et al. 2015). ‘Ōhi‘a rust affects ‘ōhi‘a as well as other plants in the same family (Myrtaceae) (HEAR 2010). In severe infections, growing tips wither and die back. Koa wilt is a serious, often fatal disease of the native tree, koa. Trees affected with the disease rapidly lose their canopies and may die within a few months (UH-CTAR 2010).

Climate Change and Natural Disturbances

Climate change may affect the Laupāhoehoe Forest by altering rainfall patterns and amounts. Changing climate may affect the abundance and seasonality of precipitation, thereby altering forest composition, growth and structure (Iwashita et al. 2013). Rare ecosystems and species may be negatively affected by relatively rapid changes in precipitation, temperature, and humidity that result from a rapid and drastic change in regional or local climate patterns (e.g. prolonged drought, higher temperatures). Detrimental invasive species may change their distribution and abundance due to changes in the climate (e.g. mosquitoes may be more frequently found at higher elevations due to warming temperatures). Monitoring and relating climate and any climate change to the ecology of the Laupāhoehoe Forest is a major goal of the HETF.

Although natural disturbances such as hurricanes, droughts, and flooding are regular occurrences in Hawai‘i, wide spread insect-driven defoliation can also impact the forest (koa moth *(Scotorythra paludicola)*). Similarly, ‘ōhi‘a undergoes periodic declines where entire stands of ‘ōhi‘a die off at the same time (Akashi and Mueller-Dombois 1995, Anderson et al. 2001, Mueller-Dombois 1980). Native species and ecosystems may have evolved under these disturbance regimes, but today, they may not be able to recover from such disturbances as readily due to small populations, changing climate, introduced diseases (rapid ‘ōhi‘a death and ‘ōhi‘a

rust), and/or competition with non-native plant species. Further, these types of natural disturbances may increase as a result of climate change.

Illegal Human Activity

Illegal human activity occurs on a small scale, primarily in the form of illegal camping, off-road all-terrain vehicle use, dumping, unpermitted harvesting (koa, maile, hāpuʻu, and other native trees and plant collection without possession of a DOFAW permit), poaching, marijuana cultivation, and vandalizing signs and fences. These activities destroy infrastructure and native species. Some illegal activities create openings in the forest that can be invaded by invasive non-native plants.

Wildfire

Fire poses a threat to Laupāhoehoe Forest, particularly in the drier upper elevation during times of drought and in areas adjacent to human activity. Hawaiʻi's flora evolved with infrequent, naturally-occurring fire, so most native species are not fire-adapted and are unable to recover quickly after wildfires. Wildfires leave the landscape bare and vulnerable to erosion and non-native weed invasions (D'Antonio et al. 2000, Dunkell et al. 2011, Smith and Tunison 1992). Continued feral ungulate damage to native ecosystems can convert native forest to non-native grasses and shrubs, which provide more fuel for fire (Ainsworth and Kauffman 2010, Cabin et al. 2000, Chynoweth et al. 2013, Cole et al. 2012, Nogueira-Filho et al. 2009, Scowcroft and Giffin 1983, Thaxton et al. 2010). Invasive non-native plants, particularly grasses, are often more fire-adapted than native species and will quickly exploit suitable habitat after a fire (D'Antonio et al. 2000, Mack and D'Antonio 1998). The principal human-caused ignition threats are from catalytic converters and other hot surfaces of vehicles or heavy equipment and illegal campfires. The principal natural ignition source is lightning.

There have been three fires recently in the vicinity of Laupāhoehoe Forest. The Piha Fire in 2008 started off Mana Rd. from a vehicle parked in dry grass. The fire burned 2,800 acres (1133 ha) of non-native grasses and koa canopy from Hopuwai Corral above Piha FR across to Laupāhoehoe FR and up to Mauna Kea FR. The Waipunalei Fire in 2012 was probably started from a lightning strike. The fire burned 22.2 acres (9 ha) near the koa mill in Waipunalei, between Laupāhoehoe Forest and the Humuʻula section of Hilo FR. Fuels were mainly kikuyu grass with koa, ʻōhiʻa and sugi pine canopy. The Keanakolu fire in 2013 started from an abandoned campfire below Keanakolu Cabins in the Humuʻula Section of Hilo FR and burned approximately 3 acres (~1.2 ha).

2013 Keanakolu fire

Threats to Cultural Resources

Threats to cultural resources are in large part the same as the threats to biological and physical resources described below in excerpts from Maly and Maly 2006.

> "In Hawaiian culture, natural and cultural resources are one and the same. Native traditions describe the formation (literally the birth) of the Hawaiian Islands and the presence of life on and around them, in the context of genealogical accounts. All forms of the natural environment, from the skies and mountain peaks, to the plateau lands, watered valleys and lava plains, and to the shoreline and ocean depths are believed to be embodiments of Hawaiian gods and deities.
>
> The forest lands of this region represent significant native (endemic and indigenous) resources, and are part of a unique cultural landscape—in that the native flora, fauna, mist, rains, water, natural phenomena and resources, are all believed to be kino lau (the myriad body-forms) of gods, goddesses, and lesser nature spirits of Hawaiian antiquity. Knowledge of the environment and respect for the resources ensured a sustainable life upon the land. And in their evolving relationship with natural resources such as those of this region, Hawaiians came to consider everything about them as godly manifestations. Care for, and respect of the earth, meant that in-turn, the earth would care for the kānaka (people)."

Threats to resources such as stone features (walls, terraces, mounds, platforms, shelters, caves, trails or boundary ahu) and burials include vandalism and destruction during ground altering activities such as construction. The Hawai'i State Historic Preservation Statute (Chapter 6E), affords legal protection to historic sites, including traditional cultural properties of ongoing cultural significance. Threats such as rapid 'ōhi'a death, poses a great threat to the native tree 'ōhi'a, which is an important cultural resource.

Merry Monarch Festival & Rapid 'Ōhi'a Death

Traditionally, participants in the Merrie Monarch Festival in Hilo would gather 'ōhi'a. In 2016, diverse groups including conservation agencies and hula practitioners joined together to prevent the spread of rapid 'ōhi'a death. Efforts included discouraging the gathering of 'ōhi'a from Hawai'i Island for the festival and afterwards, restricting returning material to the other islands. The Hawai'i Island community hosted the Pua'ena'ena Ceremony, a fire ceremony to provide a way for people to offer their kinolau, hakina, lei, and kūpe'e with thoughts of full recovery for 'ōhi'a to the fire of Ke Ahi O Hi'iaka.

(Kekuhi Kanae Kanahele Keali'ikanaka'oleohaililani Letter to the Hula Community)

ʻŌhiʻa, Lehua & Pele

Legend says that one day Pele met a handsome warrior named ʻŌhiʻa. ʻŌhiʻa, however, had already pledged his love to another woman, Lehua. Pele raged in anger and turned ʻŌhiʻa into a twisted tree in the hopes that no one would love him. Lehua was heartbroken, and longed for her lover. The gods took pity on Lehua and decided it was unfair to keep them separated. The gods then turned Lehua into a flower on the ʻōhiʻa tree so that the two lovers would be forever joined together. It is said that if you pluck this flower you are separating the lovers, and that day it will rain as a symbol of Lehua crying out to ʻŌhiʻa.

(Moʻolelo)

OVERVIEW OF EXISTING MANAGEMENT

Numerous management actions have been completed and/or are ongoing in Laupāhoehoe Forest. The section below summarizes these actions and accomplishments.

Natural Resources

Forest Protection and Management

To date, DOFAW staff has built small fenced exclosures to protect approximately 35 acres (14 ha) of native forest habitat and rare and endangered plant species from feral ungulates (3 exclosures: Kilau Uka, Loulu, and Scowcroft units are each approximately 10 acres, and 10 exclosures are < 1/4 acre). The Kilau Uka exclosure near Blair Rd. was completed in 2008; the Loulu exclosure was completed in 2010, and the Scowcroft exclosure was installed in 2014. These exclosures are also used for restoration of rare plants through outplanting.

Invasive Non-Native Plant Control

DOFAW staff control priority non-native invasive plants in rare plant exclosures, along roadsides and in other priority areas. Staff spends approximately 30 person days/year working on weed control, with additional work scheduled in the summer when Youth Conservation Corps (YCC) crews are available.

Rare Species Restoration

DOFAW staff work cooperatively with other organizations and agencies on rare plant recovery including the Hawaiʻi State Plant Extinction Prevention Program (PEPP) and the Volcano Rare Plant Facility (VRPF) of the University of Hawaiʻi. Management actions specific to rare plant recovery include rare plant surveys to locate wild individuals, protection of wild plants in fenced exclosures, collection of propagation and genetic storage materials and reintroduction through outplanting in fenced, protected exclosures. PEPP is focused on preventing the extinction of taxa with fewer than 50 individuals in the wild.

DOFAW staff follow rare plant collection and reintroduction guidelines recommended by the Hawaiʻi Rare Plant Restoration Group (interagency group of rare plant experts)

http://hear.org/hrprg/. DOFAW staff tag and map the locations of all outplanted plants and monitor their survival and growth. Rare plants reintroduced into Laupāhoehoe Forest in fenced, protected exclosures through outplanting include: *Anoectochilus sandvicensis*, *Clermontia lindseyana*, *Clermontia pyrularia*, *Joinvillea ascendens*, *Ochrosia haleakalae*, *Phyllostegia macrophyllus*, *Phyllostegia warshaueri*, *Stenogyne macrantha* and *Trematolobelia grandifolia* (see Table 3 for species status and common (Hawaiian) names).

Monitoring

In 1982, a rare plant survey of the proposed NAR noted the presence or absence of certain priority invasive non-native plants (Cuddihy et al. 1982). More intensive invasive non-native plant monitoring was completed across nine transects in the NAR portion of Laupāhoehoe Forest in 1988, to gather information for the 1989 management plan. These transects were re-monitored in 1998. In addition, in 2008 NAR staff monitored vegetation plots along new transects which included invasive non-native plant monitoring.

Forest birds in Laupāhoehoe Forest were surveyed as part of the Hawai‘i Forest Bird Survey (Hamakua Study Area) from 1976-1983 (Scott et al. 1986). These same transects were re-surveyed in 1993. In 2013, additional surveys were conducted to assess the status of forest birds as part of this management plan. Recent survey data has not yet been analyzed; however, four species of endangered bird species were detected: ‘akiapōla‘au, Hawai‘i `ākepa and Hawai‘i creeper was present above 4,500 ft (1,372 m), and ‘io was also detected during the survey.

Right to left, DOFAW staff installs fencing to protect the forest and monitors rare plants in Laupāhoehoe Forest

Research

Research conducted in the Laupāhoehoe Forest is a combination of long-term monitoring of environmental conditions and biotic responses, and directed research to address key questions about forest ecosystem function, health, and sustainability. Research in the Laupāhoehoe Forest is conducted by universities, government agencies including the USFS, and private organizations. Projects vary in focus, scope and length. Research projects proposed for the Laupāhoehoe Forest are subject to review and permitting prior to access being granted for project implementation. A complete list of projects that have been conducted in Laupāhoehoe Forest to date can be found in Appendix C and is also available in HETF annual reports at www.hetf.us.

Long-Term Data Collection

Long-term monitoring is an integral component of research field sites such as the HETF. In the Laupāhoehoe Forest, long-term monitoring infrastructure has been established for vegetation, climate, and stream monitoring. The Hawai‘i Permanent Plot Network (HIPPNET), a collaborative project between the University of Hawai‘i, the USFS, and University of California Los Angeles, has established a co-located vegetation plot and climate station in the Laupāhoehoe Forest that is part of a worldwide study of tropical forests with the Smithsonian Tropical Research Institute's Center for Tropical Forest Science (www.ctfs.si.edu). Climate conditions in the forest are monitored by a weather station installed in 2009. The climate station extends 10 feet (3.3 m) above the forest canopy and collects data on rainfall, temperature, relative humidity, wind-speed, solar radiation (sunlight), soil moisture, soil temperature, and wind direction. The Laupāhoehoe climate station is part of the EPSCoR-ENDER (Experimental Program to Stimulate Competitive Research - Environmental Dynamics and Ecosystem Responses) Climate Network, an island-wide network of climate stations at locations across the island of Hawai‘i. Research conducted in the HIPPNET will enable advancement in the studies of global change, ecohydrology, ecosystem services, remote sensing, restoration, community structure and organization, population genetics, comparative forest ecology and biogeochemical processes.

The Forest Inventory and Analysis Program (FIA) is a nationwide USFS program aimed at collecting, analyzing, and reporting information on the status and trends of America's forests. The Laupāhoehoe Forest includes 29 FIA plots (12 in the FR and 17 in the NAR) which represent a portion of the approximately 600-700 plots proposed for all of Hawai‘i. With the support and coordination of numerous entities in Hawai‘i, Hawai‘i's FIA program collects additional information on the presence of invasive plants and other disturbances such as feral pigs to provide a baseline assessment of the current state of forests all over Hawai‘i. Plots are scheduled to be re-measured every 10 years to provide insights into changes in forest extent, composition, structure, and disturbances.

The hydrology of native forests and watersheds is an integral part of long-term sustainability of forest ecosystems, including aquatic biota. Freshwater availability for a variety of human uses and for its contribution to nearshore marine ecosystems is also critical. One facet of understanding forest hydrology is by monitoring flow in major streams through the use of stream gauges. One stream gauge has been established in Manowai‘ōpae Stream for monitoring Laupāhoehoe Forest and the gauge is currently maintained by the USFS.

Short Term Research Projects

In addition to long term data collection, the HETF supports a range of research projects that contribute to the greater ecological understanding of Hawai‘i's forests and species. Research topics include species identification, monitoring, ecosystem services and life history studies, koa productivity, biodiversity and invasive species impacts and control. Representative examples of the diversity of topics include:

- Hawaiian hoary bat habitat occupancy, reproduction and diet
- Acoustic variability and loss of song complexity in Hawaiian honeycreepers
- Adaptive radiation in Hawaiian spiders
- *Drosophila* bar coding project as a method to determine species

- Native and non-native snail surveys
- ʻŌhiʻa rust monitoring
- Assessing the *Scotorythra paludicola* (Lepidoptera: Geometridae) outbreak on koa: population abundance, rates of parasitism and patterns of spread
- Comparative nutritive values of traditional and exotic foraging substrates for upper elevation forest birds
- Quantifying the effects of ungulate and vegetation on the hydrology of Hawaiian tropical forests
- Sources and fates of nutrients on a substrate age gradient across the Hawaiian archipelago and their consequences for forest dynamics

Education and Outreach

Educational activities associated with Laupāhoehoe Forest currently include support for internships that focus on restoration and education (AmeriCorps, Youth Conservation Corps (YCC), and Pacific Internship Programs for Exploring Science (PIPES)), and securing national, regional, and local grants that fund educational programs. Further, IPIF staff collaborations with teachers at local middle and high schools have resulted in classroom field trips into the forest to learn about botany, ecology, natural resources management, traditional ecological knowledge and cultural geography. Many of the educational activities involve substantial contributions from additional partners including Mauna Kea Watershed Alliance, the USFWS, and the University of Hawaiʻi (UH) at Hilo and UH-Mānoa.

Sharing aloha ʻāina with the Ocean Warriors through the Forest Service Manaulu Manoʻwaiōpae program.

Public Access and Recreation

Public access for recreational and cultural uses is ongoing in Laupāhoehoe Forest in accordance with existing rules and policies described earlier in this plan (see DESCRIPTION AND CURRENT CONDITION section). Current public access routes are shown Figure 4.

Infrastructure

Plans for development of Laupāhoehoe Science and Learning Center located outside the forest boundary were finalized in the 2011 Laupāhoehoe Construction Project EA (more information at (http://www.hetf.us/page/projects_plans/). See DESCRIPTION AND CURRENT CONDITION section for more information.

PROPOSED MANAGEMENT PROGRAM

The proposed management program outlined in this section includes new proposed actions as well as ongoing research, management and education projects. This section provides background information on projects within the main management focal areas, management objectives, and proposed actions to accomplish the objectives. In addition, some sections provide rationale for the proposed actions in cases where there were alternative actions considered.

For proposed management activities, staff will perform field surveys prior to on the ground implementation to avoid any negative impacts to botanical, faunal, cultural and historic resources as required by State and Federal law and recommended by community stakeholders.

Mele Komo No Manowai'ōpae

Kāhikohiko nā uka o Laupāhoehoe	In the ancient uplands of Laupāhoehoe
Pa'a i nā kīkepa wai o Poliʻahu	Steadfast are the waters of Poliʻahu
ʻAʻala ka Honua o Waiʻōpae	The land of Manowaiʻōpae is made fragrant
I ka wao a ke akua e noho nei	In the realm where the gods dwell
E ia ka leo	Here is the voice

Mele Komo (entrance song) is offered to ask permission when entering a space to demonstrate humility and deference to local elemental forces. The use of song enables the entrant to psychologically connect with the place and address its needs - shedding any preconceived notions or assumptions. The Mele Komo gives the intelligence of the place time to decide whether or not the entrant is welcomed. Practicing the Mele Komo protocol opens the entrant to their full potential of learning what exactly the place has to teach them.

The above Mele Komo was written for entering Laupāhoehoe Forest through the collaborative efforts of James J. Akau and Kekuhi Kanae Kanahele Kealiʻikanakaʻoleohaililani.

Footnotes for further interpreting the Mele Komo are as follows:

Line 1: Use of kāhiko in reference to the father of Mauna A Wakea, Wākea-kahiko-luamea; First line from the point of view of the person(s) requesting entrance to Laupāhoehoe; nā uka refers to all upland belonging to the mauna in relationship to Laupāhoehoe ʻāina;

Line 2: Kīkepa wai refers to female's clothing made of water; an image of Poli'ahu, Lilinoe and Waiʻau's functions at the top of the mountain that act as the zone of contribution for Manowaiʻōpae; like a woman wearing a kīkepa made of snow, mists, and water;

Line 3: 'A'ala ka honua in reference to the fragrance bearing wind, ʻaʻala honua;

Line 4: Ke akua e noho nei refers to the presence of major elements or akua in the area that are required for this exchange--like the Pele underneath, the soil layer, roots, bugs, water, trees, forest, cloud, kanaka;

Line 5: Gift of the breath of voice is the most prized.

Natural Resources

Forest Protection and Management

Background: The protection and management of forested watersheds and unique native Hawaiian ecosystems is a priority for Laupāhoehoe Forest. Effective management of forested watersheds provides fresh water for public use, improves water quality, reduces soil erosion, improves coastal water quality, and maintains native ecosystems. In addition, many native, threatened and endangered species rely on forested watersheds for their survival. These forested watersheds require active management to effectively address threats in order to persist for the benefit of current and future generations.

- Locations for conservation units were chosen in consultation with the LAC and high use hunting areas were avoided where possible.
- The areas planned for fencing have some of the highest quality, most intact native habitat in Laupāhoehoe Forest.
- Planned conservation units will protect existing populations of rare plants and animals and can also be used as restoration sites for rare species recovery.

Objective: Protect, manage and restore native ecosystems and species at Laupāhoehoe Forest by effectively managing conservation units and implementing forest restoration practices.

Proposed Actions:

1. Fence and remove feral pigs from three conservation units (Figure 11) to protect the biological and water resources and limit damage to native Hawaiian ecosystems. Without fencing, ungulate control requires ongoing effort, due to reproduction of existing populations and continued ingress from adjacent properties.
    - Conduct field surveys of final fence alignment to avoid any impacts to botanical, faunal, cultural and historic resources.
    - Construct fencing of conservation units (342 acres (138 ha) and 2,317 acres (938 ha) (subdivided by a cross fence (location to be determined)).
    - Install gates and walkovers for pedestrian access into fenced conservation units.
    - Implement feral pig control using approved methods following fencing to remove all pigs from within conservation units. Public hunting will be encouraged initially, but additional control methods including drives, trapping/release, staff control, and snaring, may be needed to remove all the ungulates not removed by active hunting within the conservation units.
    - Monitor fenced conservation units for pig ingress, and control pigs, if necessary.
2. Maintain all fences through regular inspection and maintenance and replace fences, when needed, including perimeter fencing to prevent cattle ingress from adjacent ranch lands.
3. Restore forested ecosystems in areas that have been disturbed (e.g. formerly logged areas, areas disturbed by cattle) through native tree planting. Priority areas are depicted in Figure 11. Priorities include the following: 1) within the FR section along Mana Rd. and inward; 2) Shack Camp; and 3) section off Blair Rd. toward Waipunalei. Restoration is not limited to these areas and additional areas may also be restored. These priority sites

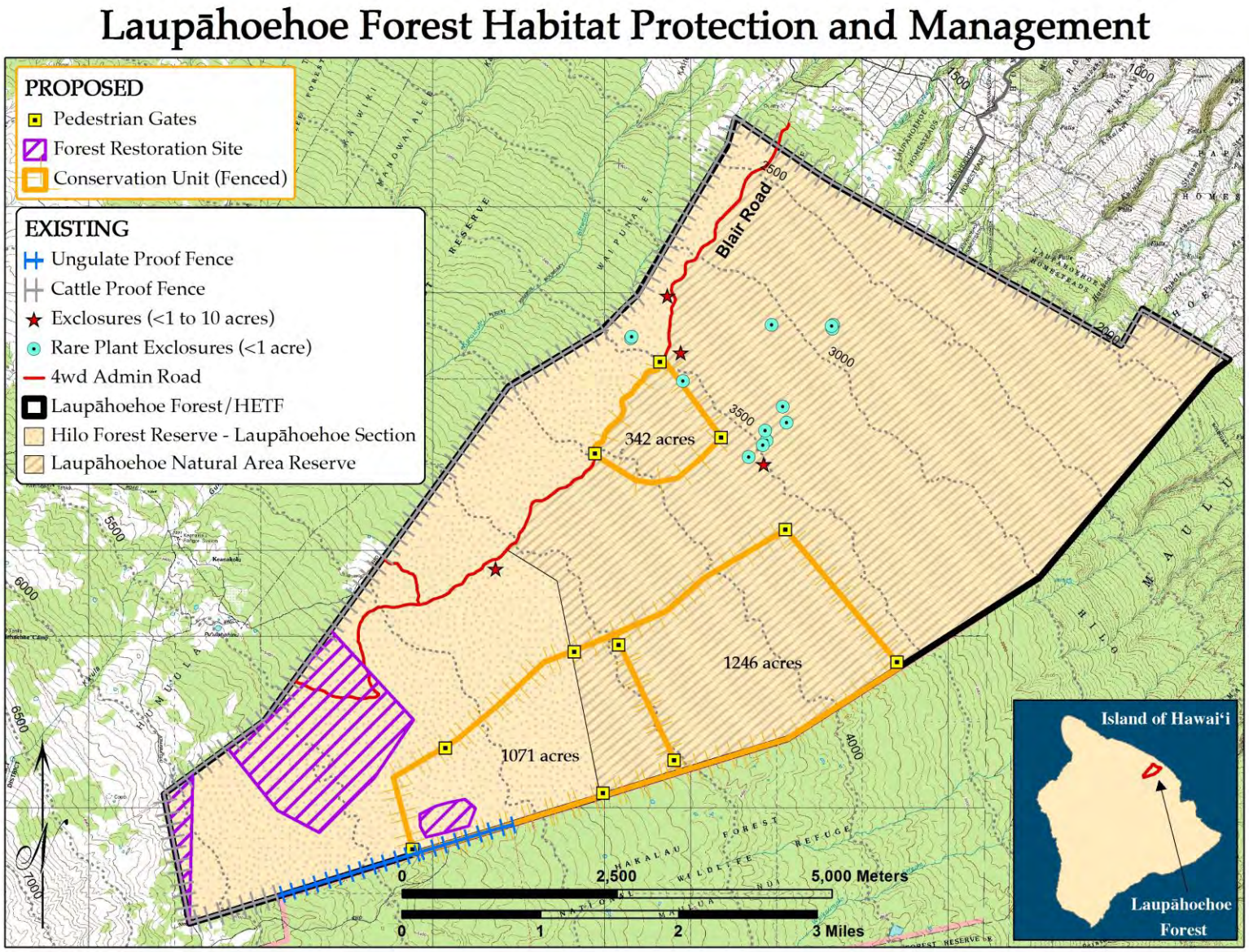
were chosen because they have past damage from logging and feral cattle and limited natural regeneration. They are also accessible for staff and volunteers, particularly with proposed infrastructure improvements at Shack camp (shelters and camping sites discussed in public recreation and access section below). Reforestation techniques include localized herbicide spraying in planting sites to remove invasive pasture grasses and weeds, manual planting of native trees with hand tools by staff and volunteers and light scarification to enhance natural regeneration or koa and/or other native species.

4. Control non-native pasture grasses and other non-native invasive weeds in restoration areas to enhance the natural regeneration of native trees and shrubs and prevent fire. Conduct thinning or removal of trees (excluding commercial logging) where needed to maintain forest health or reduce fuel loads.
5. Construct emergency rare plant exclosures between 1-5 acres in size, when needed to protect individuals or populations of endangered plants.
6. Pursue potential land acquisitions of adjacent lands from willing landowners for protection and restoration of a large conservation landscape in cooperation with conservation partners (when applicable).
7. Monitor forest health and manage threats (e.g. rapid ʻōhiʻa death or other disease or insect pests), where possible, using best available methods for remote and environmentally sensitive areas. Cooperate with researchers on emerging threats to forest health to determine best management practices to reduce the spread and negative impacts of these threats to native forest ecosystems.

Rationale: Community and LAC member feedback related to conservation units in Laupāhoehoe Forest ranged widely from fencing the entire forest for protection to desires for no additional fences. As mentioned throughout this plan, the protection and management of forested watersheds and unique native Hawaiian ecosystems is a priority for the state within Laupāhoehoe Forest as only 35 acres are currently protected. Through discussion with the LAC and community members, the importance of Laupāhoehoe Forest to the community for hunting opportunities was also documented. Across Hawaiʻi Island, state land managers are facing tough choices when tasked with protecting valuable native resources while still providing hunting opportunities. In particular with feral pigs, the negative impacts to the forest are well documented. The proposed conservation units in this plan attempt to meet conservation needs while considering hunting community desires. High quality native forest habitat areas that are less heavily used for public hunting were purposely selected. The proposed conservation units also provide suitable habitat for the recovery of rare and endangered species and are more feasible to manage because they are not dominated by invasive species, as is the case in lower elevation portions of the forest. One conservation unit with high quality native forest habitat includes an area dominated by tropical ash but this area has high restoration potential once fenced and the tropical ash controlled. When this plan is fully implemented, approximately 2,694 acres (1090 ha) or 22% of Laupāhoehoe Forest will be protected through conservation unit fencing.

In conjunction to Action 6 above, the state is also pursuing the development of additional access and/or acquisition of lands from willing landowners to expand hunting opportunities on appropriate lands.

Figure 11


Laupāhoehoe Forest Habitat Protection and Management
PROPOSED
Pedestrian Gates
Forest Restoration Site
Conservation Unit (Fenced)
EXISTING
Ungulate Proof Fence
Cattle Proof Fence
Exclosures (<1 to 10 acres)
Rare Plant Exclosures (<1 acre)
4wd Admin Road
Laupāhoehoe Forest/HETF
Hilo Forest Reserve - Laupāhoehoe Section
Laupāhoehoe Natural Area Reserve
Blair Road
342 acres
1246 acres
1071 acres
0
2,500
5,000 Meters
0
1
2
3 Miles
Island of Hawai'i
Laupāhoehoe Forest

Invasive Non-Native Plant Control

Background: Invasive non-native plants are a major threat to Laupāhoehoe Forest, and species with high potential for spreading and modifying habitat are a high priority for control. The overall approach includes preventing the establishment of new habitat modifying species that are either not currently present (e.g. miconia) or are still localized through biosecurity measures. For priority weeds already present, the goal is to identify control areas, eliminate all known occurrences within targeted control areas and/or to contain the further spread.

Objective: Protect intact native forest by preventing the establishment and/or removing high priority non-native, invasive plants and other invasive species.

Proposed Actions:

1. Regularly monitor and map the distribution of high priority invasive non-native plants, develop a comprehensive control strategy and revise control strategy, as needed, based on monitoring data.
    - Regularly compile transect monitoring data, incidental observations and reconnaissance surveys to map changes in invasive plant distribution and abundance and detect new species.
    - Cooperate with research on new mapping technologies (high resolution aerial imagery) to assist in monitoring and/or locating priority weeds for control.
2. Control priority non-native invasive plants in identified areas using approved methods.
    - Control invasive non-native plants in high quality native forest, particularly within fenced, ungulate-free management units. These areas are a high priority for more intensive management, and the recovery of native vegetation, reductions in ground disturbance, and the spread of weeds by ungulates may increase the effectiveness of invasive plant control.
    - Target control of certain incipient invasive non-native plants (just beginning to invade) in unfenced areas to prevent their establishment and spread.
    - Focus control efforts in disturbed areas such as roads and trails as these often serve as corridors for weed establishment and spread.
    - High priority species present in Laupāhoehoe Forest include Australian tree fern, banana poka, Florida blackberry, cane tibouchina, *Clidemia*, *Ficus*, Himalayan ginger, mules foot fern, palm grass, passion fruit, *Polygonum chinensis*, strawberry guava, tropical ash, and yellow Himalayan raspberry.
    - A combination of control techniques including manual, mechanical and approved herbicides will be used to remove weeds. The technique selected will be based on the characteristics of the target species, the sensitivity of the area in which the species is found, and the effectiveness of the control technique.
    - Due to widespread and heavy infestations of certain weeds and limited resources, DOFAW will use approved biocontrol agents within the forest, when available, and if shown to be effective.
3. Monitor non-native invasive plants to determine whether weed control measures are effective and to detect changes in long term distribution and abundance.

4. Maintain procedures to prevent introduction of new weeds (see biosecurity section).
    - Avoid and/or reduce the inadvertent introduction and spread of weeds by staff, researchers and the general public working through education regarding biosecurity and implementation of biosecurity protocols for staff and research/education permitees.
    - Prevent the establishment of high priority invasive non-native plants species that are present in adjoining areas but not yet detected in Laupāhoehoe Forest. These species include miconia, faya, gorse, firethorn, *Cotoneaster pannosus*, and New Zealand flax.

Rare Species Restoration

Background: Landscape-scale habitat protection and management through management actions described in the habitat protection and management section are critical to the long-term integrity and recovery of native ecosystems including rare plants, forest birds and other native species. Such management actions, along with non-native invasive plant management and the prevention of new habitat-modifying weeds and harmful non-native species are the most critical actions needed to protect existing native habitat and rare species. However, in some instances, these actions are not enough to recover certain rare and endangered plants and animals. These species may have additional threats and/or wild populations that are so small that the species cannot survive and recover without additional species-specific management.

ʻAkiapōlāʻau (*Hemignathus munroi*)

Objective: Protect threatened and endangered plants and animals in Laupāhoehoe Forest and restore populations of these species in appropriate habitat to assist with the overall recovery of these species.

Proposed Actions:

1. Maintain the integrity of high quality forest ecosystems to the extent possible through fencing, feral ungulate control, non-native invasive plant control and preventing the introduction and establishment of other habitat-modifying species and new threats.
2. Map, monitor and protect existing wild populations of rare and endangered plant and animal species to contribute to their population recovery and stabilization. Identify and remove threats to these species and ensure their long-term survival in secure and self-sustaining wild populations.
3. Re-introduce certain species of rare and endangered plants (Table 3) in appropriate protected habitat through outplanting. Over the past decade, numerous species of rare plants have been propagated and reintroduced into fenced, ungulate-free areas to contribute to their overall recovery in the wild.
    - Coordinate rare plant management actions with the PEPP, VRPF and other agencies and organizations working on rare plant recovery.

- Survey rare plants to locate wild individuals, collect propagation and genetic storage materials and reintroduce through outplanting.
- Follow rare plant collection and reintroduction guidelines recommended by the Hawai‘i Rare Plant Restoration Group.
- Tag and map the locations of all outplanted plants and monitor survival and growth.
- Provide additional management of wild and/or reintroduced populations if needed (e.g., small fences around wild plants and populations that are not within fenced management units, control of damaging weeds, insects, slugs, plant disease and/or mammalian predators).

4. Determine additional actions needed to protect rare invertebrates. Previously discussed habitat management will also benefit rare native invertebrates, as they are generally dependent on native plants for food and as host plants.
   - Perform additional invertebrate surveys to inventory species, identify important habitat for rare species, and determine threats and needed recovery actions.
5. Enhance habitats and recovery of native forest birds and other native species through small mammalian predator removal and other habitat management actions.
   - Small mammalian predator removal (e.g., removal of rats, mongoose, cats) may provide significant benefits to endangered birds, plants, and endemic invertebrates, but is extremely difficult and costly to implement. DOFAW staff may implement predator removal in certain high priority areas (e.g., endangered bird nesting sites, rare plant restoration sites) using approved methods.
   - Other management may be implemented, as feasible. These include removal of larval habitats (e.g. standing water providing mosquito breeding habitat) that may be responsible for seasonal epizootics of avian pox and malaria. Reducing or eliminating vespulid wasps (yellow jackets) may also provide benefits to forest birds, as these wasps prey on insects that provide food for forest birds.

Monitoring

Background: DOFAW staff will continue to implement basic monitoring programs which are directly informing ongoing management. DOFAW staff regularly monitor ungulates, non-native invasive plants, rare plants and forest birds and are planning on continuing these monitoring programs. Additional monitoring is described under research, and will primarily be implemented by USFS staff and other researchers.

Objective: Monitor current status and trends of natural resources throughout Laupāhoehoe Forest as part of a long-term monitoring program.

Proposed Actions:

1. Continue ongoing monitoring programs for ungulates, non-native invasive plants and rare plants to measure the success of management and detect changes in abundance and distribution.
   - Monitor ungulates in fenced management units to detect the presence or absence of ungulates. Units that are free of ungulates will be regularly monitored to detect

ingress animals. Units with active ungulate control programs will be monitored to assess the success of and/or direct control efforts.

- Continue non-native invasive plant monitoring along transects to detect changes in distribution and abundance over time as well as detect incipient invaders. Control areas are monitored to determine the success of management efforts.
- Rare plant monitoring is conducted to assess the survival and growth of wild and re-introduced rare plants. DOFAW and PEPP program staff monitor rare plants to assess their survival and reproduction, collect propagation materials, search for additional wild individuals and determine if additional management is necessary.

2. Continue ongoing monitoring program for forest birds. Provide monitoring data to the Hawai‘i Forest Bird Interagency Database Project for analysis of bird population densities and trends.
3. Develop improved monitoring protocols, data management and analysis for existing monitoring programs and review and summarize past monitoring data and inventories.
4. Develop and/or identify appropriate monitoring protocols and implement monitoring for key indicators and threats that are not currently being monitored (e.g., native vegetation communities, invertebrates, forest health (e.g. rapid ‘ōhi‘a death) etc.).

Wildfire Prevention and Response

Background: Fire is a threat to the drier upper elevation portions of the Laupāhoehoe Forest. Many fires are caused by humans, so fire prevention measures will include increased educational efforts. It will also include clearing of fuel breaks and other similar fire pre-suppression actions to reduce fire potential and minimize fire severity. DOFAW staff will respond to fires in Laupāhoehoe Forest using measures that result in the least amount of impact or disturbance to natural and archeological resources. The method of suppression will be determined by the on-site situation, with special regard to the potential expansion of fire damage to natural resources. Minimum impact methods of suppression will be applied whenever such methods are sufficient. Bulldozing is justified when a fire cannot be otherwise controlled and potential bulldozing damage is outweighed by a probable greater loss of natural and archeological resources.

Objective: Employ appropriate fire management strategies including pre-suppression, suppression, and post-suppression rehabilitation to reduce wildfire occurrence and minimize wildfire impacts.

Proposed Actions:

1. Implement fire prevention measures, including educational outreach to neighbors and signage along roads and road or area closures in the event of extreme fire danger.
2. Control invasive plants, particularly non-native grasses and plant common native species to restore certain disturbed areas to prevent fire and/or following damage from fire.
3. DOFAW staff to suppress fires safely and aggressively using appropriate means to minimize wildfire impacts.
4. Continue DOFAW staff training and certifications for effective and safe fire response.
5. Maintain access and fuel breaks for fire pre-suppression and suppression.

Research

Background: The USFS and state of Hawai‘i, along with the consortium of institutions and agencies involved with the HETF, will continue to encourage and facilitate research in Laupāhoehoe Forest. Research projects that contribute to the greater purpose of the HETF, that are relevant to land management issues and that are compatible with existing research and management will be encouraged. USFS will support facilities to enhance the ability of the experimental forest to meet its goals for research and science. In addition, the USFS will facilitate access to basic biological, physical, and climatological data for the experimental forest through readily accessible web-based platforms and tools for researchers and the public to provide a foundation on which research projects can be built. All research within the HETF requires a valid permit.

Laupāhoehoe Forest provides many opportunities for research. Information on the basic natural history and abundance of the many endemic and often endangered plants and animals associated with Laupāhoehoe Forest is needed to understand how species may respond to changing environmental conditions (e.g. as a result of climate change) and how management and conservation measures can be used to help enhance adaptation. With its mixture of native and non-native dominated landscapes, Laupāhoehoe Forest provides an ideal site in which to test hypotheses about how invasive species impact ecosystems and determine the most effective methods of controlling or eliminating invasive species. Research aimed at effective ecosystem restoration is of great relevance in Hawai‘i and the Pacific Islands, and throughout the wet tropics.

‘A‘ohe pau ka ‘ike i ka hālau ho‘okahi. All knowledge is not taught in the same school. One can learn from many sources.)

(Pukui 1983)

Objective: Provide lands for conducting research that serves as a basis for the restoration, conservation and management of tropical forest ecosystems in Hawai‘i and across the tropics.
Proposed Actions:

1. Promote applied research with direct relevance to land management issues such as effective management of invasive species, forest restoration, forest health and climate change impacts on Laupāhoehoe Forest.
    - Host semi-annual meeting with land managers and community members to outline pressing information needs.
    - Host semi-annual meetings with research community to identify opportunities for collaboration and funding.
    - Bring together research institutions and conservation land stewards on Hawai‘i Island (e.g., USFWS, US Park Service, Nature Conservancy, Kamehameha Schools) to establish a network of field sites that together can be used to promote research on a broader suite of questions about tropical ecosystem conservation.
    - Offer stimulus funding in the form of modest awards to promote research in key areas.

- Host theme-based research discussions and symposia at the Laupāhoehoe Science and Learning Center, or elsewhere, that is sponsored by the experimental forest.
- Promote and support dissemination of research conducted in association with the experimental forest (e.g., research highlights, presentations, acknowledgements in publications and presentations).

2. Effectively administer and coordinate the research application process including review of applications, issuance of research permits, research compliance with permit conditions and relevant land designation statutes and rules.
   - Provide administrative support to research permit review and approval process.
   - Provide research expertise and management guidance to address potentially controversial or complex research proposals.
   - Promote timely and efficient processing of requests to encourage use.
3. Establish and maintain a system for archiving research data and reports to facilitate the exchange and transfer of information among agencies, scientists, and the community.
   - Maintain a publically available, web-based archive of baseline monitoring data, historical data and descriptions of all research activities. Historical data includes archive of maps, land-use histories, cultural practices and historical data relating to the HETF and Laupāhoehoe Forest.
   - Require all permitted researchers to make appropriate contributions to the data archive, including project descriptions, project reports, sampling locations, and publications that have resulted from research.
   - Maintain an electronic library of publically available reports, research and publications that pertain to the HETF available on the Internet. Materials protected through copyright would be available by request.
   - Publish syntheses of research and monitoring activities and results from HETF to provide information and findings more readily accessible to research, conservation, and local community members.
4. Improve dissemination of scientific research information and results to land managers and the local community.
   - Provide presentation series, workshops and seminars in association with the experimental forest to disseminate information to the local community.
   - Partner with University of Hawai‘i, Hawai‘i Community College, and local K-12 schools to jointly host field trips and field courses.
   - Host annual open houses at the experimental forest units to highlight research activities, associated knowledge gained, and opportunities for community involvement.
   - Develop a diversity of outlets for information in non-technical formats (e.g., calendars, posters, computer apps).
5. Promote cultural research including information on traditional Hawaiian use/presence in the forest, oral histories, cultural impacts of management actions and archeological studies.

- Collaborate with cultural researchers at University of Hawai‘i and other schools to use Laupāhoehoe Forest as a focus of cultural research.
- Seek funding for cultural research including integration of culture into scientific research as well as archeological and ethnographic studies.

6. Link ongoing research to education programs by encouraging researchers to work with local schools such as the Laupāhoehoe Community Public Charter School and universities.
   - Collaborate with University of Hawai‘i and Hawai‘i Community College to develop courses and seminars that incorporate field site visits to the experimental forest.
   - Collaborate with local educators to develop course curricula and materials that highlight or utilize research findings associated with the experimental forest.
7. Encourage basic research and monitoring to establish historical baselines of all natural resources.
   - Collect data on vegetation as part of a global tropical forest monitoring network, to monitor the status and condition of vegetation at Laupāhoehoe Forest and to develop vegetation maps.
   - Maintain a weather station as part of a larger island-wide network of climate stations across the island of Hawai‘i to collect data on rainfall, temperature, relative humidity, wind-speed, solar radiation (sunlight), soil moisture, soil temperature, and wind direction.
   - Establish and maintain stream gauges to monitor natural stream flows, water quality and sediment in a non-destructive manner. Hydrologic information can be used as a foundation for research on aquatic ecology, watershed dynamics, and climate change.
   - Perform regular surveys that systematically document and describe plant and animal species distribution and status to provide a baseline for research and assist with developing management actions and assessing their success.

Education and Outreach

Background: Education and outreach are key component of the overall vision for Laupāhoehoe Forest. Education and outreach goals span six focal areas: formal training for professionals; community outreach; cultural training; demonstration for natural resources managers; student research; and academic education. Educational goals will be accomplished through a strong reliance on partnerships and will be integrated with other aspects of research and natural resource management.

Objective: Serve as a center for forest education, training, demonstration and outreach on tropical forests, conservation biology, and natural resource management for groups ranging from school children to land managers, scientists and the general public.

Proposed Actions:

1. Encourage appropriate educational and cultural uses of Laupāhoehoe Forest through the development of general criteria, priorities and rules to effectively manage multiple educational uses.

2. Provide general orientation and training (e.g. on-line video) for all new research permittees and educational programs that includes recommendations on forest stewardship and invasive species prevention protocols as well as cultural components.
3. Collaborate with universities and relevant non-governmental organizations to integrate classes, student research/internships and provide support via Center facilities.
    - Host courses from local and visiting universities.
    - Co-develop courses with local and off-island universities that incorporate the HETF into the field component of classroom courses or where the HETF and perhaps other field sites are the focus of field courses.
    - Work with instructors from various universities to formulate courses that also contribute to our understanding of tropical ecosystems.
4. Foster and support undergraduate and graduate student research opportunities and research internships through partnerships with the University of Hawai‘i, other universities and local research agencies and organizations.
    - Identify research projects suitable for undergraduate and graduate students.
    - Sponsor students (e.g., projects, mentoring, equipment, funding) in conducting research pertinent to the HETF.
    - Invite researchers from other institutions to come to the HETF to conduct their research.
5. Provide a connection to nature and promote forest stewardship through engagement activities that involve the public and through collaboration with K-12 education program partners and other community partners including but not limited to the Laupāhoehoe Community Public Charter School. Educational activities include:
    - Educator workshops and programs
    - Field projects geared toward kids
    - Partnering with schools, educators, community and other non-governmental organizations to create and implement activities that facilitate forest stewardship
6. Communicate research findings, land use, and management goals to the community via:
    - Community field trips
    - Informational materials suitable for non-professionals of all ages
    - Participation in community events
    - Service learning opportunities
    - Interpretive trails and guided walks
    - Public participation in scientific research
7. Provide work experience and formal professional development training to land management professionals in ecology, conservation, and restoration of natural and cultural resources.
    - Provide opportunities for students in internship programs, such as PIPES to join research teams for short periods of time.
    - Provide opportunities for young professionals in YCC programs to understand research needs and management applications.

- Enable emerging professionals in AmeriCorps programs to experience working alongside research scientists and natural and cultural resource managers.
- Provide short-courses (0.5 to 5 days) designed for working professionals to help integrate new information and ideas into agency activities and approaches.

8. Serve as a demonstration site for land managers by providing information, tools and techniques through demonstration research, conservation, and restoration projects.
   - Engage managers in the design and implementation of research to understand effective conservation and restoration approaches.
   - Engage managers in the design and implementation of biophysical monitoring programs and projects.
   - Engage managers in the design and implementation of science based restoration projects.
   - Engage managers in the role of traditional ecological knowledge in land management.
9. Provide readily accessible scientific information through web-based platforms and tools.
10. Encourage researchers to share research results with the local community though informational presentations to schools and community groups and popular articles.
11. Hire staff and/or establish volunteer positions to facilitate educational and outreach experiences (e.g. education staff, rangers).
12. Serve as a site for alternative educational activities for non-profit groups and organizations (e.g. search and rescue training, orienteering, survival skills, back-country travel, hunter education programs, forest stewardship, Junior Youth Council, recreational and/or life skills, cultural immersion and traditional ecological knowledge training).

Public Access and Recreation

Background: Laupāhoehoe Forest is protected and managed by the state for the benefit of the people of Hawai‘i, and is open to the public for various recreational and cultural uses. While the public is allowed to access and hike or hunt in any portion of the forest, there are limited legal access points and only a few minimally maintained and marked trails. This area is a rough and remote rainforest wilderness and there are currently no amenities for recreational users. The access and recreational improvements proposed are intended primarily for local residents and to improve staff management access rather than for large-scale ecotourism. Large groups (over ten people) accessing the NAR require a DOFAW/HETF permit. The LAC is also supportive of improving public access elsewhere in the broader region, which has similar access issues.

Objective: Improve public access and recreational opportunities in Laupāhoehoe Forest consistent with maintaining natural resources and the wilderness character of these lands.

Proposed Actions:

1. Improve Public Access
   - Work with adjacent landowners to survey roads through private and state-leased lands depicted on some maps (“paper roads”) and/or work on alternative access to the forest.

- Work with the County to ensure all future subdivision plans in the area include public access to the forest.
- Pursue potential land acquisitions through fee-simple purchase from willing private landowners (e.g. possible purchase of Waipunalei from Parker Ranch to connect forest reserve sections increasing access by eliminating private land barriers).
- Consider DOFAW acquisition of long-term leases of state and/or private lands adjacent to the forest when current leases expire.
- Consider adding appropriate trails and accesses (e.g. Maulua Trail) to the Nā Ala Hele Statewide Trail and Access System to improve overall management.

2. Trail Maintenance (Pedestrian) - Maintain existing trails (Spencer & Peneki) as primitive trails (minimally maintained and marked) (Figure 12).
   - Peneki can serve as a connector trail from Spencer to Blair Rd. for both public recreational and research use.
   - Spencer can provide both public recreational and research use.
   - Exclosure trail is used by DOFAW staff for management purposes and can also be used as a connector trail by the public.
   - Control spread of non-native invasive plants by providing boot brushes and informational signage at all trailheads and access points.
3. Trail Improvement (Pedestrian) - Improve existing and/or create and maintain new trails. Trail improvement is a lower priority than maintenance of existing trails; however the trails below would be minimally maintained and marked in a similar fashion to the maintained trails above. Specific alignments for trails generally described below have not yet been determined on the ground and may vary depending on the vegetation and terrain (Figure 12).
   - Conduct field surveys of trail alignments to avoid any impacts to botanical, faunal, cultural and historic resources.
   - Create trail along the north fence line (upper boundary) from Mana Rd. to Blair Rd. This would provide a public trail from Mana Rd. to Blair Rd. and would also be useful for management access. This trail would be relatively easy to create because it would be along an existing fence line.
   - Improve Spencer trail to Peneki and Peneki to Blair. These improvements would provide the public a legal connector within the forest boundary from Spencer to Peneki as well as fulfill the public interest in connecting Spencer-Peneki-Blair-Mana Rd.
   - Maulua Trail can be used for education and outreach, public recreation and research and management. This trail is a historic route but is not currently easily visible as a trail on the ground. Trail improvement would include establishment/marking of the trail alignment along the approximate historic route, avoidance and appropriate protection/management of remnant historic trail sections.
   - Create trail from Mana Rd. to Maulua roughly parallel to the southern forest boundary (specific location to be determined). This would create a loop trail for the upper area for the public and education/outreach opportunities as well as being useful for management access.

- Create a trail at the FR/NAR boundary (specific location to be determined). This would provide a public trail through high quality forest and would help with management and research site access for management, monitoring and research, particularly for invasive non-native plants.

4. Hunting - Maintain and improve public hunting opportunities in Laupāhoehoe Forest.
   - Secure and improve/create access and trails as outlined above.
   - Facilitate additional hunter education classes in the Laupāhoehoe region.
   - Consider changing permitted hunting method for Unit C (currently rifle only) if desired by the hunting community.
   - Work with DOCARE to address hunting community concerns about illegal activities at Laupāhoehoe Forest and elsewhere on the island.
5. Camping and Shelters - Establish designated camping area at Shack Camp with primitive camp sites (Figure 12).
   - Conduct field surveys of camping and shelter sites to avoid any impacts to botanical, faunal, cultural and historic resources.
   - Construct a shelter or cabin at Shack Camp for both public recreational and management staff use. Cabin would be open to the public using a permitted reservation system.
   - Establish other infrastructure needed for camping and shelters at Shack Camp (composting toilet, fire pits, helicopter landing zone).

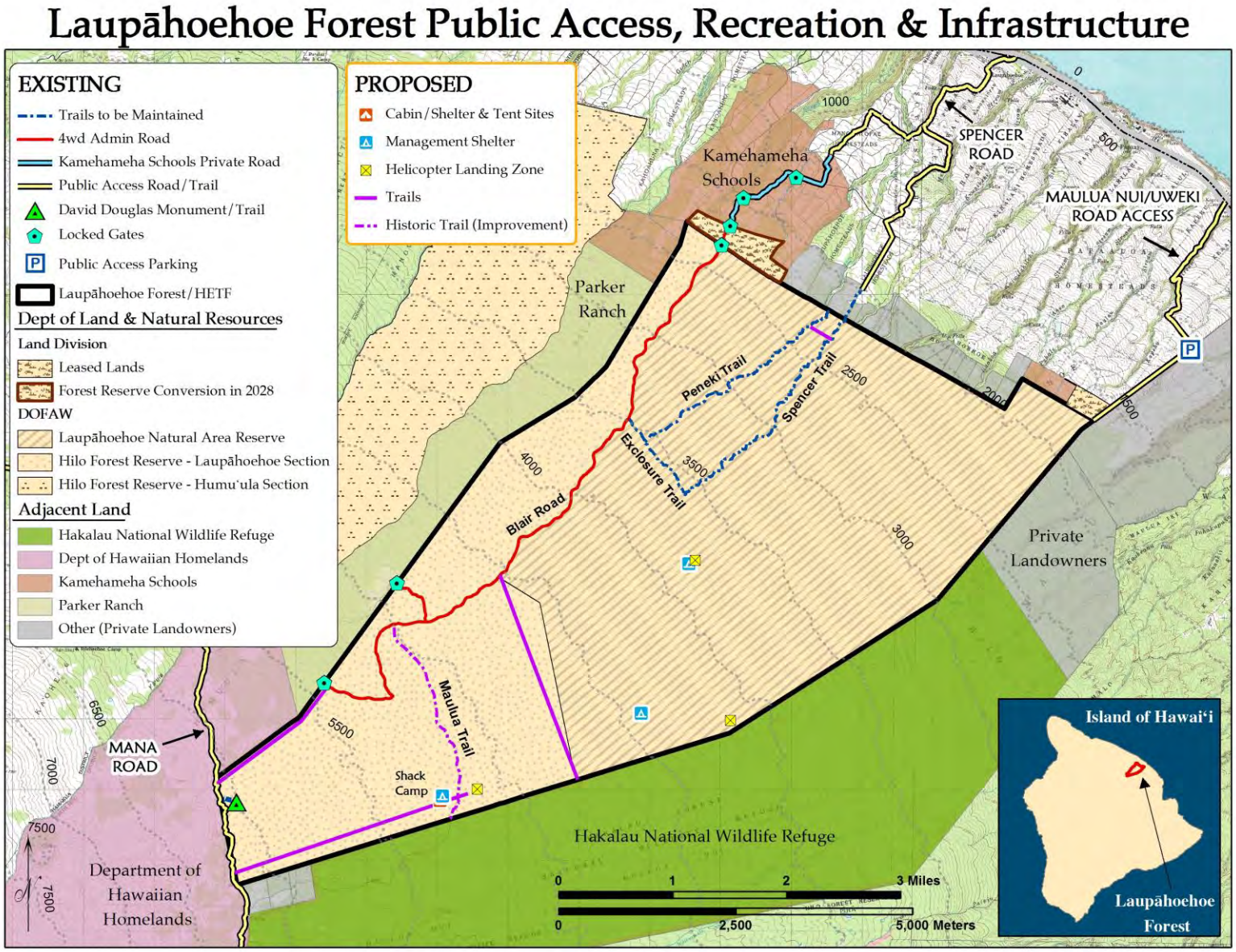
Rationale: Community and LAC member feedback related to public access in Laupāhoehoe Forest ranged widely from comments that current public access is adequate and no additional management actions are needed, to recommendations for expansion and enhancement of vehicular, mountain biking and pedestrian access.

- **Pedestrian access within the forest** – Feedback ranged from current pedestrian opportunities are adequate and no additional management actions are needed, to recommendations to consider the development of highly developed and maintained trails. A majority of comments recommended improving pedestrian access to allow a pedestrian to follow a recognized trail through the forest that would connect to Blair Rd. Due to the rugged terrain of Laupāhoehoe Forest and financial resources needed to create and maintain trails, the proposed actions primarily focus on improving existing primitive trails to allow pedestrians to traverse the forest and enter and exit at existing legal access points. There are numerous primitive trails throughout Laupāhoehoe Forest created and used by the hunting community, but only three of these existing trails would be identified as recognized public trails.
- **Vehicular access to and within the forest** – Feedback ranged from recommendations to dismantle Blair Rd., to opening Blair Rd. to public vehicular access. Blair Rd. is a valuable resource for management, research and education/outreach opportunities in Laupāhoehoe Forest and for these reasons dismantling Blair Rd. was not considered as an action. Opening Blair Rd. to public vehicular access was not considered as an action considering entry is through private lands, road maintenance considerations, and increased risks associated with transport of invasive species. Feedback from LAC

members included holding an annual open house where this could be accommodated or agencies offering chaperoned trips for the public. While an annual open house is not feasible or realistic due to public vehicular access restrictions across neighboring private lands, both USFS and DOFAW currently offer agency chaperoned service learning/outreach opportunities and these types of activities are also proposed for expansion.

- **Mountain biking** – Feedback ranged from mountain biking should not be allowed, to trails should be maintained/created to accommodate mountain biking. Biking is legal on FR roads including Blair Rd. but currently the only way to reach Blair Rd. on a bike is through private property, which is not legal. An alternative considered was multi-use trails that would allow for legal entry; however this was not selected as a plan action because there were only a small number of trails proposed for pedestrian improvement, concerns about user conflicts, and bicycle damage to trails.
- **Hunting** – Feedback from LAC hunter working group members included a desire for the state to pursue game management in the unfenced conservation units within Laupāhoehoe Forest primarily to allow for closures to create recovery periods coupled with DOCARE enforcement. Game management to increase game mammal populations for hunting conflicts with DOFAW management priorities for Laupāhoehoe Forest, as well as with federally designed critical habitat for endangered species. As mentioned elsewhere in this document, the proposed conservation units in this plan attempt to meet conservation needs while also considering hunting community desires. High quality habitat that is less heavily used for public hunting due to remoteness was purposely selected for the conservation units. This plan seeks to increase public hunting opportunities in more accessible areas outside the fenced conservation units through improvements in access. Once this plan is fully implemented, approximately 9,649 acres (3905 ha), or 78% of Laupāhoehoe Forest will be available for public hunting.

Figure 12


Laupāhoehoe Forest Public Access, Recreation & Infrastructure
EXISTING
Trails to be Maintained
4wd Admin Road
Kamehameha Schools Private Road
Public Access Road/Trail
David Douglas Monument/Trail
Locked Gates
Public Access Parking
Laupāhoehoe Forest/HETF
Dept of Land & Natural Resources
Land Division
Leased Lands
Forest Reserve Conversion in 2028
DOFAW
Laupāhoehoe Natural Area Reserve
Hilo Forest Reserve - Laupāhoehoe Section
Hilo Forest Reserve - Humu'ula Section
Adjacent Land
Hakalau National Wildlife Refuge
Dept of Hawaiian Homelands
Kamehameha Schools
Parker Ranch
Other (Private Landowners)
PROPOSED
Cabin/Shelter & Tent Sites
Management Shelter
Helicopter Landing Zone
Trails
Historic Trail (Improvement)
Kamehameha Schools
SPENCER ROAD
MAULUA NUI/UWEKI ROAD ACCESS
Parker Ranch
Peneki Trail
Spencer Trail
Exclosure Trail
Blair Road
Maulua Trail
Shack Camp
MANA ROAD
Private Landowners
Hakalau National Wildlife Refuge
Department of Hawaiian Homelands
0
1
2
3 Miles
0
2,500
5,000 Meters
Island of Hawai'i
Laupāhoehoe Forest

Infrastructure

Background: Infrastructure is needed to improve management, research and education and public recreational uses in Laupāhoehoe Forest. Infrastructure includes roads, facilities, helicopter landing zones and structures, cabins/shelters and equipment.

Objective: Provide and maintain infrastructure and facilities to enhance the ability of the Laupāhoehoe Forest to meet its goals for management, research, education, and demonstration.

Proposed Actions:

1. Develop and maintain roads, cabins/shelters and campsites and helicopter landing zones for resources management actions, the functions of the HETF and for public recreational use and safety (Figure 12):
    - Conduct field surveys of planned infrastructure improvement to avoid any impacts to botanical, faunal, cultural and historic resources.
    - Develop facilities at Shack Camp (described above in Public Access and Recreation section).
    - Establish a forest management shelter and landing zone at 3,500 feet (1067 m) elevation on the south east side of the NAR (specific location to be determined). This shelter will also be available for the public.
    - Establish approximately three other forest management shelters, as needed - locations to be determined.
    - Establish additional helicopter landing zones to be used for management and search and rescue operations - locations to be determined. Helicopter landing zones will use existing natural openings to avoid any damage to natural resources.
2. Ensure the development and maintenance of facilities and infrastructure has minimal impacts on the environment and natural and cultural resources.

CULTURAL RESOURCES

One goal of the Management Plan is to protect the existing cultural and historic resources found within Laupāhoehoe Forest.

> "The mountain landscape, its native species, and the intangible components therein, are a part of a sacred Hawaiian landscape, which itself is a highly valued cultural property. Its protection and the continued exercise of traditional and customary practices in a traditional and customary manner, are mandated by native custom, and State and Federal law" (Maly and Maly 2006).

Actions in the Laupāhoehoe Forest Management Plan are subject to historic preservation review under Hawaii state and federal laws and regulations including HRS § 6E-7 and 8, and HAR §13-275. The project is also subject to Section 106 of the National Historic Preservation Act (Title 54 U.S.C.) and its implementing regulations (36 CFR Part 800) because it may be partially funded through the USFS. As such, before implementing any management (e.g., development of Shack Camp camping site, restoration of Maulua trail, installation of fencing), DOFAW and the USFS plan to complete an archaeological inventory survey, to document and delineate the known

historic features, to identify planned measures to avoid negative impact to historic features, and where appropriate, to identify planned interpretation or preservation plans. The archaeological inventory survey will also evaluate the properties' significance for inclusion on the State and National Register of Historic Places. The inventory survey and consultation with the State Historic Preservation Division (SHPD) will be completed before any ground disturbance near known historic features will occur. Should evidence of any unanticipated archaeological or cultural properties be encountered during implementation of the Management Plan, the activity would immediately cease and the appropriate parties would be consulted immediately.

The recommendations for the treatment of cultural resources as detailed in the cultural study (Maly and Maly 2006) will be incorporated during all phases of implementing the Management Plan:

> "In regards to work which may be undertaken in the proposed Laupāhoehoe HETF, it is important that cultural resources – both tangible and intangible – be respected. For example, should fencing programs or work shelters be developed, care to ensure that cultural remains are not impacted, should be taken. It should be the goal of any undertaking to minimize the foot-print, and ensure that the landscape is left in a natural state. Fencing programs, to protect treasured natural-cultural resources from degradation by introduced animals have a long history in the region. Fencing and control of feral animals dates from the nineteenth century, and was expanded with the development of the forest reserve programs. Early fencing programs were at times destructive of the resources, today, programs designed to minimize the impacts should be employed. All participants in oral history interviews we have conducted over the last ten-plus years for lands of the Hilo forest region and Mauna Kea mountain lands have expressed the thought that care of the land, cultural resources, and forest is important.
>
> We recommend that the HETF program managers and field crew members meet with a SHPD staff person, prior to undertaking any work on fence lines or other ground altering activities. All field crew members employed on any projects in the preserve should be informed of Historic Preservation Guidelines, and made aware that if any stone feature (such as walls, terraces, mounds, platforms, shelters, caves, trails, or boundary ahu) are found, work in the area is to be stopped and modified so as to minimize impacts on such features. The management staff should also monitor all clearing as it is undertaken, to ensure proper treatment of sites, should any be discovered. Should cultural sites be encountered, it is recommended that members of the Hawaiian community at Laupāhoehoe – such as Nā Waiwai o Laupāhoehoe – be contacted, and consultation regarding site treatment should be undertaken along with representatives of the SHPD.
> HRS Chapter 6E, which affords protection to historic sites, including traditional cultural properties of ongoing cultural significance; the criteria, standards, and guidelines currently utilized by SHPD for the evaluation and documentation of cultural sites should be complied with. The Hawai'i Island Representative of SHPD should be notified of any findings, when made.
>
> If inadvertently discovered, burial remains should be protected in place. Work in the immediate vicinity of the remains should be terminated, and the Hawai'i Island Representative of SHPD should be notified of any findings. Final disposition of

remains will be determined in consultation with SHPD, and Native Hawaiian descendants of the families associated with Laupāhoehoe and adjoining lands. If any burial remains should be discovered, they should be treated on a case-by-case basis in concurrence with Chapter 6E-43 (as amended by Act 306).

Finally, it is suggested here, that if funding opportunities arise, and a work-force be needed for various projects (e.g., fencing, game control, and resource monitoring, etc.) that individuals with historical ties to the Laupāhoehoe lands be involved in the programs. Research and stewardship programs will have greater long-term success when members of the local community are informed and active participants. Educational opportunities for local school programs will also help to inform communities of the values of the research being done, while researchers will also be exposed to traditional and historical values the community places on the natural and cultural landscape."

All state and federal employees, permittees and the public are required to comply with state and federal laws relating to the protection of cultural resources. All cultural and historical sites should be left alone and artifacts should not be collected. Burial sites and archeological sites are often accidentally disturbed either by nature (erosion) or by human activity through projects that involve excavation. HAR § 13-300 addresses rules of practice and procedure relating to burial sites and human remains. If a burial site is discovered, activity in the immediate area must be stopped and remains left in place. Reporting a burial site disturbance is required by law (HRS § 6E) and reports of burial sites or other discovered cultural resources (such as but not limited to prehistoric artifacts, stone platforms, cairns, caves, etc.) should be made immediately to SHPD Kakuhihewa Building, 601 Kamokila Blvd., Suite 555, Kapolei, HI 96707; Ph: (808) 692-8015.

All Federal agencies are subject to The Native American Graves Protection and Repatriation Act (NAGPRA), a Federal law passed in 1990. NAGPRA provides a process for museums and Federal agencies to return certain Native American cultural items -- human remains, funerary objects, sacred objects, or objects of cultural patrimony -- to lineal descendants, and culturally affiliated Indian tribes and Native Hawaiian organizations. NAGPRA includes provisions for unclaimed and culturally unidentifiable Native American cultural items and penalties for noncompliance and illegal trafficking.

Cultural Resources in Laupāhoehoe Forest include maile and palapalai

ADMINISTRATION

Coordination

The Cooperative Agreement that established the HETF states that "owing to the many values and benefits that arise from research, education and demonstration on the HETF and elsewhere, the Parties (the USFS and the state of Hawai‘i) further agree they will consult and reach agreements with each other to coordinate research, management, and education activities." Coordination of research, management and education is managed by the HETF Planning Group, which includes IPIF and DOFAW staff and two to three external partners. The HETF Planning Group is facilitated by the USFS and meets quarterly. The USFS produces an annual report for the BLNR and NARS Commission summarizing research, management and monitoring actions in the HETF.

Permitting

Permit applications for research and education activities Laupāhoehoe Forest are reviewed by agency staff in the HETF Planning Group as well as the LAC (which provides comments and/or recommendations). Permit processing and tracking is administered by the USFS. Signing authority for all permits lies with the Hawai‘i Island DOFAW Branch Manager (permit approval authority for the NAR was delegated to the Branch Manager by the NARSC on May 21, 2007). All research permits are valid for one year and require an annual report. Permits include specific conditions including avoidance and reporting of historic site/artifacts and threatened and endangered species, fire prevention, appropriate research markers/infrastructure, biosecurity, etc. The HETF research application can be viewed at http://www.hetf.us/page/conducting_research/. The research permit application is reviewed and updated as needed as information and conditions change.

Biosecurity

Biosecurity is a set of precautions that aim to prevent the introduction and spread of harmful organisms (pests, pathogens or invasive species) into Laupāhoehoe Forest. New plants and animals arrive in the islands on a continual basis. On average, 100 new plants, 20 species of insects, plus the occasional disease are introduced to Hawai‘i each year (Nature Conservancy of Hawai‘i 2003). The source population of an invasive species can be the mainland, another island in the Hawaiian archipelago or even another area from the same island. Preventing the introduction of new invasive species into Laupāhoehoe Forest by staff, researchers and the general public is a high priority as these introductions only serve to increase the funding needed to control these species and further put Hawai‘i’s native forests at risk.

Organism introduction in Laupāhoehoe Forest can occur via transportation by animals or humans, the wind and/or through species nearby expanding their range (e.g., coqui frog and little red fire ant). There is also the risk of introductions from management work such as outplanting native plants grown in a nursery or road maintenance with heavy equipment that is not clean. Staff and individuals approved for research or education permits are provided information and protocols to help minimize or eliminate the introduction and spread of alien organisms (plants, animals and diseases into Laupāhoehoe Forest (Appendix B), and they are responsible for ensuring biosecurity protocols are followed.

Sightings of new alien organisms within Laupāhoehoe Forest or existing high risk organisms seen in previously un-infested areas should be reported to DOFAW or the HETF.

Safety

Overall Laupāhoehoe Forest terrain is very rugged and existing trails are primitive, uneven and muddy. The weather can be variable and conditions for heat stroke and hypothermia are possible given the elevation and weather patterns in this forest. Cell phone service is intermittent. Hunting with rifle is permitted in the upper portion and hunting with dogs is permitted in the lower portion. Forest visitors/users should dress appropriately for variable weather conditions, wear highly visible attire in consideration of hunting, and travel with adequate food and water. Other hazards include but are not limited to flash floods and falling trees and/or branches.

Vehicle access to the makai forest boundary currently includes traveling over a low water crossing. Heavy rains in the mauka areas of the forest can create flash floods and hazardous conditions at the low water crossing. Forest visitors are advised to always identify a person to check in and out with that knows their planned route and can alert search and rescue teams should the forest visitor not check in when expected.

Budget and Staffing

NAR staff for the island of Hawai‘i work on all eight NAR on the island, including Laupāhoehoe. Currently, NAR staff include six DOFAW staff, six University of Hawai‘i contractors (Pacific Cooperative Studies Unit) and 2 year-round interns. Forestry staff works on all nineteen forest reserves on the island. Currently there are eight staff (1 Botanist, 4 Foresters and 3 Technicians).

USFS staff works across the Hawaiian Islands and the Pacific. Staff dedicated to the HETF currently includes one full time and one part time administrative positions and the IPIF Director. Education and outreach goals are currently meet via contributions to partner programs such as YCC, PIPES and watershed partners as well as through USFS volunteers.

Table 7 outlines estimated expenses related to specific projects and activities such as equipment, supplies, additional staff or contractor time. Costs are very broad estimates and will vary considerably over the time-frame of the plan. Existing staff costs are considered fixed and outlined above, although these may change due to state and federal budget fluctuations. Costs described as ‘to be determined’ or ‘TBD’ are unknown at this time. Funding to implement the estimated budget will be sought from various state, federal and private entities through annual budget requests as well as grants and/or other funding sources.

Youth Conservation Corps interns assist staff with management actions while receiving training in natural resources management.

Table 7. Estimated costs

ACTION	DESCRIPTION	Periodic estimated costs		Annual estimated costs	ESTIMATED TOTAL COST (15 years)
		Amount	Time scale		
Natural Resources					
Forest Protection and Management					
1. Fence Construction and pig removal from conservation units	Fence construction (materials and contractual labor)	$5,000,000.00	one time	$0.00	$5,000,000.00
	DOFAW staff feral pig removal	$350,000.00	one time	$0.00	$350,000.00
2. Inspect/Maintain/Replace all fences	DOFAW staff, supplies/materials	$0.00	n/a	$15,000.00	$225,000.00
3. Restore forested ecosystems	DOFAW staff, supplies/materials	$0.00	n/a	$20,000.00	$300,000.00
4. Control non-native pasture grasses and other non-native invasive weeds in restoration	DOFAW staff, supplies/materials	$0.00	n/a	$20,000.00	$300,000.00
5. Construct emergency rare plant exclosures	DOFAW staff, supplies/materials	$0.00	n/a	$5,000.00	$75,000.00
6. Pursue potential land acquisitions for protection and restoration of a large landscape	DOFAW and USDA-FS Staff – No additional Costs	$0.00	n/a	$0.00	$0.00
7. Monitor forest health and manage threats (e.g. rapid ʻōhiʻa death or other disease or insect pests	DOFAW and USDA-FS Staff – No additional Costs (Monitoring). Management Costs TBD	TBD	n/a	TBD	TBD
Invasive Non-native Plant Control					
1. Monitor/ map high priority invasive non-native plants and develop a control strategy	DOFAW staff, supplies/materials	$0.00	n/a	$5,000.00	$75,000.00
2. Control priority non-native invasive plants in identified areas using approved methods	DOFAW staff, supplies/materials	$0.00	n/a	$35,000.00	$525,000.00
3. Monitor to determine whether control is effective and detect change in distribution/ abundance.	Costs included in #1 (invasive non-native plant control)	$0.00	n/a	$0.00	$0.00
4. Maintain procedures to prevent introduction of new weeds (biosecurity)	DOFAW and USDA-FS Staff – No additional Costs	$0.00	n/a	$0.00	$0.00
Rare Species Restoration					
1. Maintain the integrity of high quality forest ecosystems	Costs included in #1 (forest protection and management and invasive non-native plant control)	$0.00	n/a	$0.00	$0
2. Map, monitor and protect existing wild populations of rare and endangered species	DOFAW staff, supplies/materials - $5,000/year	$0.00	n/a	$5,000.00	$75,000

ACTION	DESCRIPTION	Periodic estimated costs		Annual estimated costs	ESTIMATED TOTAL COST (15 years)
		Amount	Time scale		
3. Re-introduce rare and endangered plants in appropriate protected habitat through outplanting.	DOFAW staff, supplies/materials - $5,000/year	$0.00	n/a	$5,000.00	$75,000
	Contractor Costs (VRPF and PEPP) - $5,000/year	$0.00	n/a	$5,000.00	$75,000
4. Determine addition actions needed to protect rare invertebrates	Costs to be determined	TBD	TBD	TBD	TBD
5. Enhance habitats for native species through small mammalian predator removal and other management	Costs to be determined	TBD	TBD	TBD	TBD
Monitoring					
1. Continue ongoing monitoring programs for ungulates, non-native invasive plants and rare plants	DOFAW staff, supplies/materials; Additional Costs included in #1 (invasive non-native plant control), #2 (rare species restoration)	n/a	n/a	$5,000.00	$75,000
2. Continue monitoring program for forest birds.	DOFAW staff and contractor monitoring/ data analysis costs - every five years (years 2019, 2024 and 2029)	$35,000.00	3	n/a	$105,000
3. Develop improved monitoring protocols, data management and analysis	Contractor staff costs - $10,000/year	n/a	n/a	$10,000.00	$150,000
4. Develop appropriate monitoring protocols and implement monitoring for key community indicators	Costs included in #3 (Monitoring)	n/a	n/a	$0.00	TBD
	Other costs TBD	TBD	TBD	TBD	
Wildfire Prevention and Response					
1. Implement fire prevention measures	DOFAW Staff – No additional Costs	0	n/a	0	0
2. Control invasive plants to restore disturbed areas to prevent fire and/or following damage from fire.	Costs included in #2 (invasive non-native plants)	0	n/a	0	0
3. DOFAW staff to suppress fires to minimize wildfire impacts.	TBD – dependent on size, location and intensity of fire	TBD	TBD	TBD	TBD
4. Continue DOFAW staff training and certifications for fire response.	DOFAW Staff – No additional Costs	0	n/a	0	0
5. Maintain access and fuelbreaks for fire pre-suppression and suppression.	DOFAW Staff – No additional Costs	0	n/a	0	0
Research					
1. Promote applied research with direct relevance to land management issues	Potential monetary incentives to promote work through competitive proposals and/or grants as well as contract work to target specific goals.	$0.00	n/a	$20,000.00	$300,000.00
2. Effectively administer and coordinate the research application process	USDA-FS and DOFAW staff – no additional costs	$0.00	n/a	$0.00	$0.00

ACTION	DESCRIPTION	Periodic estimated costs		Annual estimated costs	ESTIMATED TOTAL COST (15 years)
		Amount	Time scale		
3. Establish and maintain system for archiving research data and reports to facilitate exchange and transfer of information	USDA-FS – no additional costs; possible tie in with education/outreach staff see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
4. Improve dissemination of scientific results to land managers and the local community.	USDA-FS – no additional costs; tie in with education/outreach costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
5. Promote cultural research including information on traditional Hawaiian use/presence, oral histories, cultural impacts of management actions and archeological studies.	Promote work through competitive proposals and/or grants as well as contract work to target specific goals.	$0.00	n/a	$20,000.00	$300,000.00
6. Link ongoing research to education programs	USDA-FS staff – no additional costs; possible tie in with education/outreach staff costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
7. Encourage basic research and monitoring to establish historical baselines of all natural resources.	USDA-FS staff – no expected additional staff costs; potential monetary incentives to promote work through competitive proposals and/or grants	$0.00	n/a	$0.00	$0.00
Education and Outreach					
1. Encourage appropriate educational and cultural uses through the development of general criteria, priorities and rules.	DOFAW and USDA-FS Staff – No additional Costs; possible tie in with education/outreach staff costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
2. Provide general orientation and training for all new research permitees and educational programs.	USDA-FS staff – no additional costs; possible tie in with education/outreach costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
3. Collaborate with universities and non-governmental organizations to integrate classes, student research/internships and provide support.	USDA-FS staff– no additional costs; possible tie in with education/outreach staff see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
4. Foster and support undergraduate and graduate student research opportunities and research internships.	USDA-FS staff – no additional costs; apply for funding to support training positions	$0.00	n/a	$20,000.00	$300,000.00
5. Provide a connection to nature through educational activities that involve the public and K-12 partners.	USDA-FS and DOFAW staff – no additional costs; possible tie in with education/outreach staff costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
6. Communicate research findings, land use, and management goals to the community	DOFAW and USDA-FS staff– no additional costs; possible tie in with education/outreach staff costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
7. Provide work experience/professional development training to land management professionals	DOFAW and USDA-FS Staff – No additional costs; tie with EDU/OUTREACH #11; apply for funding to support training such as YCC and 21 CSC $50K+/year	$0.00	n/a	$50,000.00	$750,000.00

ACTION	DESCRIPTION	Periodic estimated costs		Annual estimated costs	ESTIMATED TOTAL COST (15 years)
		Amount	Time scale		
8. Serve as a demonstration site for land managers by providing information, tools and techniques	DOFAW and USDA-FS staff– no additional costs; possible tie in with education/outreach staff costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
9. Provide readily accessible scientific information through web-based platforms and tools.	USDA-FS staff– no additional costs; tie in with education/outreach costs see EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
10. Encourage researchers to share research results with the local community	DOFAW and USDA-FS Staff – No additional Costs	$0.00	n/a	$0.00	$0.00
11. Hire staff and/or establish volunteer positions to facilitate educational and outreach experiences	$75,000/year for contract staff salary/benefits, materials/supplies and volunteer program	$0.00	n/a	$75,000.00	$1,125,000
12. Serve as a site for alternative educational activities for non-profit groups and organizations	Costs included under EDU/OUTREACH #11	$0.00	n/a	$0.00	$0.00
Public Access and Recreation					
1. Improve Public Access	DOFAW and USDA-FS staff – no additional costs; TBD funds to purchase or lease adjacent lands	TBD	TBD	TBD	TBD
2. Trail Maintenance (Pedestrian) - Maintain existing trails (Spencer, Maulua & Peneki)	DOFAW and USDA-FS staff – no additional costs; apply for funding to support training positions such as YCC and 21 CSC – see EDU/OUTREACH #7	$0.00	n/a	$5,000.00	$75,000.00
3. Trail Improvement (Pedestrian) - Improve existing and/or create new trails and maintain	DOFAW and USDA-FS staff – no additional costs; apply for training funding – see EDU/OUTREACH #7	$0.00	n/a	$5,000.00	$75,000.00
4. Hunting - Maintain and improve public hunting opportunities in Laupāhoehoe Forest	TBD funds to purchase or lease adjacent lands	TBD	TBD	TBD	TBD
5. Camping and Shelters - Establish designated camping area at Shack Camp with primitive camp sites	$50K/shelter; $8K camping pavilion; 3 campsites @ $1500/each; $2,500/year maintain shelter(s)/ campsites	$62,500.00	one time	$0.00	$62,500.00
Infrastructure					
1. Develop and maintain roads, cabins/shelters and campsites and helicopter landing zones	USDA-FS staff– no additional costs; materials/ labor for project – see PUBLIC ACCESS/REC #5; $5,000/year to maintain shelter(s), camping sites and LZ's	$0.00	n/a	$5,000.00	$75,000.00
2. Ensure the development/maintenance of facilities and infrastructure has minimal impacts	DOFAW, USDA-FS, and MKWA staff – no additional costs; apply for funding to support cabins/shelters and campsites; road maintenance costs $3K/year	$0.00	n/a	$3,000.00	$45,000.00

TOTAL COST OVER 15 YEARS **$10,212,800.00**

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Appendix A – Other Available Resources

The following resources related to Laupāhoehoe Forest are available on-line at:
http://dlnr.hawaii.gov/ecosystems/nars/reserves/hawaii-island/laupahoehoe/

1) *Hilo Palikū - Hilo of the Upright Cliffs: A Study of Cultural-Historical Resources of Lands in the Laupāhoehoe Forest Section, Ahupua'a of the Waipunalei-Mauluanui Region, North Hilo District, Island of Hawai'i* (Maly and Maly 2006)

2) Laupāhoehoe Plant Species List

Appendix B – Biosecurity Protocols

HETF BIOSECURITY

What is Biosecurity and why is it important?

Biosecurity is a set of precautions that aim to prevent the introduction and spread of harmful organisms. These may be pests, pathogens or invasive species. Biosecurity measures are the practical steps designed to minimize the risk of introducing or spreading pests and diseases. Control of invasive plants and animals is a high priority for all resource managers in Hawai'i. A large amount of personnel time and resources are expended each year to battle invasive species. Biosecurity is important because invasive species have significant negative impacts to resources - including native species, ecosystem function (e.g. nutrient cycling), ecosystem services (e.g. ground-water recharge, prevention of erosion, reef sedimentation, etc.), ecosystem structure (distribution and abundance of species), etc. New plants and animals arrive in the islands on a continual basis and natural resource managers must focus on preventing their spread into natural areas. Visitors, volunteers, contractors, researchers and staff are potential vectors of invasive species. The origin of these pests can be the mainland, another island in the Hawaiian archipelago or even a weedy or urban area of the same island.

Described below are likely routes of invasive species introduction and procedures that should be followed to minimize or eliminate introduction and spread of invasive plants and animals in the Hawai'i Experimental Tropical Forest.

Required HETF Biosecurity Measures:

1. **Inspect field gear and equipment BEFORE going into the field**. Three categories of pests that merit attention are weeds/seeds, insects (especially ants and cockroaches), and slugs. Clods of dirt or mud can hide these hitchhikers. If materials have been in storage, be aware that arthropods can lay eggs within equipment. It is necessary to inspect and clean all: footwear (treads, laces, boot tongues); socks; pant legs; pockets, jackets, raingear (pockets and cuffs); food-stuffs; tools; packs (folds, pockets, Velcro); tents; hammocks; tarps; helicopter sling nets; wood and building materials; fencing materials; bottoms of plastic buckets; tool bags; and other containers or equipment.

Soil, cinder and potted plants are also major invasive species transporters. Ensure soil and cinder are sterile and free of insects. Potted plants should be visibly weed-free, pest-free, and pathogen-free, anything suspicious should not be taken into the field.

Preferably a different set of field gear should be used for each field site. If this is not possible, gear should be thoroughly cleaned before going into the field. All gear (personal or field) must be free of any plant, animal, or earthen materials. Appropriate methods for cleaning include: water and hose, brush, clean rag, knife edge, bleach rinse and/or insecticide. Cleaning should be done away from the forest in a designated area with a nearby receptacle for disposal. Laundering of washable items should be done after each trip. This is particularly important when you have come from working on different islands or different parts of the island, as each area may have its own assemblage of pests that must be prevented from spreading to new locations. If items cannot be cleaned, they should not be taken into the forest.

2. **Prepare a checklist of items to be inspected before any extended field operations or camping trips.** Note all materials that will accompany staff during these operations. On prep day, an assigned person should inspect those supplies, concentrating on those most susceptible in aiding accidental introductions. Items having the potential for carrying unwanted species: helicopter sling nets, wood, building materials, fencing material, plastic buckets, cardboard boxes (roaches and ants!), open food and water containers, tool bags, backpacks, raingear and tents. Methods for cleaning articles range from using brushes, tweezers, bleached rags, or insecticides. Have these items on hand. If contaminated supplies are found, they must be disposed of away from the HETF.

3. **Avoid carrying weed seeds from an infested part of the forest to the pristine areas.** If routes of transit go through invasive weed belts, be conscious of the potential for spread. A safeguard could be having a brush on hand to clean shoe soles at the boundary of such a site. This is especially a concern when performing priority weed work where there is a large seed bank. When working in a different area, be very careful to avoid spreading pests by inspecting and cleaning gear before and after each excursion into the field. It is important to use completely different gear on each island or area.

4. **Keep field vehicles clean.** Clean field gear can easily be compromised by using a dirty truck. The inside of field vehicles should be vacuumed and pickup truck beds swept out regularly, especially if used off-road. When cleaning vehicles it is important to pay particular attention to the inside lip of bummers, seats, floors, dashboards, door jambs, tires (especially treads) and the undercarriage. All mud should be hosed off to avoid transporting weed seeds.

Continued on next page

L-R: Faya *(Morella faya)*, Miconia *(Miconia calvescens)*, Smoke bush *(Buddleja madagascariensis)*, Cotoneaster *(Cotoneaster pannosus)* and Pampas grass *(Cortaderia jubata)*. *ALL are invasive.*

Photo credits: Forest and Kim Starr

5. **Pack out your trash and unused foodstuffs.** Something as harmless as an apple core or banana peel could result in dire consequences out in the field. Discarded foods can become food for invasive insects, like ants; seeded fruits (apples, pear, avocado, peach, etc.) could germinate, as certain seeds have a strong potential to naturalize. Many foods carry unseen insects, fungus, bacteria and parasites that could affect native flora and fauna, Hawai'i has many closely related species that could be negatively affected by leaving behind foodstuffs.

6. **Become acquainted with invasive species in Hawai'i** and their varying status regarding particular localities. Learn which of these species is localized to your area and which to be on the alert for that are established in other areas. Take inventory of weeds that occur along trails and byways, and pay attention to any unusual changes or additions to these. There is plenty of literature on the identification of weedy plants that will provide current status throughout the various islands. Start with www.hear.org.

7. **Educate visitors to these protocols.** This includes other researchers, visitors, or volunteer groups. A very high probability exists that much of these visitors' gear (primarily packs and footwear) has been to other areas in Hawai`i that have infestations of alien species, and they could act as dispersal agents. People who share our appreciation of Hawai`i's native forests will not be insulted by these procedures if related firmly yet politely, but rather will be impressed with their conscientious implementation.

New Invasive Species Detection

Sightings of new invasive species within the HETF or existing high risk species seen in previously un-infested areas should be reported to the:

Hawai'i Experimental Tropical Forest
(808) 443-5931
hawaii_experimental_tropical_forest@fs.fed.us

Please provide the following information in your report: 1) Your name and contact information, 2) date you observed the species, 3) species name and/or detailed description, 4) approximate location (latitude/longitude, UTM, or other approximate estimation) of the organism, and 5) a rough estimate of the overall size of the area infested (if stationary).

There are additional invasive species of serious concern to land managers that are present in adjoining areas but have not yet been detected in HETF Units. It is a high priority to prevent the establishment of these species, which include but are not limited to:

Fire Thorn *(Pyracantha angustifolia)*

Laupāhoehoe
- Miconia (Miconia calvescens)
- Faya (Morella faya)
- Gorse (Ulex europaeus)
- Firethorn (Pyracantha angustifolia)
- Cotoneaster (Cotoneaster pannosus)
- New Zealand flax (Phormium tenax)
- Indonesian cinnamon (Cinnamomum burmanii)
- Red Robin (Photinia davidiana)
- Ants (especially Little Red Fire Ants)

Pu'u Wa'awa'a
- Cotoneaster (Cotoneaster pannosus)
- Pampas Grass (Cortaderia jubata and selloana)
- Pereskia (Pereskia aculeata)
- Rubbervine (Cryptostegia madagascariensis)
- Smokebush (Buddleja madagascariensis)
- Wax Myrtle (Morella cerifera)
- Barbados Gooseberry (Pereskia aculeata)
- Jerusalem Thorn (Parkinsonia aculeata)
- Axis Deer (Axis axis)
- Ants (especially Little Red Fire Ants)

KNOWN AND POTENTIAL RISKS

FOR INFORMATION ON CURRENT PEST SPECIES THAT SHOULD BE REPORTED IF SEEN VISIT:
http://www.reportapest.org/pestlist.htm

L-R: Gorse (*Ulex europaeus),* Pereskia *(Pereskia aculeata),* Axis Deer *(Axis axis),* Rubbervine *(Cryptostegia madagascariensis) and* Jerusalem Thorn (Parkinsonia aculeata). *ALL are invasive.* Plant photo credits: Forest and Kim Starr. Axis deer photo credit: daemonsandanalyses.tumblr.com

Other invasive species may be added to the priority invasive species list if monitoring shows their range and abundance increasing in native ecosystems targeted for management.

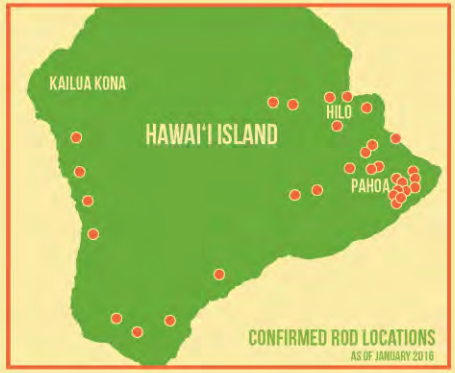
RAPID 'ŌHI'A DEATH

A NEWLY IDENTIFIED DISEASE

A disease that is new to science and new to Hawai'i has killed hundreds of thousands of 'ōhi'a trees (*Metrosideros polymorpha*) across more than 34,000 acres of Hawai'i Island. Known as **Rapid 'Ōhi'a Death (ROD)**, it is caused by a **fungus** called *Ceratocystis fimbriata*. **We can all help minimize further spread**, and buy time to help researchers find answers and potential treatments. **New information is being uncovered almost every week.**

This disease has the potential to kill 'ōhi'a trees statewide. The most important thing we can all do now is help **prevent ROD from spreading.**

'Ōhi'a lehua is the backbone of Hawai'i's native forests and watersheds which are our source of fresh water in these islands. 'Ōhi'a trees cover more than 1 million acres statewide—they are perhaps the most important tree in Hawai'i.



BROCHURE UPDATED FEBRUARY 2016

FOR THE LATEST INFORMATION, MAPS, AND UPDATES ON RAPID 'ŌHI'A DEATH PLEASE VISIT:

www.rapidohiadeath.org
www.facebook.com/rapidohiadeath

IF YOU SUSPECT ROD IN YOUR AREA PLEASE CONTACT:

Dr. J.B. Friday
UH Cooperative Extension Service
Email: jbfriday@hawaii.edu
Phone: (808) 969-8254

Dr. Flint Hughes
USDA Forest Service
Email: fhughes@fs.fed.us
Phone: (808) 854-2617

Dr. Lisa Keith
USDA Agriculture Research Service
Email: Lisa.Keith@ars.usda.gov
Phone: (808) 959-4357

UH MĀNOA COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES
USDA AGRICULTURE RESEARCH SERVICE
USDA INSTITUTE OF PACIFIC ISLANDS FORESTRY
DEPARTMENT OF LAND AND NATURAL RESOURCES, DIVISION OF FORESTRY AND WILDLIFE

RAPID 'ŌHI'A DEATH

WHAT YOU CAN DO TO HELP PREVENT THE SPREAD

NEW QUARANTINE RULE

Because this disease could have devastating impacts on Hawai'i's 'ōhi'a forests, and people could accidentally spread it, the Hawai'i Department of Agriculture passed a new quarantine rule that prohibits interisland movement except by permit of all 'ōhi'a plant or plant parts including:

- Logs, wood, leaves, twigs, flowers, seeds, stems, cuttings.
- Untreated wood, green waste, mulch, sawdust, wood chips and frass (wood dust from boring beetles).

The movement of soil is also prohibited except by permit.

All these materials could carry the fungus and spread the disease. The fungus can stay viable for over a year.

To apply for permits to move 'ōhi'a products that can be demonstrated to be free of disease or soil, please visit: **HDOA.HAWAII.GOV**

Symptoms of the Disease

- **Crowns** of 'ōhi'a trees that appear healthy turn **yellowish** or **brown** within days to weeks; **dead leaves remain** on branches for some time.
- **All ages of 'ōhi'a** trees can be affected and can have symptoms of browning of branches and/or leaves.
- If a tree with ROD is cut down, or a section of the tree is removed, the **fungus shows up as dark staining in the sapwood** along the outer edge, and there may be an over-ripe fruit-like odor.
- Trees within a given stand **die in a haphazard pattern**; the disease does not appear to radiate out directly from infected or dead trees.

FOR MORE INFORMATION:
VISIT **rapidohiadeath.org**

5 THINGS YOU CAN DO

1 DON'T MOVE 'ŌHI'A

Do not move 'ōhi'a wood, firewood or posts, especially from an area known to have ROD. If you don't know where the wood is from, don't move it.

2 DON'T TRANSPORT 'ŌHI'A INTER-ISLAND

Comply with the new quarantine rule to help prevent ROD from spreading. Don't move 'ōhi'a plants, wood, or other 'ōhi'a plant parts inter-island without a permit.

3 CLEAN YOUR TOOLS

Use only these proven cleaning methods—other methods have been tested and they don't kill the fungus. Tools used for cutting 'ōhi'a trees (especially infected ones) should be cleaned with 70% rubbing alcohol.

4 CLEAN YOUR GEAR

Clean your shoes, and clothing. Decontaminate shoes by dipping in 70% rubbing alcohol to kill the ROD fungus. Other gear can also be sprayed with 70% rubbing alcohol. Wash clothing in hot water and detergent.

5 WASH YOUR VEHICLE

Wash the tires and undercarriage of your vehicles with detergent and remove all soil or mud, especially after traveling from an area with ROD and/or if you have traveled off-road.

Appendix C - List of Research Projects to Date

Studies are grouped by total project years (one, two, or 3 and greater), then by project start date, and last name as of May 16, 2016.

Project Description	Name	Affiliation	Project Start Date	Project End Date	Total Years of Project
Comparative nutritive values of traditional and exotic foraging substrates for upper elevation forest birds.	Kapono, M.	UH-Hilo	2007	2008	1
An assessment of tropical ecosystem dynamics in response to climate variability using long-term satellite data records.	Park, S.	UH-Hilo	2007	2008	1
Sprouting vs. seeding in Hawaiian wet, mesic, and dry forests.	Busby, P.	Stanford University	2008	2009	1
Objective quantification of plumage coloration of a Hawaiian honeycreeper (*Hemignathus virens*) along environmental gradations of biogeography: does variation exist between sub-populations?	Gaudioso, J.	UH-Hilo; USGS-PIERC	2008	2008	1
Study of the molecular evolution of arthropods - phylogenetic study.	O'Grady, P.	UC-Berkeley	2008	2009	1
Study of alien snails, survey of native snails	Yeung, N	UH-Manoa	2008	2009	1
Examining the impacts of strawberry guava on Native biodiversity in Hawaiian forest	Giardina, C.	USDA Forest Service	2009	2010	1
Remote sensing across multiple spatial scales for use with calibration of satellite sensors.	Goodenough, D.G.	Canadian Forest Service Natural Resources	2009	2010	1
Soil Survey		USDA-NRCS	2009	2010	1
DNA sequencing of endemic Hawaiian Drosophila.	Price, D.	UH-Hilo	2012	2013	1
Soil Carbon Cycling Across a Hawaiian Mineralogical Gradient	Cusack, D.	UCLA	2015	2016	1
Climatic influences on Lycopsid and fern leaf physiognomy	Benca, J.	UC-Berkeley	2013	2014	1
Community assembly & diversification of Hawaiian Arthropods	Gillespie, R.	UC-Berkeley	2013	2014	1
Experimental cultivation of simple rare ferns in common garden conditions.	Husby, C.	Montgomery Botanical Center	2013	2014	1
Epiphytes as an indicator of climate change in Hawaii	Kettwich, S.	UH-Hilo	2013	2014	1

Project Description	Name	Affiliation	Project Start Date	Project End Date	Total Years of Project
Assessment of mosquito-borne avian disease risk in non-breeding habitat for foraging iiwi adjacent to Hakalau Forest NWR	LaPointe, D.	USGS-PIERC	2013	2014	1
Assessing the *Scotorythra paludicola* outbreak on koa: population abundance, rates of parasitism and patterns of spread	Peck, R.	UH-Hilo	2013	2014	1
UH Hilo Geography and Environmental Studies Senior Seminar	Price, J.	UH-Hilo	2013	2014	1
An assessment of Hawaiian tropical ecosystem dynamics in response to climate variability using long-term satellite data records.	Miura, T.	UH-Manoa	2007	2009	2
Passive study of vocalizations of Hawaiian hoary bat for evaluation of conservation status.	Bonaccorso, F.	USGS-PIERC	2008	2010	2
Developing a DNA barcoding method to be used as a system of species identification	Magnacca, K.	UH-Hilo	2009	2011	2
Do expected evolutionary trade-offs in enzyme activities manifest at the level of microbial community function?	Bradford, M	Yale University	2010	2012	2
Inventory of Hawaii's Forests	Hughes, F.	USDA-USFS	2011	2013	2
Understanding the genetic variation in *Acacia koa* across environmental gradients	Michler, C.	USDA-USFS; Purdue University	2012	2014	2
Quantifying the effects of ungulate and vegetation on the hydrology of Hawaiian tropical forests	MacKenzie, R.	USDA-USFS	2012	2014	2
Local adaptation in an ericoid mycorrhizal symbiosis	Leopold, D.	Stanford University	2014	2016	2
Long-term monitoring of forest and climate inventory	Cordell, S.	USDA-USFS	2007	ongoing	3+
Forest architecture, Carbon dynamics, and climate change interactions: linking field and remote sensing along temporal and spatial gradients.	Broadbent, E.	Stanford University; Carnegie Institute of Washington	2008	2012	3+
Investigating productivity of koa forests on different substrates and climate zones. Long-term plots.	Friday, J.B.	UH-Manoa-CTAHR	2008	2012	3+

Project Description	Name	Affiliation	Project Start Date	Project End Date	Total Years of Project
Sources and fates of nutrients on a substrate age gradient across the Hawaiian archipelago and their consequences for forest dynamics.	Vitousek, P.	Stanford University	2008	ongoing	3+
Assessing Forest Structure, community composition, diversity, carbon mass, and biomass on a landscape scale in the HETF	Hughes, F.	USDA-USFS	2009	2015	3+
Experimental Test of the impacts of rising temp on C input, allocation, and loss in model forests.	Litton, C.	UH-Manoa	2009	ongoing	3+
Hawaiian Hoary Bat habitat occupancy, reproduction and diet	Bonaccorso, F.	USGS-PIERC	2010	2014	3+
Adaptive Radiation in Hawaiian Spiders	Gillespie, R.	UC-Berkeley	2011	2014	3+
Forest Disease Monitoring for Rust Disease affecting Ohia Lehua	Yeh, A.	Contractor for DLNR/DOFAW Forest Health	2011	ongoing	3+
Impacts of strawberry guava management across a density gradient	Johnson, T.	USDA-USFS	2013	2028	3+
Operational Disease Screening Program for Resistance to Wilt in Acacia Koa in Hawaii	Yeh, A.	Contractor for DLNR/DOFAW Forest Health	2014	2017	3+