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JAN 23 2016

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COMMISSION ON WATER RESOURCE MANAGEMENT

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LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

January 8, 2015

TO: Scott Glenn, Director
Office of Environmental Quality Control

FROM: ssw Suzanne D. Case, Chairperson
Department of Land and Natural Resources

SUBJECT: Request for publication of "Draft Environmental Assessment for the Habitat Conservation Plan for Game Management at Puʻu Waʻawaʻa and Puʻu Anahulu, Nāpuʻu Conservation Project" in the January 23, 2016 Environmental Notice

We respectfully request publication of the "Draft Environmental Assessment for the Habitat Conservation Plan for Game Management at Puʻu Waʻawaʻa and Puʻu Anahulu, Nāpuʻu Conservation Project" in the January 23, 2016 Environmental Notice.

Please find enclosed a complete OEQC publication form, one hard copy of the document and one electronic copy of each document in PDF form on CD.

Please contact Division of Forestry and Wildlife, Wildlife Program Manager James Cogswell at james.m.cogswell@hawaii.gov or 808-587-4187 with any questions.

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QUALITY CONTROL

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JAN 23 2016

July 2015 Revision

**AGENCY ACTION
SECTION 343-5(b), HRS
PUBLICATION FORM**

| | |
|---|---|
| **Project Name:** | **Habitat Conservation Plan for Game Management at Pu'u Wa'awa'a and Pu'u Anahulu, Napu'u Conservation Project, Island of Hawai'i, Hawai'i** |
| **HRS §343-5 Trigger(s):** | Use of state land and state funds |
| **Island:** | Hawai'i Island |
| **District:** | North Kona |
| **TMK:** | TMKs 3-7-1-003-001,3-7-1-004-001,3-7-1-004-018,3-7-1-001-001,3-7-1-001-004,3-7-1-001-006, 3-7-1-001-007, 3-7-1-002-001, and 3-7-1-002-013 |
| **Permits:** | Incidental Take License |
| **Proposing/ Determination Agency:** | Department of Land and Natural Resources<br>Division of Forestry and Wildlife<br>1151 Punchbowl Street Room 325<br>Honolulu, Hawaii, 96813<br>808 587 4187 |
| **Consultant:** | Garcia and Associates<br>146 Hekili St, Suite 101<br>Kailua, HI, 96734<br>Attention: Huang-Chi Kuo<br>808 262 1387 |

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**Status (check one only):**

| | |
|---|---|
| _X_DEA-AFNSI | Submit the proposing agency notice of determination/transmittal on agency letterhead, a hard copy of DEA, a completed OEQC publication form, along with an electronic word processing summary and a PDF copy (you may send both summary and PDF to oeqchawaii@doh.hawaii.gov); a 30-day comment period ensues upon publication in the periodic bulletin. |
| __FEA-FONSI | Submit the proposing agency notice of determination/transmittal on agency letterhead, a hard copy of the FEA, an OEQC publication form, along with an electronic word processing summary and a PDF copy (send both summary and PDF to oeqchawaii@doh.hawaii.gov); no comment period ensues upon publication in the periodic bulletin. |
| __FEA-EISPN | Submit the proposing agency notice of determination/transmittal on agency letterhead, a hard copy of the FEA, an OEQC publication form, along with an electronic word processing summary and PDF copy (you may send both summary and PDF to oeqchawaii@doh.hawaii.gov); a 30-day consultation period ensues upon publication in the periodic bulletin. |
| __Act 172-12 EISPN | Submit the proposing agency notice of determination on agency letterhead, an OEQC publication form, and an electronic word processing summary (you may send the summary to oeqchawaii@doh.hawaii.gov). NO environmental assessment is required and a 30-day consultation period upon publication in the periodic bulletin. |
| __DEIS | The proposing agency simultaneously transmits to both the OEQC and the accepting authority, a hard copy of the DEIS, a completed OEQC publication form, a distribution list, along with an electronic word processing summary and PDF copy of the DEIS (you may send both the summary and PDF to oeqchawaii@doh.hawaii.gov); a 45-day comment period ensues upon publication in the periodic bulletin. |
| __FEIS | The proposing agency simultaneously transmits to both the OEQC and the accepting authority, a hard copy of the FEIS, a completed OEQC publication form, a distribution list, along with an electronic word processing summary and PDF copy of the FEIS (you may |

send both the summary and PDF to oeqchawaii@doh.hawaii.gov); no comment period ensues upon publication in the periodic bulletin.

__ Section 11-200-23 Determination

GM

The accepting authority simultaneously transmits its determination of acceptance or nonacceptance (pursuant to Section 11-200-23, HAR) of the FEIS to both OEQC and the proposing agency. No comment period ensues upon publication in the periodic bulletin.

__Section 11-200-27 Determination

The accepting authority simultaneously transmits its notice to both the proposing agency and the OEQC that it has reviewed (pursuant to Section 11-200-27, HAR) the previously accepted FEIS and determines that a supplemental EIS is not required. No EA is required and no comment period ensues upon publication in the periodic bulletin.

__Withdrawal (explain)

**Summary** (Provide proposed action and purpose/need in less than 200 words. Please keep the summary brief and on this one page):

The Department of Land and Natural Resources Division of Forestry and Wildlife has been developing a Habitat Conservation Plan (HCP) for land managed primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat in the Pu'u Wa'awa'a Forest Reserve and the Pu'u Anahulu Game Management Area, in North Kana, on the island of Hawai'i. The development of this HCP will provide for the incidental take of fifteen threatened and endangered plants and one endangered insect. This Environmental Assessment (EA) supports the proposed HCP and Incidental Take License (ITL) for game management at Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area. The proposing agency for this program is the Hawai'i State Department of Land and Natural Resources, Division of Forestry and Wildlife. This EA identifies proposed and alternative actions of the HCP, describes the existing physical, biological, and socioeconomic environments, and analyzes potential environmental impacts to the existing environment resulting from the proposed action.

# DRAFT Environmental Assessment

# Habitat Conservation Plan for Game Management at Pu‘u Wa‘awa‘a and Pu‘u Anahulu, Nāpu‘u Conservation Project Island of Hawai‘i, Hawai‘i

**TMKs (3) 7-1-001:001, 004, 006, 007; (3) 7-1-002:001, 013; (3) 7-1-003:001; (3) 7-1-004:001, 018**

**Prepared For**:

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

**Prepared By:**

Garcia and Associates
146 Hekili St., Suite 101
Kailua, Hawai‘i 96734

6 January2016

## PROJECT SUMMARY

**Project Name**: Nāpuʻu Conservation Project: Draft Habitat Conservation Plan for Game Mammal Management at Puʻu Waʻawaʻa and Puʻu Anahulu

**Proposing Agency**: Division of Forestry and Wildlife
Department of Land and Natural Resources
State of Hawaiʻi

**Approving Agency**: Department of Land and Natural Resources

**Project Location**: Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa,
Island of Hawaiʻi, Hawaiʻi
TMKs (3) 7-1-001:001, 004, 006, 007; (3) 7-1-002:001, 013; (3) 7-1-003:001; (3) 7-1-004:001, 018

**Property Owner**: State of Hawaiʻi

**State Land Use Classification**: Conservation District Protective Subzone
State of Hawaiʻi

**Agency Determination**: Anticipated Finding of No Significant Impact (AFNSI)

**Agencies, Organizations, and Other Stakeholders Consulted:**

*U.S. Senate*

- Senior United States Senator for Hawaiʻi, The Honorable Brian Schatz
- Junior United States Senator for Hawaiʻi, The Honorable Mazie Hirono

*U.S. House of Representatives*

- First Congressional District, The Honorable Colleen Hanabusa
- Second Congressional District, The Honorable Tulsi Gabbard

*U.S. Government*

- U.S. Department of Transportation, Federal Highway Administration, Hawaiʻi Division
- U.S. Fish and Wildlife Service, Office of Law Enforcement
- U.S. Fish and Wildlife Service, Conservation Partnerships Program
- U.S. Fish and Wildlife Service, Hakalau Forest National Wildlife Refuge
- U.S. Fish and Wildlife Service, Pacific Islands Office
- U.S. Forest Service, Hawaiʻi Experimental Tropical Forest
- U.S. Forest Service, Institute for Pacific Island Forestry
- U.S. Geological Survey, Biological Resources Discipline
- U.S. Geological Survey, Pacific Island Ecosystems Research Center

- U.S.D.A. Natural Resources Conservation Service

*State Senate*

- Senate District 3, The Honorable Joshua Green
- Senate District 4, The Honorable Malama Solomon

*State House of Representatives*

- House District 5, The Honorable Denny Coffman
- House District 6, The Honorable Nicole Lowen
- House District 7, The Honorable Cindy Evans

*State of Hawai‘i*

- Lt. Governor of Hawai‘i
- Department of Agriculture
- Dept. of Business, Economic Development & Tourism, Land Use Commission
- Dept. of Business, Economic Development & Tourism, Office of Planning
- Dept. of Education, Superintendent, West Hawai‘i
- Dept. of Hawaiian Homelands, Land Management Division
- Dept. of Health, Clean Water Branch
- Dept. of Health, Program Manager
- DLNR, Chairperson
- DLNR, Division of Aquatic Resources
- DLNR, Division of State Parks
- DLNR, Land Division
- DLNR, Office of Conservation and Coastal Lands
- DLNR, State Historic Preservation Division, Hawai‘i Lead Archaeologist
- DLNR, State Historic Preservation Division, Hawai‘i Island Burial Council
- Dept of Transportation, Director of Transportation
- Dept. of Transportation, Highways Division
- Office of Hawaiian Affairs

*County of Hawai‘i*

- Hawai‘i County Office of the Mayor
- Hawai‘i County Game Management Advisory Commission
- Hawai‘i County Civil Defense
- Hawai‘i County Department of Parks and Recreation
- Hawai‘i County Department of Public Works, Director
- Hawai‘i County Fire Chief
- Hawai‘i County Native Hawaiian Chamber of Commerce

- Hawaiʻi County Planning Department, Program Manager
- Hawaiʻi County Police Chief

*Educational Institutes*

- Honokaa Intermediate School
- University of Hawaiʻi Hilo, CAFNRM
- University of Hawaiʻi Hilo, CTAHR
- University of Hawaiʻi Hilo, Dept. of Geography and Environmental Sciences
- University of Hawaiʻi Hilo, Ka Haka ʻUla O Keʻelikōlani
- University of Hawaiʻi Hilo, Office of Mauna Kea Management
- University of Hawaiʻi Hilo, Pacific Aquaculture and Coastal Resources Center
- University of Hawaiʻi Hilo, Research Corporation of the University of Hawaiʻi
- University of Hawaiʻi Mānoa, College of Tropical Agriculture and Human Resources
- University of Hawaiʻi Mānoa, Wildland Fire Specialist

*Businesses, Non-governmental Organizations, and Individuals:*

- Big Island Country Club
- Big Island Invasive Species Committee, Springer Kaye
- Boy Scouts of America, Hawaiʻi Service Center
- Hawaiʻi Forest and Trail, Rob Pacheco
- Hawaiʻi Forest Industry Association, Yvonne and Keoki Carter
- E Mau Nā Ala Hele, Deborah Chang
- Hawaiʻi Agriculture Research Center, Stephanie Whalen
- Hawaiʻi Audubon Society, Wendy Johnson
- Hawaiʻi Community Foundation, Environment & Sustainability, Program Director, Josh Stanbro
- Hawaiʻi Conservation Alliance, Lihla Noori
- Hawaiian Ecosystems at Risk
- Hawaiʻi Forest Industry Association, Heather Gallo
- Hawaiʻi Forest Industry Association, Mike Robinson
- Hawaiʻi Hunting Association, Tom Lodge
- Hawaiʻi Island Economic Development Board
- Hawaiʻi Wildfire Management Organization, Executive Director, Elizabeth Pickett
- Hui Aloha Kiholo, Jenny Mitchell
- Hui Ohana Mai Puu Anahulu a me Puu Waawaa, Debra Lee and Kailiwai-Ray
- Kamehameha Schools
- Kona Hawaiian Civic Club
- Kona Hiking Club, Kathleen Johnson

- Kona Hiking Club, Kaleopono Norris
- Kona Hiking Club, Nolan Chock
- Kukui Planning, Mike Donoho
- Kumu Pono Associates, Kepa Maly
- Mauka and Makai Access Committee
- Nā Pua No‘eau
- Nāhelehele, Sally Rice
- National Wild Turkey Federation’s Hawai‘i State Chapter, Jon Sabati
- Parker Ranch, President and CEO, Neil Kuyper
- Parker Ranch Hunt Club, Richard Hoeflinger
- Peoples Advocacy for Trails Hawai‘i, Tina Clothier
- Puu Anahulu Community Association, Roman Hao
- Puu Anahulu Resident, Karen Clarkson
- Puu Waawaa Advisory Council Member, Susan Cordell
- Puu Waawaa Advisory Council Member, Jon Giffin
- Puu Waawaa Advisory Council Member, Mary Metcalf
- Puu Waawaa Advisory Council Member, Alan Nakagawa
- Puu Waawaa Advisory Council Member, Bob Okawa
- Puu Waawaa Advisory Council Member, Frank Sayre
- Puu Waawaa Advisory Council Member, Mike Tomich
- Puu Waawaa Advisory Council Member, Chris Yuen
- Puu Waawaa Advisory Council Member, Hannah Kihalani Springer
- Puu Waawaa Advisory Council, Past Member, Kuulei Keakealani
- Puu Waawaa Advisory Council, Past Member, Clayton Tremaine
- Puu Waawaa Advisory Council, Past Member, Peter Vitousek
- Puu Waawaa Resident, Jerry King
- Puu Waawaa Resident, Paul Ponthieux
- Puu Waawaa Resident, Henk & Akemi Rogers
- Sierra Club, Moku Loa Group, Linda Larish
- The Kohala Center
- The Nature Conservancy, Director of External Affairs, Mark Fox
- The Nature Conservancy, Executive Director, Suzanne Case
- The Trust for Public Land, Hawai‘i State Director, Lea Hong
- Waikoloa Dry Forest Initiative, Jen Lawson

# CONTENTS

## FIGURES



## TABLES

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| amsl | above mean sea level |
| BSM | Blackburn's sphinx moth |
| cal. BP | calibrated years before the present |
| CAFNRM | College of Agriculture, Forestry, and Natural Resource Management |
| CFR | Code of Federal Regulations |
| CTAHR | College of Tropical Agriculture and Human Resources |
| DEA | Draft Environmental Assessment |
| DLNR | Hawai'i State Department of Land and Natural Resources |
| DOFAW | Hawai'i Division of Forestry and Wildlife |
| EA | Environmental Assessment |
| EO | Governor's Executive Order |
| EECB | Ecology, Evolution and Conservation Biology |
| ESA | Endangered Species Act |
| ESRC | Endnagered Species Recovery Committee |
| FBS | Forest Bird Sanctuary |
| g | standard gravity (9.80665 metres per second squared) |
| ha | hectares |
| HAR | Hawai'i Administrative Rules |
| HCP | Habitat Conservation Plan |
| HETF | Hawai'i Experimental Tropical Forest |
| HRS | Hawai'i Revised Statutes |
| ITL | Incidental Take License |
| km | kilometers |
| m | meters |
| NHPA | National Historic Preservation Act |
| PEPP | Plant Extinction Prevention Program |
| PHRI | Paul H. Rosendahl, Ph.D., Inc. |
| PRCS | Pacific Region Climate Services |
| RAWS | Remote Automatic Weather Station |
| SIHP | Hawai'i State Inventory of Historic Properties |
| TMK | Tax Map Key |
| U.S. | United States |
| USDA | U.S. Department of Agriculture |
| USFWS | U.S. Fish and Wildlife Service |
| USGS | U.S. Geological Survey |
| § | Section |

# 1.0 INTRODUCTION

This Environmental Assessment (EA) supports a proposed Habitat Conservation Plan (HCP) and Incidental Take License (ITL) for game management at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area in North Kona District, island of Hawaiʻi. The proposing agency for this program is the Hawaiʻi State Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW).

This EA identifies proposed and alternative actions of the HCP, describes the existing physical, biological, and socioeconomic environments, and analyzes potential environmental impacts to the existing environment resulting from the proposed action.

## 1.1 Purpose and Need

The State of Hawaiʻi's natural resources are managed under the authority and mandates of several laws and regulations. Hawaiʻi Revised Statutes (HRS) Section (§) 171-3 mandates that the DLNR shall manage and administer forests, forest reserves, wildlife, wildlife sanctuaries, game management areas, public hunting areas, and Natural Area Reserves. HRS §183D-2 mandates that the DLNR shall manage and administer the wildlife and wildlife resources of the State, which, by definition, include both game and non-game species. HRS §183D-3 further mandates that the DLNR shall adopt rules protecting, conserving, monitoring, propagating, and harvesting wildlife. Finally, under HRS §183D-4, the DLNR is given the authority to maintain, manage, and operate game management areas, wildlife sanctuaries, and public hunting areas for these purposes. Within the DLNR, the DOFAW has been delegated responsibility for terrestrial wildlife and game management. It is because of this mandate that game mammal management occurs at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area.

Hawaiʻi State statutes (HRS §195D-4) link the threatened and endangered species listed with the state to the federal list of threatened and endangered plant species (50 CFR 17.11 and 50 CFR 17.12). Under Section 195D-2 "endangered species" is defined as any species whose continued existence as a viable component of Hawaii's indigenous fauna or flora is determined to be in jeopardy and has been so designated pursuant to Section 195D-4. "Threatened species" is defined as any species of aquatic life, wildlife, or land plant which appears likely, within the foreseeable future, to become endangered and has been so designated pursuant to Section 195D-4. The DLNR may also list the federally listed threatened species as endangered, or any indigenous species as threatened or endangered, if the continued existence of the species is threatened by any natural or artificial factor. Any "take"[1] of threatened or endangered species is prohibited by law unless a temporary ITL is obtained from the DLNR. The ITL, as a part of an HCP, allows a take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

Under the current management plan for the *ahupuaʻa* of Puʻu Waʻawaʻa and the *makai* lands of Puʻu Anahulu (DLNR 2003), areas that are outside of specially designated "conservation units"

[1] "Take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect endangered or threatened species of aquatic life or wildlife, or to cut, collect, uproot, destroy, injure, or possess endangered or threatened species of aquatic life or land plants, or to attempt to engage in any such conduct.

are managed for conservation in PWW FR and as resources for sustainable yield game mammal hunting in PAH GMA. Game mammals in the Plan Area include feral pigs (*Sus scrofa*), feral sheep (*Ovis aries*), and feral goats (*Capra hircus*). Certain game mammal management activities proposed by DOFAW have the potential to result in the incidental take of federally listed endangered animal and plant species.

The endangered species include one endangered animal, Blackburn's sphinx moth (*Manduca blackburni*), and 15 endangered plant taxa: *Asplenium peruvianum* var. *insulare*, Hala pepe (*Chrysodracon hawaiiensis*), Kauila (*Colubrina oppositifolia*), Honohono (*Haplostachys haplostachya*), Maʻo hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Kokiʻo (*Kokia drynarioides*), Uhiuhi (*Mezoneuron kavaiense*), *Neraudia ovata*, ʻAiea (*Nothocestrum breviflorum*), Poʻe (*Portulaca sclerocarpa*), Hawaiian catchfly (*Silene lanceolata*), Pōpolo kū mai (*Solanum incompletum*), *Stenogyne angustifolia*, and two species of Aʻe (*Zanthoxylum dipetalum* var. *tomentosum* and *Zanthoxylum hawaiiense*). Potential negative impacts to the endangered plants are primarily from grazing, trampling, and browsing. Potential impacts to Blackburn's sphinx moth are primarily from the clearing and maintenance of fuel breaks and four-wheel-drive access roads. No other listed, proposed, or candidate plant or animal species are anticipated to be taken by the game management activities.

Because there is no clear way to implement game management activities and also assure the protection of all endangered species within the Plan Area, DLNR is seeking an ITL in accordance with Chapter 195-D, HRS. This license is issued by the Board of Land and Natural Resources after a recommendation for approval by the Endangered Species Recovery Committee. In support of the ITL, DLNR has developed an HCP which describes how DLNR will avoid, minimize, mitigate, and monitor the incidental take of endangered species during the management of non-native game mammals and hunting within Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. The HCP integrates components of the Puʻu Waʻawaʻa Management Plan (DLNR 2003). The central feature of the HCP is the establishment of protected and managed ungulate-free exclosures, "Conservation Units," which will serve as havens for various endangered species. Protection and propagation of endangered species within the exclosures will mitigate the incidental take resulting from game management activities and fire break maintenance outside exclosures at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area.

Implementation of the HCP has been identified by DLNR as an action that has the potential to impact the broader environment at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. The HCP proposes the use of state lands and state funds. It also involves land use within conservation district. Therefore, in accordance with the Hawaiʻi Environmental Policy Act (HRS Chapter 343), this EA has been conducted.

### 1.2 Proposed Action

The principal proposed action under the HCP is the construction and maintenance of 19 new ungulate exclosures and ongoing maintenance of 12 existing exclosures and fire breaks (Figure 1).

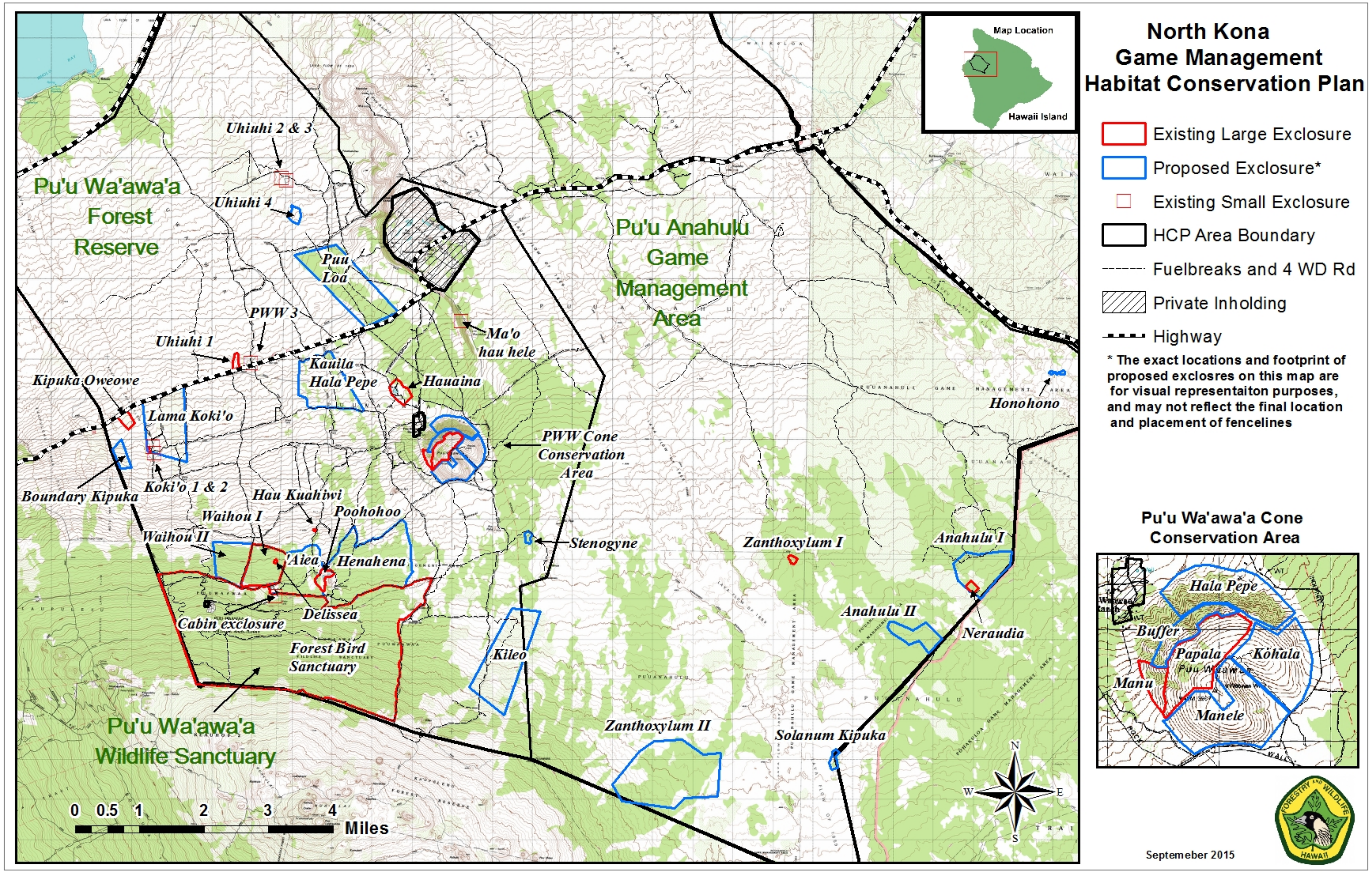


Figure 1. Plan Area showing existing and proposed exclosures.

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Table 1 gives the acreage, length of perimeter, and rationale for each of the newly proposed exclosures. These exclosure locations were selected based on the presence and density of endangered plant species and feasibility for construction and maintenance. Figure 1 shows the locations of both existing and proposed exclosures. The total Plan Area is approximately 103,988 acres, including 3,806 acres in the Pu‘u Wa‘awa‘a Forest Bird Sanctuary, 31,560 acres in the Pu‘u Wa‘awa‘a Forest Reserve and 68,622 acres in the Pu‘u Anahulu Game Management Area. The 18 new exclosures will enclose approximately 4,665 acres (1,888 hectares [ha]) of native habitat. The total enclosed area managed under the HCP will be approximately 8,863 acres (3,587 [ha]) or 8.5 percent of the Plan Area.

Specific construction and maintenance activities and sequences planned for the exclosures include: 1) installation of fencing, 2) feral ungulate removal, 3) control of alien pests, and 4) outplanting. Each of these is described in greater detail below.

The project life span for the HCP is expected to be 25 years and will proceed in three phases:

- Phase I (0–8 years) will include the construction of three new exclosures, known as the ‘Aiea, Henahena, and Pu‘u Wa‘awa‘a Conservation Units. Aiea (291 acres) and Henahena (731 acres) will be entirely enclosed. The Pu‘u Wa‘awa‘a Conservation Area (Figure 1 inset) will support four new adjacent exclosures (330 acres total) in addition to the three already present (92 acres). The new units contain *in situ* populations of covered species, critical habitat, and are a priority for protection efforts. A survey of covered species within the conservation unit will be conducted within a year of fence installation to re-establish baselines and adjust mitigation goals.
- Phase II (5–15 years) will include the construction of additional conservation units. Management activities will emphasize outplanting of covered species to reach mitigation goals as well as continuing habitat improvement through invasive species control and monitoring.
- Phase III (16–25 years) aims to maintain positive results from previous phases and make adjustments based on information collected from ongoing research. The HCP includes provisions for continuous long-term monitoring and incorporates an adaptive management approach which allows for modifications to the mitigation and monitoring measures as knowledge is gained during implementation. Any remaining unfenced exclosure units will be fenced during this phase.

Fencing priority may change based on availability of funding. Exclosure size and exact location may vary depending on Covered Plant locations, geography, roads, access, and surrounding exclosures. Exclosure size is based on GIS acres.

**Table 1. Proposed New Exclosures in HCP**

| Exclosures | Size (acres) | Fence Length (miles) | Rationale* |
|---|---|---|---|
| Henahena | 731 | 3.3 | NotBre avoidance of take. |
| Hala Pepe (PWW CCA) | 92 | 1.8 | ChrHaw avoidance of take. |
| ‘Aiea | 291 | 3.0 | NotBre avoidance of take. |
| Honohono | 5 | 0.6 | HapHap avoidance of take. Only known population on State land and PEPP species. |
| Solanum Kīpuka | 18 | 0.8 | SolInc avoidance of take. Only known population on State land and PEPP species. |
| Kauila Hala Pepe | 375 | 3.4 | Avoidance of take for ColOpp and ChrHaw. |
| Zanthoxylum II | 815 | 4.6 | ZanHaw avoidance of take. |
| Anahulu I | 255 | 2.6 | Avoidance of take for NerOva, SilLan, and SteAng. |
| Anahulu II | 124 | 2.2 | Avoidance of take for NerOva and ZanHaw. |
| Stenogyne | 10 | 0.6 | SteAng avoidance of take. |
| Uhiuhi 4 | 22 | 0.8 | MezKav avoidance of take. |
| Pu‘u Loa | 530 | 4.2 | Avoidance of take for CryHaw, MezKav, and ColOpp. |
| PWW CCA (three remaining units) | 238 | 4.8 | Mitigation for 13 of 15 Cover Species |
| Boundary Kīpuka | 42 | 1.2 | Outplanting site for lowland dry forest species |
| Waihou II | 202 | 2.3 | Outplanting site for multiple Covered Species. |
| Lama Koki‘o | 382 | 3.2 | Last known KokDry at PWW; Avoidance take for ColOpp, NotBre, and ChrHaw. |
| Kileo | 533 | 4.2 | Outplanting site for AspPer, HapHap, NerOva, NotBre, PorScl, SilLan, SolInc, SteAng, and ZanHaw. |
| Total | 4 ,665 | 43.6 | |

*Species code: ChrHaw = *Chrysodracon hawaiiensis*, ColOpp = *Colubrina oppositifolia*, HapHap = *Haplostachys haplostachya*, HibBra = *Hibiscus brackenridgei* ssp. *brackenridgei*, KokDry = *Kokio drynarioides*, MezKav = *Mezoneuron kavaiensis*, NerOva = *Neraudia ovata*, NotBre = *Nothocestrum breviflorum*, PorScl = *Portulaca sclerocarpa*, SilLan = *Silene lanceolata*, SolInc = *Solanum incompletum*, SteAng = *Stenogyne angustifolia*, ZanDipTom = *Zanthoxylum dipetalum var. tomentosum*, ZanHaw = *Zanthoxylum hawaiiense*.

### 1.2.1 Fence Construction

Exclosure fences will be constructed with 6-foot woven hog-wire fencing secured by 8-foot tall T-posts. To avoid entanglement to wildlife, barbed wire will either not be used or installed within 2 inches of the ground. Fences will be skirted with additional hog-wire or deer fence to prohibit burrowing. Fencing personnel and materials will be transported to the site along existing access roads or by helicopter.

Vegetation will be cleared for a minimum of 8 feet on both sides of the fence to serve as a fuel break. All exclosures will contain gates or step-overs to allow pedestrian access. Once established, the fences will be checked quarterly or after major storms for their integrity and will be maintained to prevent ingress of feral ungulates.

### 1.2.2 Ungulate Removal

Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawaiʻi Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawaii* (DOFAW 2007). Ungulate removal will depend on size and location of the exclosure and will include public hunting, animal drives, and if necessary, staff removal.After all ungulates are removed, the exclosures will be monitored for ingress. Any new ungulates will be removed by staff.

### 1.2.3 Invasive Species Control

The Habitat Conservation Plan proposes to control weeds, introduced animals (e.g., rats and slugs), and insect pests inside the exclosure units. Infestations will be monitored and addressed on a case-by-case basis. Strict sanitation guidelines will be followed to prevent new introductions of invasive species.

Alien plant cover reduction within the exclosures may be necessary after ungulate removal. Without the pressure of herbivorous grazing, increased vegetation can be expected. Previous studies have shown that exclosures and feral ungulate removal often increase the coverage of both native and non-native plants (Loope and Scowcroft 1985; Stone et al. 1992; Cabin 2000). The continuing control of invasive plant species is essential to prevent re-invasion following restoration (Questad et al. 2012).

Alien plant cover reduction will be carried out using physical or chemical control measures ranging from manual removal to application of herbicides. Care will be taken to prevent non-target effects on native plants and animals.

Rats, snails, and insects can negatively impact endangered plants within the exclosure by damaging or consuming seeds and individual plants. Control of rats and snails will minimize adverse effects to target species and will facilitate their recovery. Control methods may involve chemical control using pesticides and physical controls such as Goodnature traps.

### 1.2.4 Outplanting of Selected Plant Species

According to the HCP, outplanting of endangered plants will be used to mitigate the incidental take of the covered species after avoidance and minimization measures are undertaken.

Table 2 lists the 15 plant taxa covered in the HCP and the exclosure units within which their avoidance and minimization will be undertaken. In addition to covered endangered species, native plants that are either species of concern or serve to enhance overall habitat quality will also be planted.

**Table 2. Covered Species within Avoidance and Minimization Exclosures**

| Species | Exclosures** |
|---|---|
| *Asplenium peruvianum* var. *insulare* | FBS |
| *Chrysodracon hawaiiensis* | Oweowe (existing), Puʻu Loa (proposed), Kauila Hala Pepe (proposed), Hala pepe (PWWCCA) (proposed) |
| *Colubrina oppositifolia* | Puʻu Loa (proposed) and Kauila Hala Pepe (proposed) |
| *Haplostachys haplostachya* | Honohono (proposed) |
| *Hibiscus brackenridgei* ssp. *brackenridgei* | Maʻo hau hele (existing) |
| *Kokia drynarioides* | All known individuals are fenced in individual fences |
| *Mezoneuron kavaiensis* | Uhiuhi 4 (proposed)<br>Uhiuhi 1, Uhiuhi 2 (existing fences) |
| *Neraudia ovata* | NerOva 1 and 2 (existing small fences) and Neraudia (existing fences), Anahulu I and Anahulu II (proposed) |
| *Nothocestrum breviflorum* | ʻAiea (proposed), Henahena (proposed), Lama Kokiʻo (proposed), Kīpuka Oweowe (existing) |
| *Portulaca sclerocarpa* | One known individual in Anahulu I (proposed) |
| *Silene lanceolata* | Anahulu I (proposed) |
| *Solanum incompletum* | Solanum Kīpuka (proposed) will enclose current individually fenced extant population |
| *Stenogyne angustifolia* | Anahulu I (proposed), Stenogyne (proposed) |
| *Zanthoxylum dipetalum* var. *tomentosum* | Waihou I (existing), Waihou II (proposed), Puʻu Waʻawaʻa Cone Conservation Area (proposed), |
| *Zanthoxylum hawaiiensis* | Zanthoxylum I (existing), Zanthoxylum II (proposed), Anahulu I and II (proposed) |

Exclosures that will be used for mitigation outplanting include five existing exclosures (Puʻu Waʻawaʻa Forest Bird Sanctuary, Waihou I, Papala (PWWCCA), Kipuka Oweowe, and Hauaina) and seven proposed exclosures (Lama Kokio, Boundary Kipuka, Waihou II, and the four remaining PWWCCA units (Kohala, Manele, Hapa pepe, and Buffer). Seeds and vegetatively propagated materials of the rare plant species will be collected and maintained in ex situ collections or on-site nurseries. Detailed plans including potential mitigation sites, sources and methods for obtaining and maintaining the plant stocks for each species are provided for in the HCP.

Outplanting will involve the excavation of small holes in which to plant seedlings and vegetatively propagated materials. This is expected to cause very minimal ground disturbance in highly localized areas.

### 1.2.5 Maintaining Fire Roads and Fuel Breaks

The HCP proposes to maintain fire roads and fuel breaks free of vegetation year-round to provide access for fire control and reduce the risk and severity of wildland fires. Approximately 230 miles of of roads and fuel breaks in the Plan Area will be cleared of vegetation by mechanical removal and with herbicides.

Mechanical removal of vegetation may involve the use of hand tools, chainsaws, weed wackers, all-terrain vehicle tow-behind brush/grass mowers, tractors, and bulldozers. Once the vegetation has been cleared, herbicides will be used to treat new growth. Hercides with the active ingridient glyphosate is typically used. The frequency of the herbicide treatment will depend on vegetation growth and may vary from zero in drought ears up to bimonthly. Shrubs will be removed with a ‘cut and treat’ method by first cutting down the shrub and then treating the stump with herbicide (active ingredient Triclopyr). All label instructions and regulations will be followed for use of herbicide in forested and natural area.

## 1.3 Sources of Primary Environmental Impact

Primary impacts are defined in Hawaiʻi Administrative Rules (HAR) §11-200-1 as “effects which are caused by the action and occur at the same time and place.” Primary impacts from the HCP may potentially result from the fence installation, ungulate removal, alien plant cover reduction, rat and snail control, and long-term fence maintenance activities. The potential impacts of the HCP actions are further discussed below.

### 1.3.1 Fence Construction

Installation of the fences and creation of fire breaks will cause physical disturbance on the footprints of the fence alignments. Post installation and ground leveling will disturb the substrate and may increase soil erosion in highly localized areas. Vegetation clearing along the fence corridor may cause the destruction of native plants and also negatively affect animals that rely on these plants for refuge or food. These impacts are expected to be minimal considering the relatively small size of the areas to be disturbed (43.37 acres or 0.04 percent of the Plan Area assuming 10-foot-wide corridor throughout the length), and considering that a large proportion of the understory plants in the fence corridor are non-native grasses and shrubs.

On a larger scale, creation of the new exclosures will result in a land use change for a small portion of Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. This change may result in socio-economic impacts to established public and private stakeholders.

### 1.3.2 Ungulate Removal

Ungulate removal will involve a variety of methods including forced drives, public hunting, trapping, snaring, and shooting. Unintentional physical disturbance to sensitive natural and cultural resources may be caused during such efforts.

### 1.3.3 Invasive Species Control

Alien plant control may involve physical or chemical measures to kill or reduce biomass of the target plant species. These control measures may inadvertently cause damage to non-target species. The removal of alien plant biomass has the potential to reduce available refuge, food resources, or suitable microhabitat for the plants and animals that associate with the alien plants. An applicable example is the larvae of the endangered Blackburn's sphinx moth (BSM, *Manduca blackburni*), which are known to feed on several non-native plant species in the nightshade family (Solanaceae), including the invasive tree tobacco (*Nicotiana glauca*).

Control efforts for the invasive animals may involve trapping and chemical control using pesticides or poisonous bait. Similar to alien plant control, risks exist for non-target species (Johnston et al. 2005, Eisemann and Swift 2006; Rattner et al. 2012). For example, studies have shown that some anticoagulant rodenticides can cause mortality or sub-lethal effects to non-target species through direct exposure or secondary exposure by consuming contaminated target or non-target species (Eason et al. 2002; Booth et al. 2003; Brakes and Smith 2005; Hoare and Hare 2006; Albert et al. 2010; Christensen et al. 2012; Masuda et al. 2014).

#### 1.3.4 Maintaining Fire Roads and Fuel Breaks

Fire road and fuel break maintainence has the potential to adversely affect the environment. The primary shrub that will be removed is the non-native tree tabacco (*Nicotiana glauca*), which is a host plant for the endangered BSM. Removing tree tabaccos may cause mortality to the eggs and larvae of BSM and lossof host habitat. The removal of vegetation has the potential to spread invasive, non-native plants through the movement of equipment and personnel.

### 1.4 Sources of Secondary Environmental Impact

Secondary impacts are defined in HAR §11-200-1 as "effects which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable." The principal sources of secondary impact are the long-term exclusion of ungulates and active management of the exclosures over the anticipated 25-year HCP implementation timetable. Long-term recovery and restoration of habitat within the exclosures and the subsequent regeneration of native species will have no foreseeable secondary impacts to the existing environment.

### 1.5 Agency Identification

The Hawaiʻi State DLNR DOFAW, is the agency assuming responsibility for this EA in accordance with Chapter 343, Hawaiʻi Revised Statues. The primary contact is Ms. Edith Adkins, Habitat Conservation Planner with DOFAW.

### 1.6 Location

The area covered by the HCP includes portions of the northern slope of Mt. Hualālai and the northwestern flank of Mauna Loa from approximately 25 to 6,360 feet above mean sea level (amsl) (see Figure 1). The parcel encompasses TMKs (3) 7-1-001:001, 004, 006, 007; 7-1-002:001, 013; 7-1-003:001; 7-1-004:001, 018 in Puʻu Waʻawaʻa Ahupuaʻa and Puʻu Anahulu Ahupuaʻa, North Kona District on the island of Hawaiʻi. The Plan Area lies on the *mauka* side of Queen Kaʻahumanu Highway between Wainanaliʻiliʻi Ahupuaʻa to the north, Pōhakuloa Training Area to the east, and Kaʻūpūlehu Ahupuaʻa to the south.

## 1.7 Land Ownership

The property is owned by the State of Hawaiʻi and managed by DLNR, DOFAW.

## 1.8 Funding

### 1.8.1 Project Cost[2]

Total project cost for the implementation of the HCP is estimated at $30,501,833 during the 25-year life span of the ITL. The exclosures will be constructed in the first ten years according to priority as presented in Table 3 and are projected to cost $8,326,153. Other costs include $627,814 for small spot fences and fence maintainance, $2,619,000 for fire suppression and maintaining fire breaks, $177,500 for predator control, $1,422,000 for mitigation through propagation and outplanting, $442,600 for monitoring, $300,000 for Blackburn's sphinx moth research, $2,108,500 for baseyard facilities and maintenance,and $10,819,000 for maintaining a ten-person permanent crew. A funding matrix itemizing each expense is provided in the HCP (Appendix A).

**Table 3. Projected Costs for Exclosure Construction**

| Exclosures | Length (miles) | Cost ($)* | Year (YR) |
|---|---|---|---|
| Henahena | 3.3 | 555,984.00 | YR 1 |
| Hala pepe (PWWCCA) | 1.8 | 304,748.57 | YR 1 |
| ʻAiea | 3.0 | 518,766.65 | YR 2 |
| Honohono | 0.6 | 100,281.23 | YR 2 |
| Solanum Kipuka | 0.8 | 143,790.34 | YR 2 |
| Zanthoxylum II | 4.6 | 820,653.04 | YR 3 |
| Kauila Hala pepe | 3.4 | 611,519.24 | YR 3 |
| Uhiuhi 4 | 0.8 | 138,941.26 | YR 3 |
| Anahulu I | 2.6 | 482,408.26 | YR 4 |
| Anahulu II | 2.2 | 406,792.46 | YR 4 |
| Puʻu Loa | 4.2 | 799,934.04 | YR 5 |
| Stenogyne | 0.6 | 105,573.85 | YR 5 |
| PWW Cone buffer | 1.4 | 266,876.80 | YR6 |
| Mānele | 1.8 | 361,510.65 | YR 7 |
| Kohala | 1.6 | 322,399.50 | YR 8 |
| Waihou II | 2.3 | 501,422.65 | YR 9 |

[2] Project costs have been modified since the publication of the draft Habitat Conservation Plan (Appenadix A) in the OEQC (publication date 11/8/15). Please refer to Appendix F for the most recent version of the funding matrix. Upon finalization of the HCP and EA, project costs will be consistent between the two documents.

| | | | |
|---|---|---|---|
| South Kipuka | 1.2 | 249,053.62 | YR 9 |
| Kileo | 4.2 | 925,476.66 | YR 10 |
| Lama w/ Kokio | 3.2 | 710,020.30 | YR 10 |
| **Total Cost** | 43.6 | 8,326,153 | |

* Assuming 3% inflation for each year.

#### 1.8.2 Funding Sources

Funding for implementation of the HCP will be provided by the DLNR as an annual operating expense paid pari passu with other operating expenditures (operation and maintenance costs, insurance, payroll, audit costs, and agency fee costs). The DLNR is committed to request funding in every biennial budget to support the proposed monitoring and mitigation measures for the life of the ITL. Any short-fall in funding will require consultation on whether the reduced funding will impact the success of the required measures outlined in the HCP, if adaptive management measures are appropriate, and if compliance with permit obligations are no longer upheld. The DLNR will work under the constraints of its program to ensure that adequate funding for implementation of the HCP is provided.

### 1.9 Required Approvals

Approval from the U.S. Fish and Wildlife Service (USFWS) (ESA Section 7), review and recommendation of approval by the Hawaiʻi Endangered Species Recovery Committee (HRS §195D-21; HRS §195D-25; HAR §13-107; and HAR §13-124), approval from the Board of Land and Natural Resources (HRS §195D-21; HAR §13-104; HAR §13-107; and HAR §13-124), and the Hawaiʻi State Historic Preservation Division (NHPA Section 106; HRS §6E-8; HAR §13-275; and HAR §13-275) may be required for this action based on trigger.

### 1.10 Alternatives Considered

Alternatives to the proposed action include 1) No Action, 2) Modify Location, Size and Number of Exclosures, and 3) Fence Larger Areas of Native Vegetation (Table 4). These alternatives are discussed as follows:

#### 1.10.1 No Action

Under the no action alternative, the HCP will not be implemented and no ITL will be issued. No additional exclosures will be built. No avoidance, minimization, and mitigation measures such as the proposed exclosures would occur. No clearing of fire roads and fule breaks will occur. Without the ITL DLNR would use existing exclosures to outplant endangered species which would limit restoration opportunities. Habitats that harbor endangered species would be expected to continue to degrade over time.

Without the clearing of roads and fuel breaks fuel loads will increase, thereby increasing the risk and severity of wildland fire. Wildfire is currently one of the most significant threats to endangered species in the Plan Area. Finally, although DOFAW can attempt to mitigate take of endangered species within existing exclosures. Newly proposed HCP exclosures were, however, designed to capture the healthiest populations of specific endangered species.

The “No Action” alternative is considered undesirable for this project.

**Table 4. Summary of Alternatives Considered and Their Associated Advantages/Disadvantages Compared to the Proposed Action**

| | Actions | Advantages | Disadvantages |
|---|---|---|---|
| **No Action** | 1. HCP will not be implemented<br>2. no new exclosures will be built<br>3. no clearing of fire roads and fuel breaks | 1. eliminate cost to build and maintain new exclosures<br>2. No take of Blackburns sphinx moth due to fire management | 1. new exclosure fences would not be built to protect endangered species and habitats<br>2. game management actions would not occur.<br>3. unacceptable fire risk |
| **Alternative Action 1:**<br>**Modify Location, Size, and Number of Exclosures.** | 1. significantly redesign exclosure system<br>2. reduce size or number of exclosures<br>3. change locations of exclosures on the landscape | 1. lower cost for HCP implementation and maintenance<br>2. increase in quantity and quality lands available for pasture and for feral ungulates to subsist, and therefore hunting | 1. threaten issuance of ITL therefore prevent game management actions<br>2. existing exclosures not aligned with data on endangered species location and critical habitat |
| **Alternative Action 2:**<br>**Fence Larger Areas** | same as Alternative 1 but the ungulate exclosures will enclose not only areas currently occupied by the covered species but also most native vegetation | 1. more native vegetation is protected from ungulate predation<br>2. less mitigation effort required | 1. large increase in cost but only provides minimal benefits to endangered species<br>2. higher cost and difficulty of removing game mammals and controlling invasive species within large exclosures and enclosing highly degraded and fire prone areas.<br>3. increase in costs for weed management within fenced units<br>4. decrease in quantity and quality lands available for pasture and for feral ungulates to subsist, and therefore hunting |

### 1.10.2 Alternative Action 1: Modify Location, Size, and Number of Exclosures

This alternative presents additional flexibility since there are an endless number of ways to design and position exclosures in the Plan Area. Under this alternative, exclosures would be redesigned to be smaller, fewer, and placed in locations most favorable to historical stakeholders who utilize the Plan Area. This alternative would reduce the acreage available for avoidance and mitigation efforts and would hinder preservation and recovery of endangered species in the Plan Area. The exclosures currently proposed in the HCP have been designed to correspond with the best and most recoverable populations of endangered species in the Plan Area. Some are designed to capture very sparse occurrences. HCP exclosure locations are based on biological survey data and represent the result of extensive consultation within DOFAW and with other experts including the ESRC and USFWS. Significant changes to the current HCP design would likely threaten ITL issuance and may not fulfill DLNR's mandate to conserve and manage endangered endemic species.

The "Modify Exclosures" alternative is considered undesirable for this project.

### 1.10.3 Alternative Action 2: Fence Larger Area of Native Vegetation

This alternative proposes to create more and/or larger ungulate exclosures than currently proposed in the HCP. The intent is to protect and restore as much native habitat as possible, possibly enclosing whole critical habitat areas. Game management would continue in open areas, which would be greatly reduced in size. Larger portions of the landscape would be fenced off and feral ungulates removed. Weeds and harmful animals would be controlled within the exclosures. Outplanting to mitigate take would occur in the exclosures.

This alternative aims to provide greater protection to the native ecosystem; however because native vegetation in the Plan Area is patchy in distribution, to enclose most native vegetation also means that large areas of degraded habitat will also be enclosed. In addition to increased costs for fence construction, management cost for ungulate removal and the control of weeds and invasive animals will increase tremendously. Because game mammals will be removed from larger areas, public hunting opportunities will be significantly impacted. Taking vast areas out of pasture will also result in an increased fuel load on the landscape and hence a dramatically higher wildfire hazard. This alternative would have an unknown effect on ITL issuance, but at minimum would require renewed consultation with the Endangered Species Recovery Committee (ESRC).

This alternative action is deemed undesirable for this project.

## 2.0 AFFECTED ENVIRONMENT

This section presents an overview of baseline physical, biological, socio-economic, and cultural conditions within the Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. These baseline conditions constitute the "affected environment" that may be impacted by the proposed action.

### 2.1 Physical Environment

The physical environment of the Plan Area is described by a diverse set of characteristics ranging from geology and soils to air and viewshed quality. Overall, the physical environment for the proposed action consists of approximately 8,500 acres of mostly undeveloped land, ranging from 25 to 6,360 feet amsl.

#### 2.1.1 Geology and Topography

Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area (the Plan Area) are located on the northwest side of the island of Hawaiʻi in North Kona District. The Plan Area lies on the flanks of two coalescent subaerial shield volcanoes, Hualālai and Mauna Loa. A majority of the Plan Area is on the north slope of Hualālai and bordered by the 1859 lava flow on the northwestern flank of Mauna Loa. The Plan Area extends east to Mauna Loa's Keʻāmuku lava flow.

Mauna Loa is an active volcano in the late shield stage. It has erupted 36 times between 1843 and 1995, three times in the last 50 years. The largest eruption in modern history was in 1859. Lava from the massive eruption flowed over 35 miles, covering 32.7 square miles. The flow terminated at the north side of Kīholo Bay and destroyed a traditional Hawaiian fishing village and a fishpond. The northwest flank of Mauna Loa is currently classified as 'Kaʻū Basalt' (Armstrong and Bier 1973; Juvik et al. 1998; Giffin 2009; Forest Solutions 2010).

Hualālai is an active volcano in the post-shield stage and last erupted in 1800 and 1801. The 1800 to 1801 eruption from the northwest rift zone covered 17.7 square miles and reached the ocean. The lava flow from this eruption is known as the Kaʻūpūlehu flow and borders the southwestern boundary of the Plan Area (Figure 2). The majority of Hualālai is classified as "Hualālai Volcanics," which consists primarily of alkalic olivine basalts (Armstrong and Bier 1973; Macdonald et al. 1983; Clague and Bohrson 1991; Juvik et al. 1998; Giffin 2009; Forest Solutions 2010).

Puʻu Waʻawaʻa and Puʻu Anahulu, which last erupted about 105,000 years ago, contain the oldest exposed lava of Hualālai. Puʻu Waʻawaʻa is the most prominent land feature of the Plan Area. It is a trachyte pumice cone that is more than a mile in diameter and risies 500 feet above the surrounding landscape. The trachyte lave flow extends to the north for 6 miles, including nearby Puʻu Anahulu ridge. Pumice and black trachyte obsidian (volcanic glass) have been quarried and used both historically and in pre-Contact times (Armstrong and Bier 1973; Macdonald et al. 1983).

Lava tubes are important geological systems in the Puʻu Waʻawaʻa area. Lava tubes harbor many plant and animal species that are only found within subterranean ecosystems. Lava tubes also form complex subsurface channel systems that facilitate ground water movement (Giffin 2009). Pre-Contact Hawaiians used the lava tubes for shelter, food storage, burials, and water catchment. Major lava tube systems in the Plan Area include the Umiʻi Manu Lava Tube System and the Henahena Lava Tubes System (Giffin 2009).

### 2.1.2 Climate

Hawaiʻi's climate is classified as "humid tropical" and is largely determined by the interplay of latitude, surrounding ocean, storm tracks, and island topography. The effects of terrain play an especially important role in determining local scale weather and climate patterns (Armstrong and Bier 1973; Lau and Mink 2006).

Seven climatic regions are recognized in the state of Hawaiʻi and are defined chiefly by major geographic features and by location with reference to windward or leeward areas of prevailing trade winds. The Plan Area is within the Kona Coast climatic region. The weather pattern in this region features a diurnal wind regime with predictable land and sea breeze shifts resulting from ocean-land temperature and pressure differences. The upslope winds cause convectional rainfall at middle elevations in the afternoon. Because of strong land-heating effects, summers exhibit a high frequency of late afternoon or early evening showers. This is the only climatic region in the state where summer rainfall exceeds winter rainfall (PRCS 2014).

The Plan Area lies on the rain shadows of both Mauna Kea and Mauna Loa. The mountains effectively block orographic rains. Weather conditions are therefore warmer and drier than in windward locations of the island. Mean monthly temperatures measured at Hale Piula in Puʻu Waʻawaʻa Forest Bird Sanctuary were highest in September (71.6º F) and lowest in February (41.7º F). Winter frost sometimes occurs at upper elevations (Giffin 2009).

### 2.1.3 Hydrology

Infiltration of rainwater, fog drip, and dew are the primary fresh water inputs in the Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa. Rainfall in the Plan Area varies by topography and elevation. In general the southwest corner of the Plan Area, the Forest Bird Sanctuary, receives the most rainfall. Precipitation gradually decreases when moving northeast as the elevation decreases. Precipitation in the Plan Area ranges from 27.9 inches of mean annual rainfall at the Waihou I rain shed area near the Forest Bird Sanctuary, to less than 10 inches on the northern borders along Kaʻahumanu Highway (Giffin 2009; Giambelluca et al. 2013). Evaporation is relatively high, with over 100 inches of annual pan evaporation in the driest portion of the Plan Area (Ekern and Chang 1985).

Due to the high permeability of the Mauna Loa and Hualālai basaltic lava flows, there are no perennial streams in the Plan Area. Surface flow is minimal and generally restricted to short-duration flash events. Subsurface water movement down to the groundwater aquifers is the main form of water transmission (DLNR 2003).

The Plan Area lies on two aquifer units, the Kīholo Aquifer System Area and the ʻAnaehoʻomalu Aquifer System Area. The Kīholo Aquifer is on the northeast rift zone of Mt. Hualālai with an estimated sustainable yield of 18 million gallons per day. The ʻAnaehoʻomalu

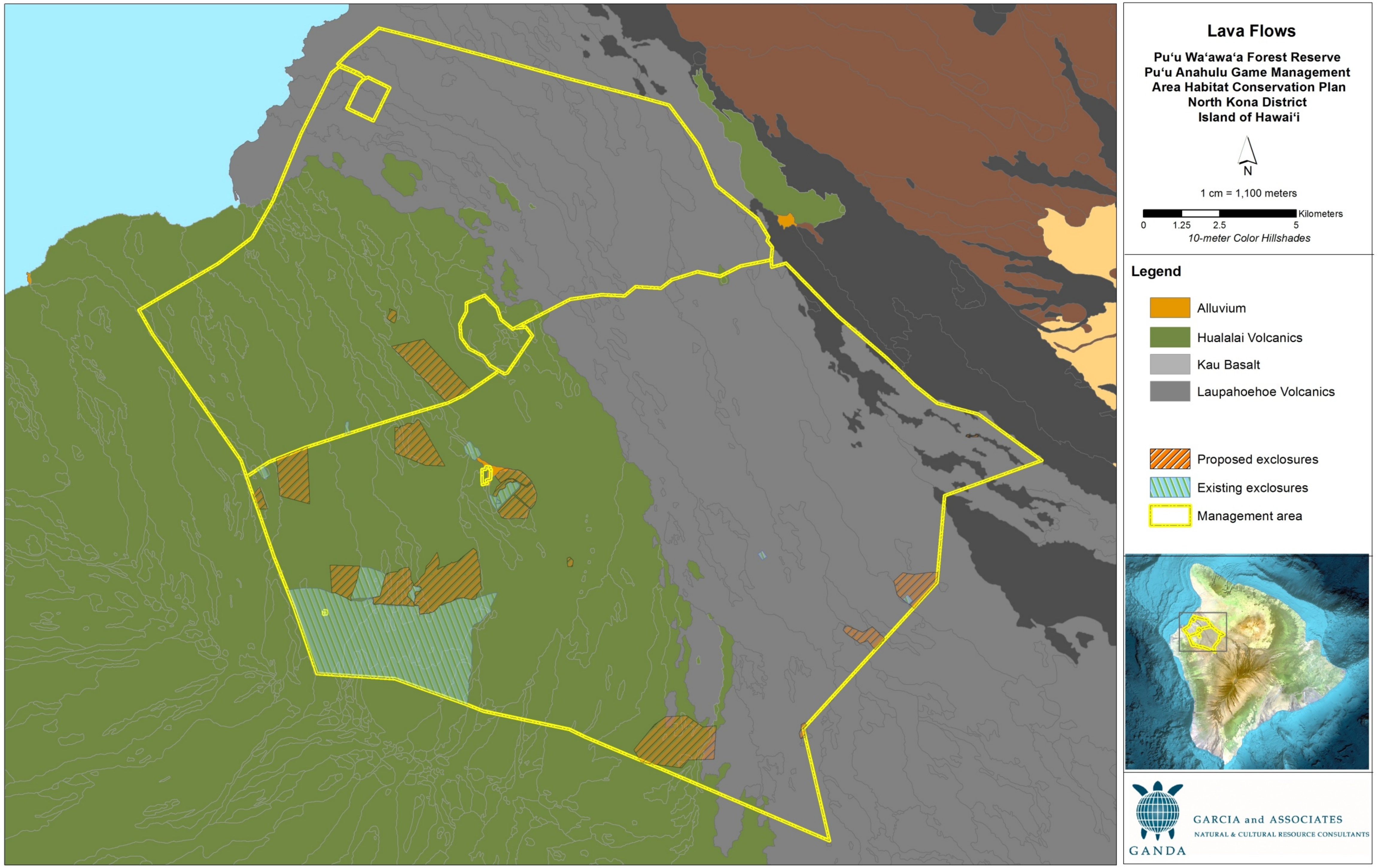


**Figure 2. Lava flow map for the Plan Area.**

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Aquifer System Area extends from the summit of Mauna Loa northwest to the western shores of ʻAnaehoʻomalu, and has an estimated sustainable yield at 30 million gallons per day. (Lau and Mink 2006; Fukunaga and Associates 2010).

Groundwater wells and rain water catchment systems are the two major sources of water supply in the area. Three man-made reservoirs are present and include two at Poʻohohoʻo and one in the Hauaina exclosure (DLNR 2003). The Poʻohohoʻo reservoirs are fed by rain catchment. The upper, smaller reservoir is partially functioning, and the lower, larger reservoir is non-functional. The reservoir at Hauaina is fed by rain as well as inputs from a well. There are two wells near the Plan Area. One is on Puʻu Waʻawaʻa Ranch property and supplies a majority of the water users. The other, Old Kīholo Well, is no longer functioning, likely due to damage from an earthquake.

#### 2.1.4 Soils

Recent soil survey data for the island of Hawaiʻi shows diverse soil types and distribution at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area (Figure 3). Soil development and depths largely correlate with ages of lava flows. Little or no soil development (except in wet forest areas) occurs on lavas less than 5,000 years old. Lavas between 5,000 and 10,000 years old have 10 to 20 centimeters (cm) of soil. Flows over 10,000 years old accumulate soils more than 20 cm deep. Waʻawaʻa series soils on Puʻu Waʻawaʻa cinder cone reach up to 2 meters (m) deep and are likely the deepest soils at Puʻu Waʻawaʻa (Giffin 2009). The twelve soil types that occur in the Plan Area are as follows:

*Kaimu extremely stony peat* (rKED) is located primarily in the western section of the Plan Area and consists of a thin layer of well drained organic soils over fragmental *ʻaʻā*. This soil series is situated at elevations ranging from sea level to 1,000 feet with 6 to 20 percent slopes. The surface layer is aproximately 3 inches of very dark brown extremely stony peat.

*Kekake extremely stony muck* (rKHD) is located in both the southwestern and southeastern sections of the Plan Area and consists of a thin layer of well-drained organic soils underlain by *pāhoehoe* bedrock. Rocky outcrops occupy 25 to 50 percent of the surface area. This soil series is situated on the uplands at elevations ranging from 3,500 to 7,000 feet with 6 to 20 percent slopes. The surface layer is about 4 inches of black muck.

*Manahaa silt loam* (MMD) is located in the southwestern section of the Plan Area and consists of well drained silt loams that formed from volcanic ash and range in elevation from 3,500 to 5,000 feet with 6 to 20 percent slopes. The surface layer is dusky red silt loam, about 6 inches thick. The subsoil is about 19 inches of dark reddish brown silt loam overlying *pāhoehoe* bedrock.

*Manahaa extremely stony silt loam* (MND) is located in the southwestern section of the Plan Area. This soil series is very similar to Manahaa silt loam except that stones cover 3 to 15 percent of the surface area.

*Mawae extremely stony muck* (rMWD) is located in the southwestern section of the Plan Area and consists of a thin layer of well-drained organic soils over fragmental *ʻaʻā*. This soil series is situated in the uplands, ranging in elevation from 3,500 to 7,000 feet with 6 to 20 percent slopes. The surface layer is black extremely stony muck about 5 inches thick.

*Punaluu extremely rocky peat* (rPYD) located primarily in the western section of the Plan Area consists of a thin layer of well-drained organic soils over *pāhoehoe* bedrock. Rocky outcrops occupy 40 to 50 percent of the surface area. The elevation of this soil series ranges from sea level to 1,000 feet, with 6 to 20 percent slopes. The surface layer is about 4 inches of black peat.

*Puu Pa silt loam* (PWD) is primarily located at the Puʻu Waʻawaʻa cinder cone and consists of well-drained stony very fine sandy loam that formed in volcanic ash. Elevations range from 1,000 to 2,500 feet with 12 to 20 percent slopes. The depth to weathering trachyte is about 48 inches.

*Puu Pa extremely stony very fine sandy loam* (PVF3) is located primarily on the slopes of the Puʻu Waʻawaʻa cinder cone and consists of a very thin layer of severely eroded soil over weathering trachyte. Slopes range from 70 to 100 percent with an average slope of 90 percent.

*Pāhoehoe lava* (rLW) is located throughout the Plan Area. This lava type has a relatively smooth glassy surface. *Pāhoehoe* has no soil covering and is typically bare of vegetation except for mosses and lichens. This land type ranges from sea level to 13,000 feet.

*ʻAʻā lava* (rLV) is the predominant land type within the Plan Area. This lava type is a rough and broken mass of hard glassy and sharp pieces piled in tumbled heaps. This lava has practically no soil covering and is bare of vegetation except for mosses, lichens, ferns, and small trees. It is found at elevations ranging from sea level to 13,000 feet.

*Rock land* (rRO) is located throughout the Plan Area and consists of *pāhoehoe* bedrock covered in some areas with a thin layer of soil. *Pāhoehoe* outcrops cover 50 to 90 percent of the surface area. Rock land ranges in elevation from sea level to 13,000 feet with 10 to 15 percent slopes. The average depth of soil is 6 to 8 inches.

*Very stony land* (rVS) is located in the northern and western sections of the Plan Area and consists of a high proportion of *ʻaʻā* outcrops with areas of shallow soil. This land type ranges in elevation from sea level to 13,000 feet with 10 to 15 percent slopes.

### 2.1.5 Air Quality

Air quality in the Plan Area is generally good. Trade winds and mountain drafts ensure a high degree of circulation and air flow. Typical anthropogenic sources of air pollutants, such as automobile and industrial emissions, are only present along the major roads such as Queen Kaʻahumanu Highway and Māmalahoa Highway. These anthropogenic pollutants are quite sparse owing to persistent air flow and, in the case of Māmalahoa Highway, a low traffic load.

The major air pollutant found in the area is volcanic smog, or "vog," which consists of sulfuric dioxide gas and sulfate aerosol emitted from active volcanoes. Vog is usually found in low concentration in the Plan Area due to the long distance from Kīlauea, the main source of emission. Periodically, however, when Kīlauea emits large amounts of sulfuric dioxide, or local weather patterns prevent normal air flow, vog can reach levels that pose a human health hazard and damage plant life (Giffin 2009).

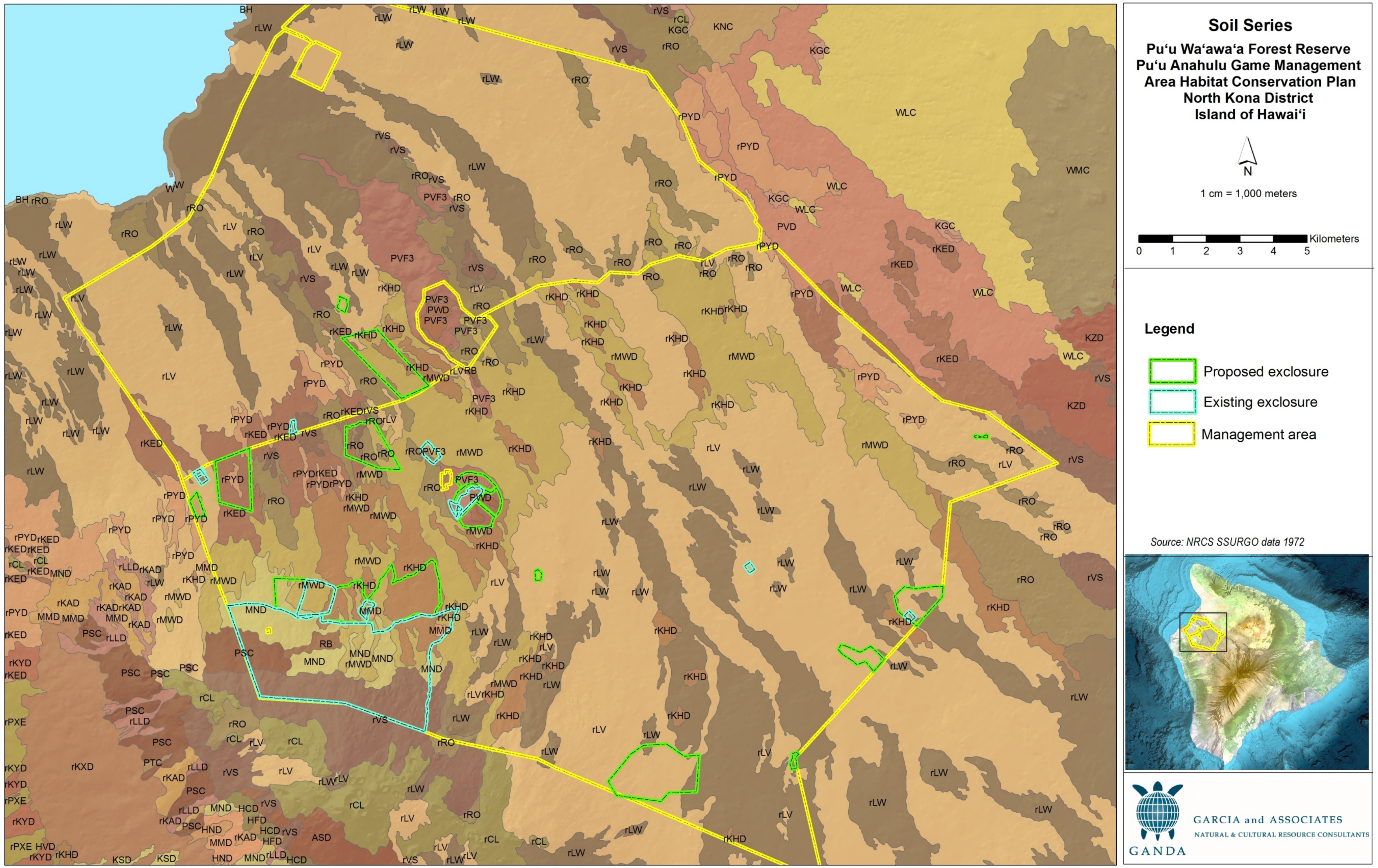


**Figure 3. Soil classification map for Plan Area.**

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### 2.1.6 Noise Levels

Noise is defined as any unwanted sound, typically generated as a by-product of other activities. Acoustically, it may also be understood as an unwanted perturbation of a desired signal, or, alternatively, a meaningless sound of greater than usual volume. Due to its remote location, the Plan Area generally experiences very low sound levels except for areas adjacent to main roads. Ambient sound is dominated by wind, occasionally punctuated by animal calls. These natural environmental sounds are generally not considered to be unwanted or undesirable. Human activities, especially during hunting season (e.g., vehicles and firearm discharge), are the main source of noise.

### 2.1.7 Hazardous Substances

The United States Forest Service conducted a phase I environmental site assessment (ESA) in 2009 for an 11.66-acre tract near Puʻu Waʻawaʻa cinder cone that was being considered for a long-term lease, development, and research by the Hawaii Experimental Tropical Forest (HETF) (USFS 2009). The environmental site assessment identified two environmental conditions: 1) an underground fuel storage tank containing fuel and 2) asbestos-containing materials. Small quantities of abandoned hazardous materials and numerous debris piles were also found. The environmental site assessment recommended further investigation and actions including removal and subsurface investigation of the underground storage tank, asbestos inspection at site buildings and removal of all asbestos hazards, removal and disposal of the small quantities of hazardous materials under the hut, and removal of surface-dumped debris. These actions have not yet been taken.

### 2.1.8 Natural Hazards

#### *2.1.8.1 Volcanism*

The Plan Area is located on two active volcanoes, Hualālai and Mauna Loa. Both have had large-scale eruptions in the historic period. Hazards associated with volcanism include lava flows, airborne lava fragments, volcanic gases, explosive eruptions, ground cracks, and settling. Lava flows are the most common of the direct eruption hazards and pose the greatest threat to property and human health. Explosive eruptions are rare in Hawaiʻi but have occurred in the historic period. Explosive eruptions produce turbulent gas clouds that carry hot ash and rock fragment at high speeds. Additionally, ground movement can create large cracks and endanger both property and human health (USGS 1997; Juvik et al. 1998).

Based probabilistic models, the U.S. Geological Survey have developed a *Lava Flow Hazard Zone Map* which divides the island into zones ranked from 1 through 9, 1 being the most likely to be covered by a new lava flow, and 9 the least likely. Zone 1 includes the summits and active rift zones of Kīlauea and Mauna Loa. The highest hazard is at historically active vents. According to the *Lava Flow Hazard Zone Map*, the northwest rift zone of Mauna Loa is rated at 3 and Hualālai at 4. Both hazard zones extend into the current Plan Area. The northwest flank of Mauna Loa is at a greater distance from recently active vents and its topography makes it less likely to produce dangerous flows. Hualālai is rated at 4 due to a lower frequency of eruptions relative to Kīlauea and Mauna Loa, although flows typically cover large areas.

#### 2.1.8.2 Earthquake and Tsunami

The state of Hawaiʻi ranks third nationally after Alaska and California in earthquake hazard. Hawaiʻi has experienced an average of over 50 earthquakes with a 3.5 magnitude or greater every year from 1974 to 2003 (USGS 2014). On the island of Hawaiʻi, earthquakes are commonly associated with volcanic eruptions (USGS 1997). Most of the earthquakes, however, are not felt and even fewer cause damage. Seismic hazard models show the highest hazard is on Hawaiʻi Island's south coast with probabilistic values of horizontal peak ground acceleration (2 percent in 50 years) exceeding 1.75 g (standard gravity = 9.81 $m/s^2$). The Plan Area, in comparison, is close to 0.8 g (Klein et al. 2001).

Major earthquakes (non-volcanic) result from movement of faults either on land or the ocean floor. A major earthquake affecting Puʻu Waʻawaʻa occurred on October 6, 1929. The 6.5-magnitude earthquake centered at Hōlualoa. This event consisted of several thousand tremors that came from a source beneath Hualālai , and caused shifting of ranch building foundations and a rock wall collapse. A more recent 6.7-magnitude earthquake occurred on October 15, 2006 with an epicenter just north of Kīholo Bay. Numerous people suffered minor injuries, at least 1,173 buildings were damaged, roads were damaged, and landslides blocked some roads. No damage was reported in the Plan Area (Armstrong 1973; Giffin 2009; USGS 2014).

The entire Plan Area is above the tsunami evacuation zone and has no tsunami hazard.

#### 2.1.8.3 Storm and Hurricane

Storm systems originating in the tropics are called tropical cyclones and are further classified into tropical depressions, tropical storms, and hurricanes. Tropical storms are tropical cyclones with sustained wind speeds between 38 and 73 miles per hour. Hurricanes are tropical cyclones with sustained wind speeds over 73 miles per hour. Although direct encounters with tropical storms and hurricanes are relatively rare in Hawaiʻi, heavy rainfall and high winds on the periphery of the storms can cause severe damage.

The most common storm hazard in Hawaiʻi is rainstorm-produced flash flooding. Hawaiʻi's heaviest rains are brought by winter cold fronts or low-pressure systems between October to April, otherwise known as "Kona storms." Flash flooding occurs when intense rainstorms bring heavy rainfall to a localized area. The Plan Area, however, is not on flood plains and is not vulnerable to flash flooding (Armstrong and Bier 1973; Juvik et al. 1998). A local informant, however, suggested that the area around the Puʻu Waʻawaʻa cinder cone is prone to landslides (Miki Kato, personal communication).

#### 2.1.8.4 Wildland Fires

Wildland fires can be either natural or anthropogenic and result in the destruction of forests, brush, field crops, grasslands, and real and personal property. The dry North Kona climate, combined with an abundance of fountain grass (*Cenchrus setaceus*), has increasing fire frequency in the area (Adkins et al. 2011). The remoteness of the area and local weather patterns make containing wildfires a challenge. There were 18 fires recorded in the Plan Area between 1958 and 2007 (Castillo et al. 2007).

Wildfires in Pu‘u Wa‘awa‘a area have been less frequent and smaller as a result of cattle grazing, which functions to reduce the fuel load. In contrast, the Pu‘u Anahulu area, which has not been grazed since the 1960s, has since experienced numerous large catastrophic fires that destroyed much of the native dryland habitat (Laitinen 2007). Currently, DOFAW is using cattle grazing as a tool for fine fuel reduction to minimize the wildfire threat in the Pu‘u Wa‘awa‘a Forest Reserve (DLNR 2003).

## 2.2 Biological Environment

The Plan Area contains a wide range of ecosystems including subalpine, montane, lowland, coastal, and cave ecosystems. The entire region was likely forested at one time, but wildfires and more than 100 years of livestock grazing have removed much of the native vegetation. Introduced grasses and increased fire frequency leading to larger and more numerous fires, have also significantly impacted native vegetation throughout the Plan Area, resulting in a mosaic of remnant native vegetation interspersed with introduced grasses.

Significant biological resources exist within the remnant native biological communities. A biological assessment for the Pu‘u Wa‘awa‘a unit was prepared by Giffin of the Department of Land Natural Resources in 2003 and updated in 2009. The updated assessment inventoried 189 native vascular plants, 36 land snails (two introduced), 264 native arthropods, 35 cave arthropods, 104 non-native arthropods, 15 native birds, and 38 non-native bird species (Giffin 2009). Thirty-seven federally listed threatened and endangered species have been recorded in the Plan Area including 29 plants, two insects, and six bird species. Many of the endangered plants, however, have been extirpated. Only 17 of the 29 endangered plant taxa were found during the HCP surveys.

23,551 acres, (22.5 percent of the Plan Area) are federally designated critical habitat for the recovery of endangered species. These include 22,564 acres for the Blackburn’s sphinx moth and 16,275 acres for 14 endangered plant species (Figure 4). Critical habitat for three endangered plants has been proposed and is currently under review.

The fence corridors for the three proposed Phase 1 Conservation Unit exclosures (Henahena, ‘Aiea, and Pu‘u Wa‘awa‘a CCA) were thoroughly surveyed by biologists from DOFAW between December 9 and 11, 2013. No threatened or endangered plant or animal species listed by the USFWS or the State of Hawai‘i were observed in the fence alignment corridor.

### 2.2.1 Flora

#### *2.2.1.1 Vegetation*

Vegetation in the Plan Area is largely determined by terrain, geology, climate, and past land use history. Botanical records show that native plant communities in the Plan Area were greatly altered in historical time (Rock 1913; Giffin 2009). Formerly forested areas were converted to pasture lands by wildfires, anthropogenic deforestation, ungulates and encroachment of non-native plants (Blackmore and Vitousek 2000). Most areas are now occupied by introduced grasses and trees (Giffin 2009). Native plant communities, however, still remain and harbor numerous threatened or endangered species. Some of these species are endemic to the area.

Plan Area vegetation can be classified into major vegetation zones according to elevation and moisture regime. Starting on the upper slopes of Hualālai and progressing downslope, the following zones are recognized by biologists: subalpine (above 6,000 feet), montane (2,500 to 6,000 feet), lowland (below 500 to 2,500 feet) and coastal (0 to 500 feet). A variety of native vegetation communities occur within each zone. At mid elevations, montane dry woodlands dominate the eastern side of the Plan Area while moister montane mesic forests lie to the west. Detailed descriptions of the vegetation zones can be found in the HCP (Appendix A).

Much of the Plan Area is now covered by sparse vegetation or bare lava. In the lowland areas, alien *kiawe* (*Prosopis pallida*) woodland and alien grasslands are the most prevalent plant communities. In the montane dry zone, sparse native shrubland and *māmane* (*Sophora chrysophylla*) and *naio* (*Myoporum sandwicense*) woodland occupy the most vegetated areas. Close-canopy forests can be found in the montane mesic zone in the Forest Bird Sanctuary and on the north-facing slopes of Puʻu Waʻawaʻa. In the subalpine zone, native shrubland and open *ʻōhiʻa* forest are the major vegetation types (Figure 5).

#### *2.2.1.2 Threatened and Endangered Plants*

Rare plants are found in all vegetation zones at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. At least 40 rare plant taxa have been reported from the area to date. Of these, 29 are federally listed as threatened or endangered (Giffin 2009). Many of these species, however, have been extirpated from the Plan Area. Seventeen endangered plant taxa and 17 plant species of concern are currently known to occur in the Plan Area (Table 5) (Giffin 2009). Fifteen of the 17 endangered plants are subject to incidental take caused by the game management activities and are covered by the Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area HCP. As stated above, no rare or endangered plants were observed with the proposed Phase 1 Conservation Unit exclosure fence corridors.

### 2.2.2 Fauna

The diverse vegetation types of the Plan Area once supported a rich native fauna. The destruction of native dry forests and the introduction of invasive plants and animals in the last two hundred years have tremendously reduced the distribution and richness of the native wildlife (Rock 1913; Cuddihy and Stone 1990; Blackmore and Vitousek 2000; Maly and Wilcox 2000). Currently rare or endangered animals are largely restricted to the remnant native plant communities (Giffin 2009). These include one federally listed endangered mammal, five endangered birds, and two endangered insects. The extensive lava tubes and caves systems also support a unique ecosystem within which many rare invertebrates are found (Giffin 2009).

Table 6 lists rare or endangered animals that occur in the Plan Area. Avian, mammal, and invertebrate resources are discussed in greater detail below.

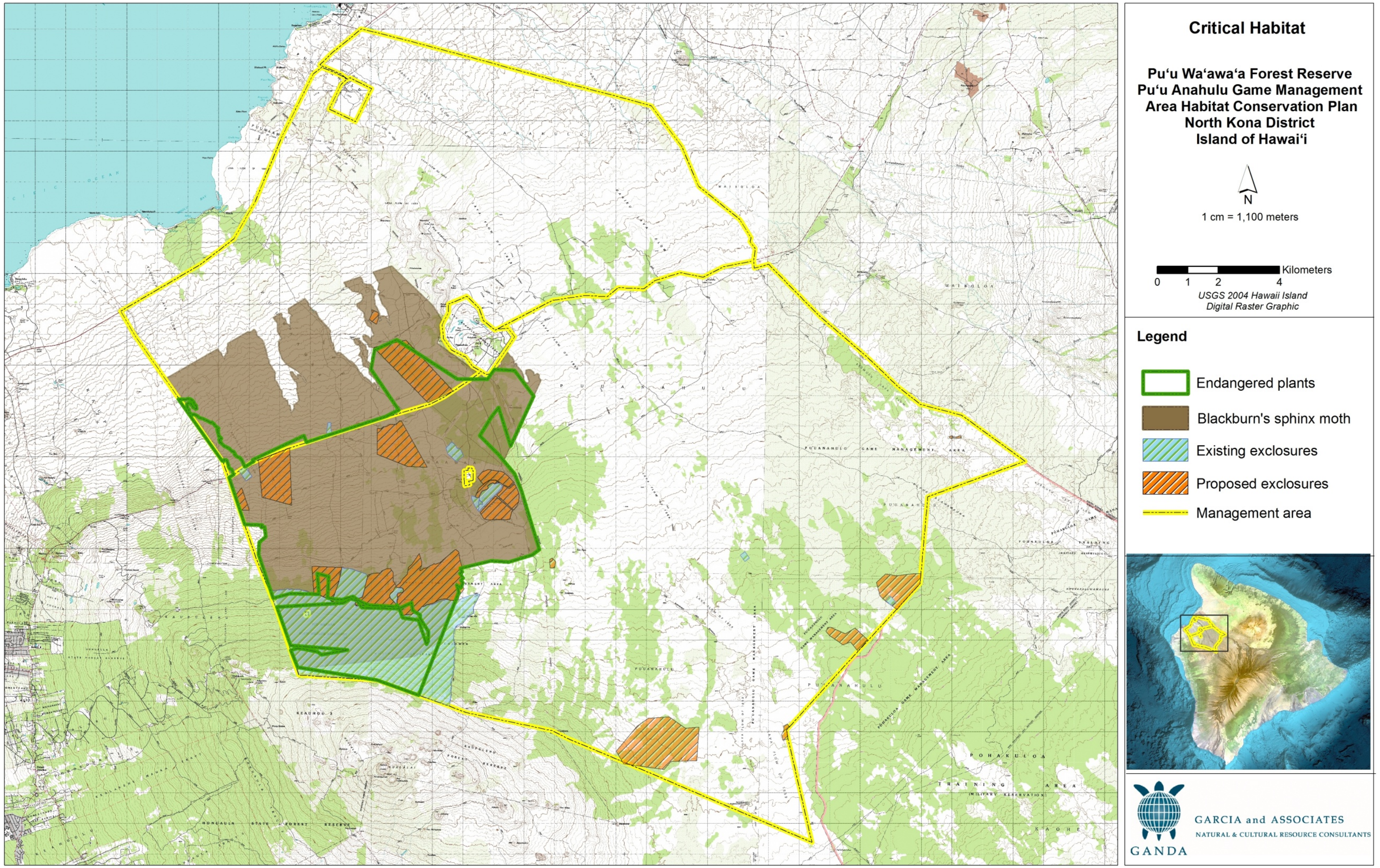


**Figure 4. Critical Habitat in Plan Area.**

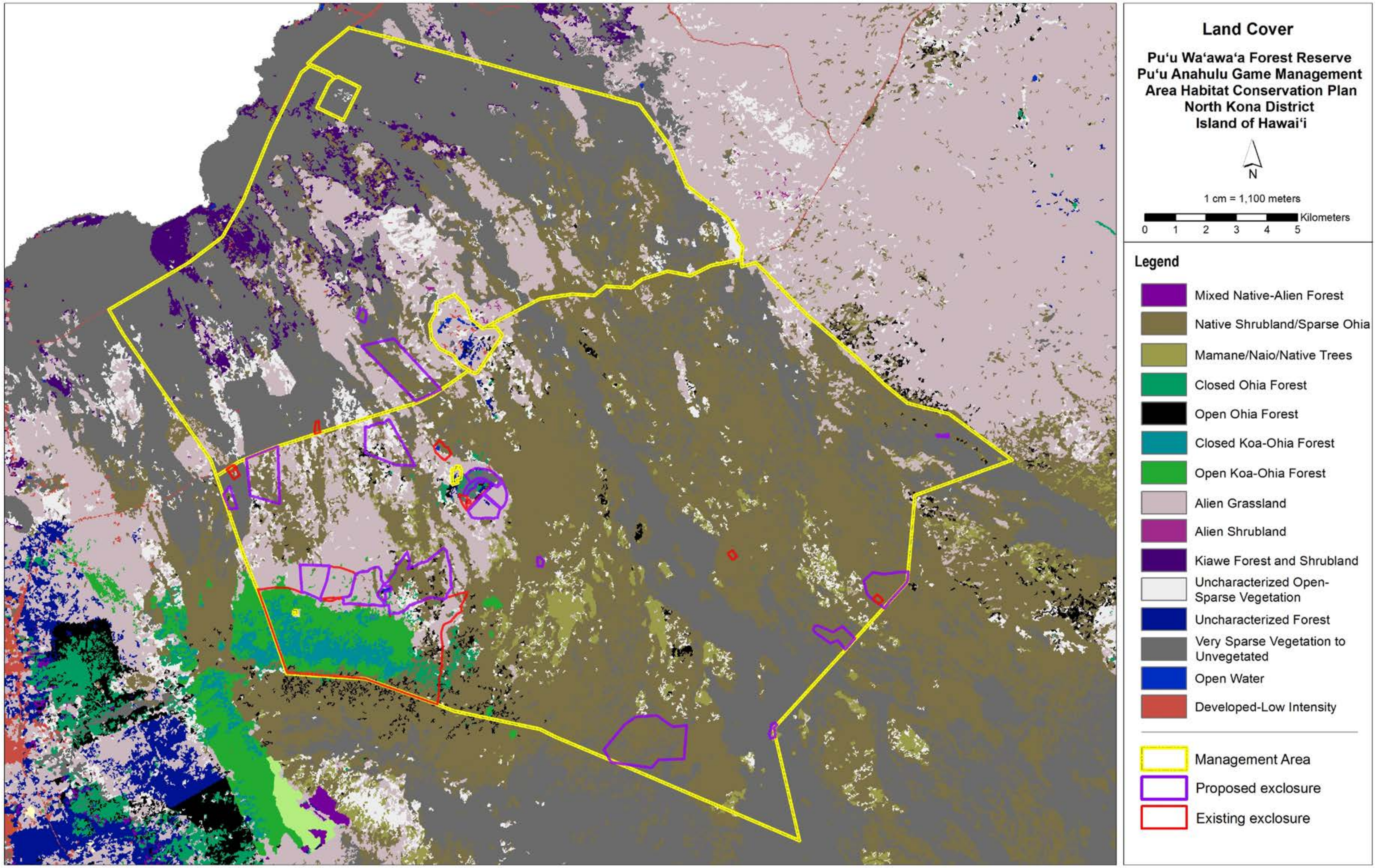


**Figure 5. Vegetation and land cover in Plan Area.**

**Table 5. Rare or Endangered Plants Currently Existing in Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area**

| Scientific name | Common name | Habitat | Status** | Critical habitat in Plan Area |
|---|---|---|---|---|
| *Asplenium peruvianum* var. *insulare* | None known | Montane dry | Endangered | |
| *Bidens micrantha* subsp. *ctenophylla** | Kōʻokoʻolau | Lowland dry | Endangered | |
| *Chrysodracon hawaiiensis* | Hala pepe | Lowland dry | Endangered | Yes |
| *Colubrina oppositifolia* | Kauila | Lowland dry | Endangered | Yes |
| *Haplostachys haplostachya* | Honohono | Montane dry | Endangered | |
| *Hibiscus brackenridgei* ssp. *brackenridgei* | M ā ʻo hau hele | Lowland dry | Endangered | Yes |
| *Kokia drynarioides* | Kokiʻo | Lowland dry | Endangered | Yes |
| *Mezoneuron kavaiense* | Uhiuhi | Lowland dry | Endangered | Yes |
| *Neraudia ovata* | | Montane dry | Endangered | Yes |
| *Nothocestrum breviflorum* | ʻAiea | Montane mesic | Endangered | Yes |
| *Phyllostegia velutina* | Velvet phyllostegia | Montane mesic | Endangered | |
| *Plantago hawaiiensis** | Laukahi kuahiwi | Subalpine | Endangered | |
| *Portulaca sclerocarpa* | Poʻe | Montane dry | Endangered | |
| *Silene lanceolata* | Hawaiian catchfly | Montane dry | Endangered | |
| *Solanum incompletum* | Pōpolo kū mai | Montane dry | Endangered | Yes |
| *Stenogyne angustifolia* | Creeping mint | Montane Dry | Endangered | |
| *Vicia menziesii* | Hawaiian vetch | Montane Mesic | Endangered | |
| *Zanthoxylum dipetalum* var. *tomentosum* | Aʻe | Montane Mesic | Endangered | Yes |
| *Zanthoxylum hawaiiense* | Aʻe | Montane dry | Endangered | |
| *Acacia koaia* | Koaiʻa | Lowland dry | Species of Concern | |
| *Alphitonia ponderosa* | Kauila | Montane mesic; montane dry | Species of Concern | |
| *Capparis sandwichiana* | Maiapilo | Coastal | Species of Concern | |
| *Euphorbia olowaluana* | ʻAkoko | Montane Dry | Species of Concern | |
| *Cyrtandra menziesii** | Haʻiwale | Montane Mesic | Species of Concern | |

**Table 5. (continued)**

| Scientific name | Common name | Habitat | Status** | Critical habitat in Plan Area |
|---|---|---|---|---|
| *Eragrostis deflexa* | Pacific lovegrass | Subalpine; montane dry | Species of Concern | |
| *Exocarpus gaudichaudii* | Gaudichaud’s exocarpus | Montane dry | Species of Concern | |
| *Fragaria chiloensis ssp. sandwicensis* | Sandwich beach strawberry | Montane mesic | Species of Concern | |
| *Melicope hawaiensis* | Manena | Montane mesic | Species of Concern | |
| *Phytolacca sandwicensis** | Pōpolo kū mai | Montane mesic | Species of Concern | |
| *Polysias sandwicensis* | ‘Ohe makai | Lowland dry | Species of Concern | |
| *Rubus macraei** | ‘Ākala | Subalpine | Species of Concern | |
| *Sicyos macrophyllus** | Alpine bur cucumber | Montane mesic | Species of Concern | |
| *Sisyrinchium acre* | Mau‘u lā‘ili | Subalpine | Species of Concern | |
| *Stenogyne macrantha* | Hawai'i stenogyne | Montane mesic | Species of Concern | |
| *Tetramolopium consanguineum* | Forest tetramolopium | Montane dry | Species of Concern | |
| *Tetramolopium humile* | Alpine tetramolopium | Subalpine | Species of Concern | |

* indicates species *not* found during HCP botanical surveys.
** ‘Species of concern’ are rare species for which concerns regarding status and threats exist, but for which there is currently insufficient information available to indicate a need to list the species under the Endangered Species Act.

**Table 6. Threatened or Endangered Animals Currently Existing in Pu‘u Wa‘awa‘a Forest Reserve and Pu‘u Anahulu Game Management Area (Data Source: Giffin 2009)**

| Scientific name | Common name | Status |
|---|---|---|
| Vertebrates | | |
| *Branta sandvicensis* | Nēnē (Hawaiian goose) | Endangered |
| *Buteo solitarius* | I‘o (Hawaiian hawk) | Endangered |
| *Himantopus mexicanus knudseni* | Ae‘o (Hawaiian stilt) | Endangered |
| *Lasiurus cinereus semotus* | ‘Ōpe‘ape‘a (Hawaiian hoary bat) | Endangered |
| *Loxops coccineus coccineus* | ‘Akepa | Endangered |
| *Oreomystis mana* | Hawai‘i creeper | Endangered |
| *Asio flammeus sandwichensis* | Pueo | Species of Concern |
| Invertebrates | | |
| *Manduca blackburni* | Blackburn’s sphinx moth | Endangered |
| *Drosophila heteroneura* | Hawaiian picture-wing fly | Endangered |
| *Anomis vulpicolor* | Red anomis noctuid moth | Species of Concern |
| *Caconemobius varius* | Kaumana cave cricket | Species of Concern |
| *Coleotichus blackburniae* | Koa bug | Species of Concern |
| *Ectemnius rubrocaudatus* | Redtail sphecid wasp | Species of Concern |
| *Hylaeus coniceps* | Conehead yellow-faced bee | Species of Concern |
| *Hylaeus difficilis* | Difficult yellow-faced bee | Species of Concern |
| *Hylaeus filicum* | Fern yellow-faced bee | Species of Concern |
| *Hylaeus hula* | Hulan yellow-faced bee | Species of Concern |
| *Hylaeus kona* | Kona yellow-faced bee | Species of Concern |
| *Hylaeus laetus* | Laetan yellow-faced bee | Species of Concern |
| *Hylaeus pubescens* | Furry yellow-faced bee | Species of Concern |
| *Micromus usingeri* | Usinger’s brown lacewing | Species of Concern |
| *Oliarus lorettae* | Oliarus planthopper | Species of Concern |
| *Omiodes monogona* | Hawaiian bean leaf-roller | Species of Concern |
| *Plagithmysus mezoneuri* | Hawai‘i Uhiuhi long-horned beetle | Species of Concern |
| *Plagithmysus elegans* | Hawai‘i elegant long-horned beetle | Species of Concern |
| *Plagithmysus simplicollis* | Simple-necked long-horned beetle | Species of Concern |
| *Rhyncogonus giffardi* | Giffard’s rhyncogonus weevil | Species of Concern |
| *Leptachatina lepida* | Unnamed land snail | Species of Concern |
| *Vitrina tenella* | Unnamed land snail | Species of Concern |

#### *2.2.2.1 Avifauna*

Extant endemic birds in the Plan Area include five honeycreepers, one monarchine flycatcher, two raptors, and one goose (Giffin 2009). The *ʻalalā* or Hawaiian crow (*Corvus hawaiiensis*) was formerly present, but is extirpated. The honeycreepers include *ʻamakihi* (*Hemignathus virens*), *ʻapapane* (*Himatione sanguinea*), *iʻiwi* (*Vestiaria coccinea*), Hawaiʻi *ʻakepa* (*Loxops coccineus*), and Hawaiʻi creeper (*Oreomystis mana*). Other endemic birds in the Plan Area include the Hawaiʻi *ʻelepaio* (*Chasiempis sandwichensis*), *nēnē* (*Branta sandvicensis*), *iʻo* or Hawaiian hawk (*Buteo solitarius*), *aeʻo* or Hawaiian stilt (*Himantopus mexicanus knudseni*), and *pueo* or Hawaiian short-eared owl (*Asio flammeus sandwichensis*). Five of the extant endemic birds are federally listed as endangered; these include *ʻakepa*, Hawaiʻi creeper, Hawaiian goose, Hawaiian hawk, and Hawaiian stilt (Giffin 2009, 2010; Pratt et al. 2010).

Indigenous birds that occur in the Plan Area include *ʻaukuʻu* or black-crowned night heron (*Nycticorax nyticorax hoactli*), *kōlea* or Pacific golden plover (*Pluvialis fulva*), *ʻewaʻewa* or sooty tern (*Sterna fuscata oahuensis*), and *ʻakekeke* or ruddy turnstone (*Arenaria interpres*). Non-native song birds and game birds include 38 species in 15 families and are more abundant than native birds.

#### *2.2.2.2 Mammals*

One federally listed endangered species, the Hawaiian hoary bat (*Lasiurus cinereus semotus*), inhabits the Plan Area. The Hawaiian hoary bat is a small insectivorous bat and considered a subspecies of the mainland hoary bat. The bat feeds on flying insects at night and roosts during the day under tree canopies. Bats have been observed emerging from trees in the Forest Bird Sanctuary as well as lava tube openings (Giffin 2009) and were seen foraging in the Hauaina unit.

Non-native mammals include both game and non-game mammals. The game mammals are feral sheep, feral goats, and feral pigs. Feral sheep are more abundant in higher elevations, primarily above Māmalahoa Highway. Feral goats occur throughout the area, but are most abundant at lower elevations. Feral pigs are widely distributed, but are most abundant in wetter, dense forest regions. Statistics from open hunting season reports and control hunts in the Puʻu Waʻawaʻa Forest Reserve indicate that goats are the most commonly harvested game, with 2,097 animals harvested between 2003 and 2012, while only 330 sheep and 120 pigs were harvested during the same period (DOFAW data).

Non-game mammals include small Indian mongooses (*Herpestes auropunctatus*), Polynesian rats (*Rattus exulans*), roof rats (*Rattus rattus*), house mice (*Mus domesticus*), feral cats (*Felis catus*), and feral dogs (*Canis familiaris*). These non-native mammals prey on native plants and animals and are considered detrimental to the native ecosystems.

#### *2.2.2.3 Invertebrates*

Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area support a rich fauna of terrestrial invertebrates. Giffin (2009) reported 33 native land snails, 264 native insects, and 15 native non-insect arthropods. Non-native invertebrates are also abundant in the Plan Area with two land snails, 110 insects, and 10 non-insect arthropods reported (Giffin 2009).

Caves and lave tube systems in the Plan Area support assemblages of specialized cave-dwelling invertebrates. These invertebrates have adapted to perpetual darkness, high humidity, and barren rock surfaces and are usually blind with lightly pigmented exoskeletons. Giffin (2009) observed 25 insect and 10 non-insect arthropods in the cave ecosystems. Obligate cave dwellers include beetles, crickets, plant hoppers, moths, spiders, amphipods, isopods, centipedes, and millipedes (Howarth 1973; Giffin 2009).

Two federally listed endangered insects, Blackburn's sphinx moth (*Manduca blackburni*) and a Hawaiian picture-wing fly (*Drosophila heteroneura*) are known to inhabit the Plan Area. The sphinx moths are found on the endangered host plant ʻAiea (*Nothocestrum breviflorum*) as well as other non-native plants in the nightshade family (Solanaceae). Tree tabacco is a non-native host plant of BSM and is commonly found on recently cleared areas such as fire breaks and unpaved roads. The HCP includes the BSM as one of its covered species and contains measures to avoid, minimize, and mitigate incidental take of the sphinx moth (see Appendix A). The *Drosophila heteroneura* is extremely rare and was considered extinct until it was rediscovered in 1983. It is endemic to the island of Hawaiʻi and only found in the bark of ʻŌlapa (*Cheirodendron trigynum*), ʻŌhā wai (*Clermontia* spp.), and ʻŌhā (*Delissea* spp.) in mesic to wet forests (USFWS 2006). Eighteen other rare invertebrates are considered species of concern. Many of these are endemic to cave ecosystem.

## 2.3 Socio-economic Environment

The Plan Area is located in a sparsely populated portion of northern North Kona District and includes almost all of the traditional *ahupuaʻa* land divisions of Puʻu Waʻawaʻa and Puʻu Anahulu. Plan Area lands are classified by the State Land Use Commission as either Conservation District or Agricultural District and are largely undeveloped. The only significant population center in the Plan Area is the Puʻu Anahulu Homesteads and surrounding neighborhood, including the Pu'u Lani Ranch subdivision.

### 2.3.1 Population

The great majority of Hawaiʻi Island's estimated 190,821 residents live in the urban centers of Kailua-Kona and Hilo, and to a lesser extent in the smaller towns and villages that dot the island's extensive coastline. North Kona District supports approximately 29,000 residents with small inland population centers located just north of the Plan Area at Waikoloa Village (6,362) [3] and more distantly at Waimea (9,212). Neither of these population centers border the Plan Area, but they may be significant potential contributors of recreational users.

The population within the Plan Area boundaries is currently zero. There are technically no permanent residents within Puʻu Anahulu Game Management Area or Puʻu Waʻawaʻa Forest Reserve. There are, however, populations that immediately border the Plan Area, and are in fact entirely surrounded by Game Management and Reserve lands. These include the Puʻu Anahulu community on Route 190 and Puʻu Waʻawaʻa Ranch at the base of Puʻu Waʻawaʻa. 2010 census

[3] 2010 census data.

data indicate that the ranch supports a population of 14 individuals and that the Pu‘u Anahulu community supports approximately 260 (calculated manually from 2010 census blocks[4]) persons. Pu‘u Anahulu community is mixed, containing long-established residents descended from nineteenth century Hawaiian homesteaders and ranch workers, as well as the newer residents of Pu‘u Lani Ranch subdivision. Although the population is reported as 260, it is likely that the actual effective population is variable owing to a degree of seasonal occupation at Pu‘u Lani Ranch subdivision. Finally, there is one in-holding within Pu‘u Wa‘awa‘a Forest Bird Sanctuary, but the parcel is currently unoccupied.

### 2.3.2 Existing Land Use

Land use in Hawaii is regulated by HRS Chapter 205. Under this law, all state land is classified into four land use districts: urban, agricultural, rural, and conservation. The Plan Area contains land classified as agricultural and conservation. According to HRS Chapter 205, agricultural district lands can be used for a range of agricultural and related uses such as ranching and open-space recreation. The conservation district lands are divided into five subzones based on environmental sensitivity and intended uses. The Plan Area contains “general,” “resource,” and “limited” subzones (Figure 6). Currently, land use in the Plan Area is primarily controlled by DOFAW and managed as forest reserve, game management area, and wildlife sanctuary.

According to DLNR policy, “Forest Reserves are multi-use land areas that encompass and incorporate a variety of public uses and benefits. Each forest reserve within the Forest Reserves System has differing management and use goals associated with it depending on the nature of the resources found within the reserve.”[5] Along these lines, land use in Pu‘u Anahulu Game Management Area and Pu‘u Wa‘awa‘a Forest Reserve is best classified as “mixed-use,” with a variety of competing and complementary activities supported by DOFAW. Use of the Plan Area is currently split between ranching, recreation, conservation, research and educational, and cultural and customary practice uses. Within the recreational category, there is a further break-down into hiking, hunting, and eco-tourism, although hunting is also sometimes considered an economically significant subsistence activity. These various types of land use have coexisted for many years, although significant tensions have developed over the last decade. The following sections will describe grazing, hunting, conservation, research, and educational land uses. Hiking and eco-tourism, also important land uses, are discussed in Section 2.3.3 below.

#### *2.3.2.1 Grazing*

Portions of Pu‘u Anahulu Game Management Area and Pu‘u Wa‘awa‘a Forest Reserve have historically been leased for cattle grazing (Figure 7). The area has been used for pasture since the 1860s and this land use has largely shaped the local Pu‘u Anahulu Homestead community and is also responsible for most of the infrastructure within Pu‘u Wa‘awa‘a Forest Reserve (see Section 2.3.5).

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[4] http://histategis.maps.arcgis.com/apps/OnePane/basicviewer/index.html?appid=413d11d2e0e44a4fa687694cb98b43c3

[5] http://dlnr.hawaii.gov/forestry/frs/management-goals/

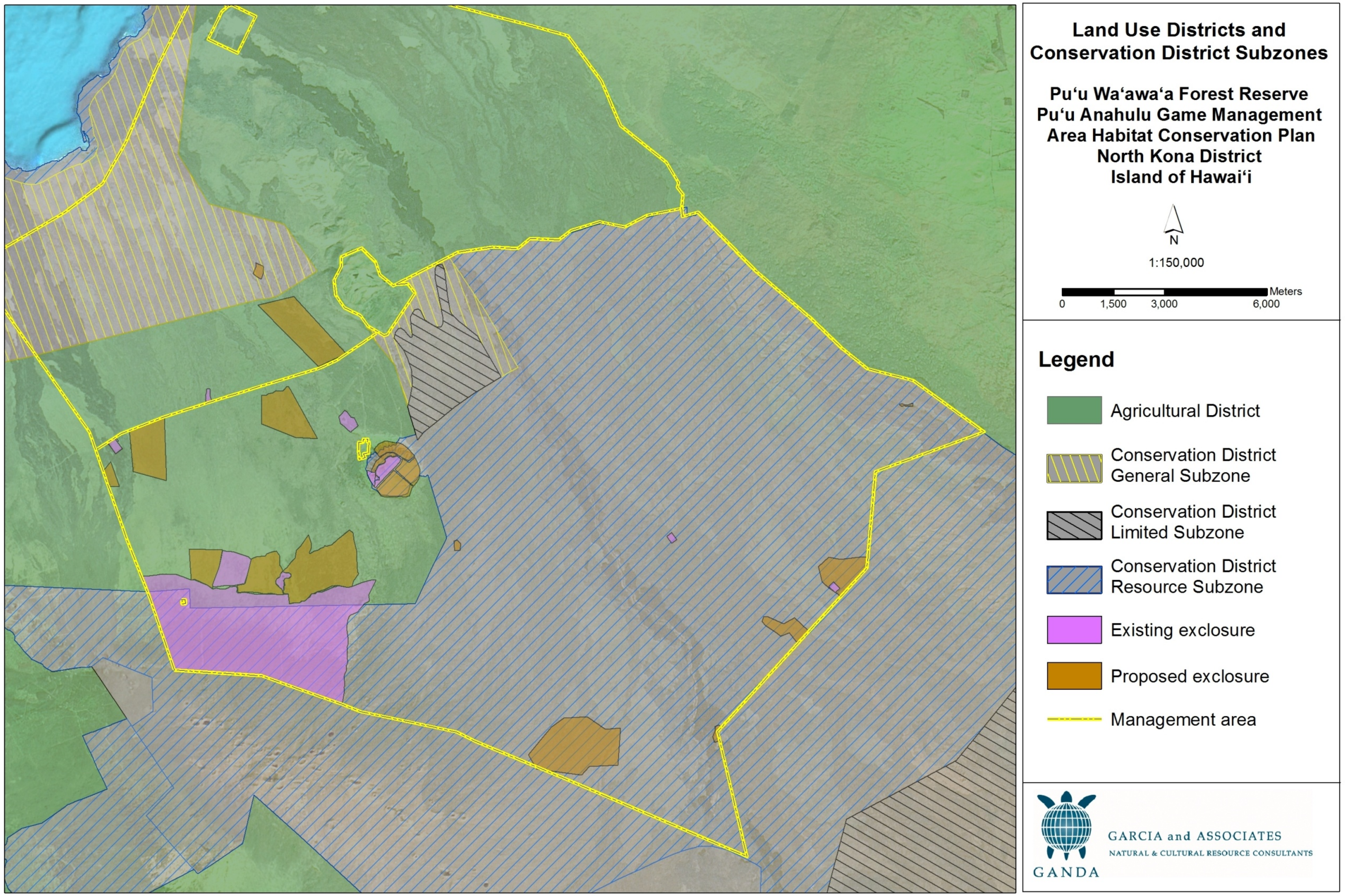



**Figure 6. Land use districts and subzones of the Plan Area.**

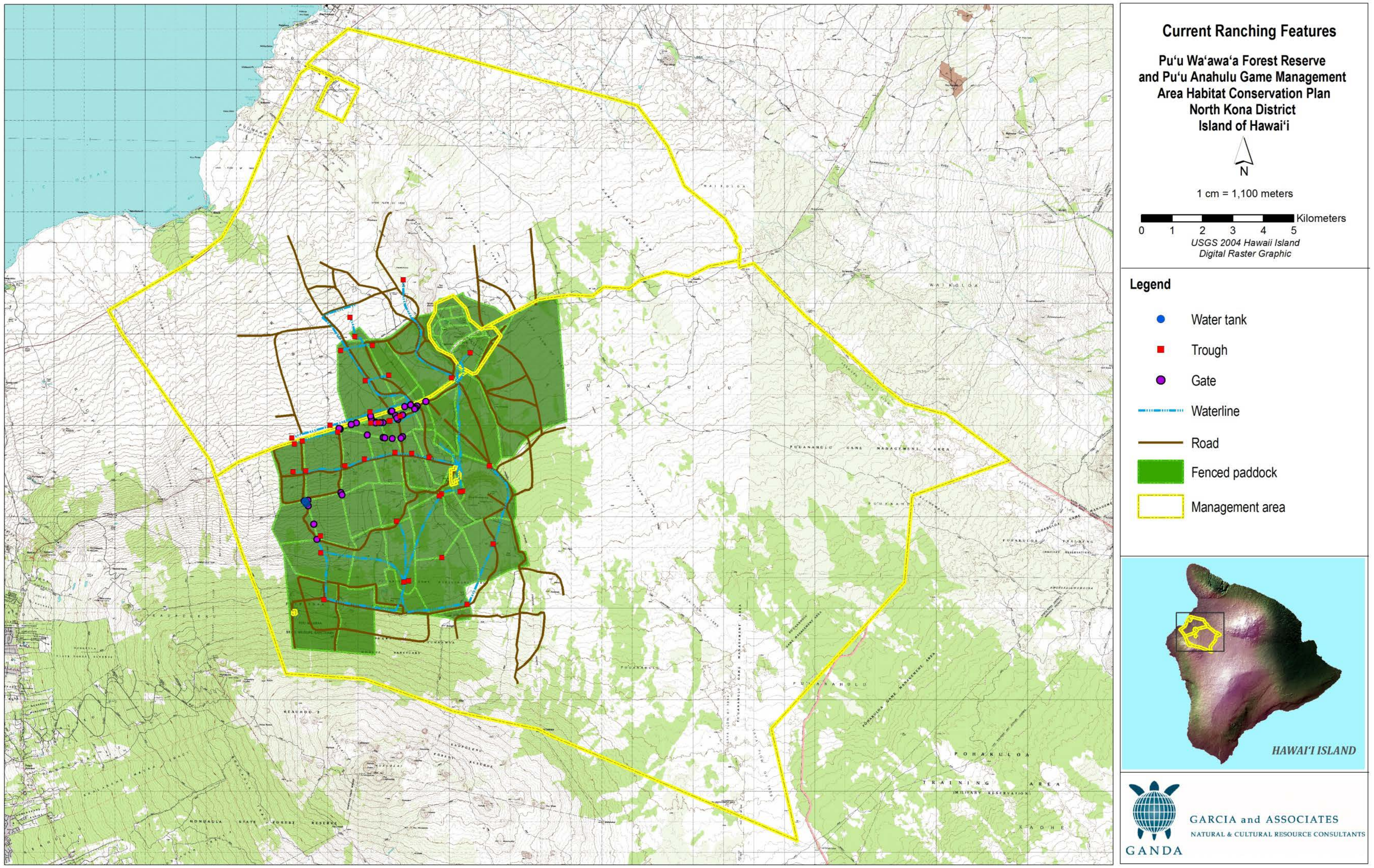



**Figure 7. Pasture and infrastructure utilized for cattle grazing prior to installation of Forest Bird Sanctuary exclosure. Many waterlines and troughs are now non-functional.**

Although it has historically contributed to the degradation of the native ecosystem, cattle grazing now serves as an important mitigation method to prevent the buildup of fire fuels. Livestock grazing is currently conducted under revocable month-to-month Special Use Permits issued through the DOFAW Forest Reserve System. Three permit holders are currently allowed to use approximately 19,310 acres for cattle grazing at Puʻu Waʻawaʻa Forest Reserve. A total of 13,610 acres are permitted in the *mauka* portion of Puʻu Waʻawaʻa Forest Reserve above the Māmalahoa Highway. Another 5,000 acres are permitted in the *makai* of Māmalahoa Highway, and 7,000 acres to the west and north of the Big Island Country Club golf course.

Grazing is not currently permitted within Puʻu Anahulu Game Management Area and the Forest Bird Sanctuary.

#### ***2.3.2.2 Hunting***

Concurrent with ranching, Puʻu Anahulu Game Management Area and Puʻu Waʻawaʻa Forest Reserve (formerly known as Puʻu Waʻawaʻa Cooperative Game Management Area) are actively used by hunters for both bird and mammal hunting. Hunting is conducted by residents from all over the state for food, sport, recreation, and social interaction. Formal public hunting programs at Puʻu Waʻawaʻa Ranch date back to 1978, although this activity has a much longer history in the area, likely dating to pre-Contact times. Species subject to hunting include feral sheep, goat, pig, and game birds. Game bird species are particularly diverse and include Erckel's francolin (*Pternistis erckelii*); black francolin (*Francolinus francolinus*); gray francolin (*Francolinus pondicerianus*); Kalij pheasant (*Lophura leucomelanos*); wild turkey (*Meleagris gallopavo*); Indian peafowl (*Pavo cristatus*); spotted dove (*Spilopelia chinensis*); and barred dove (*Geopelia maugei*).

All public hunting is currently administered via either manned or unmanned hunter check stations and requires licenses and additional harvest tags for selected game. Game bird hunting in both Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area usually opens from November through January, and in March during weekends and state holidays. Game mammal hunting in Puʻu Anahulu Game Management Area usually opens from March to June during weekends and state holidays and closes from July to the following February. In Puʻu Waʻawaʻa Forest Reserve, feral sheep and goats are harvested through the issuance of nuisance control permits on as needed basis.

In 1996, the lands of Puʻu Waʻawaʻa were identified by the USFWS and the hunting community as an important place to safeguard for future hunting, although the USFWS also acknowledged the importance of reconciling game management with the protection of endangered species and critical habitat (DLNR 2003). The volume of hunting has increased so much over the years that DLNR currently uses a phone-in reservation system and has instituted trip limits into Puʻu Waʻawaʻa. Historical trends in Puʻu Waʻawaʻa Forest Reserve show a sharp increase in the harvest of goats since 2007, with a corresponding decrease in sheep and pig harvest, which reached a peak in 2000 (Figure 8).

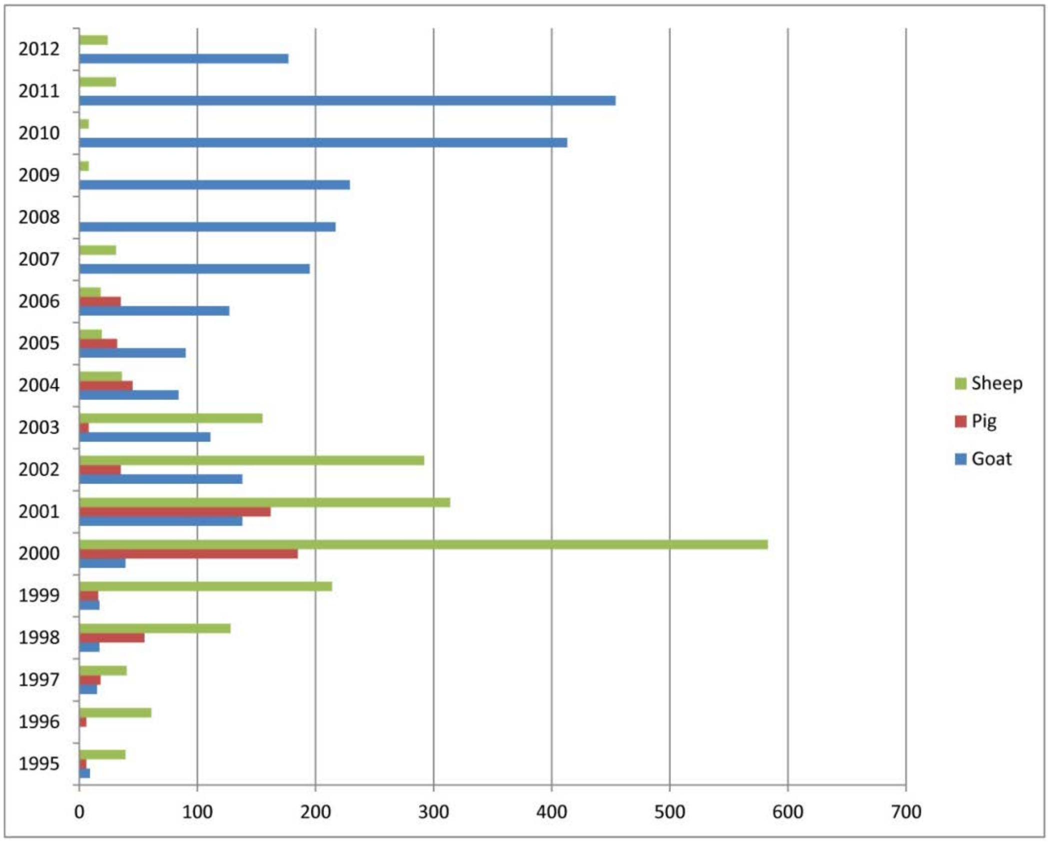



**Figure 8. Historical trends in goat, sheep, and pig harvest in Pu‘u Wa‘awa‘a Forest Reserve (includes both controlled and open hunting harvest).**

#### *2.3.2.3 Conservation*

In addition to grazing and hunting, Pu‘u Anahulu Game Management Area and Pu‘u Wa‘awa‘a Forest Reserve are actively managed to maintain and enhance sensitive indigenous Hawaiian natural resources. The Plan Area contains a significant acreage of tropical dry forest, a globally endangered ecosystem (Miles et al. 2006). One of DOFAW’s principal Forest Reserve System management goals (DOFAW 2014) is to “Maintain biological integrity of native ecosystems” and to:

- Protect, create, and manage native and endangered species habitat.
- Survey and monitor known habitats and populations.
- Propagate and outplant key species.
- Protect rare plants and wildlife individuals and populations.
- Propagate rare and endangered wildlife species.

- Monitor the extent and condition of forests and their associated resources.

One of the earliest conservation efforts in the Plan Area was the establishment of Puʻu Waʻawaʻa Forest Bird Sanctuary in 1984 by the State Board of Land and Natural Resources. Puʻu Waʻawaʻa Forest Bird Sanctuary includes 3,806 acres of habitat extending from 4,000 to 6,500 feet elevation (Governor's Executive Order No. 3937). Of this area, about 800 acres are zoned as agriculture with the remaining 3,006 included in the Conservation District (R Subzone). As the name implies, PWWFBS was created to preserve habitat for endangered forest birds. The Puʻu Waʻawaʻa Forest Bird Sanctuary was added to the state's wildlife sanctuary system when HAR §13-126 took effect on January 22, 2010.

Conservation efforts at Puʻu Anahulu Game Management Area and Puʻu Waʻawaʻa Forest Reserve began in earnest on January 25, 2002 when the Board of Land and Natural Resources transferred responsibility for all state-managed lands within the *ahupuaʻa* of Puʻu Waʻawaʻa and the *makai* lands of Puʻu Anahulu from the Land Division to DOFAW and State Parks (Governor's Executive Order No. 4203). Following the transfer, DOFAW and State Parks teamed with the Puʻu Waʻawaʻa Advisory Council to develop the *Management Plan for the Ahupuaʻa of Puʻu Waʻawaʻa and the Makai Lands of Puʻu Anahulu*, which was approved in concept by the BLNR on July 15, 2003 (DLNR 2003). This seminal planning document presented a series of resource management recommendations intended to promote sustainable resource management and community access to natural resources within the Plan Area. Conservation efforts over the last decade have largely focused on implementing the recommendations of this management plan which advocates for a cooperative approach to balancing natural and cultural resource management, fire management, grazing, public hunting, hiking and ecotourism, and research and education.

Finally, conservation and research efforts at Puʻu Anahulu Game Management Area and Puʻu Waʻawaʻa Forest Reserve have benefited greatly from the establishment of the HETF Puʻu Waʻawaʻa Unit in 2006. The HETF was authorized by the Secretary of Agriculture in 1992 through passage of the Hawaiʻi Tropical Forest Recovery Act (Public Law 102-574, 1992). Section 606 of the Hawaiʻi Tropical Forest Recovery Act states that the HETF shall be managed as (1) a model of quality tropical forest management where harvesting on a sustainable basis can be demonstrated in balance with natural resource conservation; (2) a site for research on tropical forestry, conservation biology, and natural resource management; and (3) a center for demonstration, education, training, and outreach on tropical forestry, conservation biology, and natural resources research and management. In 2006, the Hawaiʻi DLNR Land Board approved a Cooperative Agreement between the USDA Forest Service and DLNR to manage the HETF, which would include State Lands in Puʻu Waʻawaʻa. In 2007, DLNR granted a use permit to the USDA Forest Service for the HETF for purposes of research, education, demonstration, and related purposes. DLNR DOFAW and USDA Forest Service currently work together to coordinate research, management, outreach, access and education within HETF lands.

#### *2.3.2.4 Research*

Research and educational efforts are ongoing within the HETF Puʻu Waʻawaʻa Unit and included 13 active research projects in 2013 (Figure 9; HETF 2014). Since 2008, 46 research projects have been initiated in the HETF Pu‘u Wa‘awa‘a Unit. Research is conducted by scientists at U.S. Forest Service, University of Hawai‘i and other universities, and various governmental and non-governmental organizations. Examples of current research include molecular phylogenetics and

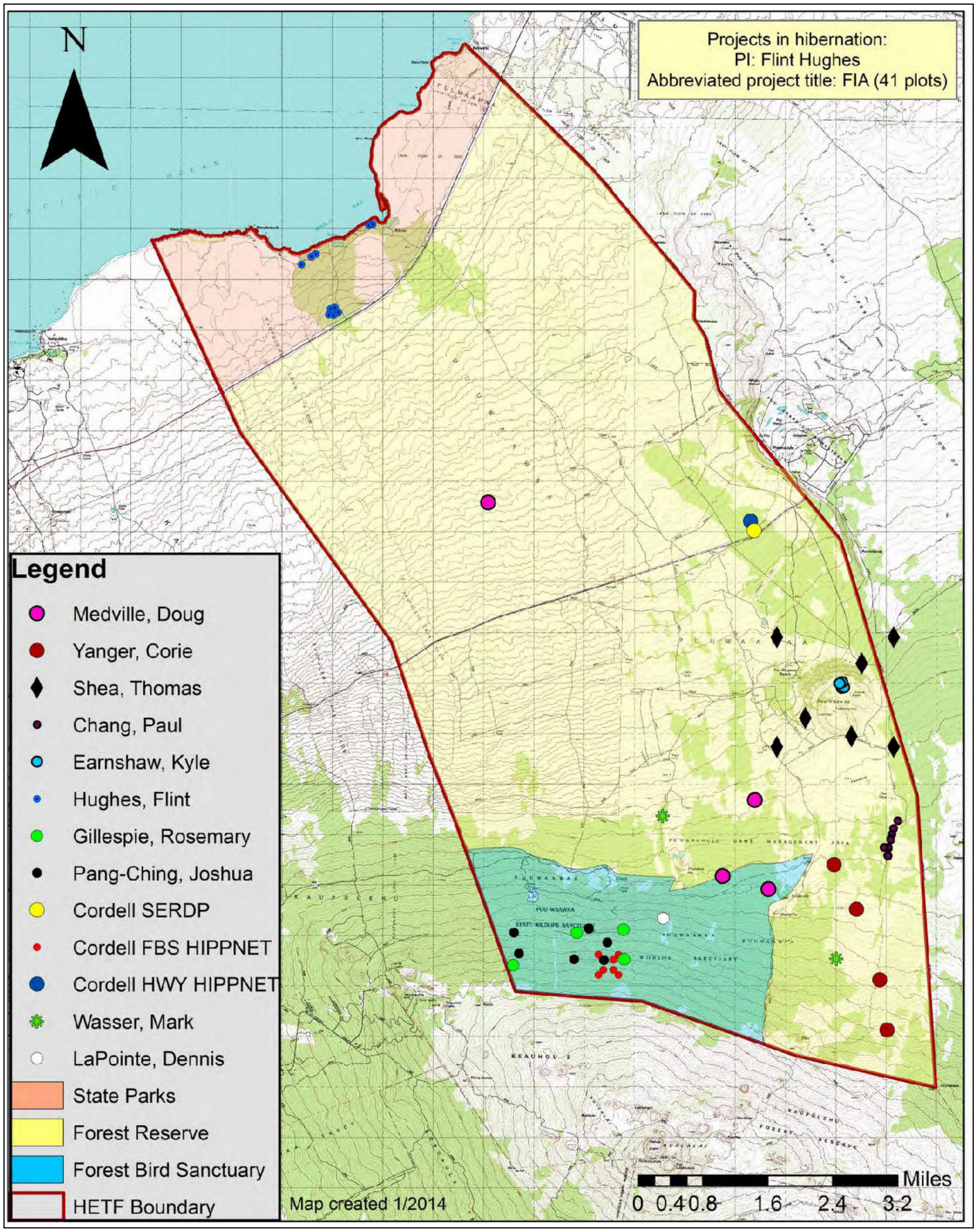



**Figure 9. Distribution of 2013 research projects in HETF Puʻu Waʻawaʻa Unit (from Dean and Block 2014 pp. 12).**

taxonomy work on Hawaiian *Tetragnatha* spiders by Dr. Rosemary Gillespie at the University of California, Berkeley. Other important research on the grass–fire cycle in dryland ecosystems is being conducted by Dr. Susan Cordell (USDA Forest Service) through a grant from the Strategic Environmental Research and Development Program. This work examines altered fire regimes and is developing new methods to interrupt the grass–wildfire cycle, and colleagues are using both remote sensing and field-based experiments.

##### *2.3.2.5 Education and Public Service*

Establishment of the HETF has greatly expanded the utilization of the area within the Puʻu Waʻawaʻa Forest Reserve and the Forest Bird Sanctuary for educational and public services. Current data from the HETF 2013 Annual Report indicate that 500 participants accessed the area on educational permits in 2013. Educational trips included visits by university classes, public and private schools from across Hawaiʻi Island, the Boy Scouts of America, the Kona Hiking Club, and the Hawaiʻi Youth Conservation Corps, to name just a few. In addition to educational activities, many groups also conducted public service work focused on dryland forest restoration through invasive weed control and the outplanting of native Hawaiian plants. Historical trip totals and affiliation are shown in Figure 10 from the HETF 2013 Annual Report, and the data demonstrates the diversity and intensity of educational involvement in the study area.

### 2.3.3 Recreation

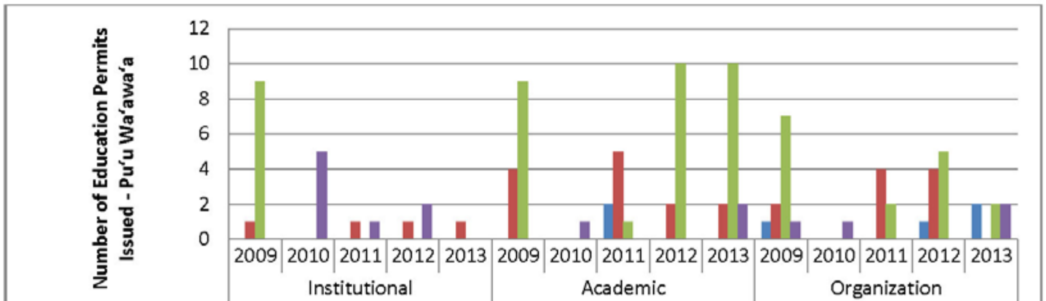
Recreational activities at Puʻu Anahulu Game Management Area and Puʻu Waʻawaʻa Forest Reserve, excluding hunting which is discussed above, primarily include DOFAW's network of hiking trails in upland Puʻu Waʻawaʻa. Publicly accessible trails were first established in January 2006 and have since been expanded by volunteers to include approximately 8 miles of trails extending from Route 190 (the Māmalahoa Highway) to the peak of Puʻu Waʻawaʻa. Trails include the 1.3-mile ʻŌhiʻa/Cone Trail system and the 1.1-mile Halapepe Trail.

The trails are frequently used, with 1,368 visitors between March 2013 and May 2014. Monthly totals of total hikers range between 38 and 147 or 9 to 36 visitors per week (Figure 11). Among the three trails the Cone Trail received the most traffic, followed by the Ohia Trail, then the Hala pepe Trail (Figure 12).

The trail alignments follow old bulldozer tracks and remnants of ranch roads originally designed to lead cattle between grassy areas around and across *ʻaʻā*. Trail creation along these routes mainly requires the clearing of fountain grass. Native trees and geological features are marked along the trails.

### 2.3.4 Scenic and Visual Resources

The scenic and visual landscape of the study area ranges from bare *pāhoehoe* and *ʻaʻā* flows to rolling grasslands and forested upland areas. The principal scenic and visual resources in the Plan Area include the Puʻu Waʻawaʻa cinder cone and Puʻu Anahulu bluff. These two prominent landscape features are the primary visual and cultural landmarks for the region and have significant aesthetic value to the local population and other land-users. The two hills are located in the upper portions of the Plan Area and are not always easily discernible from the lower coastal elevations,




| | Institutional | | | | | Academic | | | | | Organization | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2011 | 2012 | 2013 | 2009 | 2010 | 2011 | 2012 | 2013 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Service | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| Education | 1 | 0 | 1 | 1 | 1 | 4 | 0 | 5 | 2 | 2 | 2 | 0 | 4 | 4 | 0 |
| Service/Education | 9 | 0 | 0 | 0 | 0 | 9 | 0 | 1 | 10 | 10 | 7 | 0 | 2 | 5 | 2 |
| Other | 0 | 5 | 1 | 2 | 0 | 0 | 1 | 0 | 0 | 2 | 1 | 1 | 0 | 0 | 2 |

**Figure 10. Pu‘u Wa‘awa‘a trip totals and affiliation, 2009 to 2013 (from Dean and Block 2014 pp. 18).**

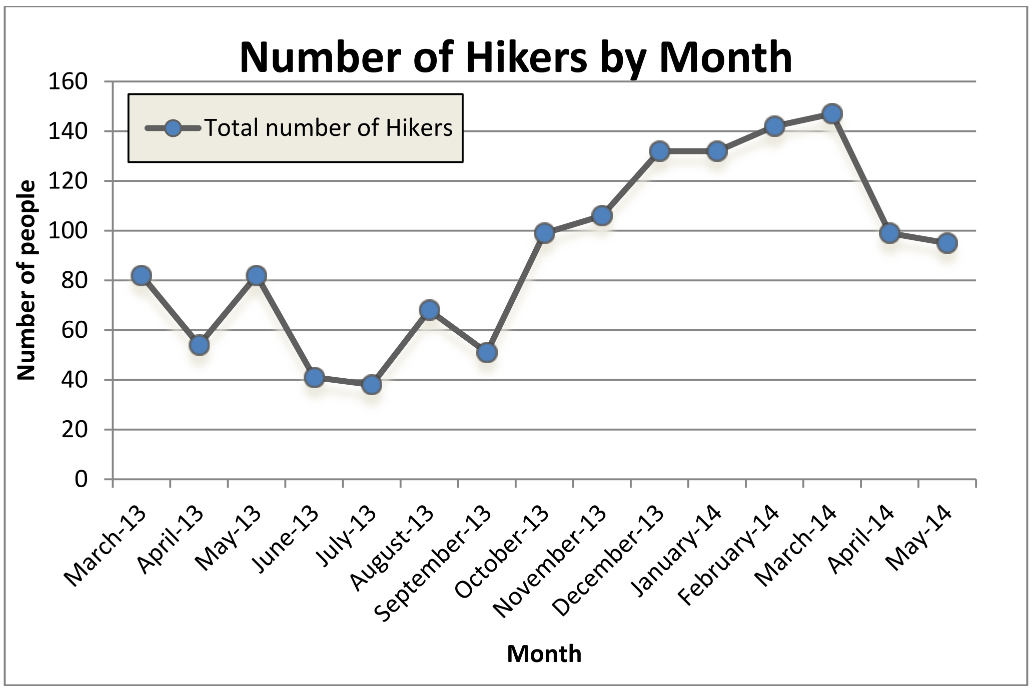



**Figure 11. Monthly totals of hikers that used the Pu‘u Wa‘awa‘a trail system between March 2013 and May 2014.**

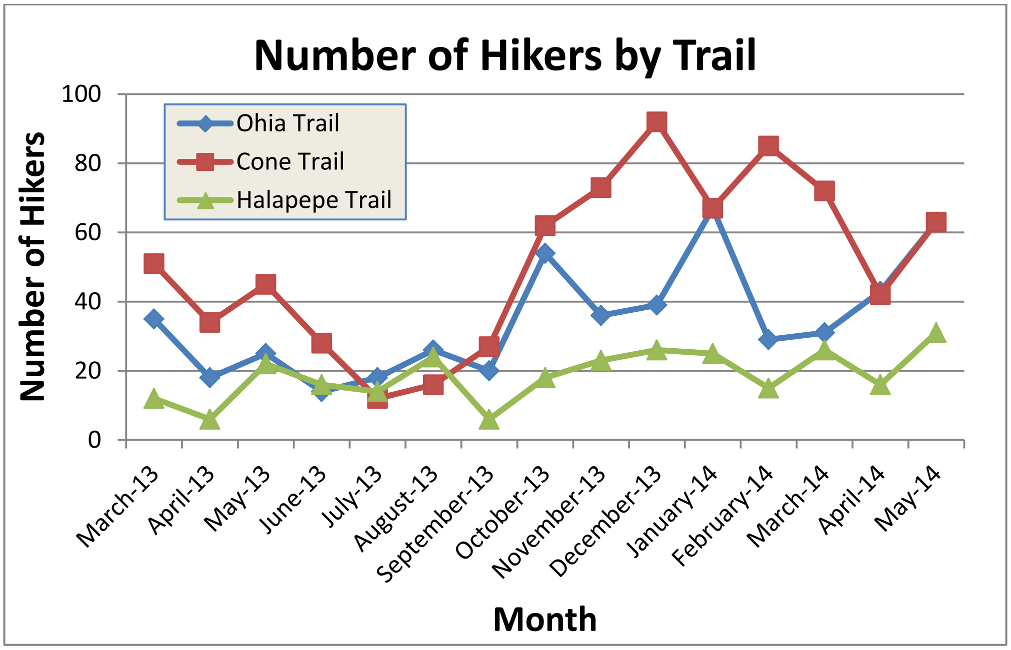



**Figure 12. Monthly totals of hikers of the three trails between March 2013 and May 2014.**

being often enshrouded in low clouds. On clear days, however, the hills provide a needed visual break in the broad undulating lava and grasslands that comprise most of the landscape. They provide important scenic vistas for visitors and locals alike and are therefore valuable visual resources.

### 2.3.5 Infrastructure and Utilities

Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area contain the minor infrastructure elements that would be expected in an undeveloped, rural landscape. Roads, buildings, and water supply are present in the Plan Area, most of which have historically supported grazing operations (see Figure 7). Infrastructure is most highly developed in Puʻu Waʻawaʻa area and includes 16 structures, approximately 133 miles (214 km) of roads, four water sources, approximately 30 miles (48 km) of waterlines, and miles of fencing and rock walls. In total, there are approximately 230 miles of road within the Plan Area. Water sources and transmission systems within Puʻu Waʻawaʻa include reservoirs (one at Hauaina and two at Poʻohohoʻo), water catchment sites (Hale Piula and Poʻohohoʻo), and wells. It should be noted that many of these infrastructure elements are in a state of disrepair. For example, there is a standpipe at the hunter check station which played a key role in fire suppression efforts in the past but is now non-functioning (Juvik and Tango 2003).

Transportation infrastructure within Puʻu Waʻawaʻa includes a network of paved and unpaved roads that provide access to most parts of the parcel. These include approximately 4 miles (6.4 km) of paved road and 129 miles (207.7 km) of unimproved four-wheel drive roads. Although utilized by all land-users, the roads were primarily constructed for ranching purposes and provide access to all paddocks and fencelines. They also provide access for fire suppression and in most cases constitute fire breaks in their own right.

In addition to standard infrastructure elements, the Puʻu Waʻawaʻa parcel also once supported a small, privately built and operated airstrip named Puu Waa Waa Ranch Airport (HI13) in Federal Aviation Administration records. The airport was activated in 1976 and at the time contained a single asphalt runway that was 2950 feet long and 40 feet wide. The airstrip was built and operated by F. Newell Bohnett and historically served Puʻu Waʻawaʻa Ranch, but is now decommissioned.

In addition to transportation and hydrologic infrastructure, the Plan Area also contains equipment emplacements and monitoring stations supporting ongoing research at Puʻu Waʻawaʻa. Active facilities include multiple weather stations including two remote automatic weather stations (RAWS) in the Forest Reserve, installed in 2003 and 2011, and one in the Forest Bird Sanctuary, installed in 2012 (Dean and Block 2014).

### 2.3.6 Cultural Resources

This section contains a review of cultural and archaeological resources within the area that may be affected by the proposed action. It includes an ethno-historical background focusing on traditional Hawaiian historical information and traces land use into the post-Māhele period. This is followed by a review of previous archaeological investigations in the *mauka* portion of Puʻu Anahulu and Puʻu Waʻawaʻa as well as a summary of archaeological inventory survey results for the exclosure fence corridors that are slated for construction in the near future.

#### *2.3.6.1 Ethno-Historical Background*

The *ahupuaʻa* of Puʻu Anahulu and Puʻu Waʻawaʻa are located in an arid region of the North Kona District known as Kekaha (Maly and Maly 2006). The name Puʻu Anahulu literally means "Ten-day Hill" and the name Puʻu Waʻawaʻa literally translates to "furrowed hill." The Kekaha region in which the hills Puʻu Anahulu and Puʻu Waʻawaʻa are situated was commonly known as Nāpuʻu until, according to traditional histories, Waʻawaʻa and his priestess-chiefess wife Anahulu moved into the area., They left their home in Pūʻālaʻa near the border of Kaʻū and Puna and moved to the Kekaha region to accompany their daughters, ʻAnaehoʻomalu and Puakō, who were in search of suitable husbands. Puʻu Anahulu was named for Anahulu (Maly and Maly 2006).

Puʻu Anahulu and Puʻu Waʻawaʻa were noted for their abundance of natural resources, which supported several Hawaiian coastal villages. The coastal areas contained rich nearshore fisheries and numerous salt pans. Crops were cultivated in the forested uplands which also provided important resources for the construction of *heiau*, fishponds and canoes. Regional narratives describe the seasonal practice of cultivation in the uplands during the winter wet planting season, then migration to the coast during the dry summer season to harvest the resources of the ocean (Maly and Maly 2006).

During the late eighteenth century, the lands of Kekaha were under the control of the powerful twin chiefs Kameʻeiamoku and Kamanawa (Kamakau 1992), said to be the uncles of Kamehameha. Kamanawa was among Kamehameha's strongest supporters and periodically resided in Kīholo (Kelly 1973).

From 1800 to 1801, lava from Hualālai volcano flowed from the low slopes of Huʻehuʻe westward into Kaʻupulehu, extending into the coastal area of Puʻu Waʻawaʻa. A variety of traditional explanations were developed within the Hawaiian community to explain the event (Kamakau 1992:184):

> Another important event which occurred in the fourth year of Kamahameha's rule was the lava flow which started at Huʻehuʻe in North Kona and flowed to Mahaiʻula, Kaʻupulehu and Kiholo. The people believed that this earth-consuming flame came because of Pele's desire for *awa* fish from the fishponds of Kiholo and Kaʻupulehu and *aku* fish from Kaʻelehuluhulu; or because of her jealousy of Kamehameha's assuming wealth and honor for himself and giving her only those things which were worthless; or because of his refusing her the tabu breadfruit of Kamahaʻikana which grew in the uplands of Huʻehuʻu where the flow started.

Although Kamehameha I rebuilt Kīholo fishpond in 1810, Mauna Loa later erupted in the 1850s, culminating in the 1859 flow that destroyed the villages of Waināliʻi and Kapalaoa and again filled in Kīholo fishpond. The lava flow covered a considerable part of Puʻu Anahulu and created a new coast line. According to the Hawaiian newspaper *Ka Hae Hawaii* (November 1859):

> The flow began to go seaward in the months of February of this year, from the northwest side of Mauna Loa . . . it turned south to Wailoa, and continued on to the deep sea, smooth lava (pahoehoe) extending into it about forty chains or more in length. This new point [of land] has been named Lae-Hou. The flow turned on the south side of Wailoa and went to Kiholo where it covered the pond. Then it turned to the west, where a new point is burning now. Lae-Hou is a long point, but this new one is shorter. The lava has not finished building it, but it is now in the depths of the sea. I think it is forty or more fathoms deep where it is burning, and from there it is about forty fathoms to shore. In the year 1810, the Kiholo fishpond had been built, or rebuilt, during the reign of Kamehameha I. It was a fishpond in which many kinds of deep sea fish were kept and in this year, in the reign of Kamehameha IV, Kiholo is closed by the lava. It is now only a heap of rocks.

##### *2.3.6.1.1 The Māhele of 1848*

The Māhele of 1848 abolished the traditional Hawaiian system of land and natural resource tenure in favor of a Western system of land title. All land in the Kingdom of Hawaiʻi was placed into one of three categories: 1) Crown Lands; 2) Government Lands; and 3) Konohiki Lands. The Kuleana Act of the Māhele provided a framework by which Hawaiians could apply for and be granted land to sustain their livelihood; however, the restrictions of the act made it difficult to receive a land award and discouraged Hawaiians who did not actively cultivate land. No *kuleana* claims made by registered native tenants were awarded in the *ahupuaʻa* of Puʻu Anahulu or Puʻu Waʻawaʻa. Both *ahupuaʻa* were claimed as Crown Lands in their entirety and were retained by the government.

The Crown Lands Act declared the King's Land quasi-public, which placed them under the control of appointed commissioners. These lands became available for lease in large acreages suitable for plantation farming or cattle ranching. In 1863, the lands of Puʻu Anahulu were leased to three Native Hawaiian lessees—G. Kaukuna, M. Maeha and S. Kanakaole—to conduct ranching activities. The lease agreements were for a term of five years. Two years into their lease agreements, the three Native Hawaiians sold their interests to Francis Spencer, who incorporated the land holding into the Waimea Grazing and Agricultural Company, which used the land for ranching until 1895.

In 1895, a portion of Puʻu Anahulu was selected for homesteading under the Homestead Act of 1884.[6] By 1898, Eben Low and Robert Hind entered a leasehold agreement with the government for the *ahupuaʻa* of Puʻu Waʻawaʻa and the remainder of the adjacent *ahupuaʻa* of Puʻu Anahulu, which became Puʻu Waʻawaʻa Ranch. Puʻu Waʻawaʻa Ranch encompassed approximately 128,000 acres of land, 100,000 of which were lava flows and therefore classified as "waste lands." In total there were only about 1,500 acres of prime grazing lands, 100 acres of which were planted with crops (Henke 1929). 300 acres of land on the ranch were held in fee simple and the rest were government-leased lands. According to Henke (1929):

> The real beginning of the Puʻu Waʻawaʻa Ranch was about 1892 when Robert Hind and Eben Low leased about 45,000 acres from the government and purchased about 2,000 head of cattle, a mixture of Shorthorned, Angus and Devon breeds, from Frank Spencer, who had previously leased the lands of Puʻu Anahulu, consisting of approximately 83,000 acres from the government. In 1893, Hind and Low acquired the lease on 12,000 acres of this area and in about 1917 Hind acquired the lease on the other 71,000 acres formerly in the Spencer lease. No cattle were carried over on these 71,000 acres during this period 1893-1917, but the land was pretty overrun with goats . . . Since 1902 Robert Hind has been the sole owner of the Puʻu Waʻawaʻa Ranch and he is still general manager of the ranch.

Robert Hind worked to consolidate his interest in Puʻu Waʻawaʻa Ranch and by the late 1920s formed the corporation Robert Hind LTD, which operated the ranch until 1959 when the lease was acquired by Dillingham Ranch Inc.

#### *2.3.6.2 Archaeological Resources*

Both Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa cover a wide range of environmental zones that contain different resources and subsequently, varying archaeological site or feature types. These zones are generally referred to in Hawaiian as *wao* and collectively provided pre-Contact Hawaiians with resources important to all economic, political, and religious aspects of life. The lowland *wao* consisted of the *kahakai* which included near-shore fisheries and the coastal strand, the *kula kai*, or seaward plains, and the *kula uka*, or inland plains. Beyond these more intensively inhabited and utilized lowland zones were the inland zones including the *wao kanaka* or region of man and the *wao nahele* or forest region (Dye et al. 2002:15). The EA study area lies at approximately between 25 and 6,360 feet amsl. While this range in elevations covers all environmental zones within the two *ahupuaʻa*, most of the exclosures proposed for Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Areas lie above 1,000 feet amsl

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[6] The law was an effort to allow more Hawaiians to have possession of fee simple property.

(see Figure 1) and generally correspond with the upland *wao* including *kula uka*, *wao kanaka*, and *wao nahele*.

Archaeological investigations within the *ahupuaʻa* of Puʻu Waʻawaʻa and Puʻu Anahulu have been predominantly conducted below 300 feet amsl along the coastal areas in response to large-scale resort development and highway construction (Ching 1971; Rosendahl 1973; Kirch 1974; McEldowney 1979; Ahlo 1982; Jenson 1989; Rechtman and Wolforth 1999). Generally, archaeological research in the coastal, or *kahakai* zone, has documented various clustered village sites with associated ponds and an extensive range of features including long-term habitation of religious and ceremonial sites. Also, in the more barren areas just inland, an extensive lava scoria procurement zone near ʻAnaehoʻomalu Bay and a large cave that contained over 1,700 artifacts and abundant midden deposits were recorded (Borthwick and Hammatt 1992:13).

Two projects were conducted within the intermediate, or *kula kai* zone by Borthwick et al. 1991 and Borthwick and Hammatt 1992. These studies were conducted for the West Hawaii Land Fill and the West Hawaii Power Plant. No archaeological sites or cultural resources were recorded during the survey of the proposed power plant, and six sites were recorded during the survey of the adjacent land fill. These included three lava tubes, a cave, and a C-shape that were likely used as temporary shelters, and a modified ridge that was interpreted as a quarry site. Borthwick et al. (1991) argue that the temporary shelters are typical of the intermediate zone where permanent occupation was unlikely. Shelters in this zone were temporarily occupied by travelers moving between the coastal areas and upland planting zones.

In the remote upland regions of Puʻu Waʻawaʻa Ahupuaʻa and Puʻu Anahulu Ahupuaʻa, at elevations above 1,000 feet, formal archaeological research has been far more limited. Table 7 presents all archaeological studies conducted at elevations above 1000 feet in the vicinity of the proposed exclosures. The results of these studies are also discussed below.

Most archaeological surveys conducted in the upland *kula uka, wao kanaka, and wao nahele* zones has been related to the development of a golf course and residential subdivisions in Puʻu Anahulu. In 1989 and 1990, Paul H. Rosendahl, Ph.D., Inc. (PHRI) conducted a survey of 400 acres for the development of the Royal Vistas Estates. This resulted in the identification of 11 sites consisting of 26 constituent features (Walker and Rosendahl 1989, 1990). Site types included a terrace, mound with a *pāhoehoe* boulder alignment, enclosure, boulder alignments, a modified outcrop, a C-shape, a cistern with possible cultural deposit, a cairn, and a possible cultural deposit. Functional interpretations include habitation, burial, water catchment, ceremonial, possible agriculture, and a possible boundary marker. Site 13161, an 18.0-m-long, 9.0-m-wide, and 1.7-m-high terrace, was identified by an informant as the Kumua Heiau (Walker et al. 1990). In 1993 a supplemental survey of approximately 63 acres of additional land for the same development (renamed Big Island Country Club Estates) was conducted by PHRI archaeologists Joseph Jimenez and Earl Fujishige. This resulted in the identification of seven sites with ten constituent features. Formal and functional site types included a platform and rock wall complex interpreted as a permanent habitation with boundary walls, three rock boundary walls, a terrace interpreted as a temporary habitation, modified outcrop interpreted as a temporary habitation feature, and a modified outcrop also interpreted as a temporary habitation with a mound with indeterminate function. Subsurface testing was conducted at a small mound feature from Site 19439. An unidentified sample of charcoal recovered from 112 cm below excavation datum was submitted for radiocarbon analysis. This yielded an adjusted $^{14}C$ age of 190 ± 90 cal. B.P. dating the sample to sometime in the late pre-Contact to the early historic period (Jimenez 1994). The results of both surveys revealed the presence of limited pre-Contact resources. However, the surveys also revealed that the area had been

**Table 7. Previous Archaeological Research in the *Mauka* portion of Puʻu Anahulu and Puʻu Waʻawaʻa Ahupuaʻa**

| Author and Date | Location | Work Completed | Results |
|---|---|---|---|
| Walker and Rosendahl 1989 | Kapalaoa Project Site, Puʻuanahulu | Archaeological Inventory Survey | Recorded historic period house sites, graves, and cemeteries. |
| Jimenez 1994 | Big Island Country Club Estates, Land of Puʻu Anahulu | Archaeological Inventory Survey | Recorded historic period house sites, graves, and cemeteries. |
| Barrera 1997 | Puʻu Lani Ranch | Archaeological Inventory Survey | Documented more than 30 Hawaiian homestead and ranching activity sites. |
| McGerty and Spear 2000 | Puʻu Anahulu and Puʻu Waʻawaʻa Ahupuaʻa, TMKs: (3) 7-1-01:04, 7-1-01:06, 7-1-02:13, 7-1-03:16, and 7-1-04:18. | Reconnaissance survey | Documented 32 sites including permanent and temporary habitation caves, burial caves, agricultural sites, trails, boundary markers, and tubes for water collection. |
| Dye and Maly 2001 | Puʻu Lani Ranch and Puʻu Anahulu | Archaeological Inventory Survey | Documented 35 previously recorded and 10 unrecorded sites including burials, enclosures, graves, mounds, modified outcrops, platforms, terraces, walls, caves and shelters. |
| Desilets 2002 | Puʻu Anahulu | Archaeological Reconnaissance Survey | Recorded one historic period schoolhouse, one stone wall, and historic-period farm implements. |
| Gregg et al. 2006 | Puʻu Lani Ranch and Puʻu Nana Estates | Archaeological Inventory Survey | Recorded various Hawaiian homestead and ranching sites. |
| Kouneski et al. 2006 | Puʻu Lani Ranch and Puʻu Nana Estates | Archaeological Inventory Survey | Recorded various Hawaiian homestead and ranching sites. |
| Elison et al. 2007 | Puʻu Lani Ranch and Puʻu Nana Estates | Archaeological Inventory Survey | Recorded various Hawaiian homestead and ranching sites. |
| Dougherty and Moniz- Nakamura | Puʻuwaʻawaʻa, TMK: (3) 7-7-001:006, 007 | Archaeological Inventory Survey | Identified six historic period resources including |

| Author and Date | Location | Work Completed | Results |
|---|---|---|---|
| 2008 | | | a wooden water tank, a wall, enclosure, modified cave, trail, and isolated artifact (bottle). |

**Table 7. (continued)**

| Author and Date | Location | Work Completed | Results |
|---|---|---|---|
| Rechtman and Muise 2009 | Hale Piula Haina Research Facility, TMK (3) 7-1-01-003 | Archaeological Inventory Survey and Cultural Impact Assessment | Documented and assessed one historic period site: SHIP Site 26171, the Hale Piula Water Catchment Area. |

extensively modified by cattle ranching during the historic period, which has likely destroyed evidence of intensive pre-Contact utilization of the area. Particularly, this includes evidence of pre-Contact permanent habitation and dry-land agriculture of the area.

Other archaeological investigations in the Puʻu Anahulu area to the north of Puʻu Waʻawaʻa, include work conducted for the development of the Puʻu Lani Ranch and Puʻu Nana Estates subdivisions. Collectively, these projects identified 46 sites, the majority of which were associated with Hawaiian homesteading and ranching (Barrera 1997; Dye and Maly 2001; Desilets 2002; Dye et al. 2002; Gregg et al. 2006; Kouneski et al. 2006; Elison et al. 2007). Traditional Hawaiian sites were well represented, including burials, mounds, enclosures, fire pits, petroglyphs, modified outcrops, and a platform. Volcanic glass was also recovered from two fire pits and one cave shelter.

While a majority of the archaeological studies of the upland environmental zones have been concentrated around Puʻu Anahulu various projects have documented significant evidence of pre-Contact use and historic period ranching of areas surrounding Puʻu Waʻawaʻa.

Three archaeological surveys were conducted within the Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Areas, including an archaeological reconnaissance survey of 22,000 acres of in the upland areas of Puʻu Anahulu and Puʻu Waʻawaʻa Ahupuaʻa by Scientific Consultant Services Inc. (McGerty and Spear 2000), a survey of three proposed fence alignments within the Puʻu Waʻawaʻa Forest Reserve by National Park Service personnel, and an archaeological inventory survey (Ketner et al. 2008) and cultural impact assessment (Rechtman and Muise 2009) within the uplands of Puʻu Waʻawaʻa Ahupuaʻa by Rechtman Consulting LLC.

The reconnaissance survey of 22,000 acres of in the upland areas of Puʻu Anahulu and Puʻu Waʻawaʻa Ahupuaʻa consisted of 23 pedestrian sweeps conducted throughout the Plan Area and spot-checks of special interest areas and areas with known but unrecorded sites. Methods for the reconnaissance survey of this vast area were specifically designed to locate and explore culturally utilized or modified caves. This resulted with the identification of 32 sites; however, only a few of these were identified as culturally utilized caves. Various formal site types were identified and included a wide variety of staked rock features (walls, enclosures, C-shapes, U-shapes, mounds, and *ahu*), terraces, and lava tubes containing midden, non-human bone, and burials. Functional site types included temporary habitation and permanent habitation features, burial caves, agricultural sites, historic ranching features, trail or boundary markers, and water collection features. Unfortunately, project time constraints limited the collection of data during the survey. Because of this, only summary descriptions of the each site and photographs of a sample of the sites are presented in the report and no assessments of cultural affinity, integrity, and significance for each site are currently available. As the authors note, however, more sites than expected were encountered during this limited reconnaissance survey (McGerty and Spear 2000:13).

The National Park Service inventory survey of proposed fenceline corridors for the Henahena Paddock area, the Oweowe exclosure extension, and the Eastern Boundary Survey area resulted in the identification of five sites and an isolated artifact. These were predominantly historical sites and included a water tank, a wall, an enclosure, a cave, a trail, and a glass bottle. It could not be determined if the trail and cave dated to the pre-Contact period and the water storage tank, rock wall, enclosure, and bottle are likely related to historic-era goat and cattle ranching that began by the mid-nineteenth century (Dougherty and Moniz-Nakamura 2008:22).

The archaeological inventory survey and cultural impact assessment conducted by Rechtman Consulting, LLC covered a 2.7-acre parcel (TMK (3) 7-1-001:003) located in the *mauka* portion of Puʻu Waʻawaʻa Ahupuaʻa within the Forest Bird Sanctuary. The Plan Area was identified as a historical water catchment area associated with the Puʻu Waʻawaʻa Ranch (SIHP Site 26171). This area was known as Hale Piula and was first developed in the in the mid-1930s as a water source for the ranch. The catchment facility was expanded during the late 1930s and in the early 1960s (Ketner et al. 2008). The site consisted of two large rainwater catchment structures constructed of corrugated roofing material, remnants of three metal flumes, and concrete foundation blocks that supported wooden water tanks. The catchment structures cover approximately one-third of the project parcel and approximately 318 linear feet of metal flume supported by wooden trestles are still present. The wooden tanks were dismantled by a previous landowner. This site dated no earlier than the 1930s (Rechtman and Musie 2009).

The volcanic cinder cone known as Puʻu Waʻawaʻa is unique in the area as a source for high-quality volcanic glass, which was used for the manufacture of volcanic glass tools (McCoy 2011). These included scrappers and expedient multipurpose cutting tools. Puʻu Waʻawaʻa was formed from a trachyte flow and is composed of trachyte pumice (Macdonald et al. 1983). Scattered throughout the pumice are geodes of volcanic glass. The primary source of glass consisted of small nodules of high-quality material, found in beds that are easily accessible on the north-facing gullies of the hill, which could be flaked to form small tools. Currently, Puʻu Waʻawaʻa is the only known source of green-colored volcanic glass in the Hawaiian Islands. Research has chemically characterized the volcanic glass from Puʻu Waʻawaʻa, allowing it to be distinguished from materials derived from other volcanic sources. Subsequently, some 3,329 artifacts made from Puʻu

Wa‘awa‘a trachytic volcanic glass have been identified from 87 sites located throughout the major islands of the Hawaiian Archipelago.

##### 2.3.6.2.1 Historic Pu‘u Wa‘awa‘a Ranch (50-10-19-7190)

Since the inception of Pu‘u Wa‘awa‘a Ranch in 1893 to its closure in 2000, the ranch was the sole proprietor of Pu‘u Wa‘awa‘a Ahupua‘a, consisting of some 40,000 acres. By 1917, the ranch was also utilizing 83,000 acres of the adjacent northern *ahupua‘a* of Pu‘u Anahulu. A systematic archaeological inventory survey of all of the land used by Pu‘u Wa‘awa‘a Ranch has never been conducted.

Pu‘u Wa‘awa‘a Ranch was initially documented in 1973 during the Department of Land and Natural Resources, State Parks Division, statewide archaeological inventory survey of Hawai‘i Island. The brief site description of the ranch defines the site as consisting of 19,000 acres and, although it is not specified in the site record, presumably includes the ranching facilities and surrounding paddock system.

Subsequent archaeological studies conducted at the inventory level within the former Pu‘u Wa‘awa‘a Ranch lands have focused on relatively small portions of land in Pu‘u Wa‘awa‘a and Pu‘u Anahulu. These studies were in support of regional development and ecological initiatives including infrastructure improvements, residential construction, wildlife conservation, and habitat restoration. The archaeological investigations detailed in the previous section have documented and evaluated a wide range of site types interpreted to be associated with the operation and infrastructure of Pu‘u Wa‘awa‘a Ranch. These historic ranching sites include the core ranch buildings (Site 26170), the Hale Piula water catchment area (Site 26171), the paddock system, core-filled walls, building foundations, water tanks and delivery lines, road-beds, enclosures, temporary shelters, cairns, mounds, and terraces. It is important to note, however, that while all of these historic ranching sites have been assigned individual site numbers, they are all inter-related components of Site 7190.

##### 2.3.6.2.2 Summary

The previous research summarized above clearly indicates that significant archaeological resources could potentially occur anywhere within Pu‘u Anahulu and Pu‘u Wa‘awa‘a Ahupua‘a. Historical ranching features and traditional Hawaiian sites are quite common across the landscape. Pu‘u Anahulu, in particular, seems to have been a locus of temporary or semi-permanent pre-Contact Hawaiian habitation, as well as intensive settlement in the early historic era. The Pu‘u Wa‘awa‘a cinder cone was an important volcanic glass source for pre-Contact Hawaiian, which was traded throughout the Big Island. Relative to the vast land area encompassed by upland Pu‘u Anahulu Ahupua‘a and Pu‘u Wa‘awa‘a Ahupua‘a, however, archaeological resources are relatively sparse compared with the denser settlements and site complexes found on the coast (Planning Solutions 2014). Importantly, Dougherty and Moniz-Nakamura’s (2008) survey of narrow linear corridors for previous fence exclosure alignments identified few sites.

#### 2.3.6.3 Archaeological Inventory Survey

An archaeological inventory survey was conducted for proposed fence corridors at the three conservation units to evaluate the presence or absence of archaeological resources in the areas proposed for the first phase of exclosure construction. This survey covered the conservation areas that are planned for immediate installation: the ‘Aiea Unit, Henahena Unit, and Pu‘u Wa‘awa‘a Cone Conservation Area. Fences were already present along some corridor sections and the proposed units also sometimes shared fenced boundaries with other units. The survey focused on corridors that required new fence installation, although many of the existing fences were also examined. Survey corridors varied from 50 to 250 m wide, a variation which is intended to allow flexibility during fence installation to avoid any sensitive cultural and natural resources. In addition to surveying fence corridors, Miki Kato and Ku‘ulei Keakealani were consulted to obtain information about features observed during the archaeological survey. Results for each conservation unit are presented below. The complete archaeological inventory survey report can be found in Appendix B.

#### 2.3.6.3.1 ‘Aiea Unit

Two fenceline corridors totaling approximately 1.4 linear kilometers were surveyed for the ‘Aiea Unit (Figure 13). The corridors consisted of relatively short sections that ran between other existing conservation units with existing fences. The shortest section was approximately 100 m long, 50 m wide, and covered 0.6 ha

The ‘Aiea Unit survey corridor produced examples of all three major classes of ranch infrastructure—paddock fencing, water distribution lines, and access roads. In the western part of the unit, two major fencelines were recorded. Moving east, two small lateral irrigation lines were identified as well as a major line running toward Henahena Unit. Finally, two historic ranch roads were identified. These include the current Forest Bird Sanctuary Road and a minor offshoot running to the northeast side of Po‘ohoho‘o Reservoir. All of the features identified in the ‘Aiea Unit survey corridor are constituent elements of historic Pu‘u Wa‘awa‘a Ranch (Site 7190).

#### 2.3.6.3.2 Henahena Unit

The proposed fenceline corridor was surveyed for the western, northern, and eastern boundaries of the Henahena Unit. These sections totaled approximately 6 km in length and varied from 50 to 150 m in width (Figure 13).

The Henahena Unit survey corridor produced a variety of features associated with historic Pu‘u Wa‘awa‘a Ranch including three historic fencelines, a water pipeline, ranch roads, and a large corral. The fencelines include one intra-paddock fence of the same type recorded in Waiho 1 Waimea Paddock in the ‘Aiea Unit. The single water pipeline observed along the Section 1 alignment is defunct and has largely been removed. The ranch roads are mostly linear and are relatively well developed. All of the ranch roads parallel, and provide access to, water or fence infrastructure. None of the roads appear on older historic USGS quadrangle maps. They all appear to date to the mid-twentieth century. In addition to the general infrastructure features, one major stone corral was recorded in the center of Fence 5. This feature had been previously recorded by Dougherty and Moniz-Nakamura as Temporary Feature 3 (Dougherty and Moniz-Nakamura 2008:19) and is now assigned Site 50-10-20-30311.

#### *2.3.6.3.3 Pu'u Wa'awa'a Unit*

A total of 8 km of proposed fenceline corridor was surveyed for the Puʻu Waʻawaʻa Conservation Area (CCA). The transects were 50 m wide and covered an area of approximately 37.6 ha (Figure 14).

Survey of the Puʻu Waʻawaʻa CCA corridor identified numerous historic properties. These included a possible pre-Contact shelter (Site 30307), various infrastructure features and sites associated with historic Puʻu Waʻawaʻa Ranch (Site 7190), and the Puʻu Waʻawaʻa Trachyte Quarry (Site 30306). Ranch infrastructure features include historic fencelines, waterlines, and ranch roads. Sites associated with historic Puʻu Waʻawaʻa Ranch include portions of a stacked rock wall (Site 30310) and a chute and corral complex (Site 30308). Fencelines in the Puʻu Waʻawaʻa CCA include three quarry boundary fences, two intra-paddock fences, and one paddock boundary fence. A water pipeline was observed in running from Site 30307 to Site 30308. The line is defunct and has largely

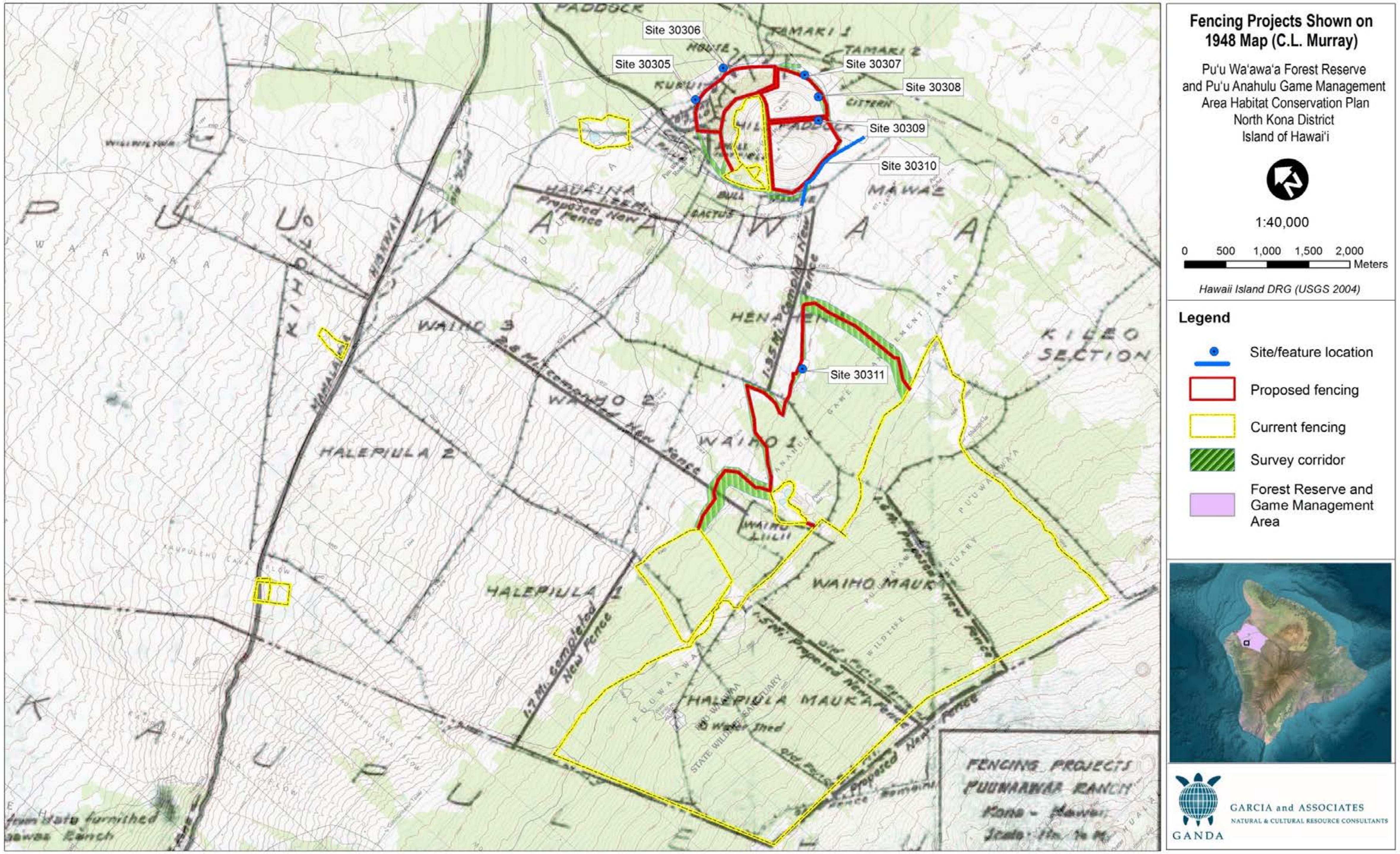


**Figure 13. Survey corridors and site locations.**

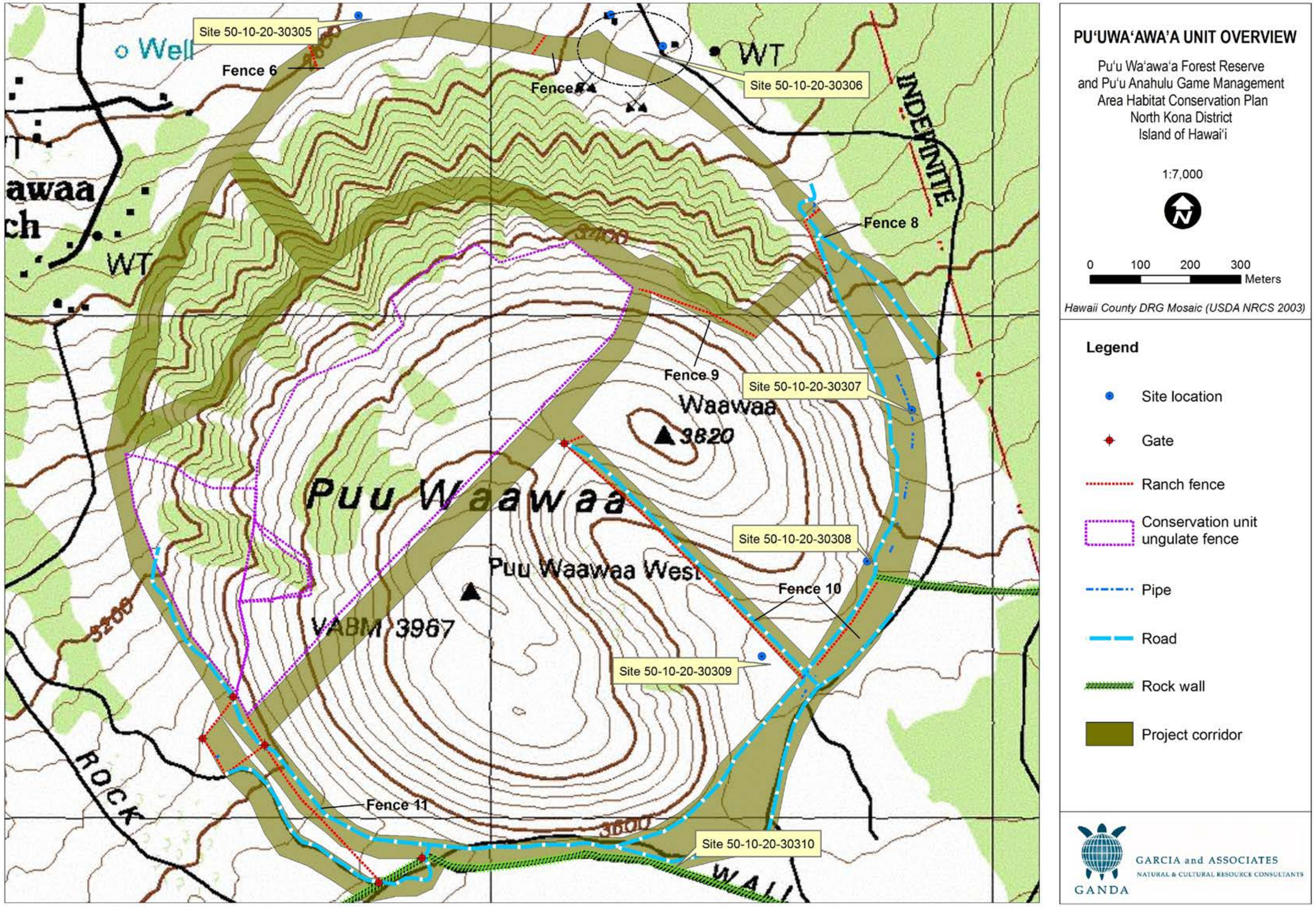


**Figure 14. Site locations at Pu'u Wa'awa'a Conservation Area.**

been removed with only isolated segments remaining. Ranch roads run along the base of the east, south, and west sides of Puʻu Waʻawaʻa. There is also a road running to the top of the *puʻu*. The ranch roads are all relatively well developed. All of the ranch roads parallel, and provide access to, water or fence infrastructure.

#### *2.3.6.4 Summary*

Archaeological inventory survey of 15.4 linear kilometers (103.6 ha) of proposed ungulate fenceline corridor produced one temporary Hawaiian encampment (Site 30307), one historic quarry (Site 30306), and three discrete sites (Sites 30308, 30310, and 30311) which are associated with historic Puʻu Waʻawaʻa Ranch (Site 7190). In addition to the discrete historic ranch sites, a large amount of historic Puʻu Waʻawaʻa Ranch infrastructure was also identified and recorded. These infrastructure features include paddock fences, waterlines, and ranch roads, all of which contribute to the significance of historic Puʻu Waʻawaʻa Ranch. The six identified archaeological sites are summarized in Table 8.

**Table 8. Summary of Archaeological and Historic Sites**

| Conservation Unit | Site No. | Site/Feature Type | Cultural Affiliation/ Historic Context | Function | Period |
|---|---|---|---|---|---|
| All | 50-10-19-7190 | Paddock fencelines, waterlines, ranch roads | Historic Ranching | Paddock enclosure, water distribution, and circulation | Early 1900s–present |
| Puʻu Waʻawaʻa | 50-10-20-30306 | Trachyte quarry | Modern Commercial Quarrying | Mineral extraction | 1955–1988 |
| Puʻu Waʻawaʻa | 50-10-20-30307 | Modified outcrop | Traditional Hawaiian | Temporary shelter | Pre-Contact |
| Puʻu Waʻawaʻa | 50-10-20-30308 | Chute and corral complex | Historic Ranching | Cattle management, water storage | Early 1900s–present |
| Puʻu Waʻawaʻa | 50-10-20-30310 | Stone wall | Historic Ranching | Paddock enclosure | Early 1900s–present |
| Henahena | 50-10-20-30311 | Stone corral | Historic Ranching | Cattle management | Early 1900s–present |

### 2.3.7 Contemporary Cultural Practice

Traditional and customary practices and knowledge of Hawaiian culture are sustained by native descendants from Puʻu Anahulu and Puʻu Waʻawaʻa Ahupuaʻa (Napuʻu) and neighboring *ahupuaʻa*. The *Hui ʻOhana mai Puʻu Anahulu a me Puʻu Waʻawaʻa* (*Hui ʻOhana*) is a community-based organization comprised of Hawaiian families, descendants of the Napuʻu region, and native tenants and historic homesteaders who are recorded as having lived in the region prior to the 1840s. The *Hui ʻOhana* is recognized as an integral part of the history of Napuʻu and important partner for stewardship of the inseparable cultural and *natural* landscape, using the *ahupuaʻa* concept of land management (DLNR 2003; Maly and Maly 2006).

Traditional and cultural rights are recognized for both native Hawaiians and local community members for cultural practices. Cultural access to lands and resources in the Plan Area is currently controlled by special use permit issued by DOFAW. Twenty-four cultural access and collection permits were issued between 2006 and 2014. The access permits largely involved family ceremonies held by lineal decedents of Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa. A majority of the collection permits involved gathering of forest resources for arts, crafts, and education about native Hawaiian culture. Resources gathered include foliage, plant cuttings, fruits, and woods, and lava rocks. Kauila, uhiuhi, and wiliwili woods are among the most desirable forest resources. Other cultural practices that do not require special use permits are likely also performed but are difficult to quantify.

## 3.0 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

This section evaluates the potential environmental impacts of the Proposed Action and suggests avoidance, minimization, and mitigation measures for potential adverse impacts. As discussed in Sections 1.2 and 1.3, impacts may be either direct or indirect. Impacts may also be of short-term or long-term duration, and may furthermore have cumulative effects that must be considered. This analysis examines impacts to resource classes in proportion to the magnitude of the potential effects. More detailed consideration is given to classes more susceptible to adverse effects.

### 3.1 Physical Environment Impact Analysis

#### 3.1.1 Geology

The major physical HCP activity with potential for geological impact is fence installation. While installation of the fence posts will involve ground disturbance, the footprint of the disturbance is very small in relation to the Plan Area. Fence construction will not significantly affect the underlying geologic substrate of the Plan Area nor impact the landscape or topography. Other activities such as ungulate removal, invasive species control, and outplanting will have a negligible effect on geology and topography. The implementation of the HCP therefore will not have significant impact on geology and topography.

##### *3.1.1.1 Soil*

Construction of the exclusion fence is anticipated to have no significant short-term, direct impact on Plan Area soils. Installation of fence posts will involve disturbance to the shallow soils or lava rocks with no significant increase in erosion relative to the existing landscape. Ungulate removal within the exclosures will eliminate the primary source of soil destabilization and accelerated erosion. Invasive plant control and outplanting may have short-term impacts on the soil by reducing vegetation cover or disturbing surface soils. The disturbance will be localized and is expected to recover quickly through revegetation.

Over time, natural and assisted revegetation is expected to stabilize soils and significantly reduce erosion rates within the exclosures. Indirect, long-term effects of the implementation of the HCP actions are anticipated to be beneficial with respect to revegetation, soil retention, and reduced erosion rates.

#### 3.1.2 Hydrology

Two types of hydrologic resources are relevant to the proposed action: ground water and surface water. Construction of the exclusion fence will have no short-term direct impact on either surface or ground water resources.

The implementation of the HCP is expected to have a minimal long-term effect on groundwater resources. Soil stabilization and revegetation resulting from ungulate exclusion and removal can be expected to cause an increase in the organic fraction of the soil, increased root density, and slightly reduced permeability. A small part of the annual water budget that previously went straight to groundwater will be taken up by roots and exit the system via transpiration. The percentage of precipitation entering the aquifer therefore may be slightly reduced. The increased forest cover, on the other hand, can collect fog drip and increase water input, especially in mid-elevation locations where fog is prevalent (Juvik and Tango 2003). Although the effect of the exclosures on aquifer recharge is not clear, due to the small size of the fenced exclusion area relative to the surface area contributing to the two aquifer systems, the impact is considered less than significant.

Overall, reforestation will have a net positive effects on watersheds by enhancing deep soil water transfer to upper soil horizons, thereby increasing soil moisture, slowing runoff, and preventing erosion. At larger scales, the restoration effort should enhance water quality and decrease sedimentation levels in the downslope lands and coastal waters. The environmental consequence in hydrology is expected to have a net positive effect.

### 3.1.3 Climate

The implementation of the HCP will have no effect on large-scale climate. Revegetation within the exclusion area after ungulate removal will almost certainly affect the micro-climate. Increased vegetation cover buffers temperature and moisture fluctuations. Added canopy in the exclusion area should produce an increase in average soil moisture and decrease in surface temperature (i.e., air temperature at ground surface), soil temperature, solar intensity, and wind speed. Furthermore, spatial and temporal variability of these variables will likely decrease with increased canopy coverage (Chen et al. 1999).

Reforestation within the exclosures is expected to produce a beneficial long-term impact on local micro-climate. Canopy-induced micro-climactic changes will help support the restoration of native biota.

### 3.1.4 Air Quality

The HCP actions will have no significant short or long-term effect on air quality. Construction of exclusion fencing may create highly localized, short-term impacts to air quality if gas-powered vehicles are used for the transportation of personnel and materials. Use of gas-powered tools or machines to install fence posts may also create highly localized, short-term impacts to air quality. The use of pesticides to control invasive weeds may affect the air quality in the immediate vicinity of the treated site. The effect however will be temporary and localized. Good air circulation provided by the prevailing winds should disperse any emissions or volatilized pesticide residues in a very short period of time. There are no long-term air quality issues for the HCP activities. Overall, the proposed action will have a less than significant effect on air quality.

### 3.1.5 Noise Levels

Although long-term use and management of the exclosures will have no significant acoustic impact, there may be short-term impacts during construction of fenced exclosures, ungulate removal, and invasive plant control. Construction of fence posts will increase localized noise levels if power tools are used. The removal of feral ungulates may involve the use of firearms, and the control of invasive plants may involve the use of brush cutters. These noises will be of short duration and not likely to cause lasting effects on humans or wildlife. Implementation of the HCP will therefore have no significant adverse effect on the environment.

### 3.1.6 Hazardous Substances

The potentially contaminated site identified in the phase I ESA (USFS 2009) is close to the Hala Pepe Unit. The fence alignment, however, doesn't overlap the locations where the potentially hazardous materials were documented. The implementation of the HCP is not expected to increase risk of release.

The construction of fences with power equipment can potentially expose areas to hazardous substances such as oil, solvents, and fuel. The fencing contractor will be required as a condition of the contract to develop and implement Best Management Practices that prevent the release of any hazardous substances, including oil, fuel, and solvents.

Control of invasive plants and animals may involve chemical control using pesticides. Pesticide usage will be limited to licensed pesticides that are approved for use in natural areas. Application methods will strictly follow label directions. Any unused pesticide will be stored or disposed of as hazardous materials. Under these provisions, the use of pesticides is not expected to cause adverse impacts to the environment.

### 3.1.7 Natural Hazards

The implementation of the HCP will not increase risks associated with natural hazards such as volcanism, earthquakes, or storms. The HCP and the ITL will support fire risk management activities in the Plan Area, such as reducing fuel loads through grazing and maintaining fire breaks and access roads for firefighting and emergency evacuation.

In the long term, habitat restoration within the exclosures is expected to decrease fire hazards by transforming the vegetation from fire-prone, grass-dominated communities to more fire-resistant native shrub and tree-dominated communities. The long-term effect of the exclosures is expected to decrease fire hazards in the Plan Area.

## 3.2 Biological Environment Impact Analysis

This section presents an assessment of anticipated environmental impacts to biological resources resulting from the proposed actions. Avoidance, minimization, and mitigation measures are proposed for potential adverse impact.

For federally listed threatened or endangered species, DOFAW has consulted with USFWS and received an Internal Section 7 Effect Determination for Pu‘u Wa‘awa‘a Forest Reserve Protection and Restoration (Henahena Unit) on March 19, 2014 (Appendix C). USFWS determined that although the project may create minor disturbance to listed and proposed species, any adverse effects are considered to be insignificant and/or discountable. Overall, the project is expected to benefit the listed species and their habitat by protecting the area from negative environmental impacts of ungulates and invasive plants species.

Additionally DOFAW has consulted with USFWS for the clearing of 230 miles of fire roads and fuel breaks at Pu‘u Wa‘awa‘a Forest Reserve and Pu’u Anahulu Game Management Area. The Biological Opinion issued by USFWS concluded that the implementation of the proposed action is not likely to jeopardize the continued existence of the Blackburn's sphinx moh (Appendix D).

### 3.2.1 Flora

#### *3.2.1.1 Impact Analysis*

In the long term, the implementation of the HCP is expected to have net positive effects to rare and endangered plants. The ungulate exclosures will protect rare and endangered plants from take caused by trampling, herbivory, and predation by feral ungulates. Also, weed and introduced predator control is expected to increase survival and regeneration of native plants. Outplanting of rare and endangered species is expected to mitigate any net loss and stabilize the population of the 15 covered endangered plants.

Fence construction and vegetation clearing around the fence have the potential to negatively affect the native flora that resides in the fence corridors. These corridors, however, amount to a negligible percentage of the Plan Area, and are limited to areas where rare or endangered species are absent and native plants are sparse. Native vegetation will be avoided whenever possible. The direct impacts will not be significant after implementation of avoidance measures.

#### *3.2.1.2 Avoidance Measures*

A biological survey was conducted for the proposed fence alignment of the Henahena, ʻAiea, and Puʻu Waʻawaʻa extension units on December 9 and 10, 2013. The survey was conducted by DOFAW biologists Elliott Parsons, Kealakaʻi Knoche, Tara Seely, Justin Ramos, Kylen Damo. The survey team walked a 50-m corridor for the entire length of the proposed Henahena, ʻAiea, and Puʻu Waʻawaʻa Extension Units' fence alignment to identify any sensitive biological resources that may occur on the fence alignment.

During the survey no threatened or endangered plants were observed on the proposed fence alignment for Henahena Unit. The survey team however did find 16 living and one dead ʻAiea trees (*Nothocestrum breviflorum*) within 200 m of the proposed fence alignment.

To ensure none of these trees are impacted by the fencing contractors, temporary orange plastic fencing and/or flagging will be placed near or around each tree for easy identification. Site visits with the selected contractor prior to construction will further ensure the contractors are aware of the plants for avoidance.

The same survey method and protective measures will be used for fence alignments of all proposed exclosures. The fence alignments will be moved to avoid potential impacts when sensitive natural resources are located on the proposed fence alignments.

### 3.2.2 Avian Fauna

#### *3.2.2.1 Impact Analysis*

The implementation of the HCP is expected to have net positive effects on native avian populations by preserving and regenerating native plant species and by the overall improvement of habitat quality within the exclosures. The control of introduced predators, such as rats, is expected to increase survival and nesting success of native bird species. The improvement of habitat quality will not only benefit the native birds, but also introduced birds. It is expected that non-native birds, including game bird populations, will increase with the improved native vegetation cover that provides better refuge and food resources. Under this mitigation plan, the proposed action will have no short-term adverse impact to avian resources.

The increase of introduced bird populations may raise the risk of avian malaria and avian pox epidemics for the native birds by increasing the density of potential carriers. The risk of avian disease, however, is more dependent on the presence of vector mosquitoes, which are largely limited by elevation and precipitation (van Riper III et al. 2002; Atkinson et al. 2005). Removal of feral pigs, on the other hand, is expected to reduce available breeding habitat for vector mosquitoes (Nogueira-Filho et al. 2009). The HCP therefore is not expected to significantly increase risk of avian malaria epidemics.

Individual birds, eggs, and nests of native avian fauna may be disturbed or destroyed by vegetation removal during fence construction and routine invasive plant control. To avoid impacts, biological surveys will be conducted to locate any sensitive birds, eggs, or nests. If native birds or nests are identified, the fence alignment will be redesigned or construction will be halted until the native birds voluntarily relocate, and/or nestlings fledge and leave the nest.

### 3.2.3 Mammal

#### *3.2.3.1 Impact Analysis*

The Hawaiian hoary bat is known to inhabit the Plan Area. The potential direct impact of the HCP involves bats striking or being entangled on fence posts and wires. Vegetation clearing on the fence corridors can potentially disturb roosting bats and remove roosting sites. The implementation of the HCP is expected to improve habitat quality within the exclosures in the long term by encouraging regeneration of vegetation which will support insect fauna. This would improve food resources and potential roosting sites for the Hawaiian hoary bat. The long-term effect is expected to be positive.

#### *3.2.3.2 Avoidance Measures*

To prevent impacts to hoary bats and their young, no woody plants greater than 4.5 m tall will be removed or trimmed during the June 1 to September 15 nursing season. Additionally, to avoid entanglement, barbed wire will either not be used or installed within 2 inches of the ground surface. Under these avoidance provisions the implementation of the HCP will not result in significant impacts to the Hawaiian hoary bat.

### 3.2.4 Invertebrates

#### *3.2.4.1 Impact Analysis*

Blackburn’s sphinx moth, an endangered species, and its designated critical habitat area are present within the Plan Area. The native host plant of Blackburn’s sphinx moth, ‘Aiea, is also in the Plan Area. Biological surveys of the three Phase 1 Conservation Unit fence alignments produced no evidence of Blackburn sphinx moth native host plants within the corridor. Construction of the fences will therefore have no short-term adverse impacts on this species.

Tree tobacco (*Nicotiana glauca*), an alternative host plant of the Blackburn's sphinx moth, may be present on fire roads, fuel breaks, and fence alignments proposed for this project. Fence construction and routine vegetation clearing around the fence corridors, fire roads and fire breaks can directly cause take of the moth by destroying eggs and larvae and also by indirectly reducing available host plants for the Blackburn's sphinx moth in the short-term.

Based on the Biological Opinion issued by USFWS (Appendix D), the clearing of fire roads and fuel breaks will result in the loss of 38.6 acres of occupied non-native BSM habitat and the mortality of up to 0.9 percent of larvae eggs within the Plan Area per year. The clearing of fire roads and fuel breaks is not expect to impact the critical habitat of the BSM. Roads and fuel breaks are not included in the critical habitat designation because they were existing man-made features when critical habitat was designated. The action area for the proposed project only includes four wheel drive roads and fuel breaks; no work will occur outside these areas. In addition, tree tobacco is not a primary constituent element for BSM critical habitat.

The clearing of roads and fuel breaks will improve fire prevention and control that protect BSM critical habitat. In the long term, outplanting and restoration of the native forest ecosystem will likely produce suitable habitat for the sphinx moth in the lower elevation portions of the fenced area. The outplanting of ‘Aiea and other native solanaceous host and nectar plants such as Ilie‘e (*Plumbago zeylanica*) would likely increase the moth's abundance. The long-term impact of the action on the Blackburn's sphinx moth will therefore be beneficial.

#### *3.2.4.2 Avoidance, Minimization, and Mitigation Measures*

All fence alignments will be surveyed for sphinx moth habitat prior to design finalization and construction. Vegetation clearing will involve no cutting of ‘Aiea. To minimize impacts to Blackburn's sphinx moth habitat, all known ‘Aiea (the native host plant) within the Plan Area will be permanently protected from ungulates. Blackburn's sphinx moth larvae have been documented on tree tobacco year round with highest numbers found from December to March. Surveys have shown that larvae primarily use trees larger than one meter in height (98 percent of larvae observed).

To minimize impacts to Blackburn's sphinx moth, whenever possible control and removal of tree tobaccos will be timed to reduce adverse effects to BSM eggs and larvae. The presence of BSM eeegs and larvae on tree tabacco is strongly influenced by moisture and tree height, with increases presence during wet months and on plants taller than 1 meter. Therefore, whenever possible, tree tabacco, especially over 1 meter tall, will be controlled during dry periods. Tree tabacco clearing will occur year-round at intervals designated to prevent new growth from exceeding 1 meter tall. These conservation measures will reduce the number of BSM eggs and larvae on roads and fuel breaks and minimize the amount of take anticipated to occur.

The USFWS is currently recommending a 5 to 1 offset ratio for loss of degraded habitat for Blackburn's sphinx moth. Approximately 38.6 acres of fuel break and 4x4 roads are currently occupied by tree tobacco and are actively cleared (through herbicide and/or manual cutting)., therefore approximately 7.2 acres of habitat will need to be restored in order to mitigate for this loss of degraded habitat. All of the proposed or current exclosures that will be used for mitigation purposes fall within the range of ‘Aiea and far exceed the recommended ratio suggested by the

USFWS. Mitigation for losses of Covered Plant species will also provide and enhance native habitat known to be used by Blackburn's sphinx moth.

A detailed plan for the avoidance, minimization, and mitigation is provided in the HCP (Appendix A). Under these mitigation measures, the proposed action will have no short or long-term adverse impacts to the endangered Blackburn's sphinx moth.

## 3.3 Socio-economic Environment Impact Analysis

This section presents assessments of the impact of the proposed action on various elements of the socio-economic environment. Mitigation measures are proposed for elements that may incur significant impacts from the project or for which there is insufficient data to make a firm determination. Implementation of the proposed mitigation measures will result in a "less than significant" impact determination for these elements.

### 3.3.1 Population

The proposed action does not involve elements that would have a significant effect on population levels in North Kona generally or in proximity to Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa specifically. Although some increase in temporary short-term land use is expected to result from improved game hunting opportunities and trail use, implementation of the HCP would not result directly or indirectly in increased regional development. Development and population trends in the area are driven by higher-order economic forces such as resort and agricultural expansion and contraction. Implementing conservation measures in the remote lands of Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa, by contrast, will have a negligible effect. The proposed action will therefore have no significant impact on population.

### 3.3.2 Land Use

The proposed action would result in some change to current land use activities. Exclusion fencing for conservation units will clearly entail some adjustments for hunters and ranchers (see below), but will not significantly alter the types or intensity of land use activities currently practiced at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. Overall land use levels are expected to remain within historical bounds for the near and medium-term. It is important to note, however, that increases in land use may result from the publicity associated with development of the HCP and resultant heightened public awareness of the forest reserve and game management areas. This should not be confused with impacts associated with implementation of the HCP, which is considered to be negligible. DOFAW will, however, monitor annual usage levels for hiking and hunting to ensure that unanticipated spikes are tracked and assessed for adverse impacts to the socio-economic, biological, and physical environments. Tracking will be accomplished by consultation with local user groups and by hiker and hunter sign-in sheets at trail heads.

#### *3.3.2.1 Hunting*

Implementation of the HCP will result in enclosing an additional 4,665 acres (4.5 percent) for a total of 8,863 acres (8.5 percent) of area within exclosures in the Plan Area. Since these lands are currently utilized by hunters, the reduction in accessible acreage is expected to have an impact on hunting activities. At minimum, hunters will have reduced game mammal hunting opportunities within the conservation unit areas once ungulate removal has been achieved.

Although game mammal hunting inside the proposed exclosures will no longer be viable due to the removal of feral ungulates, the area of loss is relatively small when compared with the acreage still available within Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area. Overall, implementation of the HCP will support game mammal management activities that are expected to enhance sustainable game hunting in the Plan Area. The net effect of game mammal management activities (i.e., habitat enhancement, game guzzlers, food plots, and road and fire break maintenance) will be an overall improvement to the quality of the hunting experience. Furthermore, the reduction in hunting acreage will not necessarily translate to a reduction in mammal populations within the Plan Area. Although game mammals will eventually be removed from the exclosures, population levels in the surrounding areas will likely remain stable or increase through time with the subsequent efforts in game mammal management. As per DOFAW policy, public participation in animal removal from exclosures will be facilitated as long as it is feasible, effective, and safe. Per DOFAW's standard procedures, ungulate removal will depend on size and location of the exclosure and will include public hunting, animal drives, and if necessary, staff removal.

Importantly, the restoration of native vegetation and ecosystems inside the exclosures will enhance habitat quality for game birds by providing food and refuge. Game bird hunting is allowed within conservation units and exclosures. Thus, implementation of the HCP is expected to have a net positive effect on game bird hunting opportunities.

In the long-term, the complete removal of ungulates from the exclosures will result in a reduction in potential hunting area for game mammals. However, the broader set of policies and activities associated with game management and HCP implementation will improve the overall hunting experience and are intended to result in increased game animal populations. Removal of approximately 4 percent of the currently available hunting grounds will not have a significant, long-term negative impact on mammal hunting opportunities and will be compensated for by improvements to bird and exterior mammal stocks and supporting actions such as maintaining access roads.

#### *3.3.2.2 Grazing*

Implementation of the HCP will result in a 13 percent (2,423-acre) reduction of the total land (18,466 acres) that has historically been used as pasture. The role of ranching within Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area has evolved into a tool for fire risk management and natural resource conservation. Its role in maintaining low fuel levels on the landscape and thereby reducing wildfire risk is an important consideration for implementation of the HCP.

Although a 13 percent reduction in available pasturage will affect ranch activities, cattle ranching will still be economically viable on the remaining lands. Management and planning for the reduced acreage will correspond with the changing role of ranching for fire management, and by extension, natural resource conservation. Currently the major factors that determine viability of ranching operation are the cost and availability of water. The game management activities that are supported by the HCP, such as establishment of water catchment systems and water troughs, can also improve the quality of the remaining area for cattle grazing. The proposed action is not expected to have a significant impact to the long-term economic viability of grazing, relative to other more significant market factors.

#### *3.3.2.3 Conservation, Research, Education, and Public Service*

Conservation, research, education, and public service activities within Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area will be enhanced by implementation of the HCP. The exclosure fencing, ungulate removal, and ecological restoration efforts contained in the HCP are at their core conservation-oriented and will provide important research opportunities for HETF scientists and to the academic community generally. Potential research projects may include tracking and evaluating the effectiveness of the exclosures over time and studying the ecological impact of outplanting and weed eradication efforts in the exclosures. The exclosure units will likewise provide important educational tools for the many schools and public organizations that currently visit Puʻu Waʻawaʻa Forest Reserve. Educational and public service opportunities, particularly for identification and outplanting of endangered and rare native plant species, will be greatly enhanced by construction of the controlled exclosure environments.

### 3.3.3 Recreation

Non-hunting recreational activities in Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area consist primarily of hiking. This activity will continue to be supported by DOFAW and both the ʻŌhiʻa/Cone Trail and Hala pepe Trail will remain accessible. All HCP exclosure units will have access points available to the public. This may include fence walk-over ladders or self-closing gates in high-use areas to facilitate access for people and hunting dogs.

Overall, ungulate exclusion fencing and long-term forest restoration is expected to result in an increase of native species diversity in the Plan Area, thereby improving the quality of ecologically-oriented recreational activities such as hiking and bird-watching. The proposed action will therefore have a beneficial impact on recreation at Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area.

### 3.3.4 Scenic and Visual Resources

The study area contains two visual resources of concern, the Puʻu Anahulu bluff and Puʻu Waʻawaʻa cinder cone. The only potentially visible aspect of the HCP is the new hog wire fence used to construct the exclosures. Of the vast majority of this fencing is in upper elevation areas that are not directly visible to the public, and no new fencing is currently being planned along Puʻu Anahulu's *makai*-facing bluff. New fencing at Puʻu Waʻawaʻa will not be visible from Route 190, the closest public highway to the *puʻu*. There is currently a significant amount of existing fencing on and around Puʻu Waʻawaʻa which is not visible from the vantage of the general public. The proposed action will therefore have no significant impact to scenic and visual resources.

### 3.3.5 Infrastructure and Utilities

Existing infrastructure within Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area will be largely unaffected by the construction of the ungulate exclosures. Existing roads will be maintained for aceess and fire break. Vehicle access gates will be put in place if an access road goes through a fenced unit. No utilities will be affected by the action. The proposed action will have no significant impact to infrastructure or utilities.

### 3.3.6 Cultural Resources

Puʻu Anahulu and Puʻu Waʻawaʻa Ahupuaʻa both contain many important cultural and archaeological resources. The great majority of these sites and places are associated with the Hawaiian coastal villages of Kekaha, located far *makai* of the present Plan Area. The proposed HCP implementation actions will not occur in these coastal areas, but rather in the uplands above 1000 feet in elevation. In these *mauka* lands, Puʻu Anahulu bluff and Puʻu Waʻawaʻa cone are the primary cultural sites and have important roles in traditional Hawaiian history. No work associated with this HCP will be conducted on Puʻu Anahulu bluff and work on Puʻu Waʻawaʻa cone will consist of installation of 8 kilometers of new ungulate-proof fence, in addition to 4,636 linear meters of existing fence already in place on the *puʻu*.

Installation of the new fencing and removal of ungulates from Puʻu Waʻawaʻa will not be detrimental to this cultural place. Past land use on the *puʻu* has included grazing and mining, and feral ungulates have traditionally had unrestricted access. The proposed exclosure will stabilize Puʻu Waʻawaʻa from further impact, especially from erosion caused by feral ungulates. Active restoration of native forest is expected to enhance the forest resources that can be used in cultural practices (e.g., *kauila*). The proposed fencing action is therefore considered beneficial to Puʻu Waʻawaʻa in its capacity as a traditional Hawaiian cultural place.

#### *3.3.6.1 Archaeological Resources*

The HCP action with the greatest potential to impact archaeological resources is exclosure fence installation. During the archeological inventory survey, wide corridors (50 to 250 m) were surveyed for the proposed fence alignement. This approach allows great flexibility in the selection of the exact fence route to avoid all identified archeological resources. During fence construction, fence alignment will stay at least 10 feet away from all identified archeological features to avoid potential impact.

##### *3.3.6.1.1 Phase I Exclosures*

Six archeological sites were identified within the survey corridors during the archeological inventory survey. Each site is evaluated for potential impact from the plan actions and measures to avoid, minimize, and mitigate potential impacts are presented.

###### *Site 50-10-19-7190 (Historic Puʻu Waʻawaʻa Ranch)*

Installation of ungulate exclosure fencing will affect the historic paddock fencelines but will have no effect on ranch roads or water pipelines. These latter features will be avoided during construction. Major ranch roads will continue to be accessible in most locations through gates. Minor fenceline access roads will also be accessible, though possibly in a more restricted manner due to the new exclosure fencing.

Historic paddock fencelines will be directly affected by the fence construction. These fences, including newer intra-paddock fencelines, will be cut to allow the new ungulate fence to pass through. The fences will be restrung, tensioned, and tied off to the ungulate fence to maintain the original paddock alignments. Because the original fence alignments will be maintained, the action will not significantly impact the integrity of Site 7190.

#### *Site 50-10-20-30306 (Trachyte Quarry)*

The ungulate fenceline will run through the middle of the quarry site and will not affect the two buildings or any other site element. The ungulate fence will intersect existing cattle fence (Site 7190) at the northwest and southeast quarry site boundaries (Figure 15). As with other fencelines, these will be cut and retied to maintain their original alignments and functionality. The proposed ungulate fencing will therefore not significantly impact Site 30306.

#### *Site 50-10-20-30307 (L-Shaped Mound)*

The ungulate fence will pass more than 20 m west of Site 30307 (Figure 15). The proposed ungulate fenceline will therefore not impact Site 30307.

#### *Site 50-10-20-30308 (Chute and Corral Complex)*

The ungulate fence passes 45 meters west of the main Chute and Corral Complex but does intersect a nearby historic fenceline (Figure 15). This is a barbed wire fence running along the base of Puʻu Waʻawaʻa cinder cone. As with all other intersected historic fencelines, it will be cut and retied to maintain its original alignment and functionality. The proposed ungulate fencing will therefore not significantly impact Site 30308.

#### *Site 50-10-20-30310 (Rock Wall)*

Proposed ungulate fencing in Puʻu Waʻawaʻa Cone Conservation Area will avoid Site 30310. It is important to note, however, that the ungulate fence will come in very close proximity to it in two locales, both on the southwest side of the cinder cone. These are locations where the ungulate fence meets two existing stone wall gates. The new fence will anchor at the ends of the older gates, and a new gate will be installed to facilitate movement through the stone wall, as originally designed. The new ungulate fence gate will be constructed without impact to the existing stone wall. Because of its close proximity to Site 30310, this work will be carefully monitored during construction to avoid impacting the site. The proposed ungulate fencing will not impact Site 30310.

#### *Site 50-10-20-30311 (Stone Corral)*

Although the Site 30311 Stone Corral is within the undertaking APE, it will be avoided during ungulate fence installation. The fence centerline is about 20 meters *makai* of the corral along most of its length and there is a very low likelihood of impact in these areas. However, the fence comes within two meters of the corral at its northeastern end. There is a potential for inadvertent impact at this locale. This risk will be reduced by either 1) off-setting the ungulate fence further from the corral or 2) installing high visibility orange construction fencing between the ungulate fence and the corral during construction and ensuring that construction is monitored closely. Under these provisions, the proposed ungulate fencing will not impact Site 30311.

##### *3.3.6.1.1.1 Phase I Exclosure Summary*

Five discrete archaeological sites and one historic ranch complex (Site 7190) are present within the exclosure fenceline corridors. All of the discrete sites will be avoided. Fence features associated with Site 7190 will be minimally impacted. However, installation of the new fence will be completed in such a way as to avoid significant impact. The features will be cut and then repaired after the exclosure fence is installed. Fence construction will not affect water piplines and roads associated with the historic ranch.

To account for the unlikely event that an unidentified lava tube is discovered, special requirements will be incorporated into fence construction contract documents. The construction contract will stipulate that if a previously undetected lava tube is breached during construction, contractors will immediately notify DOFAW and cease work in the area. DOFAW will notify the State Historic Preservation Division and consult on steps to evaluate the possible site.

Other HCP activities have a very low probability for impacting archaeological resources. Subsurface deposits in the Plan Area are extremely rare and outplanting activities involve very limited ground disturbance.

The proposed action will not significantly impact archaeological resources within the Phase I exlosure areas.

#### *3.3.6.1.2 Future Exclosures*

Future planned exclosure fence corridors will be surveyed prior to fence construction. Archaeological survey teams will identify archaeological and historic resources within the corridor alignments, including any fuel break buffer, and report these results to the Hawaiʻi State Historic Preservation Division for review and comment. DOFAW will then work in consultation with the Hawaiʻi State Historic Preservation Division to develop methods for avoiding or mitigating any potential significant impacts to these resources.

### *3.3.6.2 Contemporary Cultural Practices*

Cultural access to the Plan Area will continue to be supported by DOFAW and will not be significantly affected by the HCP. Access to the proposed exclosures will be provided by gates or step-overs. Access and collection permits for traditional and cultural uses will continue to be issued by DOFAW. The HCP action will have a negligible effect on cultural access.

The HCP action is expected to protect and enhance the native ecosystem within the exclosures, which support important resources such as the endangered *kauila* and *uhiuhi*. The HCP is expected to benefit cultural practices by protecting the forest resources from further degradation and through active restoration, which is expected to promote sustainability of the cultural use of forest resources.

## 3.4 Growth-Inducing Impacts

Growth-inducing impacts involve the potential for a project to induce unplanned development, substantially accelerate planned development, encourage shifts in growth from other areas in the region, or intensify growth beyond the levels anticipated and planned without the project. No aspect of the proposed action has the potential to encourage growth.

### 3.5 Cumulative Impacts

Cumulative impacts result when implementation of several projects that individually have minor impacts combine to produce more severe impacts or conflicts among mitigation measures.

All potential adverse impacts of the proposed action are either negligible, extremely restricted in geographic scale, or are capable of mitigation through proper enforcement of permit conditions. There are thus few, if any, appreciable adverse impacts that might accumulate with those of other past, present, and future actions to produce more severe impacts. In the context of the large extent of existing forest of similar type in the area, the small area lost to exclosures does not represent a substantial loss, particularly when given the significant benefits in terms of environmental restoration.

### 3.6 Consistency with Government Plans and Policies

The proposed action is consistent with all government plans and policies, especially those that call for conservation of natural resources.

#### 3.6.1 Hawaiʻi State Plan

The Hawaiʻi State Plan was adopted in 1978. It was revised in 1986 and again in 1991 (chapter 226, HRS as amended). The Plan establishes a set of goals, objectives and policies that are meant to guide the State's long-run growth and development activities. The proposed project is consistent with State goals and objectives that call for increases in employment, income and job choices, and a growing, diversified economic base extending to the neighbor islands.

Chapter 226-4 sets forth goals associated with the *Hawaiʻi State Plan*:

1. A strong, viable economy, characterized by stability, diversity, and growth, that enables the fulfillment of the needs and expectations of Hawaiʻi's present and future generations.
2. A desired physical environment, characterized by beauty, cleanliness, quiet, stable natural systems, and uniqueness, that enhances the mental and physical well- being of the people.
3. Physical, social, and economic well-being, for individuals and families in Hawaiʻi, that nourishes a sense of community responsibility, of caring, and of participation in community life.

The aspects of the plan most pertinent to the proposed classification are the following:

> Chapter 226-11 *Objectives and policies for the physical environment—land-based, shoreline, and marine resources*. Planning for the State's physical environment with regard to land-based, shoreline, and marine resources shall be directed towards achievement of prudent use of Hawaiʻi's land-based, shoreline, and marine resources and effective protection of Hawaiʻi's unique and fragile environmental resources. To achieve

the land-based, shoreline, and marine resource objectives, it shall be the policy of the State to:

1. Exercise an overall conservation ethic in the use of Hawai‘i’s natural resources.
2. Ensure compatibility between land-based and water-based activities and natural resources and ecological systems.
3. Take into account the physical attributes of areas when planning and designing activities and facilities.
4. Manage natural resources and environs to encourage their beneficial and multiple uses without generating costly or irreparable environmental damage.
5. Consider multiple uses in watershed areas, provided such uses do not detrimentally affect water quality and recharge functions.
6. Encourage the protection of rare or endangered plant and animal species and habitats native to Hawai‘i.
7. Pursue compatible relationships among activities, facilities, and natural resources.
8. Promote increased accessibility and prudent use of inland and shoreline areas for public recreational, educational, and scientific purposes.

The proposed action is consistent with the goals, objectives and policies of the *Hawai‘i State Plan*. Specifically, it is an appropriate use of an isolated land area that will encourage the protection of rare or endangered plant and animal species and habitats.

### 3.6.2 Conservation District

A significant portion of the Plan Area is in the State Land Use Conservation District. Any proposed use in such areas must undergo an examination for its consistency with the goals and rules of this district and subzone. Consultation with the DLNR Office of Conservation and Coastal Lands indicates that,

> According to DLNR policy (c. 1992), divisions within DLNR that are proposing to conduct land uses on their own managed lands inside the Conservation District are not required to apply for a Conservation District Use Permit (CDUP) when, 1) a management plan is already in place for the specified land use, and 2) the proposed land use is consistent with that specific divisions management objectives for the Plan Area. However, those divisions must adhere to the criteria REF: OCCL: AJR COR: HA-14-39 and guidelines of § 183C Hawaii Revised Statutes (HRS) and § 13-5 Hawaii Administrative Rules (HAR). Similarly, those divisions proposing land use actions in the conservation district shall ensure compliance with §343 HRS in regards to specific environmental review requirements.

Because the project is inside a Forest Reserve and Game Management Area, DOFAW will not be required to obtain a Conservation District Use Permit for the project. Actions to affirmatively manage the forest reserve are viewed as operation and maintenance of an existing use and thus exempt from any requirement for a Conservation District Use Permit. Nevertheless, it should be noted that the project is consistent with the criteria of the Conservation District, as listed in Chapter 13-5, HAR:

- The proposed land use complies with provisions and guidelines contained in chapter 205A, HRS, titled *Coastal Zone Management*.
- The proposed land use will not cause substantial adverse impact to existing natural resources within the surrounding area, community or region, and in fact will result in substantial environmental benefit.
- The proposed land use, including fences, is compatible with the locality and surrounding areas, appropriate to the physical conditions and capabilities of the specific parcel or parcels.
- The existing physical and environmental aspects of the land, such as natural beauty and open space characteristics, will be preserved and improved upon by allowing forest regeneration. Open space will be preserved.
- Subdivision of land will not be utilized to increase the intensity of land uses in the Conservation District. The proposed action will not subdivide the property and will not lead to any increase in intensity of use.

### 3.6.3 Hawai‘i’s Comprehensive Wildlife Conservation Strategy

The proposed action is consistent with the goals, objectives, and policies of Hawai‘i’s Comprehensive Wildlife Conservation Strategy (Mitchell et al. 2005). The Comprehensive Wildlife Conservation Strategy reviews the status of the full range of the State’s native terrestrial and aquatic species and presents strategies for long-term conservation of these species and their habitats. The Comprehensive Wildlife Conservation Strategy identifies the following seven priority conservation objectives for the State:

1. Maintain, protect, manage, and restore native species and habitats in sufficient quantity and quality to allow native species to thrive;
2. Combat invasive species through a three-tiered approach combining prevention and interdiction, early detection and rapid response, and ongoing control or eradication;
3. Develop and implement programs to obtain, manage, and disseminate information needed to guide conservation management and recovery programs;
4. Strengthen existing and create new partnerships and cooperative efforts;
5. Expand and strengthen outreach and education to improve understanding of our native wildlife resources among the people of Hawai‘i;
6. Support policy changes aimed at improving and protecting native species and habitats; and

7. Enhance funding opportunities to implement needed conservation actions.

## 4.0 ANTICIPATED DETERMINATION

Section 11-200-12 of the HAR sets forth the criteria by which the significance of environmental impacts shall be evaluated. The following discussion restates these criteria individually and evaluates the project's relation to each.

1. *The project will not involve an irrevocable commitment or loss or destruction of any natural or cultural resources.*

The HCP actions are designed and will function to conserve natural resources and mitigate unavoidable take of threatened and endangered species caused by game management activities. During fence installation, cultural resources will be protected by routing fence corridors around archeological resources and implementing measures to avoid significant impact. Other HCP activities such as ungulate removal and outplanting will not impact cultural resources and are expected to benefit natural resources. Implementation of the HCP and construction of ungulate exclosures will not result in the loss or destruction of any natural or cultural resources.

2. *The project will not curtail the range of beneficial uses of the environment.*

No future beneficial use of the environment will be curtailed by the proposed project actions. Recreational hunting will benefit from active game management despite minor loss of game mammal hunting grounds. Trail use, gathering of forest products for cultural use, ecotourism, research, and education are expected to benefit from the restoration of native ecosystems within the exclosures.

3. *The project will not conflict with the State's long-term environmental policies.*

The State's long-term environmental policies are set forth in chapter 344, HRS. The broad goals of this policy are to conserve natural resources and enhance the quality of life. A number of specific guidelines support these goals. No aspect of the proposed project conflicts with these guidelines. The project's goals of protection of endangered species and environmental restoration are a direct fulfillment of policies that call for conserving natural resources.

4. *The project will not substantially affect the economic or social welfare of the community or State.*

The HCP will benefit the social and economic welfare of Hawaiʻi by improving the natural environment and providing enhanced recreational and subsistence hunting opportunities through active game management in the Plan Area.

5. *The project does not substantially affect public health in any detrimental way.*

No adverse effects to public health are anticipated.

6. *The project will not involve substantial secondary impacts, such as population changes or effects on public facilities.*

No adverse secondary effects are expected. The project will not enable or encourage development.

7. *The project will not involve a substantial degradation of environmental quality.*

The project will not degrade environmental quality in any substantial way and will improve the natural environment within the exclosures.

8. *The project will not substantially affect any rare, threatened or endangered species of flora or fauna or habitat.*

No endangered flora or fauna will be adversely affected in any way by the project. The HCP is expected to benefit not only the covered endangered species but overall ecosystem integrity.

9. *The project is not one which is individually limited but cumulatively may have considerable effect upon the environment or involves a commitment for larger actions.*

The project does not involve a commitment for any further actions. Anticipated impacts from this project are minor and will therefore not have a significant cumulative effect in combination with other projects. Beneficial cumulative impacts are expected for biological resources by increasing available habitat area.

10. *The project will not detrimentally affect air or water quality or ambient noise levels.*

The project will have negligible effects on water quality, air quality, and noise levels.

11. *The project will not affect or will not likely be damaged by being located within an environmentally sensitive area such as flood plains, tsunami zones, erosion-prone areas, geologically hazardous lands, estuaries, fresh waters or coastal waters.*

Except for the unlikely event of an eruption and lava flow from Hualālai and Mauna Loa, no environmental hazards have the potential to affect this project.

12. *The project will not substantially affect scenic vistas and viewplanes identified in county or state plans or studies.*

No scenic vistas or viewplanes will be impacted by the project.

13. *The project will not require substantial energy consumption.*

None of the HCP activities involves substantial energy consumption.

## 4.1 Conclusion

For the reasons above, and in consideration of comments received during early consultation, the State of Hawaiʻi, DLNR, DOFAW has concluded that the proposed project will not have a significant impact in the context of chapter 343, HRS and Section 11-200-12 of the HAR, and has determined an Anticipated Finding of No Significant Impact with the Draft Environmental Assessment (DEA).

## 5.0 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

The following legislators, agencies, advisory commissions, and educational institutes received a letter inviting their participation in the preparation of the DEA:

*U.S. Senate*

- Senior United States Senator for Hawaiʻi, The Honorable Brian Schatz
- Junior United States Senator for Hawaiʻi, The Honorable Mazie Hirono

*U.S. House of Representatives*

- First Congressional District, The Honorable Colleen Hanabusa
- Second Congressional District, The Honorable Tulsi Gabbard

*U.S. Government*

- U.S. Department of Transportation, Federal Highway Administration, Hawaiʻi Division
- U.S. Fish and Wildlife Service, Office of Law Enforcement
- U.S. Fish and Wildlife Service, Conservation Partnerships Program
- U.S. Fish and Wildlife Service, Hakalau Forest National Wildlife Refuge
- U.S. Fish and Wildlife Service, Pacific Islands Office
- U.S. Forest Service, Hawaiʻi Experimental Tropical Forest
- U.S. Forest Service, Institute for Pacific Island Forestry
- U.S. Geological Survey, Biological Resources Discipline
- U.S. Geological Survey, Pacific Island Ecosystems Research Center
- U.S.D.A. Natural Resources Conservation Service

*State Senate*

- Senate District 3, The Honorable Joshua Green
- Senate District 4, The Honorable Malama Solomon

*State House of Representatives*

- House District 5, The Honorable Denny Coffman
- House District 6, The Honorable Nicole Lowen
- House District 7, The Honorable Cindy Evans

*State of Hawaiʻi*

- Lt. Governor of Hawaiʻi
- Department of Agriculture
- Dept. of Business, Economic Development & Tourism, Land Use Commission
- Dept. of Business, Economic Development & Tourism, Office of Planning

- Dept. of Education, Superintendent, West Hawaiʻi
- Dept. of Hawaiian Homelands, Land Management Division
- Dept. of Health, Clean Water Branch
- Dept. of Health, Program Manager
- DLNR, Chairperson
- DLNR, Division of Aquatic Resources
- DLNR, Division of State Parks
- DLNR, Land Division
- DLNR, Office of Conservation and Coastal Lands
- DLNR, State Historic Preservation Division, Hawaiʻi Lead Archaeologist
- DLNR, State Historic Preservation Division, Hawaiʻi Island Burial Council
- Dept of Transportation, Director of Transportation
- Dept. of Transportation, Highways Division
- Office of Hawaiian Affairs

*County of Hawaiʻi*

- Hawaiʻi County Office of the Mayor
- Hawaiʻi County Game Management Advisory Commission
- Hawaiʻi County Civil Defense
- Hawaiʻi County Department of Parks and Recreation
- Hawaiʻi County Department of Public Works, Director
- Hawaiʻi County Fire Chief
- Hawaiʻi County Native Hawaiian Chamber of Commerce
- Hawaiʻi County Planning Department, Program Manager
- Hawaiʻi County Police Chief

*Educational Institutes*

- Honokaa Intermediate School
- University of Hawaiʻi Hilo, CAFNRM
- University of Hawaiʻi Hilo, CTAHR
- University of Hawaiʻi Hilo, Dept. of Geography and Environmental Sciences
- University of Hawaiʻi Hilo, Ka Haka ʻUla O Keʻelikōlani
- University of Hawaiʻi Hilo, Office of Mauna Kea Management
- University of Hawaiʻi Hilo, Pacific Aquaculture and Coastal Resources Center
- University of Hawaiʻi Hilo, Research Corporation of the University of Hawaiʻi
- University of Hawaiʻi Mānoa, College of Tropical Agriculture and Human Resources
- University of Hawaiʻi Mānoa, Wildland Fire Specialist

The following businesses, non-governmental organizations, and individuals received a letter soliciting their participation in the preparation of the DEA:

- Big Island Country Club
- Big Island Invasive Species Committee, Springer Kaye
- Boy Scouts of America, Hawaiʻi Service Center
- Hawaiʻi Forest and Trail, Rob Pacheco
- Hawaiʻi Forest Industry Association, Yvonne and Keoki Carter
- E Mau Nā Ala Hele, Deborah Chang
- Hawaiʻi Agriculture Research Center, Stephanie Whalen
- Hawaiʻi Audubon Society, Wendy Johnson
- Hawaiʻi Community Foundation, Environment & Sustainability, Program Director, Josh Stanbro
- Hawaiʻi Conservation Alliance, Lihla Noori
- Hawaiian Ecosystems at Risk
- Hawaiʻi Forest Industry Association, Heather Gallo
- Hawaiʻi Forest Industry Association, Mike Robinson
- Hawaiʻi Hunting Association, Tom Lodge
- Hawaiʻi Island Economic Development Board
- Hawaiʻi Wildfire Management Organization, Executive Director, Elizabeth Pickett
- Hui Aloha Kiholo, Jenny Mitchell
- Hui Ohana Mai Puu Anahulu a me Puu Waawaa, Debra Lee and Kailiwai-Ray
- Kamehameha Schools
- Kona Hawaiian Civic Club
- Kona Hiking Club, Kathleen Johnson
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- Kumu Pono Associates, Kepa Maly
- Mauka and Makai Access Committee
- Nā Pua Noʻeau
- Nāhelehele, Sally Rice
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- Parker Ranch, President and CEO, Neil Kuyper
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- Peoples Advocacy for Trails Hawaiʻi, Tina Clothier
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- Puu Waawaa Advisory Council Member, Frank Sayre
- Puu Waawaa Advisory Council Member, Mike Tomich
- Puu Waawaa Advisory Council Member, Chris Yuen
- Puu Waawaa Advisory Council Member, Hannah Kihalani Springer
- Puu Waawaa Advisory Council, Past Member, Kuulei Keakealani
- Puu Waawaa Advisory Council, Past Member, Clayton Tremaine
- Puu Waawaa Advisory Council, Past Member, Peter Vitousek
- Puu Waawaa Resident, Jerry King
- Puu Waawaa Resident, Paul Ponthieux
- Puu Waawaa Resident, Henk & Akemi Rogers
- Sierra Club, Moku Loa Group, Linda Larish
- The Kohala Center
- The Nature Conservancy, Director of External Affairs, Mark Fox
- The Nature Conservancy, Executive Director, Suzanne Case
- The Trust for Public Land, Hawai‘i State Director, Lea Hong
- Waikoloa Dry Forest Initiative, Jen Lawson

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1990 *Archaeological Inventory Survey, Kapalaoa Project Site, Land of Puuanahulu, North Kona District, Island of Hawaii*. Prepared for Kona Residence Trust. Paul H. Rosendahl, Ph.D., Inc., Hilo, Hawai‘i.

# APPENDIX A: NĀPUʻU CONSERVATION PROJECT: DRAFT HABITAT CONSERVATION PLAN FOR GAME MAMMAL MANAGEMENT AT PUʻU WAʻAWAʻA AND PUʻU ANAHULU

DEPARTMENT OF LAND AND NATURAL RESOURCES, DIVISION OF FORESTRY AND WILDLIFE

# Draft Habitat Conservation Plan for Game Management at Puʻu Waʻawaʻa and Puʻu Anahulu

## Nāpuʻu Conservation Project

**10/20/2015**

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# EXECUTIVE SUMMARY

The Hawaiʻi Department of Land and Natural Resources (DNLR), through the Division of Forestry and Wildlife (DOFAW), manages lands in the Puʻu Waʻawaʻa Forest Reserve (PWWFR) and the Puʻu Anahulu Game Management Area (PAHGMA), in North Kona, on the Island of Hawaiʻi. Nāpuʻu (The-hills) is the historical name used for the ahupuaʻa of Puʻu Waʻawaʻa and Puʻu Anahulu (Maly and Maly 2006) and is the title we have chosen to represent the conservation project that incorporates the actions of this Habitat Conservation Plan (HCP). The area is home to native bird, plant and invertebrate species as well as non-native game mammal and bird species. Current land management in the Puʻu Anahulu Game Management Area is primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat. Puʻu Waʻawaʻa Forest Reserve is a multi-use area where management includes game population maintenance for hunting, natural resource conservation and restoration, and other activities such as cattle grazing and trail use.

This Habitat Conservation Plan is intended to consider and mitigate for the potential impacts from DOFAW game mammal management activities on endangered species within the Puʻu Waʻawaʻa and Puʻu Anahulu areas (Plan Area 103,988[1] acres). Potential negative impacts on Covered Plant species are primarily in the form of direct take from grazing, browsing, and trampling associated with the management of game mammals and cattle in the Plan Area. This plan as a whole intends to provide for avoidance and minimization measures, and mitigation which will provide net benefit to the species and environment, above and beyond any incidental take of protected species which may occur due to Plan actions. This plan will also utilize the grazing activities of game mammals and cattle to reduce fuel loads outside of planned and existing exclosures to prevent wildland fire which is a primary threat to dryland forests.

Covered Species likely to be impacted by Plan activities were identified through consideration of previous botanical and wildlife surveys, as well as on-the-ground botanical and wildlife surveys performed as part of the HCP planning process. The development of this HCP will provide for the incidental take of one endangered insect, Blackburn's sphinx moth *(Manduca blackburni)* and fifteen threatened and endangered plants:, *Asplenium peruvianum* var. *insulare*, Hala pepe (*Chrysodracon hawaiiensis*), Kauila (*Colubrina oppositifolia*), Honohono (*Haplostachys haplostachya*), Maʻo hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Kokiʻo (*Kokia drynarioides*), *Neraudia ovata*, ʻAiea (*Nothocestrum breviflorum*), Uhiuhi (*Mezoneuron kavaiense*) Poʻe (*Portulaca sclerocarpa*), Hawaiian Catchfly (*Silene lanceolata*), Pōpolo kū mai (*Solanum incompletum*), Creeping Mint (*Stenogyne angustifolia*), Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*), and Aʻe (*Zanthoxylum hawaiiense*).

A model has been developed to estimate the density of individuals of each covered plant species within the Plan Area. These estimates are used to quantify the level of take anticipated for the covered plant species over the course of the HCP. All plant species located outside of fenced units are considered subject to take.

Blackburn's sphinx moth (*Manduca blackburni*) is the only insect species that has been identified as potentially impacted by activities within the Plan Area, from removal of non-native tree tobacco (*Nicotiana glauca*) from fuelbreaks to allow access for management and hunting activities. Clearing of fuelbreaks and roads is critical for overall fire suppression in the Plan

[1] Plan Area acreage is based on TMK acreage.

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Area. Data from larval surveys are used to estimate take of larvae in the Plan Area as well as guide avoidance, minimization, and mitigation actions.

The focus for the stabilization of threatened and endangered species occurring within the Plan Area will be on restoration of functional communities. These communities should support not only stable Covered Species populations, but represent fully functional (insofar as possible), self-sustaining communities with minimal dependence on human management.

Exclosures are the most effective tool for the avoidance and minimization of threats from ungulate grazing, browsing, and traffic on plant populations. Currently, 4,181[2] acres (4 % of Plan Area) are fenced within eleven exclosures across the Plan Area, and additional 4,757 acres (4.5% of Plan Area) are proposed for fencing under this HCP. Take estimates are combined with species stabilization criteria to define mitigation goals for each plant species. Monitoring of compliance and take of protected species, review and implementation of adaptive management measures are required by law and to ensure that the HCP is implemented correctly, efficiently, and effectively for the species, environment, and all parties concerned.

[2] Fenced unit acreage based on GIS acreage.

**Table 0.1** Summary of Avoidance/Minimization and Mitigation Measures to Offset the Requested Take of Covered Species.

**Avoidance and Minimization within the Plan Area**

1. Install all avoidance and minimization exclosures by Year 8 (See Section 4.3.6.2).
    a. Remove ungulates from within exclosures within first year of fencing (this may be dependent upon unit size).
    b. Invasive species control:
        i. Reduce overall alien cover by 50% around Covered Species by Year 8.
        ii. Conduct rodent and slug control or other threats as needed.
        iii. Maintain fuelbreaks around fencelines semi-annually.
        iv. Conduct quarterly fence line and ungulate ingress checks.
    c. Census of all Covered Species within a unit within first year of fencing.
    d. A monitoring plan for *in situ* populations will be developed by Year 3.

**Mitigation within the Plan Area**

1. Install all mitigation exclosures by Year 15 (See Section 6.1).
2. Collection of propagules from *in situ* plant populations
    a. Identify propagule collection needs by Year 3.
    b. Collect propagules from each known plant population by Year 5 (see Section 6.5).
3. Collection of propagules from *in situ* plant populations
    a. Identify propagule collection needs by Year 3.
    b. Collect propagules from each known plant population by Year 5 (see Section 6.5).
4. Propagation of propagules for all Covered Species at Volcano Rare Plant Facility, DOFAW Waimea Tree Nursery, or PWW on-site nursery.
5. Outplanting of no less than the mitigation target for each Covered Species within appropriate exclosures in the Plan Area (see Section 6.1).
    a. Individuals (or clusters of individuals) will be tagged and documented with GPS.
    b. GPS location information, accession numbers, plant status, and any other pertinent information will be inputed into a database for long-term monitoring.
    c. Site preparation consists of removal of non-native vegetation, through weed whacking, herbicide, and/or manual pulling.
    d. A minimum of 50% of each Covered Species mitigation goal (Table 6.18) will be outplanted by Year 8.
    e. A minimum of 100% of each Covered Species mitigation goal (Table 6.18) will be outplanted by Year 15.
    f. A monitoring plan for mitigation populations will be developed by Year 3.
    g. Mitigation populations (individuals or clusters of individuals) will be monitored annually.
6. Management of outplanted populations for 25 years:
    a. Outplanted individuals are watered upon planting and follow up watering is provided as needed in the first 3 months.
    b. Pest control (aphids etc) will be conducted as needed.
    c. Removal of non-native species from outplanting areas:

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i. Remove 90% of fountain grass and kikuyu grass from within 3 meters of an individual (or cluster of) outplants
ii. Maintain a 25-50 m buffer of less than 50% invasive grass coverage around an individual (or cluster of) outplants.
iii. Weeding is scheduled as needed.

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## ACRONYMS

| | |
|---|---|
| AS | Apparently Secure |
| ATV | All-terrain Vehicle |
| BLNR | Board of Land and Natural Resources |
| BSM | Blackburn's Sphinx Moth |
| CE | Critically Endangered |
| CH | Critical Habitat |
| CTTIA | Core Tree Tobacco Infestation Area |
| DDIT | DLNR-DOFAW Implementation Team |
| DLNR | Department of Land and Natural Resources |
| DOFAW | Division of Forestry and Wildlife |
| EA | Environmental Assessment |
| ESA | Endangered Species Act |
| ESRC | Endangered Species Recovery Committee |
| FBS | Forest Bird Sanctuary |
| FR | Forest Reserve |
| FWS | Fish and Wildlife Service |
| GIS | Geographic Information System |
| GMA | Game Management Area |
| GPS | Global Positioning System |
| HCP | Habitat Conservation Plan |
| HEPA | Hawaiʻi Environmental Policy Act |
| HETF | Hawaiʻi Experimental Tropical Forest |
| HPPRCC | Hawaiʻi and Pacific Plants Recovery Coordinating Committee |
| HRPRG | Hawaiʻi Rare Plant Restoration Group |
| HRS | Hawaiʻi Revised Statutes |
| HVNP | Hawaiʻi Volcanoes National Park |
| ICUN | International Union for Conservation of Nature |
| ITL | Incidental Take License |
| ITP | Incidental Take Permit |
| NAR | Natural Area Reserve |
| NEPA | National Environmental Policy Act |
| PAHGMA | Puʻu Anahulu Game Management Area |
| PEPP | Plant Extinction Prevention Program |
| PEP | Species that has fewer than 50 wild plants remaining (PEPP designation) |
| POP | Potentially PEP Species (PEPP designation) |
| PTA | Pōhakuloa Training Area |
| PWW | Puʻu Waʻawaʻa |
| PWWFR | Puʻu Waʻawaʻa Forest Reserve |
| PWWMP | Puʻu Waʻawaʻa Management Plan |
| ROI | Rare on Island (PEPP designation) |
| SOC | Species of Concern |
| TMK | Tax Map Key |
| UH | University of Hawaiʻi |
| USDA | United States Department of Agriculture |
| USFS | United States Forest Service |
| USFWS | United States Fish and Wildlife Service |
| UTM | Universal Transverse Mercator |

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# 1.0 INTRODUCTION AND PLAN OVERVIEW

The Hawaiʻi Department of Land and Natural Resources (DNLR), through the Division of Forestry and Wildlife (DOFAW), manages lands in the Puʻu Waʻawaʻa Forest Reserve (PWWFR) and the Puʻu Anahulu Game Management Area (PAHGMA), in North Kona, on the Island of Hawaiʻi. Puʻu Waʻawaʻa is often coupled with its neighbor to the north, the ahupuaʻa of Puʻu Anahulu, the natural and cultural resources of these lands, as well as the familial associations, have been shared together since the earliest of Hawaiian times, and the relationship of the native families of the land remains strong to this present day (Maly and Maly 2006). These lands are collectively called "Nāpuʻu"[3], and share common threads of environment, traditions, land tenure, and familial and cultural attachments. The Nāpuʻu Conservation Project represents the the actions defined in this Habitat Conservation Plan.

The proposed Plan Area (total of 103,988 acres)[4] is on the western side of North Kona, includes the Puʻu Waʻawaʻa Forest Reserve (TMKs 3-7-1-003-001, 3-7-1-004-001 and 3-7-1-004-018) and Puʻu Anahulu Game Management Area (TMKs 3-7-1-001-001, 3-7-1-001-004, 3-7-1-001-006, 3-7-1-001-007, 3-7-1-002-001, and 3-7-1-002-013)(Figure 1.1). The area is home to native and non-native game, bird, plant and invertebrate species. Current land management in the Puʻu Anahulu Game Management Area is primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat. Puʻu Waʻawaʻa Forest Reserve is a multi-use area where management includes game population maintenance for hunting, and natural resource conservation and restoration, as well as other activities such as cattle grazing and trail use. It is anticipated that these activities have the potential to result in the incidental take of one animal species, Blackburn's sphinx moth *(Manduca blackburni*), and 15 state and federally listed plant species: *Asplenium peruvianum* var. *insulare*, Hala pepe (*Chrysodracon hawaiiensis*), Kauila (*Colubrina oppositifolia*), Honohono (*Haplostachys haplostachya*), Maʻo hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Kokiʻo (*Kokia drynarioides*), *Neraudia ovata*, ʻAiea (*Nothocestrum breviflorum*), Uhiuhi (*Mezoneuron kavaiense*) Poʻe (*Portulaca sclerocarpa*), Hawaiian Catchfly (*Silene lanceolata*), Pōpolo kū mai (*Solanum incompletum*), Creeping Mint (*Stenogyne angustifolia*), Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*), and Aʻe (*Zanthoxylum hawaiiense*). Potential negative impacts on these listed plant species are primarily in the form of direct take from grazing, browsing, and trampling associated with the management of game mammals and cattle in the Plan Area. Potential impacts to Blackburn's sphinx moth larvae and eggs are from the clearing and maintenance of fuelbreaks and four-wheel drive access roads. No other listed, proposed, or candidate plant or animal species are anticipated to be taken by Plan activities.

State (HRS §195-D) law requires provisions for protected species impacted by Plan actions and therefore, DLNR is seeking an Incidental Take License (ITL) in accordance with Chapter 195-D, Hawaiʻi Revised Statutes. This permit is issued by the DLNR. The Habitat Conservation Plan (HCP) supports the issuance of this permit, and describes how the Applicant will avoid, minimize, mitigate, and monitor the incidental take of endangered species that may occur in the Plan Area during the management and maintenance of non-native game mammals and hunting

[3] Nāpuʻu (The-hills) is a general name for the hilly region of Puʻu Waʻawaʻa and Puʻu Anahulu. The name also includes variations, such as Nā-puʻu-pūʻalu (The-loose, crumpled, or folded-hills) or Nā-puʻu-pūʻalu-kinikini (The-many-folded-hills), which describe the topography - the rolling folds of the hills.

[4] Calculated based on TMK tax acreage.

within the PWWFR and PAHGMA. The HCP integrates components of the current Puʻu Waʻawaʻa Management Plan (PWWMP) (2003), and outlines a monitoring protocol to determine successful mitigation for each species throughout the duration of the Plan. Additionally, this HCP incorporates adaptive management provisions to allow for modifications to the mitigation and monitoring measures as knowledge is gained during implementation.

Timely implementation of this plan should provide net benefit to the species and environment, and will increase the likelihood of recovery of the endangered and threatened species that are the focus of the plan. This plan, with an approved Incidental Take License for anticipated take of these species, should address applicable requirements under State endangered species law.

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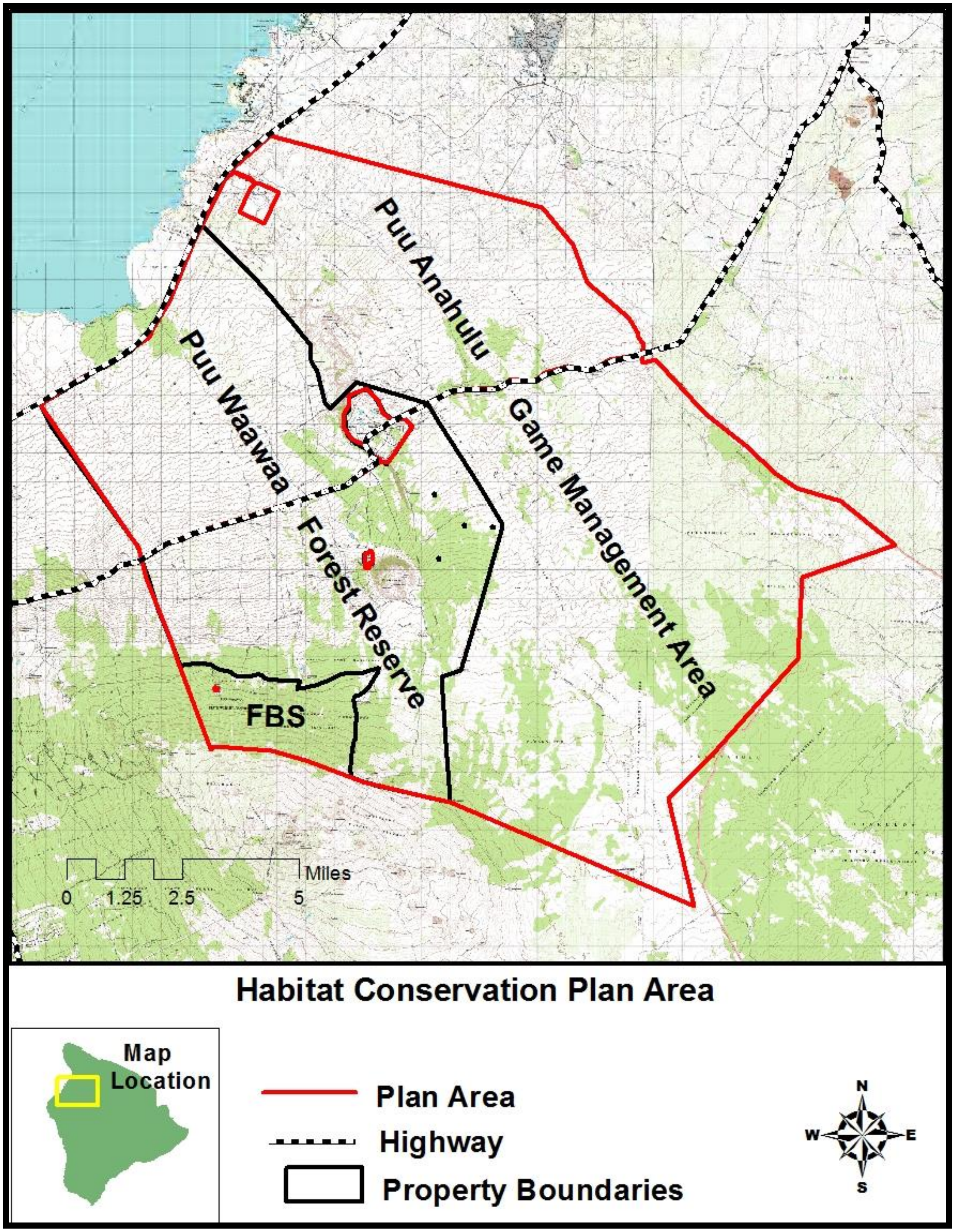


**Figure 1.1** Plan Area (103,988 acres), including Pu‘u Wa‘awa‘a forest reserve, Pu‘u Anahulu game management area, and the Pu‘u Wa‘awa‘a forest bird sanctuary, North Kona, island of Hawai‘i. Internal red outlines signify private inholdings and are excluded from the Plan Area.

## 1.1 REGULATORY SETTING

### 1.1.1 Endangered Species Act

The ESA and its implementing regulations prohibit the take of any fish or wildlife species that is federally listed as threatened or endangered without prior approval pursuant to either Section 7 or Section 10 (a)(1)(B) of the ESA. Section 9 of the ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The term harm means an act that actually kills or injures a federally listed wildlife species, and may include significant habitat modification or degradation (50 Code of Federal Regulations [CFR] section 17.3). In addition, Section 9 of the ESA details generally prohibited acts and Section 11 provides for both civil and criminal penalties for violators regarding species federally listed as threatened or endangered.

ESA section 4(f) requires the USFWS to develop and implement recovery plans for the conservation and survival of listed species. Recovery plans must describe specific management actions, establish objectives and measurable criteria for delisting, and estimate the time and cost to carry out measures needed to achieve recovery. The USFWS has developed recovery plans for all the species covered under this HCP (USFWS 1993, 1996b, 1998b, a, 1999, 2003b). The biological goals and objectives identified in Section 4.0 are consistent with these recovery plans.

This HCP is being written to fulfill requirements under the state of Hawaii endangered species laws for the issuance of an Incidental Take License (ITL) for the incidental take of endangered species (described in more detail below). An HCP is needed because project actions may have the potential to result in take of listed species that occur in the Plan Area. Under HRS Chapter 195D-4, DLNR may authorize incidental take through the issuance of an ITL. In support of an application for the ITL, the applicant must prepare an HCP. This document establishes the methods and measures of success required to meet the conservation needs of listed species potentially impacted by the project. Additionally, to ensure compliance under the Federal ESA, DOFAW has initiated formal consultation under Section 7 of the ESA for potential take of Blackburn's sphinx moth resulting from road clearing activities in the Plan Area financed by federal funding. If in the future consultation under the Federal ESA with regards to take of listed species addressed in the State HCP becomes necessary, DOFAW will initiate formal consultation under Section 7 to ensure compliance with all Federal ESA requirements.

### 1.1.2 Chapter 195D, Hawaiʻi Revised Statutes

The purpose of Chapter §195D of Hawaiʻi Revised Statutes (HRS) is "to ensure the continued perpetuation of indigenous aquatic life, wildlife, and land plants, and their habitats for human enjoyment, for scientific purposes, and as members of ecosystems…" (§195D-1). §195D-4 states that any endangered or threatened species of fish or wildlife recognized by the ESA shall be so deemed by State statute. Like the ESA, the unauthorized "take" of such endangered or threatened species is prohibited [§195D-4(e)]. Under §195D-4(g), the Board of Land and Natural Resources (BLNR), after consultation with the State's Endangered Species Recovery Committee (ESRC), may issue a temporary Incidental Take License (subsequently referred to as an "ITL") to allow a take otherwise prohibited if the take is incidental to the carrying out of an otherwise lawful activity.

In order to qualify for an ITL, the following must occur:

- The Applicant minimizes and mitigates the impacts of the take to the maximum extent practicable.
- The Applicant guarantees that adequate funding for the HCP will be provided.
- The Applicant posts a bond, provides an irrevocable letter of credit, insurance, or surety bond, or provides other similar financial tools, including depositing a sum of money in the endangered species trust fund created by §195D-31, or provides other means approved by BLNR, adequate to ensure monitoring of the species by the State and to ensure that the applicant takes all actions necessary to minimize and mitigate the impacts of the take.
- The HCP increases the likelihood that the species will survive and recover.
- The HCP takes into consideration the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed.
- The activity permitted and facilitated by the license to take a species does not involve the use of submerged lands, mining, or blasting.
- The cumulative impact of the activity, which is permitted and facilitated by the license, provides net environmental benefits.
- The take is not likely to cause the loss of genetic representation of an affected population of any endangered, threatened, proposed, or candidate plant species.

Section 195D-21 outlines the requirements of HCPs. According to this section, HCPs submitted in support of an ITL application shall:

1. Identify the geographic area encompassed by the HCP; the ecosystems, natural communities, or habitat types within the Plan Area that are the focus of the HCP; and the endangered, threatened, proposed, and candidate species known or reasonably expected to be present in those ecosystems, natural communities, or habitat types in the Plan Area.
2. Describe the activities contemplated to be undertaken within the Plan Area with sufficient detail to allow the department to evaluate the impact of the activities on the particular ecosystems, natural communities, or habitat types within the Plan Area that are the focus of the HCP.
3. Identify the steps that will be taken to minimize and mitigate all negative impacts, including without limitation the impact of any authorized incidental take, with consideration of the full range of the species on the island so that cumulative impacts associated with the take can be adequately assessed; and the funding that will be available to implement those steps.
4. Identify those measures or actions to be undertaken to protect, maintain, restore, or enhance the ecosystems, natural communities, or habitat types within the Plan Area; a schedule for implementation of the measures or actions; and an adequate funding source to ensure that the actions or measures, including monitoring, are undertaken in accordance with the schedule.
5. Be consistent with the goals and objectives of any approved recovery plan for any endangered species or threatened species known or reasonably expected to occur in the ecosystems, natural communities, or habitat types in the Plan Area.
6. Provide reasonable certainty that the ecosystems, natural communities, or habitat types will be maintained in the Plan Area, throughout the life of the HCP, in

sufficient quality, distribution, and extent to support within the Plan Area those species typically associated with the ecosystems, natural communities, or habitat types, including any endangered, threatened, proposed, and candidate species known or reasonably expected to be present in the ecosystems, natural communities, or habitat types within the Plan Area.

7. Contain objective, measurable goals, the achievement of which will contribute significantly to the protection, maintenance, restoration, or enhancement of the ecosystems, natural communities, or habitat types; time frames within which the goals are to be achieved; provisions for monitoring (such as field sampling techniques), including periodic monitoring by representatives of the department or the ESRC, or both; and provisions for evaluating progress in achieving the goals quantitatively and qualitatively.
8. Provide for an adaptive management strategy that specifies the actions to be taken periodically if the plan is not achieving its goals.

In addition to the above requirements, all HCPs and their actions should be designed to result in an overall net benefit to the threatened and endangered species in Hawai‘i (Section 195D-30).

### 1.1.3 Chapter 343, Hawai‘i Revised Statutes

DLNR has determined that the approval of an HCP and issuance of an ITL under HRS Chapter §195D will be accompanied by environmental review pursuant to HRS Chapter §343.

### 1.1.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. Section 40 *et seq.*), requires federal agencies to take into account the effects of their proposed actions on properties eligible for inclusion in the National Register of Historic Places. “Properties” are defined herein as “cultural resources,” which includes prehistoric and historic sites, buildings, and structures that are listed on or eligible for the National Register of Historic Places. An undertaking is defined as a project, activity, or program funded in whole or in part under the direct or indirect jurisdiction of a federal agency; including those carried out by or on behalf of a federal agency; those carried out with federal financial assistance; those requiring a federal permit, license or approval; and those subject to state or local regulation administered pursuant to a delegation or approval by a federal agency. The issuance of an ITP is an undertaking subject to Section 106 of the National Historic Preservation Act. Cultural and archeological resources surveys have been conducted for the Plan. The DLNR will coordinate with the State Historic Preservation Division office on cultural resources and address any potential issues in the EA.

## 1.2 PLAN DESCRIPTION

### 1.2.1 Plan History

The PWWFR and lands just northeast within PAHGMA have been identified as the Plan Area (103,988 acres) for the purposes of this HCP. In 2003, BLNR approved in concept a *Management Plan for the Ahupuaʻa of Puʻu Waʻawaʻa and the Makai Lands of Puʻu Anahulu* (PWWMP). Currently, the lands within the Plan Area are being managed for grazing of non-native mammals, fire management, natural resource management, and public hunting according to the guidelines in the Management Plan. In particular, management for endangered plants involves the construction of fence exclosures, the maintenance of existing exclosures, outplanting, and weed control for 30 conservation units ranging in size from five to approximately 4,000 acres for a total of approximately 8,841 acres (approximately 8.5 % of the Plan Area (103,988 acres)). Currently, 4,181 acres comprising eleven exclosures are fenced within the Plan Area. Nineteen new conservation units, an approximate total of 4,757 acres (4.5 % of the Plan Area (103,988 acres)) will be constructed to protect *in situ* plant populations and allow for additional mitigation area for Covered Species. The current and proposed fenced exclosures will function to protect Covered Species as well as serve as outplanting sites for mitigating take of Covered Species found within the Plan Area.

To date, several botanical surveys, Blackburn's sphinx moth larval surveys (Appendix D), a multi-year game mammal study (Appendix A), a multi-year ecological restoration study (Parsons et al. 2014), and a vegetation monitoring study (Appendix C) have been conducted to identify the location of endangered species within the Plan Area, calculate game mammal home ranges, monitor outplanting success, and measure the effects of ungulates on endangered plants, respectively. Data from botanical surveys were used, in conjunction with moisture and substrate maps and species range data, to estimate Covered Species population size within unsurveyed areas. The survey and predicted values from these studies serve as the basis for avoidance and minimization strategies and mitigation goals.

Data gathered from game mammal home ranges are used to determine the geographic scope of the area of impact, hereafter "Area of Potential Impact (149,228 acres)". The calculated home ranges for mammals in the Plan Area are 9.35 km2 for female sheep, 12 $km^2$ for male sheep, and 16.3 $km^2$ for goats. The largest of the three home ranges (16.3 $km^2$ for goats, or 2.25 km diameter) was used to calculate the Area of Potential Impact. The Area of Potential Impact includes a 2.25 km buffer extended out on all sides from the FR and GMA boundaries, except for the uphill (mauka) boundary along the Pōhakuloa Training Area (PTA) border where a boundary fence limits ungulate ingress (Figure 1.2). The buffer is based on half the maximum home range width. Because the game management activities within the Plan Area support game mammals and the animals may potentially leave the Plan Area boundary, DOFAW is responsible for the impacts of those animals within the buffer outside the Plan Area.

Background information from the Management Plan (DLNR 2003) applies directly to the HCP, and is therefore repeated here (pages 1-5)[5]. In addition, the coverage area of the Management Plan does not extend into the mauka lands of Puʻu Anahulu, and there is currently no

[5] Note that the geographic setting and scope of activities in the Management Plan show some overlap but differ from than that of the current this HCP.

management plan in place for this area. In lieu of a management plan, the guiding principles of the Puʻu Waʻawaʻa Management Plan will be used wherever applicable. For more in depth background information, please refer to the PWWMP.

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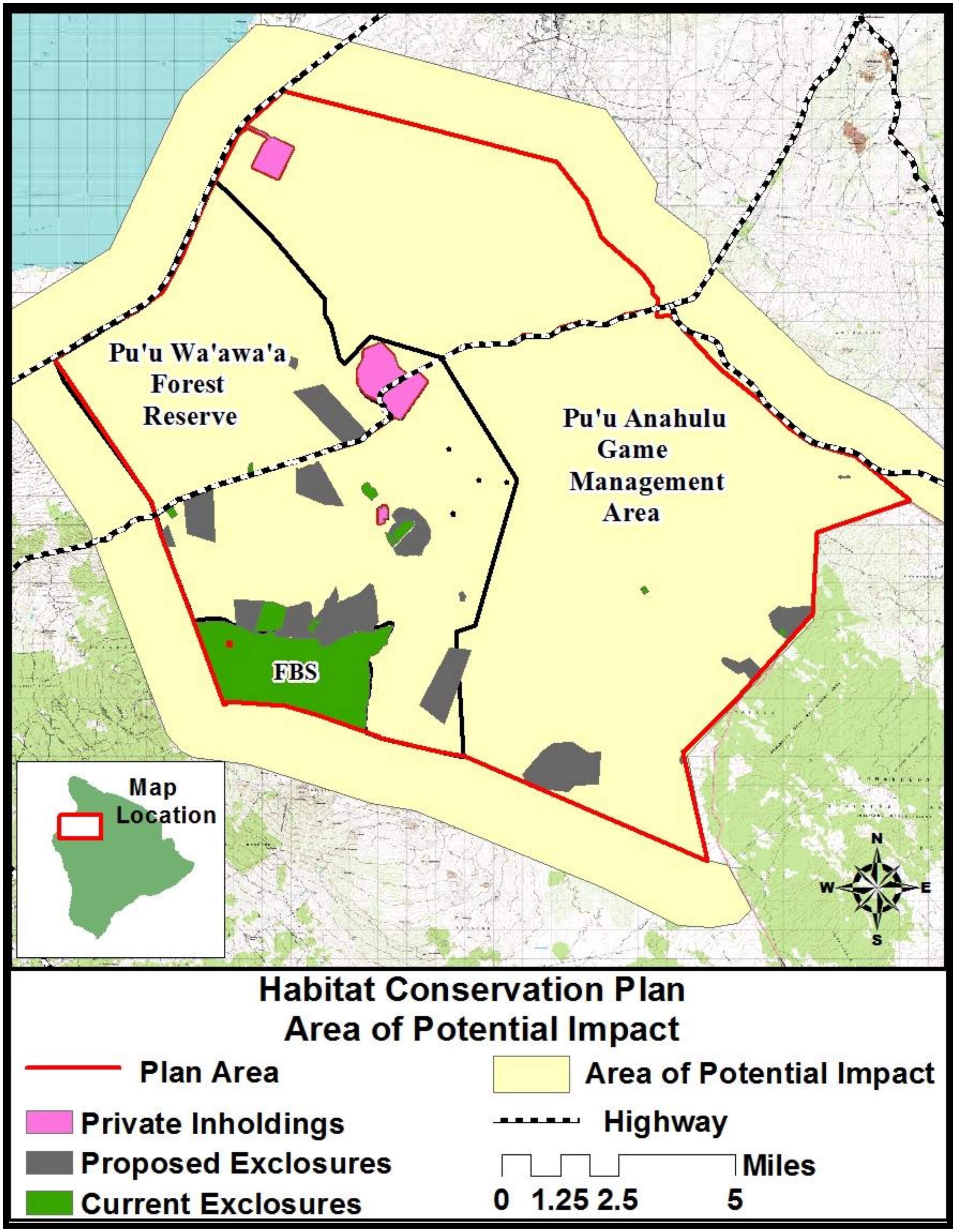


**Figure 1.2** Area of Potential Impact (149,228 acres).

### 1.2.2 Purpose and Need for the Plan

Hawaiʻi's natural resources are managed under the authority and mandates of several laws and regulations. State law authorizes and mandates the protection, conservation, development, and utilization of wildlife resources of the State. Specifically, HRS §171-3 mandates that the Department of Land and Natural Resources (DLNR) shall manage and administer forests, forest reserves, wildlife, wildlife sanctuaries, game management areas, public hunting areas, Natural Area Reserves (NARs), and other functions assigned by law. HRS §183D-2 mandates that the Department shall manage and administer the wildlife and wildlife resources of the State which, by definition, includes both game and non-game species. §183D-3 further mandates that the Department shall adopt rules protecting, conserving, monitoring, propagating, and harvesting wildlife and under §183D-4, and that the Department is given the authority to maintain, manage, and operate game management areas, wildlife sanctuaries, and public hunting areas for these purposes. Within the DLNR, DOFAW has been delegated the management responsibility for terrestrial wildlife and the game management component of that program. It is because of this mandate that game mammal management occurs at Puʻu Waʻawaʻa and Puʻu Anahulu. This HCP seeks to strike a balance between the needs of the game management program and the protection of the native biota found in the area.

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## 1.3 COVERED ACTIVITES: Game and Fire Management in the Plan Area

### 1.3.1 Background

Hawaiʻi's game mammal management program provides public hunting opportunities across the state and Puʻu Waʻawaʻa FR and the Puʻu Anahulu GMA (collectively the Plan Area) are popular hunting areas on the Island of Hawaiʻi. Game mammals that are managed by the state in the Plan Area include feral pigs (*Sus scrofa*), mouflon sheep (*Ovis orientalis orientalis*), feral sheep (*Ovis aries*), and feral goats (*Capra hircus*). These animals, with the exception of mouflon sheep, were first introduced to Hawaii as a food resource, beginning with the Polynesian introduction of the feral pig. A 10 year ban on the slaughter of sheep and "other European animals" was set in 1794, to increase the stock. Mouflon were introduced to Hawaii in 1957 to improve the quality of the feral sheep (Tomich 1986). Today, these game mammals continue to be an excellent resource for food, in addition to providing opportunities for both recreational and subsistence hunting. The custom of recreational hunting has evolved in Hawaiʻi over the last 150 years as native Hawaiians assimilated western hunting traditions. Although only two percent of the state's residents obtain a hunting license, hunting is a visible and common occurrence across the state (Maly et al. 2013). However, game mammals in Hawaiʻi are not native and have negative impacts on sensitive native species and ecosystems (Coblentz 1978, Miller and Travis 1996, Cabin et al. 2000, Campbell and Long 2009, Spear and Chown 2009, Nunez et al. 2010, Thaxton et al. 2010, Cole et al. 2012). Both PWWFR and PAHGMA contain a significant area of tropical dry forest (Giffin 2003), a globally endangered ecosystem (Miles et al. 2006, Thaxton et al. 2010) that contains many rare and endangered plant and animal species.

Native plants in Hawaiʻi evolved in the absence of browsing and grazing mammals and they often lack physical and chemical defenses that would help to protect them (Stone, 1984). Within tropical dry and mixed-mesic ecosystems in Hawaiʻi, the effects of non-native ungulates on the environment interact with other factors including drought, invasive plants (e.g. fountain and kikuyu grasses [*Pennisetum setaceum* and *P. clandestinum*]), wildfire, and anthropogenic disturbances (Allen 2000, Blackmore and Vitousek 2000, Cabin et al. 2000, Cabin et al. 2002, Elmore and Asner 2006, Castillo et al. 2007, Cordell and Sandquist 2008, Brooks et al. 2009, Thaxton et al. 2010). In particular, large-scale wildfires have eliminated large portions of dryland forest in Hawaiʻi due to the buildup of alien grass biomass, creating a persistent grass-wildfire cycle (Hughes et al. 1991, D'Antonio and Vitousek 1992, Hughes and Vitousek 1993, D'Antonio et al. 2011). This *grass—fire cycle*, where ecosystems that are heavily invaded by alien grasses are more likely to burn, and consequently are more likely to be further invaded by alien grasses, can limit the re-establishment of natives (Hughes and Vitousek 1993). Furthermore, conversion of forests to grasslands due to fire can degrade and reduce habitat quality for game mammals. The result of these combined factors is habitat alteration and loss for Hawaiʻi's native flora and fauna and consequent decline in populations and loss of native species. Wildfire has been identified as a priority threat to the Plan Area, and fire management is critical if natural resource management and game management are to continue. Below is a description of the game mammals present in the Plan Area, a history of their introduction to Hawaii, and a summary of game management in the Plan Area. Following this background information are the specific Covered Activities for game and fire management for this HCP.

#### 1.3.1.1 Feral Pigs (*Sus scrofa*)

Pigs were the first ungulates (hooved mammals) introduced to the Central Pacific Islands by the earliest colonists to Hawai‘i over 1000 years ago (Kirch 1982, Hess and Jacobi 2011). In 1793, other pig varieties, notably the European boar, were introduced to Hawai‘i and presumably hybridized with the pacific variety (Tomich 1969, Ziegler 2002, Nogueira-Filho et al. 2009). Today, feral pigs are abundant in Hawai‘i's tropical forests. Pigs disturb soil by rooting for invertebrates, especially non-native earthworms (Environment 2015), and they can act as vectors for the spread of invasive plant species such as banana poka (*Passiflora tarminiana*) and strawberry guava (*Psidium cattleianum*), (Diong 1982, Nogueira-Filho et al. 2009). Notably, disturbances by pigs create breeding grounds for mosquitoes which spread diseases among birds such as avian malaria and avian pox (LaPointe 2006). Feral pigs are most abundant in the more mesic areas of Pu‘u Wa‘awa‘a (above 1,067 m elevation), though they do occur as low as 762 m in elevation.

#### 1.3.1.2 Feral Sheep (*Ovis aries*)

Sheep were initially introduced to the island of Hawai‘i by Captain George Vancouver in 1793 (Hess and Banko 2011). Because of a lack of predators, feral sheep populations have increased dramatically in Hawai‘i since their introduction. Feral sheep are often considered grazers, preferentially consuming grass, but they can also browse woody vegetation such as māmane (*Sophora chrysophylla*) (Scowcroft and Giffin 1983). Feral sheep can cause soil erosion and degradation when herds occur in high densities on steep slopes. On Mauna Kea, damage to native vegetation due to grazing and browsing by feral sheep has been cited as one of the causes for the inclusion of 15 Hawaiian plant species in the list of threatened and endangered species in the U.S. (Ripley 1974, Scowcroft and Giffin 1983, ISSG 2010). In the Plan Area, aerial surveys conducted by DOFAW have documented that feral sheep are widespread in many areas, especially near the Pu‘u Lani Ranch subdivision in Pu‘u Anahulu. A study of sheep movement patterns (2002-2005) in the Plan Area showed that sheep generally used well-defined ranges, characterized by repeated movements back and forth across their established ranges. There were no instances of clear dispersal from one area to another. Sheep were found more frequently in open areas during the morning and late afternoon periods, feeding in small herds. On cloudy days, sheep tended to remain in more open areas for longer periods. During the hottest portion of the day sheep were often found bedded down beneath the shade of trees or shrubs. The calculated home ranges for sheep in the Plan Area are 9.35 $km^2$ for ewes and 12 $km^2$ for rams. See appendix A for a detailed description of this study.

#### 1.3.1.3 Feral Goats (*Capra hircus*)

Feral goats were likely first introduced to the island of Hawai‘i by Captain James Cook in 1778 (Stone & Anderson 1988). They are currently present from sea level to higher elevations on all of the main Hawaiian Islands with the exception of Lāna‘i and Kaho‘olawe where they were successfully eradicated in 1981 and 1990 respectively (Hess and Jacobi 2011). Feral goats are mainly considered browsers, consuming the vegetation of woody plants, but they also consume graminoids (*grasses, sedges, and rushes*) (Williams 1980). By preferentially browsing on palatable tree species, goats limit or prevent the replacement of adult trees that form a native canopy (Scowcroft and Giffin 1983, Stone and Anderson 1988, Hess and Jacobi 2011)(Stone & Anderson, 1988). For example, by 1900 on the island of Lāna‘i, large areas of the island were deforested due to the activities of sheep and goats that were introduced in the mid-1800s (Hess and Jacobi 2011). Historically at Puʻu Waʻawaʻa Ranch, large goat drives were conducted by early ranchers where goats were pushed to lower elevations at Kīholo Bay and dispatched (Maly and Maly 2006, Springer 2012). In the Plan Area, aerial and roadside surveys conducted by DOFAW show that most of the goat populations occur below Māmalahoa Highway surrounding the Hawaiʻi Island Country Club in Puʻu Anahulu, though other populations exist near Puʻu Waʻawaʻa itself and along the Māmalahoa Highway. The calculated home ranges for for goats in the Plan Area was16.3 km2 (See Appedix A, section 8.0).

### 1.3.1.4 Research on Game Population Abundance

Knowing the abundance of game species in the Plan Area is critical for making management decisions regarding harvest limits and acceptable impacts on habitat. Game mammal abundance for feral sheep, goats, and pigs will be estimated by DOFAW staff using aerial surveys in the Plan Area. Flight transects will be established and will be flown repeatedly, and flight time, belt-transect length, search time and protocol, and weather will be standardized as much as possible so that repeated surveys will provide information on relative abundance. Relative abundance estimates will provide an index of changing ungulate abundance over time that can be correlated with environmental variables and habitat impacts. However, more research on foraging, seasonal patterns and movements, and habitat use will improve future management decisions.

Conservation and research efforts in the Plan Area have benefited greatly from the establishment of the Hawaiʻi Experimental Tropical Forest (HETF) Puʻu Waʻawaʻa Unit in 2006. The HETF was authorized by the Secretary of Agriculture in 1992 through passage of the Hawaiʻi Tropical Forest Recovery Act (1992). Section 606 of the Hawaiʻi Tropical Forest Recovery Act states that the HETF shall be managed as: (1) a model of quality tropical forest management where harvesting on a sustainable basis can be demonstrated in balance with natural resource conservation; (2) a site for research on tropical forestry, conservation biology, and natural resource management; and (3) a center for demonstration, education, training, and outreach on tropical forestry, conservation biology, and natural resources research and management. In 2006, the Hawaiʻi DLNR Land Board approved a Cooperative Agreement between the USDA Forest Service and DLNR to manage the HETF, which include State Lands in Puʻu Waʻawaʻa. In 2007, DLNR granted a use permit to the USDA Forest Service for the HETF for purposes of research, education, demonstration, and related purposes. Currently, DOFAW and the USDA Forest Service work together to coordinate research, management, outreach, access, and education within HETF lands. Future collaboration on research within the HETF relating to game mammal management will inform game management activities in the Plan Area.

### 1.3.1.5 Habitat Management for Game Resources

To continue to provide public hunting opportunities in the Plan Area, areas outside of current and proposed exclosures are available for public hunting areas and are managed as a sustained yield resource. In this context, sustained yield of feral, non-native ungulates will be defined as maintaining sufficient game population abundance and productivity to provide on-going public hunting opportunities (DOFAW Management Guidelines 2001[6]). DOFAW will also take into account the needs of the hunting community when considering management actions in the Plan

[6] The DOFAW Management Guidelines are being updated. Classification of management in the Plan Area may change based on the new guidelines.

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Area. Management actions that enhance game population abundance (including but not limited to improving habitat quality, installation and maintenance of game guzzlers, and hunter quotas or bag limits) will be used to help facilitate an annual sustainable harvest.

Natural resource management objectives in this HCP mandate that game mammals be removed from inside fenced exclosures. Game mammals have been observed utilizing much of the habitat that is located within the proposed fenced exclosure areas, as these areas can contain relatively good game mammal habitat. It is likely that alternate habitat (habitat outside of proposed fenced areas) will need to be enhanced in order to provide game mammal hunting opportunities, and to ensure a quality hunting experience which can be quantified by hunter success rates. Additional research conducted by DOFAW, and through the Hawaiʻi Experimental Tropical Forest and other research activities in foraging behavior, seasonal patterns and movements, and habitat suitability will assist in managing these species across the landscape.

### 1.3.2 Covered Activity # 1: Hunting and Harvest

Portions of Puʻu Anahulu GMA and Puʻu Waʻawaʻa FR are actively used by hunters for both game bird and game mammal hunting. Hunting is conducted by residents from all over Hawaiʻi for food, sport, recreation, and social interaction. Formal public hunting programs at Puʻu Waʻawaʻa Ranch date back to 1978, although this activity has a much longer history in the area, likely dating to pre-contact times. Species subject to hunting include feral sheep, mouflon hybrid sheep, goat, pig, and game birds.

All public hunting is currently administered via either manned or unmanned hunter check stations and requires hunting licenses and additional harvest tags for selected game. Game bird hunting in both Puʻu Waʻawaʻa Forest Reserve and Puʻu Anahulu Game Management Area is typically open during weekends and state holidays from November through January, and in March. Game mammal hunting in Puʻu Anahulu Game Management Area is typically open during weekends and state holidays from March to June. In Puʻu Waʻawaʻa Forest Reserve, feral sheep and goats are currently harvested through the issuance of nuisance control permits. Historical trends in Puʻu Waʻawaʻa Forest Reserve show a sharp increase in the harvest of goats since 2007 with a corresponding decrease in sheep and pig harvest, which reached their peak in 2000 (Figure 1.3). These trends are driven by a combination of animal abundance and distribution, hunter preference and effort, and focal game species that are selected by wildlife officials, as well as bag limits.

Information from biannual aerial surveys will be used in part to determine acceptable harvest limits that lead to sustained populations of game mammals in the Plan Area. Adaptive management will be used to readjust harvest limits over time if necessary. For example, if sensitive areas are being affected by mammal activities, such as increased soil erosion, then nuisance control permits may be issued to reduce populations of game mammals. If public hunting does not adequately reduce ungulate abundance in these cases, then staff control will be used to help protect the resources.

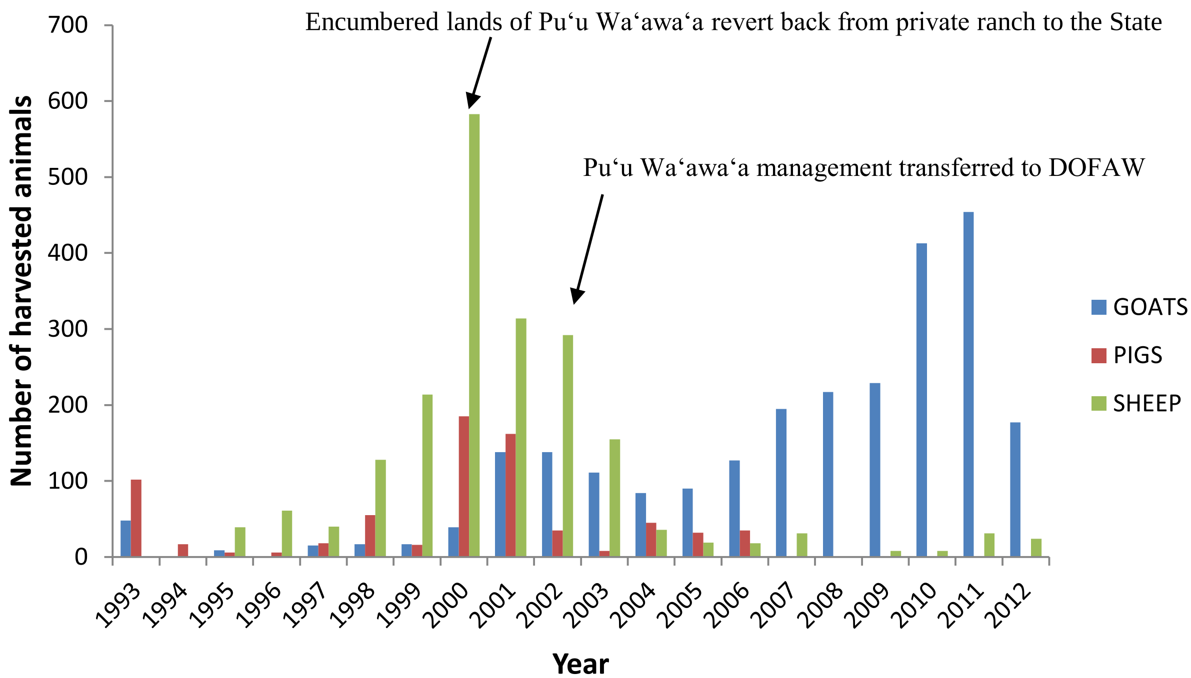


**Figure 1.3** Historical trends in number of animals harvested (goat, sheep, and pig) from 1993 to 2012 at Pu‘u Wa‘awa‘a Forest Reserve (includes both nuisance control permits and regular hunting).

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### 1.3.3 Covered Activity # 2: Habitat Enhancement for Game Mammals

Planting and protection of seedlings are necessary to recover portions of degraded forest that were lost to fire and non-native ungulates. To mitigate the previous loss of game mammal habitat, fast growing, non-fire prone, non-invasive herb, shrub, and tree seedlings (both native and Polynesian introduced) will be planted annually at multiple sites in the Plan Area that will be chosen by DOFAW staff. These areas may be temporarily fenced and when these plants reach an age and height that allows them to escape the most harmful effects of ungulate browsing, fences will be removed so that game animals may use these areas. Currently, two such sites, both less than an acre in size, in the PAHGMA, have been fenced and have been planted with Kukui (*Aleurites mollucanus*). To reduce fire threat, field crews will reduce fine fuel loads (e.g. fountain grass and kikuyu grass) around these enhancement areas and in nearby fire breaks through manual cutting and herbicide application. Habitat improvement through these techniques will provide cover, bedding sites, and foraging opportunities for game mammals. These habitat management strategies will not only improve habitat for existing populations of game species, but may also be used as a management tool to draw animals away from ecologically sensitive areas. For this reason, game habitat enhancement areas will not be placed with 2.25 km (*See Plan History section 1.2.1*) of current or proposed conservation exclosures.

#### 1.3.3.1 Food Plots

Other common habitat management and game population management practices include the use of food plots (to provide supplemental food resources), prescribed burns (to enhance and promote the growth of grasses and other fire-adapted food resources), and mineral supplementation (to improve health and nutrient resources for game animals)(Yarrow and Yarrow 1999). These management techniques are used to enhance the habitat of game species to sustain healthy populations over the long term. Food plots are used to help compensate for reduced food availability during fluctuations in resource abundance, but these will not be a substitute for properly managed habitat. Food plots can also be used to concentrate game in certain areas. To date, no food plots have been used in the Plan Area for game management purposes. Future food plots will use non-invasive plant species that are already found on the island of Hawaiʻi. Typically, plant species that are chosen for these plots are annual legumes that have high protein content, such as clover (e.g. species from the Genus *Trifolium*). For example, recommendations for food plots for white-tailed deer (*Odocoileus virginianus*) in the Southeastern United States include 4 to 5 percent cover of wheat and clover (Yarrow and Yarrow 1999).

#### 1.3.3.2 Mineral Supplementation

Mineral supplementation is often used to supplement the diet of game mammals in areas with nutrient deficient or depleted soils, which have nutrient-poor forage. Mineral supplementation is usually provided by placing mineral blocks in the vicinity of a water unit. The substrate age of much of the land within the Plan Area is between 2,000 – 15,000 years old (Sherrod et al. 2007), and thus soil development is limited and nutrient poor. Moreover, the dominant grass type is fountain grass (*Pennisetum setaceum*) across the landscape until ~2,100 m elevation which then transitions into kikuyu (*Pennisetum clandestinum*)-dominated grassland (Wagner et al. 1999). Fountain grass is neither highly palatable nor nutritious as a forage grass. It may be grazed intensively by sheep or cattle in early spring while shoots are tender and succulent. However, livestock will usually graze other desirable species first and avoid fountain grass when given a preference (USDA 2012). Kikuyu grass, however, is relatively high in protein and is a preferred foraging grass species for game mammals and other wildlife (Black et al. 1994). Therefore, in areas dominated by fountain grass, occasional mineral supplementation may be necessary to maintain healthy game populations. Mineral supplementation can help with growth, development, and also provide critical nutrients for physiological maintenance of body functions, especially in those areas dominated by fountain grass.

### 1.3.4 Covered Activity # 3: Game Mammal Infrastructure

Other game management activities include the installation and maintenance of game guzzlers (watering troughs), and installation and maintenance of informational signage and hunter check stations. These actions are described in greater detail below.

#### 1.3.4.1 Game Guzzlers and Cattle Troughs

Water is needed by game mammals for important physiological processes such as digestion, body temperature regulation, and waste elimination. However, the efficiency by which game mammals find and process water varies by species. Some species can obtain daily water requirements by eating plants or from dew on forage, and water can become available through the digestive process when it is a metabolic by-product of breaking down fat and starches. Precipitation in the Plan Area ranges from 27.9 inches of mean annual rainfall at the Waihou I rain shed area near the Forest Bird Sanctuary, to less than 10 inches on the northern borders along Kaʻahumanu Highway (Giffin 2009, Giambelluca et al. 2013). Drought combined with nutrient poor forage causes game mammals to consume more vegetation to meet nutritional needs and water requirements.

There are currently 24 game guzzlers and 41 cattle troughs scattered across different elevations and habitat types within the Plan Area (Figure 1.5), however not all the cattle troughs are functional at this time. Game guzzlers (see Figure 1.4) are watering troughs connected to large water tanks that are fed by rain catchment systems (usually tin or plastic roofing with rain gutters that lead to water tanks). Pipes from the water tank lead to a small trough with a float valve so that water will be re-filled in the container as it is emptied. The float valve shuts off the water when the water reaches a certain level in the trough to prevent overflow. Similarly, cattle troughs are larger long narrow open tanks with a float valve to refill as it is emptied. For the purposes of this HCP both game guzzlers and troughs function as a water source for game animals. Game guzzlers will not be placed in areas with endangered plant species that are unprotected (i.e. unfenced), and they may also be used strategically to draw animals away from sensitive areas. No new guzzlers will be built until HCP implementation has begun. This will help ensure that added water resources don't increase population abundance of game mammals to a point at which they harm sensitive resources in areas that currently lack large exclosures. During the 25 year ITL permit duration, we anticipate a maximum of two new units installed annually, for a total of 50 new units. Finally, all game guzzlers located within proposed exclosures will be either relocated or fenced off to restrict access to feral ungulates, leaving them accessible to game birds only.

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**Figure 1.4** Game guzzler located in the PAHGMA. Float valve and trough in the foreground, connected to the catchment system pictured in the background.

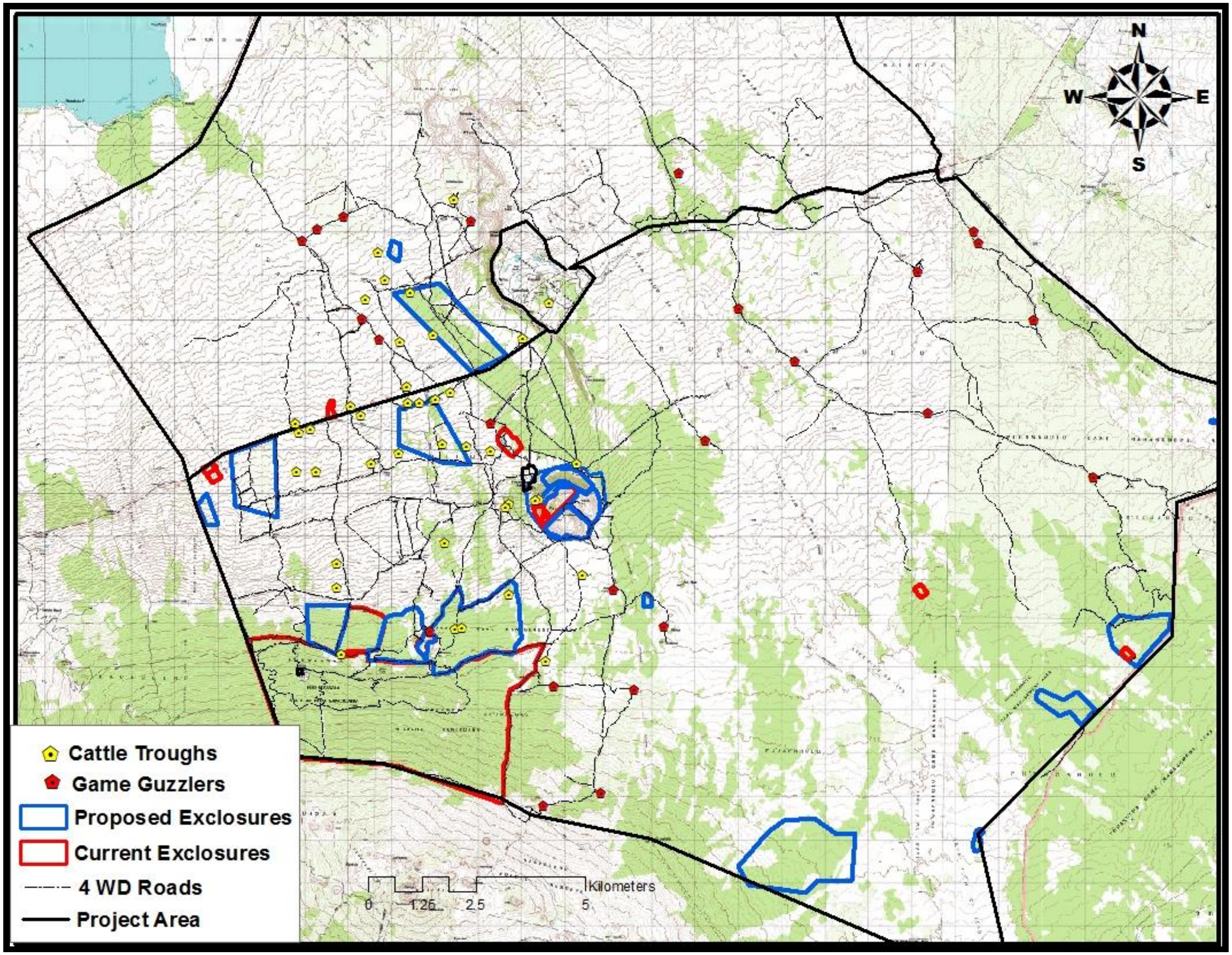


**Figure 1.5** Game guzzler and cattle trough locations in the Plan Area. Not all cattle troughs are functional.

#### 1.3.4.2 Information signage

To help facilitate smooth and efficient hunting activities for all parties involved, hunting boundaries, rules and guidelines, fire risk reduction protocols, and protected and sensitive areas that are closed to access must be known by hunters. In order to meet this objective, informational signage will be installed along hunting boundaries and in appropriate places along trails and roadsides (as well as at hunter check stations and hiking trail kiosks). A hunter check-station, located just inside the main entrance of Puʻu Waʻawaʻa, may be staffed during hunts.

### 1.3.5 Covered Activity # 4: Game Mammal Population Augmentation

Population augmentation using translocation and captive breeding has been a wildlife management tool for as long as humans have been humans (Seddon et al. 2012). To increase hunter opportunity in the Plan Area, populations of current ungulates species present (specifically mouflon and feral sheep and feral goats) will be supplemented and increased. Animals used for augmentation will be translocated from other extant populations on Hawaiʻi Island. Augmentations will not occur until Phase I of HCP implementation is complete, and fences around avoidance and minimization and mitigation areas have been constructed. Temporary holding pens may be installed in non-exclosure locations to help translocated animals acclimate to the area.

### 1.3.6 Covered Activity # 5: Fire Management

Fire management is integral to both natural resource management as well game management and hunting in the Plan Area. The below activities (1.4.6.1 to 1.4.6.2) describe the primary forms of fire management used to reduce the likelihood of fire as well as facilitate rapid response when fires do occur. For a more detailed discussion of fire management in the North Kona region, please see Appendix H.

#### 1.3.6.1 Maintenance of roads and fuel-breaks

Access to hunting areas in the Plan Area is gained through the use of 4 wheel-drive roads that also act as fuel breaks. Currently there are approximately 230 miles of roads and fuel breaks within the Plan Area. Fountain grass, tree tobacco, and other non-native species such as fireweed (*Senecio madagascarensis*) heavily colonize these roads creating hazardous fuel loads and elevated fire risk. Previous catastrophic fires in this area have been attributed to ignition from hot catalytic converters from vehicles parked on tall dead grass. To mitigate the threat of wildfire and allow hunting and management access, it is critical that roads be cleared of vegetation as needed through the use of chemical and mechanical removal methods. Specifically, road clearing consists of manually cutting weeds as well as spraying herbicides that are approved for use in forests (*Methods are described in the Impacts section 5.2.2*).

#### 1.3.6.2 Cattle grazing to reduce fuel loads

Continuous grazing operations have existed in Puʻu Waʻawaʻa for over 100 years (Fujii 1995, DLNR 2003). Many within the homestead communities of Puʻu Anahulu can trace their family history and livelihood to involvement with Puʻu Waʻawaʻa Ranch. Many of the older families in the community are direct descendants of former ranchers and ranch workers at Puʻu Waʻawaʻa. While grazing at Puʻu Waʻawaʻa and Puʻu Anahulu has contributed to the decline of native ecosystems, it has become a practical tool for protecting existing remnant dryland ecosystems by mitigating the buildup of fine fuels. Fountain grass and kikuyu grass are widespread in the Plan

Area. Both grasses produce large amounts of highly flammable fuel. Approximately 90% of all wildfires started in this area can be attributed to roadside ignition, a condition that will continue if left unmitigated. Grazing is used as a tool to mitigate the frequency of wildfires within the PWWFR. Currently, leases for cattle grazing in Puʻu Waʻawaʻa are by special use permit, renewable annually. DOFAW is working with the Puʻu Waʻawaʻa Advisory Council to develop a grazing management plan to be released for public review in the near future. Once finalized, the grazing management plan should allow for longer term cattle grazing leases in the area. This Plan considers the effects of cattle in terms of take of Covered Species to be the same as that of game mammals in the Plan Area.

**1.3.6.3 Prescribed burning for fuels management**

Prescribed burning may be used in the future as a tool to reduce fuel loads and enhance game bird and mammal habitat in Puu Anahulu GMA. Prescribed burning would only be used in highly degraded areas to avoid any impact to Covered Species in the Plan Area. Burning fountain grass and other non-native plants reduces the amount of fuels thereby limiting the risk of wildland fires. Additionally, prescribed burns can stimulated new growth that provides forage for game animals. An Environmental Assessment (EA) would need to be completed and new fire breaks constructed before prescribed burning can be used as a tool for fire management and game habitat enhancement.

# 2.0 DESCRIPTION OF THE HCP

## 2.1 PURPOSE AND NEED FOR THE HCP

This HCP has been prepared to meet the requirements of HRS Chapter §195D, which apply to the management of game and maintenance activities associated with the proposed Plan. An HCP is needed because game mammal management activities have the potential to result in take of endangered and threatened species that inhabit or utilize the Plan Area, including: Blackburn's sphinx moth and 15 plant species. Under HRS §195D-4(g), DLNR will authorize take through the issuance of an ITL. An HCP must be prepared in support of the application for a state ITL. The HCP establishes the measures and means required to meet the conservation needs of endangered and threatened species in the Plan Area, while at the same time preserving the DLNR's ability to pursue its game management objectives with assurances that incidental take of Covered Species is authorized.

The purposes of the HCP are to: 1) describe the geographical area encompassed by the plan; including the ecosytems, natural communities, or habitat types and the endangered species that occur therein; 2) determine the potential impacts that game mammal management may have on the listed species or species under consideration for listing; 3) ensure that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; 4) provide a schedule for implementation; 5) ensure that adequate funding for the HCP will be provided; 6) provide reasonable certainty the ecosystems, natural communities, or habitat types will be maintained in the plan area, throughout the life of the plan, in sufficient quality, distribution, and extent to support the species covered under the HCP; and 7) implementation of the HCP will provide a net benefit to the Covered Species.

The need for the HCP is to authorize, pursuant to HRS Chapter §195D, the take of state-listed threatened or endangered species (or species under consideration for listing) incidental to the management activities of the Plan. In order to obtain such authorization, the DLNR developed an HCP that meets issuance criteria for an ITL. The HCP assists DLNR with regulatory compliance under HRS Chapter §195D, serving as a vehicle for obtaining regulatory stability and predictability.

## 2.2 SCOPE AND TERM

This HCP seeks to offset the potential impact of the proposed game mammal management activities on the listed species (i.e. Covered Species) with measures that protect and provide a net benefit to these species island-wide and statewide. The Applicant anticipates a 25-year Plan life, throughout which this HCP would be in effect. With monitoring and review by the ESRC (Endangered Species Recovery Committee) and DLNR, the provisions for adaptive management will allow mitigation of Plan impacts to be adjusted appropriately. Accordingly, this HCP includes provisions for monitoring and adaptive management to allow flexibility and responsiveness to new information over the life of the Plan. Monitoring and adaptive management will be coordinated within DLNR.

### 2.2.1 List of Preparers

This HCP was prepared by State of Hawaiʻi, Department of Land and Natural Resources, Division of Forestry and Wildlife.

## 2.3 SCHEDULE

Implementation of this HCP will be done in three phases. Phase 1: Avoidance and Minimization Phase, years 0-8, Phase 2: Mitigation Phase, years 5-15, and Phase 3: Maintenance, years 16-25. There is considerable overlap between fencing exclosures that are used for avoidance and minimization, and mitigation. In most cases, these fenced conservation units provide avoidance of take for a given species while also allowing for mitigation sites for additional Covered Species. In these cases, avoidance/minimization and mitigation activities may occur concurrently. What follows is a general description of activities within each phase of implementation. Management and monitoring activities are described in further detail in the monitoring section of this HCP (*See section 7.2*).

The PWWMP is currently being implemented in the Puʻu Waʻawaʻa section of the Plan Area, and the activities and goals of this HCP overlap considerably. The actions taken through the PWWMP will work towards fulfilling avoidance and minimization, and mitigation goals required for this HCP. Current management activities include fuelbreak maintenance, outplanting, weed control, seed collection, fencing individual Covered plant species, establishing new fenced units, and removal of ungulates from established fenced areas.

Phase 1: 0-8 years: Avoidance and Minimization:

- Install Avoidance and Minimization fence exclosures (protection of *in situ*, or naturally occurring wild individuals of Covered Species).
- Initiate exclosure management, once fences are installed, including:
    - Remove ungulates.[7]
    - Reduce overall alien plant cover: remove 90% of fountain grass and kikuyu grass[8] from within 3 meters of an individual (or cluster of ) Covered Species and, maintain a 25-50 m buffer of less than 50% invasive grass coverage around an individual (or cluster of) Covered Species.
    - Conduct rodent and slug control, or other threats (as necessary).
    - Maintain fuelbreaks around fence lines.
    - Conduct quarterly fence line and ungulate ingress checks.
- Full census of each Covered Species within a given exclosure (within a year of installation) to re-establish baseline and add any losses to mitigation goal.

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[7] Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawaiʻi Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawaiʻi* (DLNR 2007). Ungulate removal will depend on size and location of the exclosure and will include public hunting, animal drives, and if necessary, staff removal.

[8] Fountain (*Pennisetum setaceum)* and kikuyu (*Pennisetum clandestinum)* grass have been identified as the most damaging invasive plant species in the Plan Area. Additional weed species will be controlled on a case by case basis. Some alien species, such as kikuyu grass can hinder the encroachment of more aggressive weed species allowing for better outplanting conditions and can be left in place until outplants are near ready to be planted.

- Begin using these exclosures to mitigate for additional appropriate Covered Species not currently occurring within the exclosures.
- An avoidance/minimization and mitigation monitoring plan will be developed within three years of Plan approval.
- Begin annual monitoring of *in situ* populations.
- An invasive species quarantine and response protocol will be developed within three years of Plan approval.

Phase 2: 5-15 years: Mitigation:

- Install remaining Mitigation fence exclosures.
- Initiate exclosure management:
    - Remove ungulates.[9]
    - Reduce overall alien plant cover.
    - Outplant to mitigation goal (+ expected % mortality) in appropriate exclosure for each Covered Species.
    - Conduct rodent and slug control, and other threats (as necessary).
    - Maintain fuelbreaks around fence lines.
    - Conduct quarterly fence line and ungulate ingress checks.
- Initiate mitigation outplanting and monitoring.
- Plant non-listed native species to provide net benefit to the ecosystem.

Phase 3: 16-25 years: Maintenance:

- Continue monitoring *ex situ* and mitigation populations.
- Initiate adaptive management based on monitoring results.
- Replant Covered Species to meet mitigation goals.
- Plant non-listed native species to provide net benefit to the ecosystem.

[9] Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawaiʻi Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawaiʻi* (DLNR 2007). Ungulate removal will depend on size and location of the exclosure and will include public hunting, animal drives, and if necessary, staff removal.

# 3.0 ENVIRONMENTAL SETTING

## 3.1 GEOLOGY

The Island of Hawaiʻi is relatively young on a geological time scale. Geologists estimate that the oldest lava flows are less than 500,000 years old (McDougall and Swanson 1972). Hualālai, an active shield volcano, is the third oldest (130,000 years old) of the five volcanoes on the Island (Moore and Clague 1992). The summit caldera is buried, but the mountain rises to a height of 8,271 ft above sea level. Three major rift zones radiate from the top of Hualālai. One of these, a poorly defined northern rift, extends through the Kalamalu area of Puʻu Waʻawaʻa, and is about 10 km long and 5 km wide. Lavas of Hualālai are primarily Holocene in age, but some deposits date to late Pleistocene (Moore and Clague 1992). The last eruption of Hualālai occurred in 1801 creating the Huehue lava flow. Another eruption is highly probable in the next 200 years, but could occur in the next few decades (Moore et al. 1987). Walker (1990) considered Hualālai as potentially the most dangerous Hawaiian volcano.

Seismic activity within Hualālai is currently low and there is no evidence of magmatic movement such as occurs on Kīlauea and Mauna Loa (Clague and Dalrymple 1987). The last major earthquake at Puʻu Waʻawaʻa occurred in 1929. This event consisted of several thousand tremors that came from a source beneath Hualālai (MacDonald and Abbott 1970). The quake was especially severe at Puʻu Waʻawaʻa. Several ranch buildings were moved from their foundations and rock walls collapsed.

Hualālai's surface lavas are primarily alkalic olivine basalts. Tholeiitic basalts have been found offshore and in onshore drill holes (Walker 1990). The volcano is virtually un-dissected, but a few intermittent streams are subject to flash flooding. Erosion will probably not have a pronounced effect on the mountain for a long time, possibly for tens of thousands of years (Peterson and Moore 1987).

Two historic lava flows occur within the Puʻu Waʻawaʻa region. They are the 1859 flow from Mauna Loa and the 1800-1801 Kaʻūpūlehu flow from Hualālai. Lava from these flows covered thousands of acres of native forest and was responsible for the destruction of several coastal Hawaiian villages and fish ponds. Both flows are poorly vegetated and only slightly weathered. Most substrates that are between these two historic flows originated from Hualālai. These vary greatly in age and intermingle to form a mosaic pattern in the lava bed (Giffin 2003).

### 3.1.1 Cinder Cones

An extinct volcanic vent known as Puʻu Waʻawaʻa cone and its associated 900-ft-thick lava flow (Puʻu Anahulu ridge) are the oldest geologic formations on Hualālai (100,000 + years old). This distinctive hill is over one mile in diameter and rises 372 m above the surrounding landscape to a height of 1,209 m elevation. Erosion, following a radial drainage pattern, has cut many gullies and ridges on the cone's slopes. This geologically unique landform is composed of trachyte pumice and contains scattered blocks of trachyte obsidian or black volcanic glass. Trachyte is one of the most silicic lavas known in Hawaiʻi. Due to its older age, high degree of soil development, and complex topography, Puʻu Waʻawaʻa cone has greater botanical diversity and supports a different plant community than the surrounding area.

Vegetation on the cone can be classified as an Olopua (*Nestegis*) montane forest (Wagner et al. 1999). At least 21 species of native trees have been reported from this rare mesic natural community. Some like the Mānele or soapberry (*Sapindus saponaria*) are found nowhere else in the region. Several other prominent cinder cones occur at Puʻu Waʻawaʻa. These include Potato Hill, Puʻu Iki, Poʻohohoʻo and Kileo cones. Poʻohohoʻo's dual craters were excavated and fitted with rubber liners to store water for ranch use in the mid 1900's. An asphalt catchment system collects water for the reservoirs (Juvik and Tango 2003). Many more small volcanic vents and cinder cones are scattered throughout the area, but most are unnamed (Giffin 2003).

## 3.2 SOILS

The most recent comprehensive soil survey of the Island of Hawaiʻi (USDA 1973) shows several different soil types at Puʻu Waʻawaʻa. Recent field surveys indicate that the deepest soils at Puʻu Waʻawaʻa are the Waʻawaʻa series that occur on Puʻu Waʻawaʻa cinder cone. They are almost 2 meters deep (Giffin 2003).

The ages of Hualālai lava flows have been summarized using correlations between soil depth and age (Moore and Clague 1992). Little or no soil cover (except in wet forest areas) occurs on lavas less than 5,000 years old. On lavas between 5,000-10,000 years old there is 10-20 cm of soil. Flows over 10,000 years old accumulate soils more than 20 cm deep.

## 3.3 CLIMATE

The weather pattern at Puʻu Waʻawaʻa is similar to that found along the Kona coast. Mornings are generally clear and sunny. During the day, the surface of Hualālai absorbs large amounts of solar radiation. This heats air over the mountain and creates updrafts. This rising air mass draws in moist marine air that condenses as it moves upward. The result is afternoon cloud cover and/or rain. The cycle reverses in the evening. Cold air descends from the mountain summit and drives cloud cover out to sea. Mean monthly temperatures measured at Halepiula rain shed were highest in September (71.6º F) and lowest in February (41.7º F). Winter frost sometimes occurs at upper elevations (Giffin, 2003).

Northeasterly trade winds have little influence on Puʻu Waʻawaʻa because of its leeward location in respect to other large mountains. Winds are generally light, but increase slightly during the winter months. Strong frontal storms may pass through the area once or twice a year and winds can reach hurricane force. These storms often uproot large trees or break trunks and limbs. Volcanic smog or "vog", released by Kīlauea Volcano, is often blown to west Hawaiʻi by the trade winds and trapped there under an inversion layer. This haze consists of sulfur dioxide, ammonium sulfate, and ammonium hydrogen sulfate. On windless days, this natural pollutant sometimes drifts in from Kona and blankets Puʻu Waʻawaʻa. Vog usually persists until winds shift and cause it to be blown out to sea. Recent increases in volcanic activity, beginning in March 2008, have resulted in an increase of vog ($SO_2$ emissions) in the Kona region. A study by Nelson and Sewake has shown that vog can negatively impact a number of native and introduced plant species with symptoms ranging from leaf yellowing and bleaching to plant death (2008). The study also suggests seed germination may be affected. At this time, it is unknown if the flora occurring in the Plan Area is being negatively impacted by increased $SO_2$ levels.

## 3.4 HYDROLOGY

Infiltration of rainwater, fog drip, and dew are the primary fresh water inputs in the Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa. Rainfall in the Project Area varies by topography and elevation. In general the southwest corner of the Project Area, the Forest Bird Sanctuary, receives the most rainfall. Precipitation gradually decreases when moving northeast as the elevation decreases. Precipitation in the Project Area ranges from 27.9 inches of mean annual rainfall at the Waihou I rain shed area near the Forest Bird Sanctuary, to less than 10 inches on the northern borders along Kaʻahumanu Highway (Giffin 2003, Giambelluca et al. 2013). Differences in precipitation occur with increasing elevation (Figure 3.1). The rainfall zone changes from mesic at mid elevations to xeric at the upper and lower boundaries. Evaporation is relatively high, with over 100 inches of annual pan evaporation in the driest portion of the Plan Area (Ekem and Chang 1985).

Due to the high permeability of the Mauna Loa and Hualālai basaltic lava flows, there are no perennial streams in the Project Area. Surface flow is minimal and generally restricted to short-duration flash events. Subsurface water movement down to the groundwater aquifers is the main form of water transmission (Giffin 2003). The Plan Area lies on two aquifer units, the Kīholo Aquifer System Area and the ʻAnaehoʻomalu Aquifer System Area. The Kīholo Aquifer is on the northeast rift zone of Hualālai with an estimated sustainable yield of 18 million gallons per day. The ʻAnaehoʻomalu Aquifer System Area extends from the summit of Mauna Loa northwest to the western shores of ʻAnaehoʻomalu, and has an estimated sustainable yield at 30 million gallons per day (Lau and Mink 2006, Fukunaga 2010). Groundwater wells and rain water catchment systems are the two major sources of water supply in the area. Three man-made reservoirs are present and include two at Poʻohohoʻo and one in the Hauaina exclosure (Giffin 2003). The Poʻohohoʻo reservoirs are fed by rain catchment. The upper, smaller reservoir is partially functioning, and the lower, larger reservoir is non-functional. The reservoir at Hauaina is fed by rain as well as inputs from a well. There are three wells near or within the Plan Area. One is on Puʻu Waʻawaʻa Ranch property and one is in the Puʻu Lani Subdivision. A third well, Old Kīholo well is no longer functioning, likely due to damage from an earthquake.

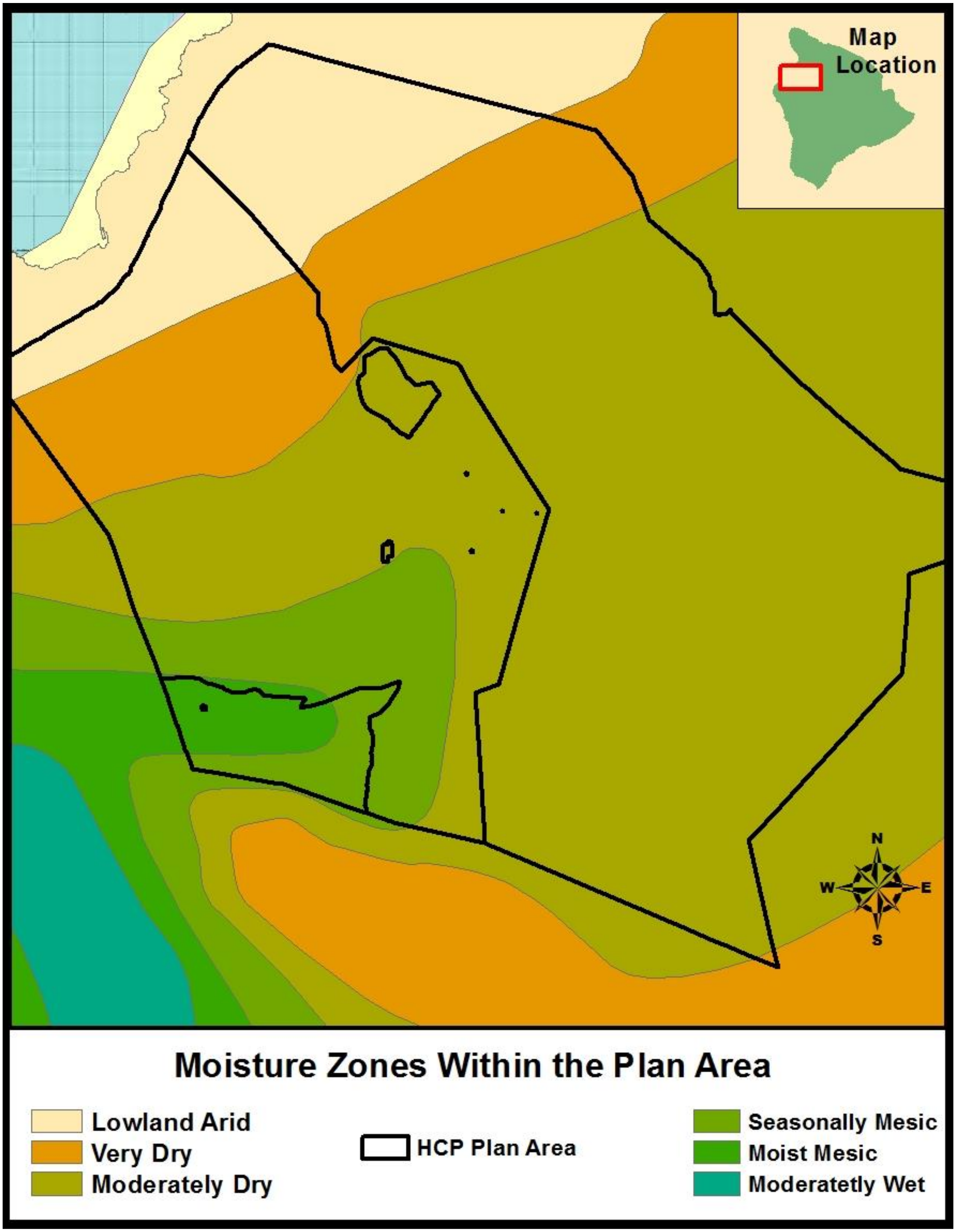



**Figure 3.1** Moisture zones within the Plan Area.

# 3.5 FLORA

Covered Species likely to be impacted by Plan activities were identified through consideration of previous botanical surveys, on-the-ground botanical surveys performed as part of the HCP process, and previous biological assessments done in the area. The results of these surveys are included in this section. Following survey results, short descriptions of the species, their historic and current distribution, and habitat needs follow. Plants known to currently and historically occur within the Plan Area are listed in Appendix B. The areas encompassed by the Plan Area represent a highly diverse array of habitat types, ranging from dry shrublands and forest, to mesic-wet forest and subalpine shrubland. The dry forests of Hawaiʻi were once host to some of the world's most unique and diverse flora, and were richer in tree diversity than comparable areas of wet forest (Rock 1913, Carlquist 1980, Sohmer and Gustafson 1987). Dry forest ecosystems have experienced a rapid and significant loss of area throughout the world (Murphy and Lugo 1986, Janzen 1988, Bullock et al. 1995), and in Hawaiʻi, these communities have now been reduced to approximately 10% of their former extent (Mehrhoff 1988, Bruegmann 1996). Extensive impacts on and alterations of these Hawaiian ecosystems began with the agricultural and hunting practices of the early Polynesians, their use of fire for land clearing, and the introduction of non-native animals such as the Polynesian rat (*Rattus exulans*) (Kirch 1982, Sadler 1999, Burney et al. 2001, Athens et al. 2002). This deterioration and loss accelerated after the arrival of Europeans through the introduction of ungulates such as cattle, sheep, pigs, and goats; further land clearing for agriculture and development, accidental and intentional fires, and the introduction of aggressive weeds including fire-carrying grasses such as fountain grass (Stone 1989, Cuddihy and Stone 1990, Loope 1998). The North Kona region of the island of Hawaiʻi contains some of the largest remaining dry forest remnants in Hawaiʻi (Giffin, 2003).

## 3.5.1 Vegetation Zones

Several different ecological regions are present at Puʻu Waʻawaʻa and Puʻu Anahulu. Starting on the upper slopes of Hualālai and continuing downward, the following zones can be recognized: subalpine (generally above 1,828 m), montane (762-1,828 m), lowland (below 762 m) and coastal (sea level). A variety of vegetation communities occur within each zone. At mid elevations, montane dry woodlands dominate the eastern side of Puʻu Waʻawaʻa while moister montane mesic forests lie to the west.

Rare plants are found in all vegetation zones at Puʻu Waʻawaʻa and Puʻu Anahulu. At least 46 rare plant taxa are historically known from the area to. Of these, 34 are officially listed as endangered or are proposed endangered species (Giffin, 2003), 17 of these species were found during HCP surveys. Botanical surveys reveal that a great number of plants have been extirpated at Puʻu Waʻawaʻa in recent years. These include the endangered and threatened *Bonamia menziesii*, *Asplenium dielerectum*, *Gardenia brighamii*, *Ochrosia kilaueaensis*, *Dissochondrus biflorus*, *Mariscus fauriei*, and *Nesoluma polynesicum*. Many of these species still exist on adjacent lands, particularly at Kaʻūpūlehu. Some rare plants, such as *Asplenium peruvianum* var. *insulare*, have only been found in lava tube openings where they are protected from ungulate damage.

### Subalpine Zone

This zone is found at upper elevations on Hualālai and other high volcanoes in Hawaiʻi. Plants growing here are adapted to relatively dry conditions and dramatic temperature fluctuations.

Days are typically hot and nights cold. These forests at Pu‘u Wa‘awa‘a are characterized by open, low stature ‘Ōhi‘a trees *(Metrosideros polymorpha)* and scattered stands of native shrubs and grasses. Dominant understory species are Pūkiawe *(Leptecophylla tameiameiae)*, ‘Ōhelo (*Vaccinium spp*.), ‘A‘ali‘i (*Dodonaea viscosa*), and various sedges and rushes. Native mints, lilies, and ferns often grow abundantly in shaded areas like lava tube openings.

**Montane Dry Forest Zone**

This zone is found directly below the subalpine zone on the eastern side of Pu‘u Wa‘awa‘a. Many rare and endangered plant species are found in this habitat type. Vegetation damage by feral ungulates, particularly goats and sheep, is widespread. These forests are dominated by ‘Ōhi‘a, Naio, and ‘A‘ali‘i. Scattered stands of Māmane, ‘Iliahi (*Santalum paniculatum*), and ‘Akoko (*Chamaesyce olowaluana*) are also present. Non-native grasses, such as fountain grass (*Pennisetum setaceum*) and weeds, such as fire weed (*Senecio madagascariensis*) have replaced most native understory species. Covered plant species that occur in the montane dry forest are *Asplenium peruvianum* var. *insulare*, *Stenogyne angustifolia*, Hawaiian Catchfly, and A‘e (*Zanthoxylum hawaiiense)*. *Eragrostis deflexa*, a native grass and Species of Concern (SOC), is scattered throughout the Plan Area above 1,219 m elevation.

**Montane Mesic Forest Zone**

This zone is relatively moist, but not as wet as rain forests. The mesic forest supports a rich assemblage of vascular plant species. It is best represented in the Forest Bird Sanctuary. Koa (*Acacia koa*) and ‘Ōhi‘a are the dominant overstory tree species. Kōlea (*Myrsine lessertiana*) dominates the mid-story, while native short-stature trees and shrubs make up the understory. Introduced grasses, primarily Kikuyu (*Pennisetum clandestinum*), and native ferns, especially Laukahi (*Dryopteris* spp.), cover the ground in forest openings. Other ferns such as Hō‘i‘o (*Athyrium sandwichianum*), ‘Akolea (*Athyrium microphyllum*), and Palapalai (*Microlepia strigosa*) are common in wetter, shaded areas. No tree fern stratum exists although Hāpu‘u (*Cibotium glaucum*) is scattered throughout the forest.

Two species covered under this HCP, ‘Aiea (*Nothocestrum breviflorum*) and A‘e (*Zanthoxylum dipetalum* var. *tomentosum*), occur in the lower mesic zone. ‘Aiea is a stout tree in the nightshade family (Solanaceae). The montane mesic forest at Pu‘u Wa‘awa‘a changes from a Koa/‘Ōhi‘a community to an open-canopied ‘Ōhi‘a/ Māmane community at about 1,280 m elevation. This latter woodland is a transitional vegetation type that descends to about 914 m elevation. Although greatly altered, it is still an important conservation link between the moist montane and dry forest types.

The ‘Ōhi‘a/ Māmane woodland supports many rare and endemic plants and is still one of the most botanically diverse sections at Pu‘u Wa‘awa‘a. Trees that characterize this zone include Koa, ‘Akoko, ‘Iliahi, Kōpiko (*Psychotria hawaiiensis*), Pāpala (*Charpentiera obovata*), Pāpala kēpau (*Pisonia brunoniana*), Po‘ola (*Claoxylon sandwicense*), A‘ia‘i (*Streblus pendulinus*), Olopua (*Nestegis sandwicensis*), and Hō‘awa (*Pittosporum hosmeri*). The understory is composed primarily of non-native pasture grasses, but scattered stands of Kulu‘i (*Nototrichium sandwicense)*, Mā‘ohi‘ohi (*Stenogyne rugosa*), and ferns (*Dryopteris*, *Pteris*, *Asplenium*) still persist.

**Lowland Dry Forest Zone**

This zone occurs below the montane forests. Lama (*Diospyros sandwicensis*) and ʻŌhiʻa are the dominant tree species and occur in both mixed and pure stands. Other less common trees include Alaheʻe (*Psydrax odoratum*), Wiliwili (*Erythrina sandwicensis*), ʻOhe makai (*Reynoldsia sandwicensis*), Hala pepe (*Chrysodracon hawaiiensis*), and Kauila (*Colubrina oppositifolia*). The relatively rare Lama and Lama/Kauila plant communities are restricted to this zone at Puʻu Waʻawaʻa. Descriptions of Puʻu Waʻawaʻa's lowland dry forests and information on their floristic composition were presented in detail by Takeuchi (1991) and The Nature Conservancy (TNC 1992).

Endangered plants of the lowland dry forest are Maʻo hau hele (*Hibiscus brackenridgei*), Uhiuhi (*Mezoneuron kaviense*), Kokiʻo (*Kokia drynariodes*), Kauila, and Hala pepe (*Chrysodracon hawaiiensis*). Koaiʻa (*Acacia koaia*) is a species of concern.

### 3.5.2 Previous Botanical Surveys in the Plan Area

Data were compiled from a number of sources documenting the locations of rare and endangered species found within Puʻu Waʻawaʻa and Puʻu Anahulu. The data were then used to guide survey efforts in 2003-2007 for this Plan, in order to calculate baseline species numbers and locations, and to update and identify areas for conservation efforts within the Plan Area. The original data sources included in this review were:

- The Heritage Database (Hawaiʻi Natural Heritage Program/Hawaiʻi Biodiversity and Mapping Program): This survey maps the occurrences of listed species in Puʻu Waʻawaʻa and Puʻu Anahulu. The primary source of these data is from botanical surveys conducted along DOFAW Forest Bird Survey transects in the early 1980s. The landscape has been greatly altered in the 30 years since these surveys and many of the individuals are no longer extant.
- Shaw, Castillo, and Close; Puʻu Anahulu, (1997): This was a general botanical survey with an emphasis on threatened and endangered species. These data focused search efforts within Puʻu Anahulu and upper Puʻu Waʻawaʻa during subsequent HCP surveys. In the years since this survey, frequent wildfires and the subsequent invasion of fountain grass (*Pennisetum setaceum*) have profoundly altered plant communities. Soil kīpuka located on the Keamuku flow, which were relatively free of fountain grass in 1997, are now overgrown by fountain grass. The result is a drastic reduction of available habitat for listed species. For example, Shaw et al. (1997) mapped the distribution of 12 individuals of *Melicope hawaiiensis* on the Keamuku flow. None of these individuals were found during subsequent HCP surveys and no recruitment of *Melicope hawaiiensis* has since been observed.
- Lyman Perry, Hawaiʻi District Botanist (DOFAW), 1999-present: Rare plant locations mapped during periodic surveys within Puʻu Anahulu and Puʻu Waʻawaʻa.
- Steve Evans (U.S. Army Pōhakuloa Training Area): This survey maps the locations of rare plants on adjacent Pōhakuloa Training Area (data property of U.S. Army and not included as appendix). This information guided survey efforts in the upper Puʻu Anahulu region.
- Arnett survey, (2002): Survey of the recently-acquired Keamuku Parcel.

### 3.5.3 Plan Specific Botanical Surveys

#### 3.5.3.1 2003-2007 Plant Surveys

Botanical surveys were conducted in the Plan Area from 2003 to 2007 to determine locations of rare and endangered species located within the Plan Area. The Plan Area is too large to survey completely; therefore a systematic sampling scheme was utilized. Survey areas were identified based on the following parameters: the likelihood of harboring listed species, mid-scale ecological conditions, predicted habitat parameters, as well as input from expert knowledge of the area. Previous survey maps, wildfire history, and lava flow substrate maps were used to select areas likely to harbor listed species. Consultations with Miles Nakahara (formerly Hawaiʻi DOFAW), Lyman Perry, (DOFAW), Mick Castillo (Hawaiʻi Natural Resource Services), and James Kwon (USFWS) also assisted in identification of these areas of high likelihood. These areas of potential habitat for listed species were then subject to systematic survey by a trained botanical survey crew.

Large portions of Puʻu Anahulu and Puʻu Waʻawaʻa (particularly makai of Highway 190) have suffered repeated wildfires in the past two decades and prior (

Figure 3.2). The fires and subsequent fountain grass invasion have virtually eliminated native species from most of these areas. Plan survey efforts were therefore focused on remaining intact kīpuka in upper Puʻu Anahulu and Puʻu Waʻawaʻa. In most cases, the surveyed areas have been spared from fires because the substrate is rough ʻaʻā lava and does not yet support a blanket of fire-carrying fountain grass.

A large portion of the HCP surveys were carried out along systematic transects (Figure 3.3). Survey teams were comprised of two trained botanists who walked roughly parallel lines along each transect, navigating between waypoints with a hand-held Garmin 12 XL GPS unit. Transects were positioned 1 km apart oriented along the contour of the land in some cases, and mauka-makai in other cases, following waypoints every 500 m along transect pathways.

Using the Garmin GPS units, tracks were recorded at two minute time intervals, along all transects. Survey crews generally followed a straight transect, but could meander along transects in order to inspect nearby vegetation, and to search the area once a rare plant was located. In total, approximately 89.5 miles of transects were surveyed (Figure 3.3). Results from systematic transects were used in population estimate calculations.

The other survey method employed was "guided searching", or sampling targeted areas with high likelihood for occurrence of rare plant species (Figure 3.3). Guided searches were conducted by two or more botanists searching in a "free form" manner in an area where a particular plant species of interest was likely to occur. Area selection for guided searches was based on elements such as past known locations, preferred substrate age and type, elevation, moisture level, and proximity to other known plant locations. GPS units were carried during guided searches and tracks were recorded at 2-minute time intervals (Figure 3.3). Successive guided searches were planned after reviewing the coverage and success of earlier search efforts.

Botanical surveys focused on endangered and threatened species. However, the location of locally rare species and SOC were also mapped. For all endangered and threatened species, the following data were recorded: date, time, UTM location, elevation, aspect, topography, slope, age, vigor, reproductive status, height, diameter at breast height (DBH), presence/absence of ungulate damage, substrate type, and habitat description (based on (Jacobi 2003). For non-listed locally rare species, the following data were recorded: number of individuals, UTM location, date, time, vigor, reproductive status, height, DBH, and notes.

Sixteen endangered plant species, totaling 2,242 individuals, as well as nine SOC totaling more than 9,000 individuals were identified and mapped during the 2003-2007 surveys (Table 3.1).

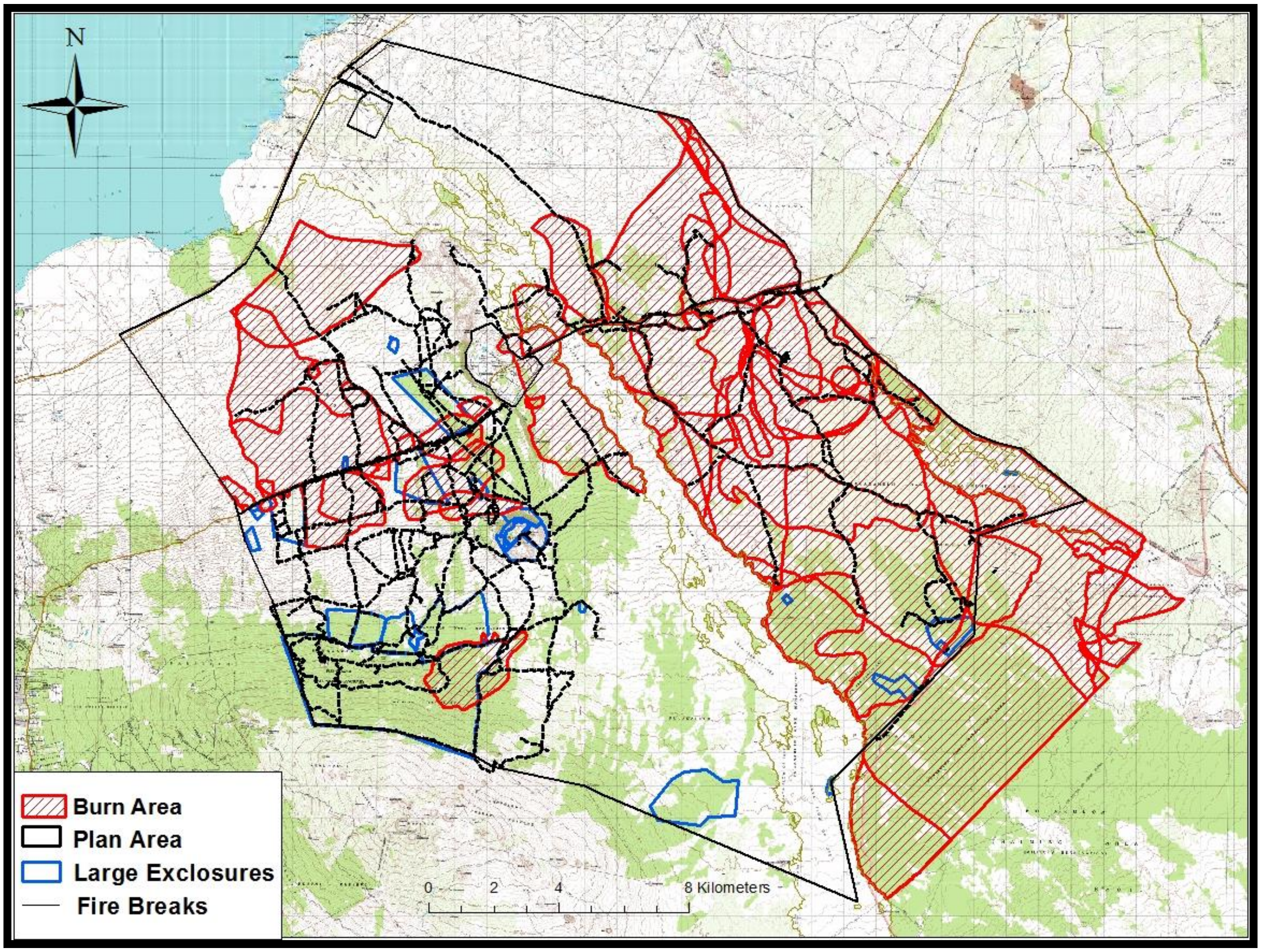



**Figure 3.2** Locations of recorded fires that occurred within the Plan Area from 1975 to 2011.

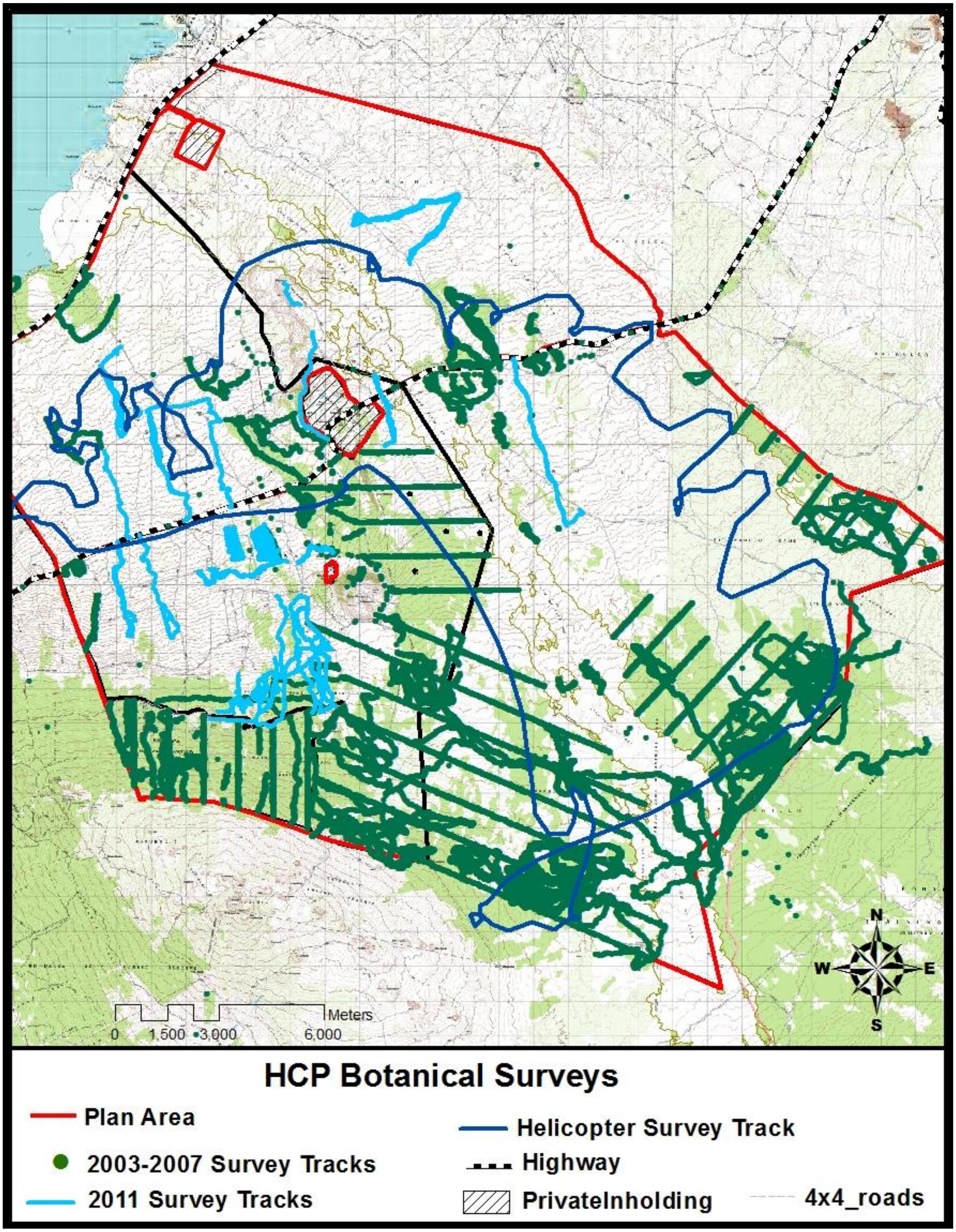



**Figure 3.3** Ground (transects and guided searches) and aerial (helicopter) botanical survey tracks completed during the 2003-2007 and 2011 survey periods totaling 144 km of transects surveyed.

**Table 3.1** List of species and number of individuals found during 2003-2007 botanical surveys.

| Scientific Name | Common Name | # of Individuals |
|---|---|---|
| **Endangered** | | |
| *Asplenium peruvianum* | | 64 |
| *Chrysodracon hawaiiensis* | Hala pepe | 334 |
| *Colubrina oppositifolia* | Kauila | 595 |
| *Haplostachys haplostachya* | Honohono | 80 |
| *Hibiscus brackenridgei* | Maʻo hau hele | 65 |
| *Kokia drynarioides* | Kokiʻo | 4 |
| *Mezoneuron kavaiense* | Uhiuhi | 48 |
| *Neraudia ovata* | | 12[10] |
| *Nothocestrum breviflorum* | ʻAiea | 151 |
| *Phyllostegia velutina*[11] | | 35 |
| *Silene lanceolata* | Hawaiian Catchfly | 333[12] |
| *Solanum incompletum* | Pōpolo kū mai | 14 |
| *Stenogyne angustifolia* | | 98 |
| *Vicia menziesii* | | 4 |
| *Zanthoxylum dipetalum* var. *tomentosum* | Aʻe | 13 |
| *Zanthoxylum hawaiiense* | Aʻe | 239[13] |
| **Species of Concern** | | |
| *Alphitonia ponderosa* | Kauila | 42 |
| *Eragrostis deflexa* | | 732 |
| *Euphorbia olowaluana* | ʻAkoko | 473 |
| *Erythrina sandwicensis* | Wiliwili | 11 |
| *Exocarpus gaudichaudii* | Hulumoa | 35 |
| *Fragaria chiloensis* | ʻŌhelo papa | 9 |
| *Melicope hawaiiensis* | Alani | 34 |
| *Polyscias sandwicensis* | ʻOhe makai | 21 |
| *Sisyrinchium acre* | Mauʻu lāʻili | 64 |
| *Stenogyne micrantha* | | 1 |
| *Tetramalopium consanguineum* | | 8,000+ |
| *Tetramalopium humile* | | 2 |

[10] Three of these individuals occur on PTA lands.
[11] *Phyllostegia velutina* and *Vicia menziesii* are both located within the FBS where no game management occurs, and are therefore not Covered Species under this HCP.
[12] 98 of these individuals occur on PTA lands.
[13] 18 of these individuals occur on PTA lands and are not included in take estimates.

#### 3.5.3.2 2011 Surveys

The data collected during the 2003-2007 botanical surveys (Table 3.1) was used to create a model (in conjunction with habitat type, species ranges, and moisture regime) to predict where within the Plan Area one is most likely to find Covered Species in unsurveyed areas. From this analysis, new areas to be surveyed were highlighted, and surveys were conducted in summer of 2011. A total of approximately 35 miles of transect were surveyed, primarily in the lower dry forest areas within the Plan Area, and additional transects were surveyed in the mauka areas abutting the Forest Bird Sanctuary (Figure 3.3). In addition, the proposed Kauila conservation unit was completely censused during these surveys (Table 3.3). The data collected during these surveys was used to update the plant population model and assist in developing more accurate take values for a number of the Covered Species (*please see section 5.3, Estimating Plan Related Impacts, for more information*).

**Table 3.2** List of species and number of individuals found during 2011 botanical surveys.

| Scientific Name | Common Name | # of Individuals |
|---|---|---|
| **Endangered** | | |
| *Chrysodracon hawaiiensis* | Hala pepe | 18 |
| *Colubrina oppositifolia* | Kauila | 87 |
| *Nothocestrum breviflorum* | ‘Aiea | 118 |

**Table 3.3** List of species and number of individuals found during the 2011 Kauila conservation unit re-survey.

| Scientific Name | Common Name | # of Individuals |
|---|---|---|
| **Endangered** | | |
| *Chrysodracon hawaiiensis* | Hala pepe | 147 |
| *Colubrina oppositifolia* | Kauila | 645 |
| *Nothocestrum breviflorum* | ‘Aiea | 5 |

### 3.5.4 Covered Species in the HCP

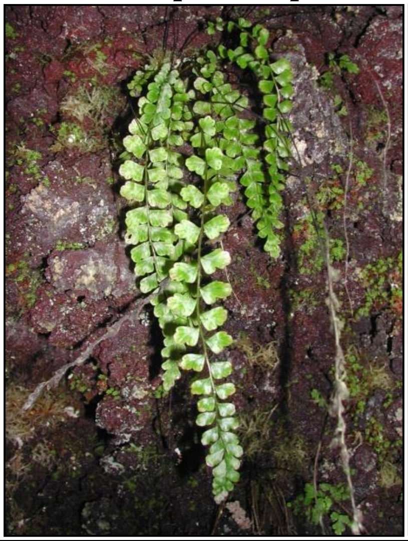
**Plant Extinction Prevention Program**

The Plant Extinction Prevention Program's mission is to protect Hawaiʻi's rarest native plants from extinction focusing on those species with fewer than 50 individuals remaining. Currently on Hawaiʻi Island, approximately 85 species are managed by the PEPP program by activities including: collection of fruits, cuttings, and seeds from each species for propagation and storage; monitoring of plants in the wild; surveying of additional areas for future conservation actions; minimization of threats to survival of individuals or populations (fencing, ungulate control); and propagation and reintroduction of plants into protected areas (Joan Yoshioka, personal communication, October, 2015). Those Covered Species which are considered PEP species are defined within this section. Of the 15 Covered Species in this HCP, five have designated PEP status (Table 3.4).

**Critical Habitat Designation**

Critical Habitat (CH) is defined in Section 3 of the ESA as: (1) The specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) Specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. In 2003, the USFWS designated critical habitat for 46 plant species on the Island of Hawaiʻi. Of those 46 species, eight species are Covered Species under this HCP. The USFWS is currently proposing a new CH designation for three additional species (*Bidens micrantha* ssp. *ctenophylla*, Uhiuhi, and *Isodendrion pyrifolium*) of which one of these species (Uhiuhi) is a Covered Species under this HCP. For those Covered Species with a CH designation within the Plan Area, maps showing critical habitat and exclosures locations are provided below.

### 3.5.4.1 *Asplenium peruvianum* var. *insulare*



Description: *Asplenium peruvianum* var. *insulare* is a fern of the spleenwort family (Aspleniaceae) with a short sub-erect stem. The leaf stalks are 5-15 cm long. The main axis of the frond is dull gray or brown, with two greenish ridges. The long and narrow fronds are thin-textured, bright green, 23-41 cm long, 2 cm wide above the middle, and pinnate with 20-30 pinnae or leaflets on each side. The pinnae are rhomboidal, 7 mm wide, and notched into two to five blunt lobes on the side towards the tip of the frond. The sori (spore-producing bodies) are close to the main vein of the pinna, with one to two on the lower side and two to four on the upper side. The Hawaiian fern species most similar to *A. peruvianum* var. *insulare* is *A. macraei*. The two can be distinguished by a number of characteristics, including the size and shape of the pinnae and the number of sori per pinna.

Historic and Current Distribution: *A. peruvianum* var. *insulare* was known historically from East Maui, where it was recorded from the north slope of Haleakalā and Kanahau Hill. At the time the taxon was federally listed in 1994, it was assumed extinct on Maui. In recent times, East Maui populations have been recorded within Kalialinui ahupuaʻa on East Maui Watershed Partnership lands, in Waikamoi on private and federal (Haleakala National Park) lands (two populations with 18 individuals), and in the Hanawi Natural Area Reserve. In 2010, *A. peruvianum* var. *insulare* was estimated to contain approximately 17 individuals from Hanawi Natural Area Reserve and Waikamoi Preserve on Maui (USFWS 2012a). See Table 3.5 for a summary table of species distribution state-wide.

On the island of Hawaiʻi, this fern was found historically below Kalaieha, Laumaia, Keanakolu, and Umikoa on Mauna Kea; Puʻu Waʻawaʻa on Hualālai; west of Keawewai, above Kīpuka Ahiu on Mauna Loa; and near Hilo. In the final recovery plan (USFWS 1998b) numbers had fallen to 278 statewide, the majority (nine subpopulations totaling 200 individuals) were found in the U.S. Army's Pōhakuloa Training Area; extant populations at that time were located at Puʻu Huluhulu, Pōhakuloa Training Area, Kulani Correctional Facility, Keauhou, the Mauna Loa Strip Road in Hawaiʻi Volcanoes National Park, Kapapala Forest Reserve, Kaʻū Forest Reserve, and the summit area of Hualālai. In 2010, the estimated statewide total of *A. peruvianum* var. *insulare* was 14 populations containing 603 to 948 individuals (USFWS 2012a). At Puʻu Waʻawaʻa, this species was only found in moist lava tubes or pit craters at 1,280-1,981 m elevation, with most individuals occurring above 1,676 m. During the HCP surveys 64 individuals were found within the Plan Area.

Habitat: This fern is found on the island of Hawaiʻi in ʻŌhiʻa dry montane forest, ʻAʻaliʻi dry montane shrubland, Naio/ Māmane dry montane forest, ʻŌhiʻa /Koa forest as well as subalpine dry forest and shrubland. *A. peruvianum* var. *insulare* grows almost exclusively in lava tubes, pits, deep cracks, and lava tree molds, with at least a moderate soil or ash accumulation, and is associated with mosses and liverworts. This fern has been found growing infrequently on the interface between younger lava flows and much older pāhoehoe lava or ash deposits. The population recently found on Maui is growing in montane wet ʻŌhiʻa forest in a rocky gulch with other species of ferns. Although this plant is found in habitats with three different moisture regimes, the micro-habitat for *A. peruvianum* var. *insulare* is fairly consistent. The fern generally occurs in areas that are moist and dark; its relatively specialized habitat requirements may account for its apparently patchy distribution. Reproductive cycles, longevity, specific environmental requirements, and limiting factors are unknown. Critical Habitat has been designated for this species, however, the CH is outside of the Plan Area (USFWS 2003c).

### 3.5.4.2 Hala pepe (*Chrysodracon hawaiiensis*)

Description: Hala pepe, in the Asparagus family (Asparagaceae), is a branching tree, 5 to 6 m tall, with leaves spirally clustered at the tips of branches and leaving large brown leaf scars as they fall off. The leaves measure 23 to 38 cm long and 1.4 to 2.7 cm wide. Flowers are numerous in terminal clusters with a main stalk 6 to 13 cm long and individual flower stalks 5 to 12 mm long. The three sepals and three petals of the flower are similar and pale yellow, 33 to 43 mm long, with a constricted base. The fruit is a red berry about 10 to 13 mm long. This species differs from other Hawaiian species in this genus by its pale yellow flowers, the size of the flowers, the length of the constricted base of the flower, and the width of the leaves (USFWS 1996a, Wagner et al. 1999).

Historic and Current Distribution: Historically, Hala pepe was found ranging from the Kohala mountains to Kaʻū. Nine populations are currently known: one in the Kohala mountains at Puʻu Kamoa (2 individuals); four from Puʻu Waʻawaʻa (2 populations of 200 individuals and 50-100 individuals), Kaʻūpūlehu (no information available), and Kaloko (11 individuals); two in the South Kona area at Manukā and Kahuku (11 individuals), one extant population at the Kipahoehoe Natural Area Reserve; and two populations in Hawaiʻi Volcanoes National Park (HVNP). As of 2009, there were 6 to 9 populations containing a total of 300 to 400 individuals (USFWS 2012d). During the HCP surveys, 299 individuals were within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Hala pepe typically grows on open ʻaʻā lava in diverse lowland dry forests at elevations between 300 and 800 m. Associated taxa include ʻŌhiʻa, Lama, Māmane, Alaheʻe, Hue hue, Naio, Olopua, Kuluʻi, ʻIlima, Wiliwili, ʻIliahi, ʻŪlei, and fountain grass as a dominant ground cover, as well as four federally endangered species: Uhiuhi, Kauila, ʻAiea, *Neraudia ovata*, and species of concern, including Pua pilo (*Capparis sandwichiana*) and Koʻokoʻolau (*Bidens micrantha* ssp. *ctenophylla*). Critical habitat was designated for this species in 2003 (Figure 3.4)(USFWS 2003c).

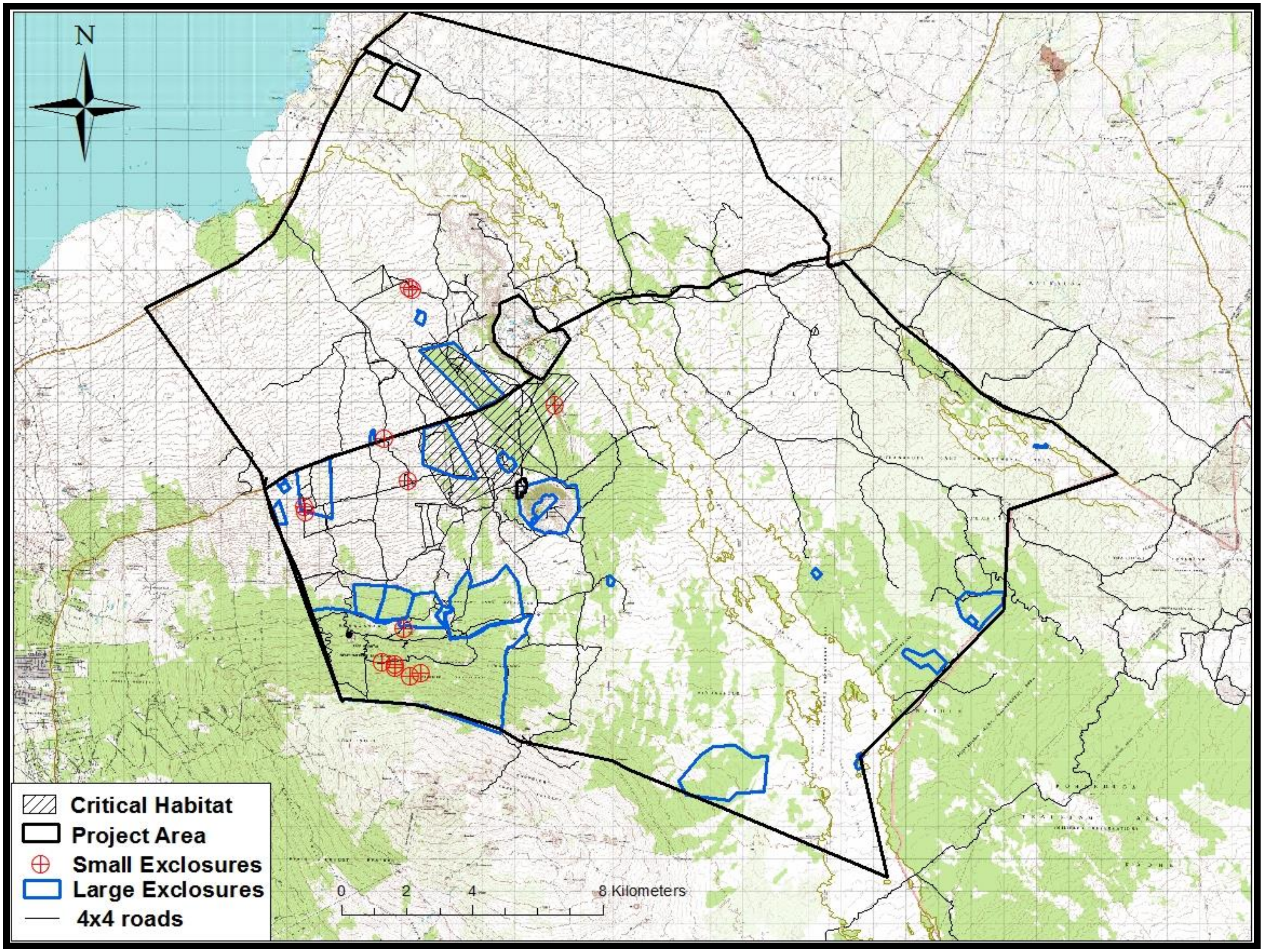
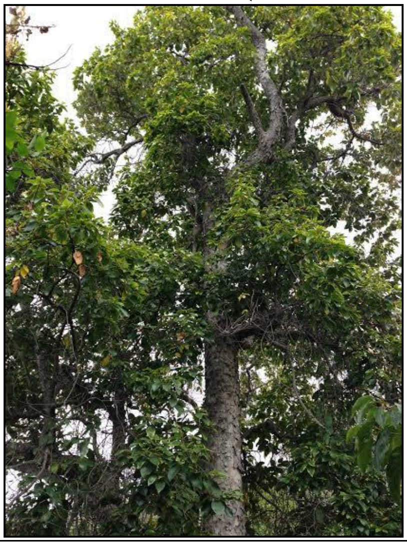



**Figure 3.4** Critical habitat for Hala pepe within the Plan Area.

### 3.5.4.3 Kauila (*Colubrina oppositifolia*)




Description: Kauila, a member of the buckthorn family (Rhamnaceae) is a tree approximately 5-13 m tall, with extremely hard red wood. Opposite, oval-shaped leaf blades are 6-12 cm long and 3-7 cm wide. Leaf blades are thin, dull green on the upper surface, and olive green beneath. Two kinds of glands occur on the lower surface: small black glands near the margin and small glandular projections in the axil of the leaf vein. Leaf stalks are 1.4-3 cm long. Lance-shaped stipules are fused at the base of each pair of leaves. Ten to 12 flowers are arranged on a flower cluster stalk 3-8 mm long. Each flower is subtended by a flower stalk 2-3 cm long, which increases in length as the fruit matures. Five sepals are triangular and about 1.5-2 mm long. Five green-yellow petals are about 1.5 mm long. Fruits are brown, almost round, about 8-11 mm long, and are explosively dehiscent, discharging oval or oblong, black, shiny, hump-back seeds, 6-8 mm long and 4-5 mm in diameter. This species is readily distinguished from the other species in Hawaiʻi by several characters: opposite leaf position, dull leaf surface, and entire leaf margins (Wagner et al. 1999).

Historic and Current Distribution: Kauila is known from Oʻahu, Maui and Hawaiʻi Island. Historic populations are known from the central and southern Waianae Mountains on Oʻahu, and from the Kohala mountains; western, southwestern, and southern slopes of Mauna Loa; and northern slopes of Hualālai on the island of Hawaiʻi Island. On Maui, there are two wild mature individuals located within the Nature Conservancy's Kapunakea Preserve. Today, there are seven populations containing at least 54 mature wild individuals on Oʻahu. There are approximately two to five populations containing 1,190 to 1,209 wild individuals on the island of Hawaiʻi (USFWS 2015f). See Table 3.5 for a summary table of species distribution state-wide.

This species was found primarily at 488-853 m elevation in Puʻu Waʻawaʻa, with some individuals at higher elevation on the Puʻu Waʻawaʻa cinder cone, and three individuals found in Puʻu Anahulu at 732 m. Previously there were thought to be 200-300 individuals at Puʻu Waʻawaʻa, however, recent HCP surveys indicate the population at Puʻu Waʻawaʻa consists of at least 739 individuals.

Habitat: Kauila occurs in lowland dry and mesic forests. The dominant species of these forests is Lama. Individuals are found at elevations between 240-910 m, sometimes on ʻaʻā lava flows and associated with Alaheʻe and ʻOhe makai. Critical habitat was designated for this species in 2003 (Figure 3.5)(USFWS 2003c).

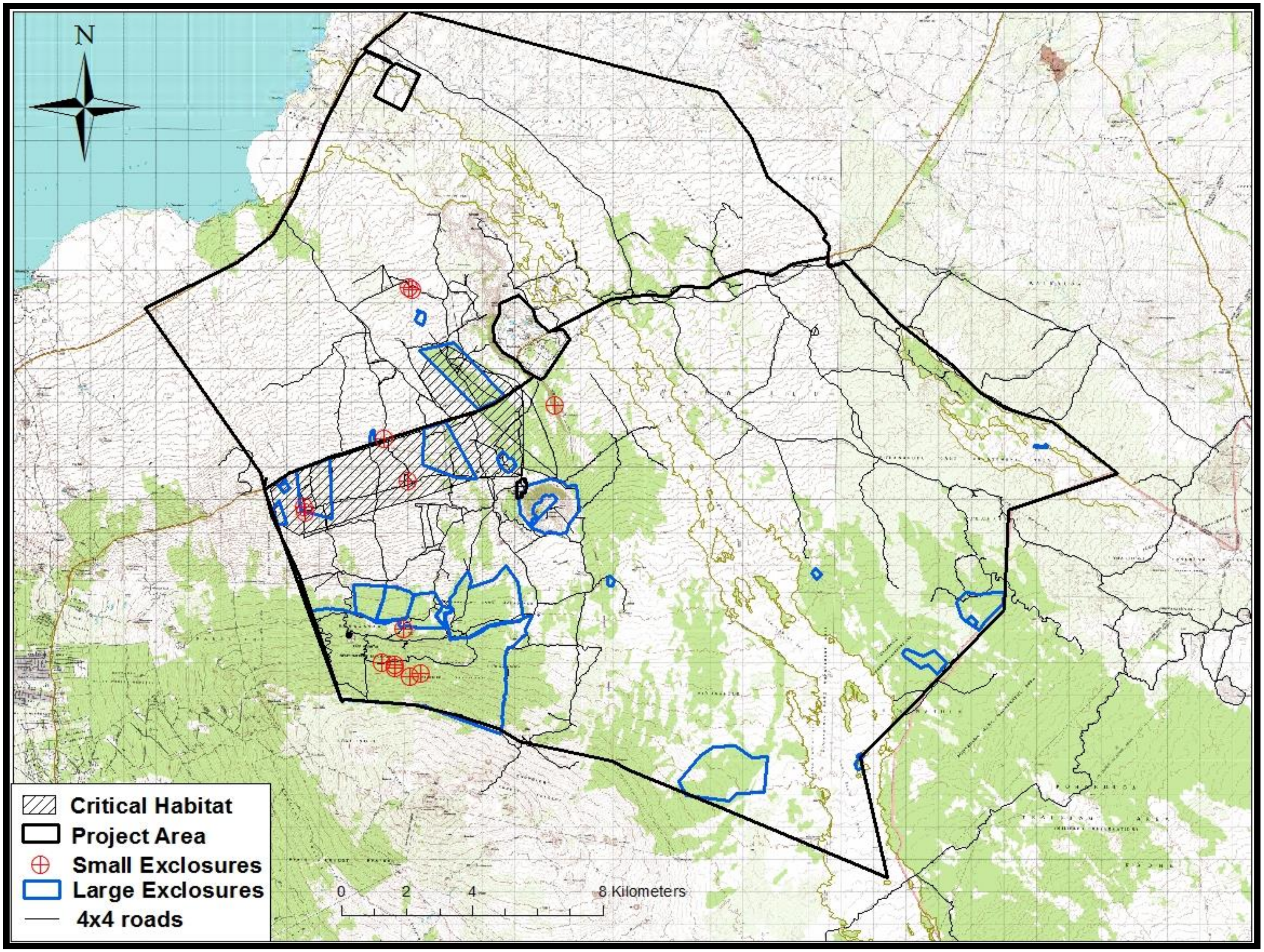



**Figure 3.5** Critical habitat for Kauila within the Plan Area.

### 3.5.4.4 Honohono (*Haplostachys haplostachya*)

Description: Honohono is an erect sub-shrub in the mint family (Lamiaceae) growing up to 1.5 m. The leaves are fleshy, narrowly cordate and the upper surfaces are green, rugose and densely puberbulent. The lower leaf surfaces are densely white tomentose. The inflorescence is racemose with white tubular flowers. Reproduction is through seed and basal sprouting (Wagner et al. 1999).

Historic and Current Distribution: Honohono was once present on the islands of Kauai, Maui, and Hawaiʻi. Currently Honohono is only known to occur on Hawaiʻi Island. It is found at Pōhakuloa Training Area and at Puʻu Anahulu. As of 2010, the listed census for Honohono is two populations at Puʻu Nohonaohae and Keamuku, containing over 10,000 individuals (USFWS 2012b). In the Plan Area, Honohono is found at 1,280 m elevation on a Mauna Kea lava flow (14,000-65,000 years old), in a kīpuka on the Keamuku lava flow. These are the only known plants that occur on State lands. During HCP plant surveys, a total of 80 individuals were located within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Honohono grows in dry exposed areas on lava, shallow soils, and lava outcrops. Historic accounts indicate it was once found as component within the upper forest zone along with stunted vegetation (USFWS 2003c). At PTA, this species is found in ʻAkoko tree land, open ʻŌhiʻa forest with dense shrub understory, and open ʻAʻaliʻi mixed shrubland. This species has been noted growing almost exclusively on Mauna Kea lava flows (USFWS 2003a). Critical habitat has not been designated for this species.

### 3.5.4.5 Maʻo hau hele (*Hibiscus brackenridgei ssp. brackenridgei*)

Description: Maʻo hau hele is a shrub in the Malvaceae family and can sometimes become a small tree growing up to 9 m tall. When planted as an ornamental, it is most often a 0.91 to 4.5 meters tall shrub with a diameter of 2.5 to 4.5 meters. Young plants have smooth tan trunks; the trunks of older plants have a wrinkled appearance. The fuzzy leaves have toothed edges; three, five, or seven lobes; and are up to 15 cm long and equally wide. The large flowers are 10 to 15 cm in diameter. They are yellow, generally with a maroon center, and form singly or in small clusters at the ends of the branches. The staminal column is yellow. Spring through early summer is the main blooming season with occasional flowers during the rest of the year. It is native to dry forests and shrub lands at elevations from 121 to 792 m.

Historic and Current Distribution: Maʻo hau hele (*Hibiscus brackenridgei ssp. brackenridgei*) is the subspecies on the islands of Lānaʻi, Maui, and Hawaiʻi. On Lānaʻi there are only two or three individuals in the Keomuku Road area. On Maui there is one population recoreded in East Maui and one population in West Maui on private land. The Island of Hawaiʻi has two wild populations of Maʻo hau hele. One population referred to as the Lalamilo population, is located just outside of Waimea. The second population is found in a one acre exclosure on the top of Puʻu Anahulu bluff across from the hunter check station at Puʻu Waʻawaʻa at 731 m elevation. During HCP surveys 65 Maʻo hau hele individuals were found within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Maʻo hau hele occurs in lowland dry to mesic forest and shrubland from 130-800 m in elevation. Associated plant species include ʻAʻaliʻi, Aaheʻe, Wiliwili, ʻOhe makai, and ʻIlima. Critical habitat was designated for this species in 2003 (Figure 3.6) (USFWS 2003c).

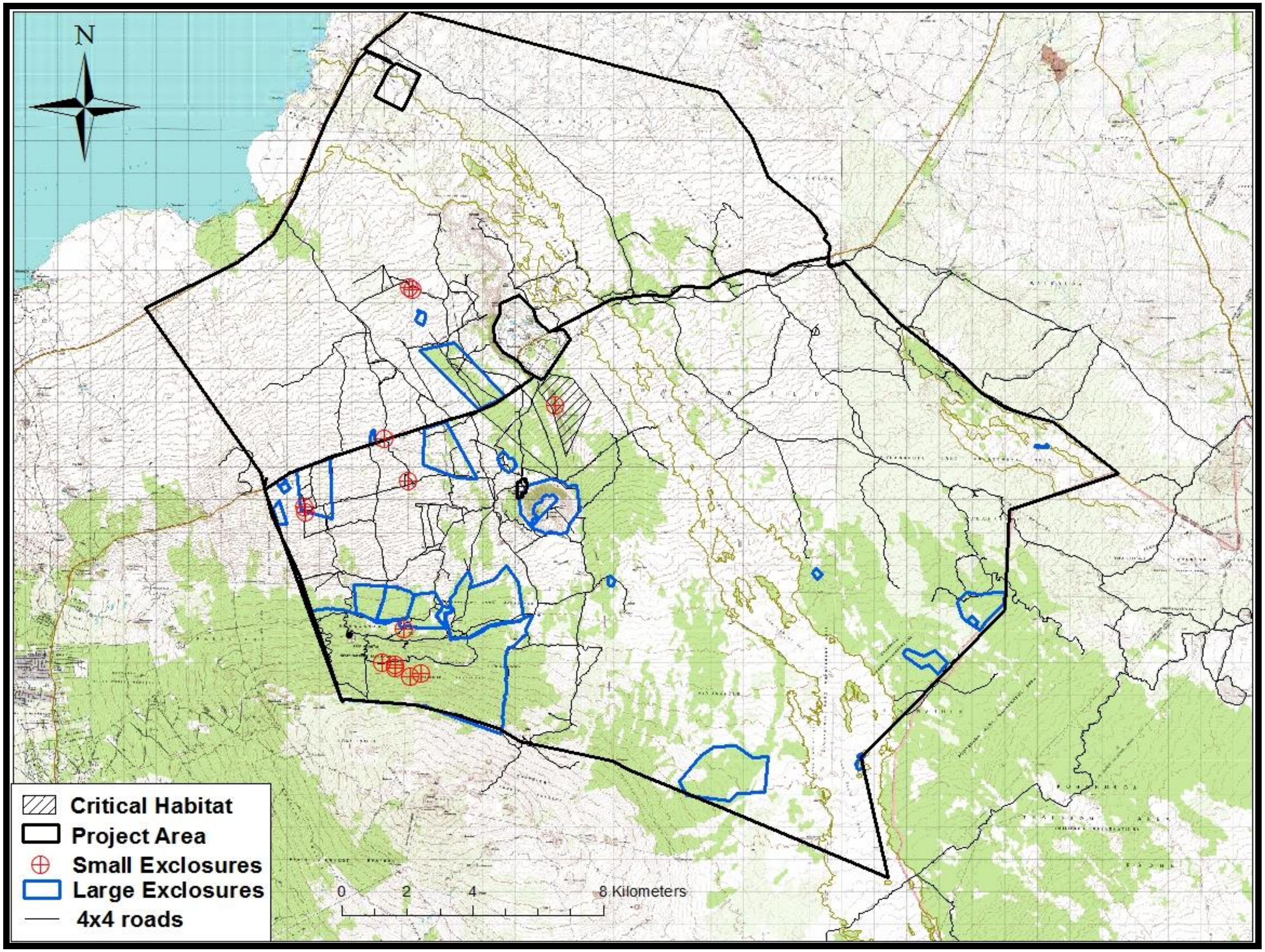



**Figure 3.6** Critical habitat for Ma'o hau hele within the Plan Area.

### 3.5.4.6 Koki‘o (Kokia drynarioides)


Description: A tree in the Malvaceae family grows to heights of 8 m tall, with shallowly lobed leaves and with large, ornamental, scarlet flowers. Koki‘o is one of four species in the *Kokia* genus and the only one found on the island of Hawai‘i. The sap of this rare tree has been used by Native Hawaiians to make red dyes for fish nets and its bark was used medicinally. In the early 1900’s, botanists became concerned about the survival of this species and collected several pounds of seed that were later distributed to various gardens and arboreta for germination. Despite this, Koki‘o has become increasingly rare in the wild. This decline may have had severe impacts on organisms that rely on the species, such as the now endangered nectar drinking honeycreepers which depend on these trees for food.

Historic and Current Distribution: Occurs in native dry forests on the island of Hawai‘i on rough lava with a thin, extremely well drained soil at elevations of 455 to 1,915 meters. Currently, two extant populations remain: the first at Ka‘ūpūlehu containing one mature individual and the second population at Kīpuka Nene containing a single surviving mature individual (USFWS 2009). In the Plan Area, the last four individuals occur in two fences along the edge of the Ka‘ūpūlehu flow above the 25 mile road entrance to Pu‘u Wa‘awa‘a. Koki‘o has been outplanted in a number of exclsoures across the Plan Area, including Hauaina, Kīpuka Oweowe, FBS, and PWWCCA. This species is considered a PEPP species (Table 3.4). See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Associated native species include ‘Āweoweo, ‘A‘ali‘i, Hala pepe, Wiliwili, Kulu‘i, ‘Ohe makai, Māmane, and Maua (*Xylosma hawaiiense*). Alien species that have invaded this habitat include fountain grass, tree tobacco (*Nicotiana glauca*), fireweed (*Senecio madagascariensis*) and lantana (*Lantana camara*). Critical habitat was designated for this species in 1984 (Figure 3.7) (USFWS 1984).

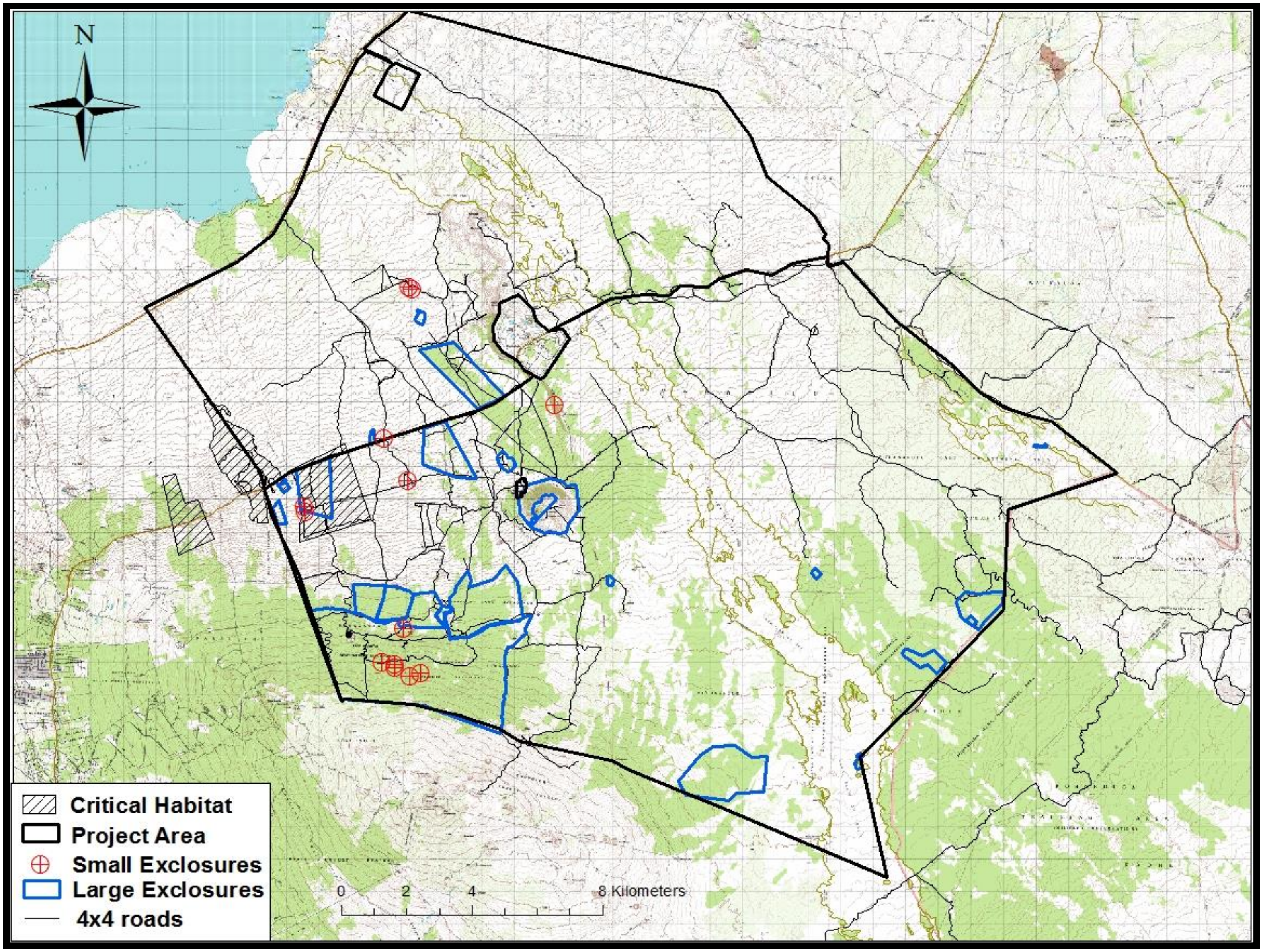
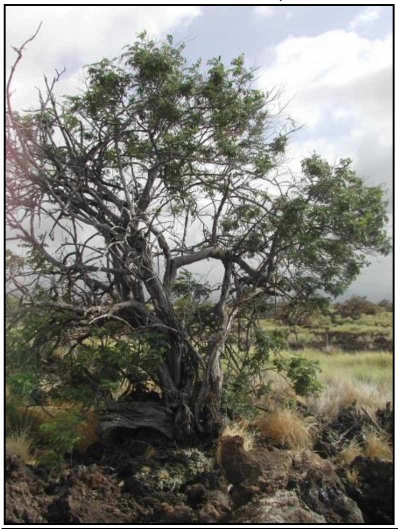



**Figure 3.7** Critical habitat for Koki'o within the Plan Area.

### 3.5.4.7 Uhiuhi (Mezoneuron kavaiense)



Description: Uhiuhi, a member of the pea family (Fabaceae), is a tree that can grow up to 10 meters tall, with trunks that have dark gray bark with rough rectangular or oblong plates. The flowers are perfect (with both male and female organs) with a pink to rose calyx and red anthers borne in terminal racemes that are pink to red in color. Uhiuhi has pink seed pods that are winged on one side, making this a very attractive tree (Wagner et al. 1999).

Historic and Current Distribution: Uhiuhi is endemic tree to the Hawaiian Islands and was once widespread on the islands of Kaua‘i (Waimea Canyon), O‘ahu (Wai‘anae Mountains), west Maui, North Kona District, Hawai‘i, and Lāna‘i. Today, Uhiuhi is extinct on Lāna‘i and is now found only on O‘ahu (Central Wai‘anae Mountains), and Hawai‘i island (Hualālai). On Kaua‘i, the species was rediscovered as one wild plant was recently found in Waimea Canyon (Letman 2012). On O‘ahu, there are two populations containing five wild mature individuals and two seedlings. On Hawai‘i Island, Uhiuhi is found on state lands at Pu‘u Wa‘awa‘a, on private land in North Kona, and on Private lands in Waikoloa in South Kohala. There are approximately 11 occurrences containing 99 wild individuals of Uhiuhi on Kaua‘i, O‘ahu, Lāna‘i, and Hawai‘i (USFWS 2015a). During HCP surveys, 48 Uhiuhi were within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Uhiuhi is restricted to dry or mesic forests between 80 to 920 m elevations. Associated native species include ‘A‘ali‘i, Lama, ‘Ōhi‘a, Alahe‘e, Wiliwili, ‘Āweoweo, and Kauila. Critical habitat has been proposed but not yet designated for this species (Figure 3.8).

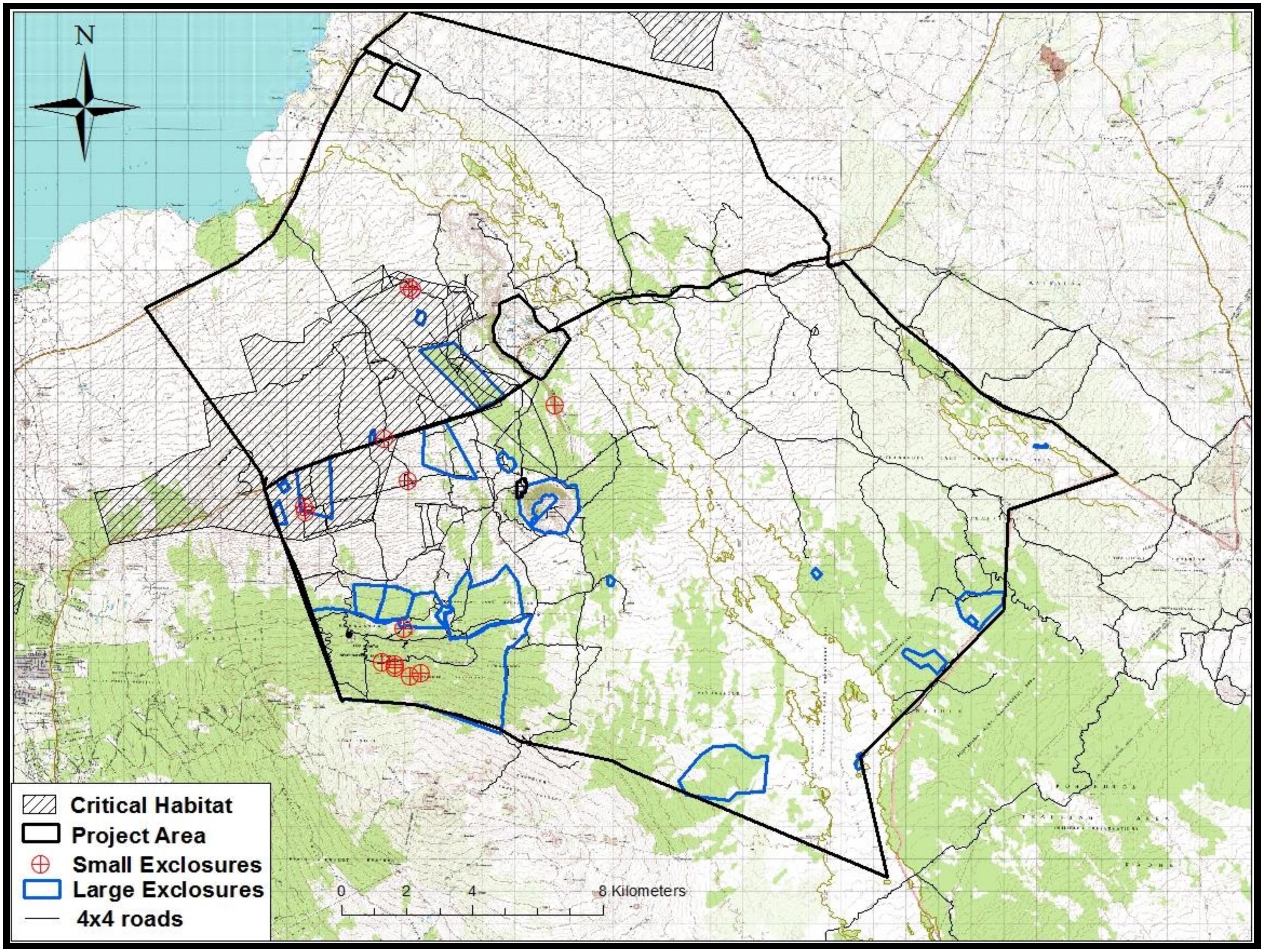



**Figure 3.8** Proposed critical habitat for Uhiuhi within the Plan Area.

### 3.5.4.8 *Neraudia ovata*


Description: In the nettle family (Urticaceae), this species is a sprawling or rarely erect shrub to a small tree, with stems 1 to 3 m long, and branches bearing short, somewhat erect hairs. The alternate, thin, stalked leaves are smooth-margined, grayish on the undersurface, 5 to 14 cm long and 2 to 6.5 cm wide, and have spreading, curved, nearly translucent hairs. Male and female flowers are found on separate plants. Male flowers have extremely short stalks and a densely hairy calyx. Female flowers have no stalks and a densely hairy, boat-shaped calyx. The fruit is an achene (a dry, one-seeded fruit that does not open at maturity). This species is distinguished from others in this endemic Hawaiian genus by the density, length, and posture of the hairs on the lower leaf surface; smooth leaf margin; and the boat-shaped calyx of the female flower.

Historic and Current Distribution: Historically, *Neraudia ovata* was found from North Kona all the way to Ka‘ū. There are currently five extant known plant locations. One population of three individuals was known from privately owned land in Kaloko, North Kona. The second population is located at the boundary of PTA and Pu‘u Anahulu, on state managed land (Shaw et al. 1997) and was resurveyed by the HCP botanical crew during the 2003 – 2007 surveys. A third population, which is located within PTA, in the fiscal year 2013, there were approximately 75 individuals. One individual is known to occur in the Manuka Natural Area Reserve (DOFAW Staff), and a final population has been located in windward Kohala. This species is considered a PEP species (Table 3.4). The number of wild individuals has decreased from 150 individuals reported in 2008 to 90 individuals in 2015 (USFWS 2015b). See Table 3.5 for a summary table of species distribution state-wide.

Habitat: *Neraudia ovata* grows in open ‘Ōhi‘a and Māmane dominated lowland and montane dry forests at elevations of 115 m at Kaloko and 1,325 and 1,520 m at Pōhakuloa Training Area. Associated taxa include ‘Ohe makai, Naio, Huehue, Kōlea species, and christmas berry (*Shinus terebinthefolius*), as well as the federally endangered ‘Aiea and Hala pepe, and other species of concern, including Pua pilo, *Fimbristylis hawaiiensis*, and Ko‘oko‘olau (*Bidens micrantha* ssp. *Ctenophylla*). Critical habitat was designated for this species in 2003 (Figure 3.9) (USFWS 2003c).

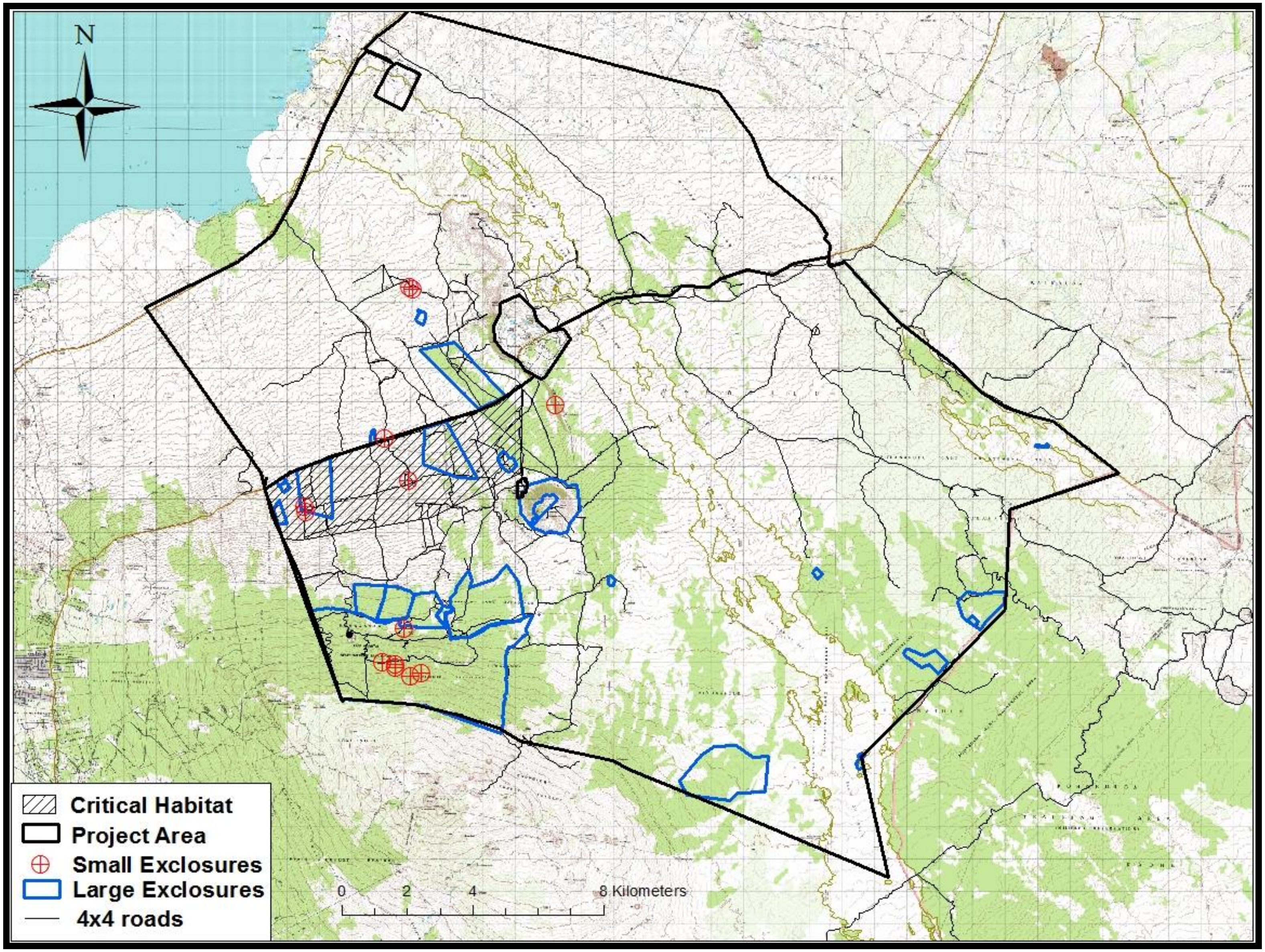



**Figure 3.9** Critical habitat for *Neraudia ovata* within the Plan Area**.**

### 3.5.4.9 ‘Aiea (*Nothocestrum breviflorum*)


Description: ‘Aiea is a stout tree that grows up to 10-12 m it is in the night shade family (Solanaceae). The trunk, is up to about 45 cm in diameter, and has a soft, sappy wood with dark brown bark. Oblong to elliptic, toothless, stalked leaves, 5-12 cm long and 3-6 cm wide are generally confined to the ends of the branches and are seasonally shed. In texture, they are relatively thick and papery. The upper leaf surface is glabrous (smooth) to sparsely whitish pubescent (downy), and the lower surface is often densely whitish pubescent. Several to numerous flowers appear in clusters at the tips of shortened, spur-like branches. Each flower is subtended by its own stalk (pedicel) 4-10 mm long. The 4-lobed, tube-shaped calyx, 6-11 mm long, is split on one side. Green-yellow, 4-lobed petals are fused at the base and generally are enclosed in the calyx. The lobes are hairy on the outside. Fruits remain enclosed by the calyx and are orange-red, round berries about 6-8 mm in diameter.

This species is distinguished from other Hawaiian members of the genus by leaf shape, number of flowers (more than three) in the flower clusters at tips of short spur-like branches, and the fruit remaining enclosed in the calyx (Symon 1990).

Historic and Current Distribution: ‘Aiea is known from the southern Kohala mountains, the western, southern, and eastern slopes of Mauna Loa, and the northern slopes of Hualālai, Hawai‘i. Since 1975, a number of populations have been identified on the western side of Hawai‘i Island from South Kohala to Kamaoa-Puueo. In 2010, there were an estimated 10 wild populations of ‘Aiea containing less than 150 total individuals (USFWS 2012c). Recent HCP surveys indicate 156 individuals are known to occur within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Habitats of ‘Aiea is lowland dry forest, montane dry forest, and montane mesic forest dominated by ‘Ōhi‘a, Koa, or Lama. Individuals occur on ‘a‘ā lava substrates at elevations ranging from 180 to 1,830 m (Gagne and Cuddihy 1990, Symon 1990). Associated taxa include ‘Iliahi, Uhiuhi, and Wiliwili. Critical habitat was designated for this species in 2003 (Figure 3.10) (USFWS 2003c).

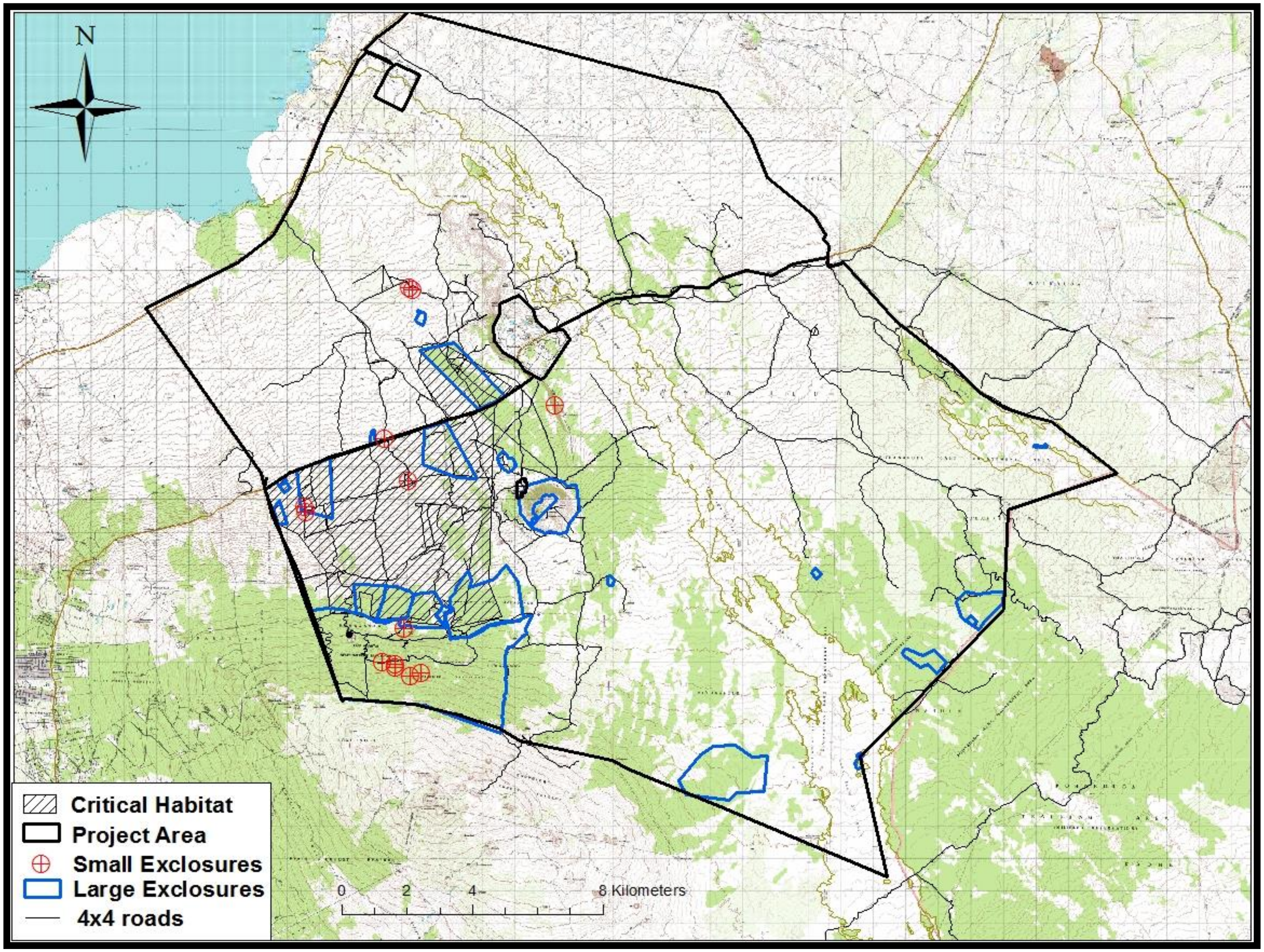



**Figure 3.10** Critical habitat for ‘Aiea within the Plan Area.

### 3.5.4.10 Poʻe (*Portulaca sclerocarpa*)


Description: Poʻe is a perennial with a fleshy, tuberous tap root that becomes woody with maturity (Wagner et al. 1999). Stems are prostrate or ascending and the leaves, 8-12 mm long and 1.5-2.5 mm wide, are narrowly oblance-shaped to linear, almost round in cross section, succulent, grey-green, and stalkless. Dense tufts of yellow-brown hairs occur in the axil between stem and leaf. Three to six flowers occur at the end of a stem and from a dense flower cluster. Flowers are white, pink, or pink with white base petals.

Historic and Current Distribution: Known from the islands of Hawaiʻi and Lānaʻi. Populations were found on an islet off of the coast of Lānaʻi, and the Kohala Mountains, the northern slopes of Hualālai, the northwestern slopes of Mauna Loa, and near Kīlauea Crater on Hawaiʻi Island (USFWS 1996a). As of 2010, there were an estimated 12 extant populations statewide of Poʻe containing more than 3,000 individuals (USFWS 2012e). One individual was found in upper Puʻu Anahulu in January 2014 by the Hawaiʻi Island PEPP Coordinator. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: This species occurs in montane dry shrubland. The taxon often is found on bare cinder, near steam vents, and in open ʻŌhiʻa dominated woodlands, at elevations between 1,030 and 1,628 m (Gagne and Cuddihy 1990, Wagner et al. 1999). Associated taxa are Māmane, ʻŌhiʻa, and Naio (USFWS 1996a). Critical habitat was designated for this species in 2003; however CH does not occur within the Plan Area.

### 3.5.4.11 Hawaiian Catchfly (*Silene lanceolata*)

Description: Hawaiian Catchfly is a sub-shrub with erect to ascending stems 15-50 cm long. Flowers are white and occur in open cymes. Leaves are linear to lanceolate, and ciliate toward the base but otherwise glabrous (Wagner et al. 1999).

Historic and Current Distribution: This plant is known from Moloka‘i, O‘ahu, and Hawai‘i; historically also known from Kaua‘i and Lāna‘i. On island Hawai‘i, within the Pōhakuloa Training Area populations of Hawaiian Catchfly are found along the western border of the military impact area. Approximately 10,394 individuals are found within 18 different areas of the Pōhakuloa Training Area. On O‘ahu, there were four known populations in 2003, with 62 individuals in Koi‘ahi Gulch and Waianae Kai on Federal and State lands. On Moloka‘i, from 1987 to 2001, 50 to 100 individuals of Hawaiian Catchfly were observed in Makolelau Gulch between 792 and 927 meters (USFWS 2010). During HCP surveys, 235 individuals were within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: Occurs from 330-1,900 m in dry to mesic shrubland on Moloka‘i, Kaua‘i, Lāna‘i, and Hawai‘i (Wagner et al. 1999). The populations on the island of Hawai‘i grow in two dry habitat types: shrubland dominated by dense Naio, Māmane, Pūkiawe with ‘A‘ali‘i, Pilo, and fountain grass; and on ‘a‘ā lava in a former ‘Akoko forest now converted to fountain grass grassland with ‘A‘ali‘i, Māmane, Naio, and ‘Āweoweo. Critical habitat was designated for this species in 2012; however CH does not occur within the Plan Area.

### 3.5.4.12 Pōpolo kū mai (*Solanum incompletum*)

Description: Pōpolo kū mai is a woody shrub in the nightshade family (Solanaceae) that grows up to 3 m tall with prominent reddish prickles scattered to abundant on stems and leaves. The oval leaves measure 10 to 15 cm long by about 7 cm wide. The leaf margins are lobed with one to four lobes on each side. Numerous flowers grow on loose branching clusters with each flower on a stalk about 9 mm long. The star-shaped flowers are white.

Historic and Current Distribution: This short lived perennial shrub is endangered and is historically known to occur from 600-2,200 m on the islands of Maui, Lānaʻi, Kauaʻi, Molokaʻi, and Hawaiʻi. There are currently no known populations on Lānaʻi, Molokaʻi, or Maui. Until recently this species was thought to be extinct, however, it was rediscovered on Hawaiʻi Island. As of 2011, an estimated 75 individuals of Pōpolo kū mai are known to occur in PTA, Puʻu Anahulu, and Puʻu Waʻawaʻa (USFWS 2015c). During HCP surveys, 13 individuals were found within the Plan Area. This species is considered a potential PEP (POP) species (Table 3.4). See Table 3.5 for a summary table of species distribution state-wide.

Habitat: This plant occurs in dry and mesic shrublands and forests on ridges and in gulches. On Hawaiʻi island, it occurs on cinder cones or on older lava flows. Critical habitat was designated for this species in 2003 (Figure 3.11)(USFWS 2003c).

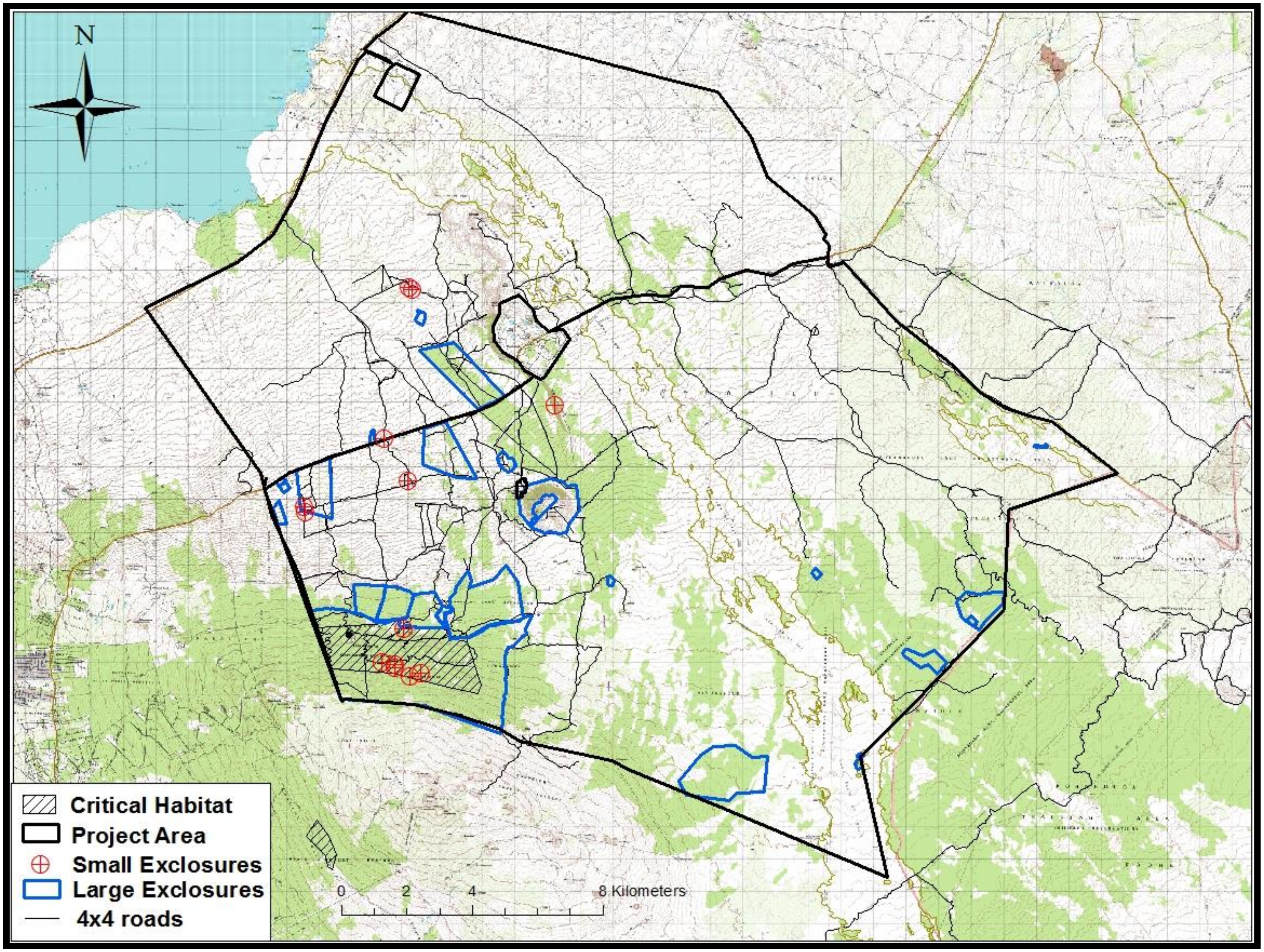



**Figure 3.11** Critical habitat for Pōpolo kū mai within the Plan Area.

### 3.5.4.13 *Stenogyne angustifolia*


Description: A member of the mint (Lamiaceae) family, this vine may sprawl on the ground for a portion of its length prior to becoming erect, but may also become a climber. It has thin oval finely toothed leaves, up to 5 cm long and 1.3 cm wide. The narrow, tubular flowers are approximately 1.9 cm long and grow at the base of the leaves. Flower color varies from yellow to red to purple and has a short lower lobed lip and a long upper lobe. The pale colored fruits become dark when mature.

Historic and Current Range: Historically, the species was known from the islands of Molokaʻi, Maui, and Hawaiʻi. *S. angustifolia* was presumed extinct until fewer than ten individuals were rediscovered in 1977 at Kīpuka Kalawamauna, located on the northwestern side of PTA, this site remains the largest extant population for the species (USFWS 2012f). Currently, estimated 5,000-7,500 individuals occur only on the Island of Hawaiʻi, at Pōhakuloa Training Area (USFWS 2003a). During the HCP surveys 98 individuals of *S. angustifolia* were located within the Plan Area. See Table 3.5 for a summary table of species distribution state-wide.

Habitat: *S. angustifolia* grows on relatively flat lava flows and shallow soils in semi-arid shrublands and ʻŌhiʻa woodlands at an elevation of 1,555-2,150 m. The species has been described as abundant on various aged lava or rock outcrops associated with the following vegetation: *Eragrostis* grassland, *Chenopodium* shrubland, ʻAkoko, open ʻŌhiʻa forest, ʻAʻaliʻi/Naio shrubland, and mixed native shrubland. Critical habitat has not been designated for this species.

### 3.5.4.14 A‘e (*Zanthoxylum dipetalum var. tomentosum*)

Description: A‘e *(Z. dipetalum* var. *tomentosum),* endemic to Hawai‘i Island, is in the citrus family (Rutaceae), is a thornless tree 4 to 15 m tall with a trunk up to 30 cm in diameter. It has alternate leaves comprised of three to seven leathery, elliptical, gland-dotted, smooth-edged leaflets usually 6 to 36 cm long and 2.5 to 13.5 cm wide. The undersurface of the leaflets is densely covered with fine, short hairs, and the lowest pair of leaflets is often strongly reduced. The stalks of the side leaflets have one joint each, and the stalk of the terminal leaflet has two joints. Flowers are usually either male or female, and usually only one sex is found on a single tree. Clusters of 5 to 15 flowers, 9 to 18 mm long, have a main flower stalk 10 to 40 mm long and individual flower stalks 3 to 8 mm long. Each flower has four broadly triangular sepals about 1 to 1.5 mm long and two or four yellowish-white petals, sometimes tinged with red, 6 to 10 mm long. The fruit is an oval follicle (dry fruit that opens along one side) 15 to 33 mm long, containing one black seed about 10 to 26 mm long. This variety is distinguished from *Zanthoxylum dipetalum* var. *dipetalum* by the hairs on the undersurface of the leaflets. It is distinguished from other Hawaiian species of the genus by its reduced lower leaflets, the presence of only one joint on some of the leaflet stalks, and the large seeds (USFWS 1996a).

Historic and Current Distribution: Only one population of A‘e (*Z. dipetalum* var. *tomentosum)* has ever been known, located at Pu‘u Wa‘awa‘a. In 2011, there were 13 wild individuals at Pu‘u Wa‘awa‘a. During 2013, two wild individuals at Pu‘u Wa‘awa‘a were noted as dead, bringing the total to 11 individuals. See Table 3.5 for a summary table of species distribution state-wide. This species is considered a PEPP species (Table 3.4).

Habitat: A‘e *(Z. dipetalum* var. *tomentosum)* grows in degraded ‘Ōhi‘a dominated montane mesic forest, often on ‘a‘ā lava, at elevations between 915 and 1,040 m. Associated species include Māmane, Lama, ‘Āla‘a (*Pouteria sandwicensis*), ‘Iliahi, Kōlea, and Kōpiko. Critical habitat was designated for this species in 2003 (Figure 3.12) (USFWS 2003c).

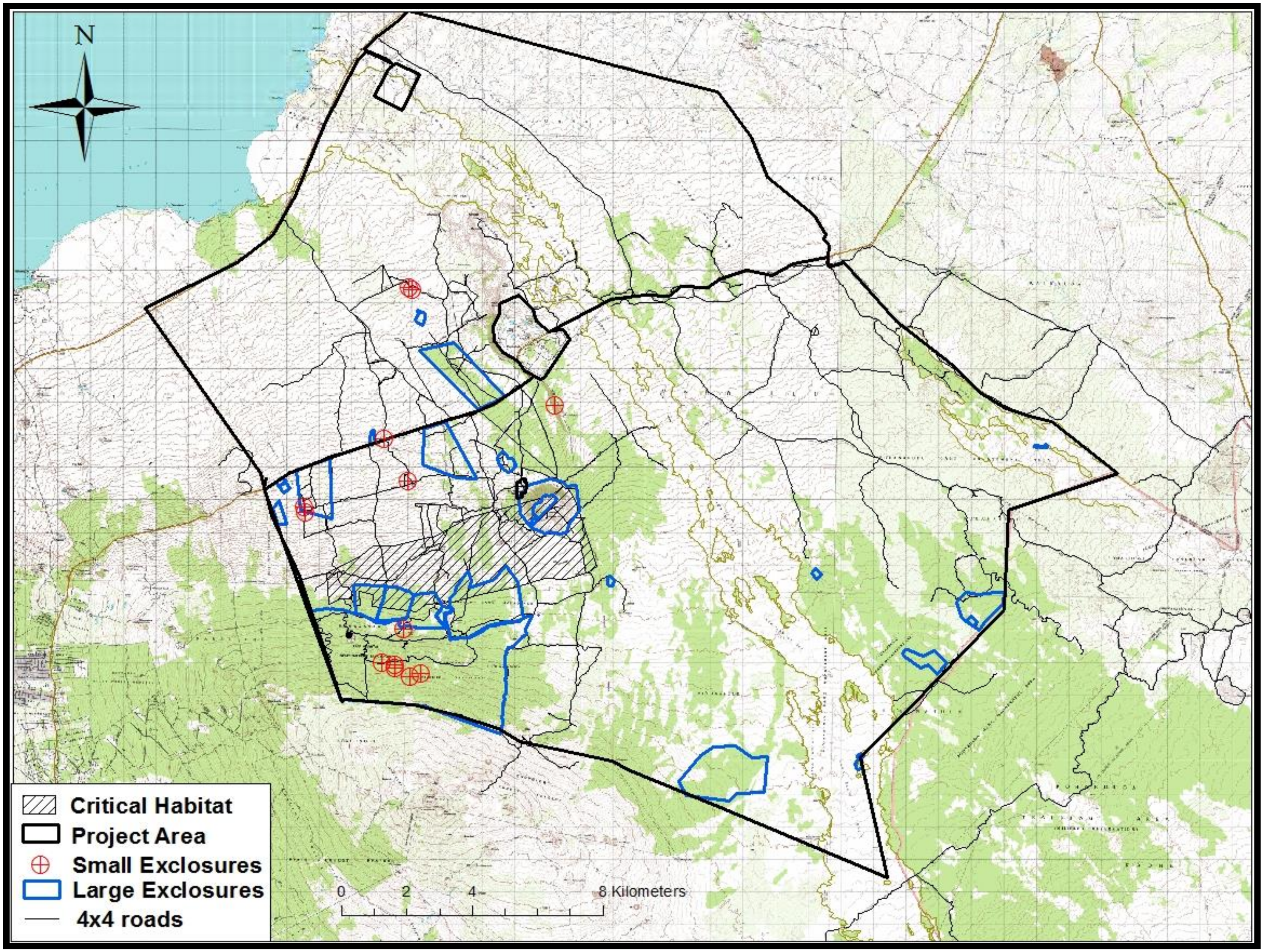



**Figure 3.12** Critical habitat for A'e (Zanthoxylum dipetalum var. tomentosum) within the Plan Area.

### 3.5.4.15 A‘e (*Zanthoxylum hawaiiensis*)

Description: A medium-size tree 3 to 8 m tall, with a trunk 25 cm in diameter (Army 2010). The bark is pale to dark gray, and the leaves are lemon-scented. Alternate leaves are composed of three small leaflets, one being terminal and two lateral. The surfaces are usually without hairs, or the lower may be finely hairy and glandular. Fifteen to 20 flowers are arranged in open flower clusters, 4 to 8 cm long, which are subtended by main flower stalks 20 to 50 mm long. Each flower is subtended by a flower stalk, 2 to 4 mm. Usually, all flowers on a tree are of one sex, either male or female. A sickle-shaped, round-tipped fruit, 8 to 10 mm long, opens on one side to release one round, slightly compressed seed. The seed covering is pitted and sculptured, about 7 to 8 mm long, distinguished from other Hawaiian members of the genus by several characters: three leaflets all of similar size, one joint on a lateral leaf stalk, and sickle-shape fruits with a rounded tip (Army 2010).

Historic and Current Distribution: A‘e (*Z. hawaiiense*) is known from five main islands: Kaua‘i, Moloka‘i, Lāna‘i, Maui, and Hawai‘i. Populations were located in central Kaua‘i; eastern Moloka‘i; central Lāna‘i; southern and southwestern slopes of Haleakalā, Maui; and Kohala mountain, northern slopes of Hualālai, and the northwestern slope of Mauna Loa, Hawai‘i (Army 2010). On Kaua‘i, A‘e (*Z. hawaiiense*) was observed at Kawaiiki Ridge in 2013 and Koaia Canyon in 2012. There are two wild individuals on Kaua‘i. On Moloka‘i and Maui, this species is known from five or six populations totaling 14 individuals in 2008. On Moloka‘i, there are three mature individuals at Kamalo and Makolelau Gulch. On West Maui there are approximately 48 individuals and on East Maui there are three individuals (USFWS 2015d). See Table 3.5 for a summary table of species distribution state-wide.

On Hawai‘i Island, A‘e (*Z. hawaiiense*) are widely scattered within Pu‘u Wa‘awa‘a, Pu‘u Anahulu, and the Pōhakuloa Training Area. Pōhakuloa Training Area most recent surveys have indicated 650 individuals. Overall, the numbers of individuals have increased from the approximately 550 wild individuals reported in the previous five year review to approximately 916 wild individuals in 2015 (USFWS 2015d). During the HCP surveys 219 individuals were within the Plan Area.

Habitat: A‘e (*Z. hawaiiense*) occurs in lowland dry and mesic forests, and montane dry forest, at elevations between 550 and 1,740 m (Gagne and Cuddihy 1990, Army 2010). The taxon grows in forests dominated by ‘Ōhi‘a, Lama, and Hala pepe. Other associated species include Hame (Kaua‘i), A‘ia‘i, Kōlea, Māmane, and Naio. Critical habitat was designated for this species in 2003; however CH does not occur within the Plan Area (USFWS 2003c).

**Table 3.4** Species distribution, PEPP Status (PEPP: Less than 50 individuals remain in the wild, ROI: rare on island, AS: assumed stable, apparently secure, POP: potentially PEP species), and Federal Status (E: endangered, SOC: species of concern, C: candidate for listing) for species mapped during HCP botanical surveys.

| Taxon | Common Name | Family | Distribution | PEP Status | Status |
|---|---|---|---|---|---|
| *Asplenium peruvianum var. insulare* | | Aspleniaceae | Hawai‘i and Maui | none | E |
| *Mezoneuron kavaiense* | Uhiuhi | Fabaceae | Hawai‘i, Maui, Lāna‘i, O‘ahu, and Kaua‘i | ROI | E |
| *Colubrina oppositifolia* | Kauila | Rhamnaceae | Hawai‘i, Maui, and O‘ahu | AS | E |
| *Haplostachys haplostachya* | Honohono | Lamiaceae | Hawai‘i, Maui, and Kaua‘i | None | E |
| *Hibiscus brackenridgei* subsp. *brackenridgei* | Ma‘o hau hele | Malvaceae | Hawai‘i, Maui, and Lāna‘i | PEP | E |
| *Kokia drynarioides* | Koki‘o | Malvaceae | Hawai‘i | PEP | E |
| *Neraudia ovata* | | Urticaceae | Hawai‘i | PEP | E |
| *Nothocestrum breviflorum* | ‘Aiea | Solanaceae | Hawai‘i | None | E |
| *Chrysodracon hawaiiensis* | Hala pepe | Asparagaceae | Hawai‘i | None | E |
| *Portulaca sclerocarpa* | Po‘e | Portulacaceae | Hawai‘i and Lāna‘i | PEP | E |
| *Silene lanceolata* | Hawaiian Catchfly | Caryophyllaceae | Hawai‘i, Lāna‘i, Moloka‘i, O‘ahu, Kaua‘i | None | E |
| *Solanum incompletum* | Pōpolo kū mai | Solanaceae | Hawai‘i, Maui, Lāna‘i, Moloka‘i, and Kaua‘i | POP | E |
| *Stenogyne angustifolia* | | Lamiaceae | Hawai‘i, Maui, and Moloka‘i | None | E |
| *Zanthoxylum dipetalum* var. *tomentosum* | A‘e | Rutaceae | Hawai‘i | PEP | E |
| *Zanthoxylum hawaiiense* | A‘e | Rutaceae | Hawai‘i, Maui, Lāna‘i, Moloka‘i, and Kaua‘i | None | E |
| *Alphitonia ponderosa* | Kauila | Rhamnaceae | Hawai‘i, Maui, Lāna‘i, Moloka‘i, and Kaua‘i | None | SOC |
| *Eragrostis deflexa* | | Poaceae | Hawai‘i, Maui, Lāna‘i, and Moloka‘i, | None | SOC |

| Taxon | Common Name | Family | Distribution | PEP Status | Status |
|---|---|---|---|---|---|
| *Erythrina sandwicensis* | Wiliwili | Fabaceae | All the main Hawaiian islands | None | SOC |
| *Euphorbia olowaluana* | ‘Akoko | Euphorbiaceae | Hawai‘i and Maui | None | SOC |
| *Exocarpus gaudichaudii* | Hulumoa | Santalaceae | All the main Hawaiian islands except Kaua‘i | None | SOC |
| *Fragaria chiloensis* | ‘Ōhelo papa | Rosaceae | Hawai‘i and Maui | None | SOC |
| *Melicope hawaiensis* | Manena | Rutaceae | Hawai‘i, Maui, Lāna‘i, and Moloka‘i, | None | SOC |
| *Polyscias sandwicensis* | ‘Ohe makai | Araliaceae | Ni‘ihau, Hawai‘i, Lāna‘i, Moloka‘i, O‘ahu, Kaua‘i | None | SOC |
| *Sisyrinchium acre* | Mau‘u lā‘ili | Iradaceae | Hawai‘i and Maui | None | SOC |
| *Stenogyne macrantha* | | Lamiaceae | Hawai‘i | None | SOC |
| *Tetramolopium consanguineum* | | Asteraceae | Hawai‘i and Kaua‘i | None | SOC |
| *Tetramolopium humile* | | Asteraceae | Hawai‘i and Maui | None | SOC |

**Table 3.5** Number of individuals of Covered Species in the Plan Area and across the state. A population is defined as a group of individuals within 1000m of one another. Values for number of individuals across the state come from the most recent USFWS 5 year review and summary evaluation reports for each of the covered Species.

| Species | Known Individuals in Plan Area | Populations in Plan Area | State wide | O‘ahu | Hawai‘i | Maui | Kaua‘i | Lāna‘i | Moloka‘i |
|---|---|---|---|---|---|---|---|---|---|
| *Asplenium peruvianum var. insulare* | 64 | 3 | 948 | | 931 | 17 | | | |
| *Chrysodracon hawaiiensis* | 299 | 5 | 400 | | 400 | | | | |
| *Colubrina oppositifolia* | 739 | 1 | 1265 | 54 | 1209 | 2 | | | |
| *Haplostachys haplostachya* | 80 | 1 | 10,000 | | 10,000 | X | X | | |
| *Hibiscus brackenridgei subsp. brackenridgei* | 65 | 1 | 76 | | 9 | 63 | | 4 | |
| *Kokia drynarioides* | 4 | 1 | 2 | | 2 | | | | |
| *Mezoneuron kavaiense* | 48 | 1 | 99 | 4 | 94 | X | 1 | X | |
| *Neraudia ovata* | 9 | 2 | 90 | | 90 | | | | |
| *Nothocestrum breviflorum* | 156 | 3 | 150 | | 150 | | | | |
| *Portulacca sclerocarpa* | 1 | 1 | 200 | | 200 | | | X | |
| *Silene lanceolata* | 235 | 3 | 20,000 | 189 | 10,394 | | X | | 622 |
| *Solanum incompletum* | 13 | 1 | 86 | | 86 | X | X | X | X |
| *Stenogyne angustifolia* | 98 | 3 | 5000 | | 5,000 | X | | | X |
| *Zanthoxylum dipetalum var. tomentosum* | 13 | 2 | 13 | | 13 | | | | |
| *Zanthoxylum hawaiiense* | 219 | 2 | 916 | | 860 | 51 | 2 | X | 3 |

### 3.5.5 Plant Species of Concern

Plant SOC were also documented during HCP surveys (Table 3.6). While these species are not ‘Covered Species’ for the purposes of licensing; exclosures and outplanting of SOC will benefit Covered Species by creating a more diverse plant assemblage that will improve ecosystem function. SOC species will be outplanted in exclosures along with appropriate common native species to increase species diversity, provide synergistic and functional gains between species, and benefit native species. Additions of these species will provide additional net environmental benefit, and will assist in the restoration of degraded natural communities within the Plan Area.

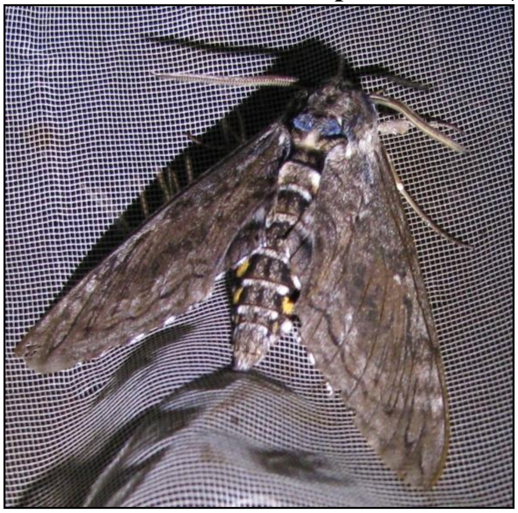
**Table 3.6** Documented flora SOC in the Plan Area. These species will potentially benefit from existing and planned exclosures. Existing and outplanted individuals of these species will be included in HCP protection and restoration, to the extent feasible and appropriate.

| Scientific Name | Common Name |
|---|---|
| *Alphitonia ponderosa* | Kauila |
| *Euphorbia olowaluana* | ‘Akoko |
| *Eragrostis deflexa* | Love Grass |
| *Erythrina sandwicensis* | Wiliwili |
| *Exocarpus gaudichaudii* | Hulumoa |
| *Fragaria chiloensis* | ‘Ōhelo papa |
| *Melicope hawaiensis* | Manena |
| *Polyscias sandwicensis* | ‘Ohe Makai |
| *Sisyrinchium acre* | Mau‘u lā‘ili |
| *Stenogyne macrantha* | |
| *Tetramolopium consanguineum* | |
| *Tetramolopium humile* | |

# 3.6 WILDLIFE

## 3.6.1 Covered Species

### 3.6.1.1 Blackburn's Sphinx Moth (*Manduca blackburni*)



Background: (Adapted from the USFWS Draft Recovery Plan for the Blackburn's sphinx moth, 2003) The Blackburn's sphinx moth (*Manduca blackburni*, BSM) is one of Hawaiʻi's largest native insects, with a wingspan of up to 12 centimeters and is one of four federally listed insects in the State of Hawaiʻi (USFWS 2003b). Like other sphinx moths in the family Sphingidae, it has long, narrow forewings, and a thick, spindle-shaped body tapered at both ends. It is grayish brown in color, with black bands across the apical (top) margins of the hind wings, and five orange spots along each side of the abdomen. The larva is a typical, large "hornworm" caterpillar, with a spine-like process on the dorsal surface of the eighth abdominal segment. Although the moth probably occurred on the islands of Kauaʻi, Kahoʻolawe, Oʻahu, Molokaʻi, Maui, and Hawaiʻi, extant populations are now limited to Maui, Kahoʻolawe, and Hawaiʻi. On Hawaiʻi, it was known from Hilo, Pāhala, Kalaoa, Kona, and Hāmākua. They have been observed from sea level to 1,525 meters elevation. *Manduca blackburni* is designated as an endangered species under federal and state laws.

*Manduca blackburni* larvae feed on plants in the nightshade family (Solanaceae). The native host plants are trees within the genus *Nothocestrum* (ʻAiea), on which the larvae consume leaves, stems, flowers, and buds. However, many of the host plants recorded for this species are not native to the Hawaiian Islands, and include commercial tobacco (*Nicotiana tabacum)*, tree tobacco (*Nicotiana glauca*), eggplant (*Solanum melongena*), tomato (*Lycopersicon esculentum*), and Jimson weed (*Datura stramonium*)(Hobdy 2014).

Little is known from direct observation of this species, as it was unobserved and considered extinct until it was rediscovered on Maui in 1984. In general, sphingid moths can develop from egg to adult in as little as 56 days, but pupae may remain in a state of torpor (inactivity) in the soil for up to a year. Adult sphingid moths have been found throughout the year and are known to feed on nectar from a variety of host plants. Sphingids generally live longer than most moths because of their ability to feed and take in water from a variety of sources, rather than relying only upon stored fat reserves.

Because they live longer, female sphingid moths will often take more time in locating the best host plants for egg laying (Kitching and Cadiou 2000), relative to other moth species.

Two field observations of feeding *M. blackburni* adults have been made, one within the Kanaio Beach area of southeast Maui, where adults were documented to be feeding upon the nectar of the native Hawaiian morning glory species, *Ipomoea indica*. The second observation was made in the upper Kanaio NAR, where a single adult was found feeding upon the nectar of *I. indica*. It is expected the native Hawaiian species of caper, *Capparis sandwichiana* and *Plumbago zeylanica* are also likely native adult *M. blackburni* food sources. All three species, *C. sandwichiana*, *P. zeylanica*, and *I. indica* bear flowers that share some traits suggestive of moth pollination, including nocturnal anthesis (opening at night), light coloration, and/or the emittance of strong fragrances (*C. sandwichiana*) upon opening.

Previous *M. blackburni* larvae sightings have been documented between the months of October and May, but more recent observations in the Plan Area confirm larval presence on tree tobacco in July, August, and September. Adult moths are found throughout the year. Recent light trapping surveys indicate that the species does occur in the Plan Area, with larvae predominantly occurring on tree tobacco in areas of high disturbance such as near fuelbreaks and roadsides and in areas previously burned by wildfires. Future surveys for larvae on ʻAiea are necessary to establish distribution and density on the native host plant. The limited data collected to date suggests that the species has a moderate to wide distribution in the Plan Area, and that potential impacts to the species should be considered and, if significant, avoided, minimized, and mitigated.

### *M. blackburni* critical habitat designation

Critical habitat is the term used to define those areas of habitat containing physical and biological features that are essential for an endangered or threatened species to recover and that require special management or protection. In July of 2003, the USFWS designated a total of about 55,000 acres of critical habitat for the Blackburn's sphinx moth. Approximately 25,000 acres of this designated critical habitat occur within the Plan Area, specifically within Puʻu Waʻawaʻa Forest Reserve (Figure 3.13). Critical habitat designation requires the Service to consult under section 7 of the ESA with regard to actions carried out, funded, or authorized by a federal agency when those actions may harm endangered species, or modify critical habitat. Four wheel drive roads and fuel breaks are not included in the critical habitat designation because they were existing man-made features when critical habitat was designated (USFWS 2003c). A section 7 consultation for federally funded road and fuelbreak clearing activities with an approved Biological Opinion was finalized in October 2015 (USFWS 2015e).

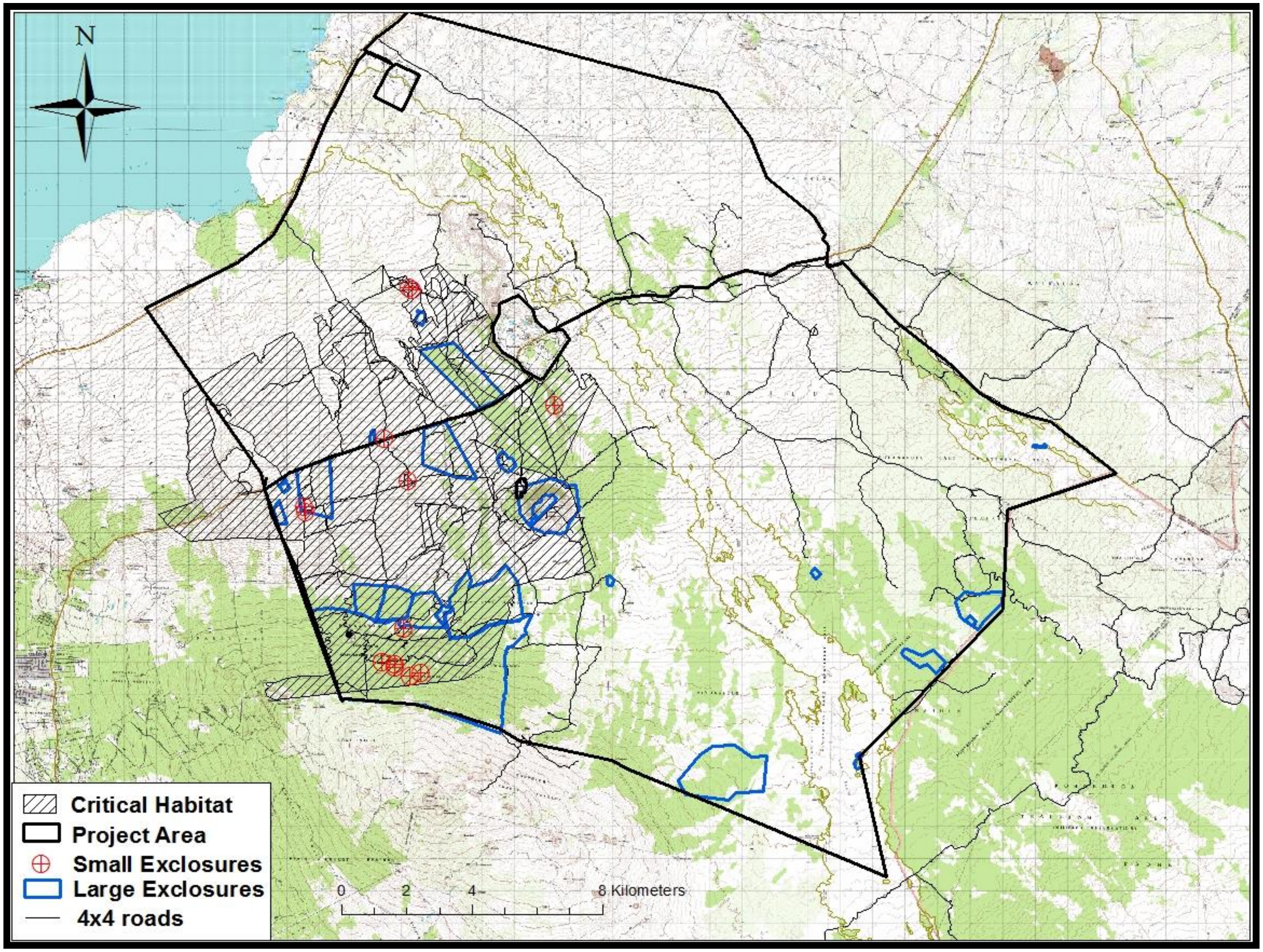



**Figure 3.13** Blackburn's sphinx moth critical habitat within the Plan Area.

## *M. blackburni* within the Plan Area

Blackburn's sphinx moth has been identified as being potentially impacted through the maintenance and creation of fuelbreaks and four-wheel drive access roads. There is no expected take of adult *M. blackburni* due to fuelbreak and road maintenance. However, take of eggs, larvae, and pupae may occur due to road clearing activities that remove host plants, specifically, tree tobacco. While take can be avoided and minimized through flexible clearing schedules, some take is anticipated and will be covered under this HCP.

Within the Plan Area, *M. blackburni* larvae have been observed on both native plants (ʻAiea), and non-native plants (tree tobacco). The HCP botanical surveys documented the location and distribution of ʻAiea within the Plan Area. Because the botanical surveys did not cover 100% of all land within the Plan Area due to financial, logistical, and staff constraints, modeling was used to determine the number of ʻAiea that may have been missed (*See Modeling and Estimated Take section 5.3 for more details*).

In January 2010, HCP staff began documenting the distribution of tree tobacco that occurs on roadsides and fuelbreaks within the Plan Area by recording plant locations using Global Positioning System (GPS) technology as HCP staff drove 4x4 roads. For each location, a general description of the number of plants (limited to those occurring along roadsides) in that given area was recorded (*For more information see Section 5.3.6*).

To quantify the distribution and density of Blackburn's sphinx moth eggs and larvae, DOFAW conducted surveys at random locations throughout the Plan Area. Surveys were conducted to quantify egg and larval densities both on roadside (2011 and 2012) and off of the road (2012), and to quantify characteristics of tree tobacco that might be important to adult moths when selecting host plants. We considered three individual plant characteristics that we hypothesized might influence the distribution and abundance of eggs and larvae; tree leaf density, tree height, and tree location (on-road or offroads). Tree tobacco leaf density and height vary greatly across the landscape from small developing plants with few large leaves to larger (3-5 m tall) trees with numerous smaller and tougher leaves. Tree density also varied across the landscape with the vast majority of individual trees and stems occurring on or directly adjacent to road-sides. We hypothesized that higher abundance of eggs and larvae would be found on shorter (younger) trees with larger leaves (because of both larger available surface area and higher quality food for larvae), and also on roadsides (as compared to off-road) because roadside trees tended to be smaller and have larger leaves and higher densities of trees. When tree tobacco is damaged (due to road clearing, tires, etc.), roots will often send out new shoots with large leaves.

The surveys indicated that while a smaller proportion of trees fall in to the high leaf density category (as compared to the low and medium leaf density categories), a higher proportion of eggs and larvae can be found on trees with high leaf density, suggesting the adult moths are preferentially selecting this category. Survey data also indicated a greater proportion of tree use with increasing tree height; specifically, moths appeared to be preferentially selecting trees of a larger size, in particular those in the 2-5 m height class. Moreover, only 2% of detected larvae were found on trees less than one meter tall. Surveys were conducted on roads as well as in off-road areas perpendicular to roadsides to see if roads themselves are something important for host site selection. We found that approximately the same proportions of trees of each category are being used by Blackburn's sphinx moth on roadsides as compared to off road areas in relation to what is available for use on the landscape. This indicates that roads do not have a measurable impact on host site selection, and that the other factors surveyed (i.e. leaf density and tree height) may be more important to Blackburn's sphinx moth (*See Appendix D, section 11.0 for detailed information on surveys and results*).

### 3.6.2 Non-Covered Species

#### 3.6.2.1 Vertebrate and Invertebrate Species

Appendix B includes a list of the endangered, threatened, and candidate vertebrate and invertebrate species that are known to occur within the Plan Area. Potential impacts to each of these protected species have been considered. Protected animal species with no expected take due to Plan activities are listed in this section.

**Nēnē (*Branta sandvicensis*)**

Nēnē, or Hawaiian geese, are known to prefer open short grassland habitats and fresh greens, and are not dependent for food or habitat upon any of the plant species covered under this HCP. No known Nēnē habitat, nesting area, or Nēnē themselves will be disturbed or destroyed by Plan actions. Nēnē will benefit from increased natural forage in protected areas. No direct or indirect take is anticipated; Nēnē will be provided net benefit due to HCP implementation.

**ʻIo (*Buteo solitaries*)**

ʻIo, or Hawaiian hawk, is found in a wide variety of habitats, from exotic forest and pastureland in the lowlands to native forest as high as 2,712 m in elevation. No ʻIo or their nesting areas will be disturbed or destroyed by Plan actions. ʻIo may benefit somewhat from an increase in nesting and roosting sites, after mature vegetation has developed in protected areas, relative to the extant fountain grass dominated landscape. No direct or indirect take is anticipated; ʻIo will be provided net benefit due to HCP implementation.

**Honu (*Chelonia mydas*)**

No Plan activities occur in the beach area potentially accessed by Honu (green sea turtles). Plan activities will not affect marine or coastal environments. No take is anticipated for Honu.

**Aeʻo (*Himantopus mexicanus knudseni*)**

The Aeʻo, or Hawaiian stilt, is known to nest in the 49 acre Hauaina fenced unit near a man made reservoir. As this exclosure is already in place, no take is anticipated for this species.

**ʻŌpeʻapeʻa (*Lasiurus cinereus semotus*)**

ʻŌpeʻapeʻa, or Hawaiian hoary bat, are known to use the Plan Area for foraging and probably for nesting. Bats can be seen nightly foraging in the vicinity of the Hauaina unit. These bats are flexible in their roosting and foraging areas, and utilize a wide variety of trees, including both native and non-native tree species for roosting, and native and non-native invertebrate species as prey. The current Plan includes no tree removal which could potentially impact ʻŌpeʻapeʻa. Increases in native tree cover, and increases in native species diversity should result in a net gain in roosting and possibly foraging opportunities, particularly in areas currently dominated by fountain grass, as trees in exclosures become more established. No direct or indirect take of bats is anticipated. ʻŌpeʻapeʻa, will be provided net benefit by Plan activities.

### Hawai‘i ‘Akepa (*Loxops coccineus coccineus*) and Hawai‘i creeper (*Oreomystis mana*)

Both the Hawai‘i ‘Akepa and Hawai‘i creeper are known to occur or have occurred within the fenced Pu‘u Wa‘awa‘a Forest Bird Sanctuary, which is already fenced. Habitat loss is listed as the greatest threat to these birds, and both species are expected to gain habitat, nesting and foraging opportunities through Plan actions, resulting in a net benefit to these endangered species. No direct or indirect take from Plan activities is anticipated. These and other forest bird species will receive net benefits from HCP activities, particularly as forests within the exclosures become more established.

### *Drosophila heteroneura*

A member of the picture wing family, this drosophilid fly inhabits rain forest communities, and is closely associated with *Cheirodendron* bark, *Clermontia* bark, and *Delissea* stem (Montgomery 1975). No negative effect is expected on the associated host plants; therefore no direct or indirect take is anticipated for this species. It is possible that the flies will benefit from an increase in natural communities in the Plan Area, an additional Plan benefit.

# 4.0 BIOLOGICAL GOALS AND OBJECTIVES

DOFAW has worked to assess the potential for the proposed Covered Activities to cause adverse effects to the Covered Species. The purpose of identifying these goals and objectives is to establish a framework for developing the conservation measures for the HCP; we are using the USFWS Five-point Policy as guidance for the HCP process (USFWS 2000).

## 4.1 GOALS

Biological goals are intended to be broad, guiding principles that clarify the purpose and direction of the HCP (USFWS 2000). The biological goal for this HCP is to secure and maintain the survival of native plant and animal species that occur within the Plan Area through restoration activities aimed at maintenance and enhancement of essential habitat and community function.

The specific goals of this HCP are to:

- Avoid, minimize, and mitigate the potential effects of the Covered Activities on the Covered Species associated with game mammal management and maintenance activities of the Plan;
- Increase the knowledge and understanding of the occurrence and distribution of the Covered Species in the Plan Area;
- Adhere to the goals of the recovery plans for each of the Covered Species; and
- Provide a net conservation benefit to each of the Covered Species.

## 4.2 OBJECTIVES

The biological objectives for achieving the HCP goals are:

- Offset the potential direct and/or indirect effects of the Plan on the 15 Covered Plant Species through protection and maintenance of a minimum of at least three populations of each covered plant species with a total number of individuals equaling the <u>take estimate</u> or <u>at least</u> the minimum number of individuals required for stabilization (whichever value is greater) as put forth by the recovery plans for each Covered Species. As well as propagate additional populations of the 15 Covered Plant species as needed to provide net environmental benefit, ensure genetic representation, and increase the likelihood of recovery.
- Provide protection for existing *in situ* populations of Covered Plant Species through maintaining or constructing exclosures. These management units or exclosures of various sizes will be managed for multi-species benefit to provide natural community function, whenever feasible.
- Offset the potential direct and indirect effects of the Plan on Blackburn's sphinx moth during road and fuelbreak maintenance through pre-maintenance avoidance measures and by outplanting and protecting native host plants and nectar plants.
- Provide adequate monitoring for each of the impacted Covered Species, including but not limited to population monitoring, monitoring measures of success, ongoing take, and net benefit.

- Provide periodic reports, review, assess, and implement appropriate adaptive management measures as needed.

## 4.3 AVOIDANCE AND MINIMIZATION MEASURES

Section 195D-21of the Hawaiʻi Revised Statutes requires that an HCP describe the steps that will be taken to avoid, minimize and mitigate the effects of the taking provided for in the plan, and that, for an HCP to be approved, such taking be minimized and mitigated to the maximum extent practicable where complete avoidance is not possible. The DLNR will take appropriate steps to avoid adverse effects to the Covered Species. DLNR has incorporated measures, identified below, to avoid and minimize take of the Covered Species.

### 4.3.1 General Plan Development Measures

The spread of invasive, non-native plant species caused by fence construction will be minimized through cleaning and inspecting equipment coming to the site and maintenance of fuelbreaks (weed-free buffers) around all fenced units. Any areas within fenced units that are disturbed by fencing activities will be replanted with native species (*see Appendix B for a list of potential outplanting species*). Trash, especially food stuffs, will be removed from the construction area on a weekly basis to avoid attraction of ants and other animals such as mongooses, cats, and rats that may negatively affect the Covered Species.

A biologist will be on staff during fencing operations to conduct post-fence construction monitoring surveys, to assist with mitigation measures, and to address any potential wildlife and botanical issues that may arise.

### 4.3.2 Pre-Road Clearing Surveys and Timing Considerations

To minimize impacts to Blackburn's sphinx moth habitat, all known ʻAiea (the native host plant) within the Plan Area will be permanently protected from ungulates.

Blackburn's sphinx moth larvae have been documented on tree tobacco year round with highest numbers found from December to March. Surveys have shown that larvae primarily use trees larger than one meter in height (*See Appendix D for survey results*). To minimize impacts to Blackburn's sphinx moth, intensive control or removal of tree tobacco along roadsides and fuelbreaks will be done when larvae are known to be less abundant, from June through August. After intensive summer clearing, roads may be cleared every two months to maintain access and keep the fuelbreaks free of vegetation. By maintaining a consistent road clearing schedule, take of larvae and eggs will be minimized as trees cleared will primarily be less than one meter in height (*see section 3.6.1*). For a detailed description of methods used for clearing roads and breaks, please see section 5.2.2.

### 4.3.3 Invasive Plant Species Management

DLNR will work actively to minimize and reduce the ingress of additional undesirable invasive plant species into the Plan Area. DLNR intends to implement measures to minimize and avoid the introduction of invasive species to the Plan Area including:

All equipment, materials, and vehicles brought onto the site during fence construction will be cleaned and inspected to prevent the introduction of invasive or harmful non-native species. An inspection station will be located at a staging area designated prior to construction (staging area location may change based on location of contracted work).

To minimize the introduction and spread of invasive plant species, potential off-site sources of materials (e.g., fence materials) will be inspected, and the import of materials from sites that are known or likely to contain seeds or propagules of particularly harmful invasive species will be prohibited.

Vehicle operators transporting materials to the proposed Plan site from off site will be required to follow protocols for removing soils and plant material from vehicles and equipment prior to entry onto the site.

The goal within conservation units is to control 90% of invasive species (primarily fountain grass and kikuyu grass[14]) from within three meters of an individual (or cluster of) Covered Species and, maintain a 25-50 m buffer of less than 50% invasive grass coverage around an individual (or cluster of) Covered Species.

Tree tobacco within exclosures will be surveyed for Blackburn’s sphinx moth eggs and larvae prior to tree removal. Unoccupied tree tobacco plants will be removed to prevent future use by the Blackburn’s sphinx moth. Plants less than one meter tall will be removed by pulling, while plants greater than one meter tall will be cut and treated with herbicide. Should any larvae be found just prior to plant removal or cutting, the larvae will be removed and relocated by trained, authorized staff to a nearby location outside the area of disturbance that contains suitable moth habitat to avoid direct take.

#### 4.3.4 Rapid Ohiʻa Death Prevention

A newly identified disease has killed large numbers of mature ʻŌhiʻa trees in forests and residential areas of the Puna and Hilo Districts of Hawaiʻi Island. Landowners have observed that when previously healthy-looking trees begin to exhibit symptoms they typically die within a matter of weeks. Pathogenicity tests conducted by the USDA Agriculture Research Service have determined that the causal agent of the disease is the vascular wilt fungus, *Ceratocystis fimbriata* (Keith et al. 2015). This disease has the potential to kill ʻŌhiʻa trees statewide. The disease affects non-contiguous forest stands ranging from 1 to 100 acres. As of 2014, approximately 6,000 acres from Kalapana to Hilo on Hawaiʻi Island had been affected with stand showing greater than 50% mortality. The disease has not yet been reported on any of the other Hawaiian Islands.

As of early 2015 the disease was confined to Hilo and the Puna district on Hawaiʻi Island. Currently, there is no effective treatment to protect ʻŌhiʻa trees from becoming infected with *Ceratocystis* or cure trees that exhibit symptoms of the disease. To reduce the spread of *Ceratocystis*, landowners should not transport wood of affected ʻŌhiʻa trees

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[14] Fountain and kikuyu grass have been identified as the most damaging invasive plant species in the Plan Area. Additional weed species will be controlled on a case by case basis. Some alien species, such as kikuyu grass can hinder the encroachment of more aggressive weed species allowing for better outplanting conditions and can be left in place until outplants are near ready to be planted.

to other areas. The pathogen may remain viable for over a year in dead wood. Tools used for cutting infected ʻŌhiʻa trees should be cleaned either with Lysol ™ or a 70% rubbing alcohol solution. A freshly prepared 10% solution of chlorine bleach and water can be used as long as tools are oiled afterwards, as chlorine bleach will corrode metal tools. Chain saw blades should be brushed clean, sprayed with cleaning solution, and run briefly to lubricate the chain. Vehicles used off-road in infected forest areas should be thoroughly cleaned underneath so as not to carry contaminated soil to healthy forests. Shoes, tools, and clothing used in infected forests should also be cleaned, especially before being used in healthy forests.

### 4.3.5 Ignition Prevention

Hot catalytic converters, exhaust systems, sparks, cigarettes, and other ignition sources may be present while staff and the public access the Plan Area. Proper ignition prevention procedures will be followed by all workers. Vehicles will not be parked in vegetation of any kind whenever possible. In some locations this may not be feasible. In these locales, vehicles will not park in vegetation greater than 10 cm in height. Smokers shall field strip their cigarettes immediately after smoking (remove tobacco from the butt and scatter it, ensuring that the tobacco is not lit), and properly dispose of cigarettes inside their vehicle.

### 4.3.6 Ungulate Proof Exclosures

Ungulate-proof exclosures are the most effective tool for minimizing impacts associated with ungulate grazing and browsing, and vehicular and foot traffic. The exclosures will be constructed based on the locality of the endangered plant species, feasibility, and effectiveness. Exclosure fences will be constructed with 6-foot woven hog-wire fencing secured by 8-foot tall T-posts. No barbed wire will be used to avoid entanglement to wildlife. Fences will be skirted with additional hog-wire or deer fence to prohibit burrowing. Fencing personnel and materials will access to the site along existing access roads by vehicle or by helicopter.

#### 4.3.6.1 Fencing Unit Priority[15]

The first phase of implementation will focus on avoidance and minimization of take through the installation of fencing units. Fencing priority is listed below in Table 4.1. This priority is based on the number of known *in situ* plant populations present within the unit as well as PEPP (Plant Extinction Prevention Program) status, and overall number of populations within the Plan Area.

[15] Priority is subject to change based on availability of funding.

**Table 4.1** Fencing priority for fencing units within the Plan Area. Type: A/M= avoidance and minimization and Mit= mitigation. Species codes are: AspPer = *Asplenium peruvianum*, ChrHaw = *Chrysodracon hawaiiensis*, ColOpp = *Colubrina oppositifolia*, HapHap = *Haplostachys haplostachya*, HibBra = *Hibiscus brackenridgei*, KokDry = *Kokio drynarioides*, MezKav = *Mezoneuron kavaiense*, NerOva = *Neraudia ovata*, NotBre = *Nothocestrum breviflorum*, SilLan = *Silene lanceolata*, SolInc = *Solanum incompletum*, ZanDip = *Zanthoxylum dipetalum*, ZanHaw = *Zanthoxylum hawaiiensis*

| **Fencing Unit** | **Type** | **Size[16](acres)** | **Rationale** |
|---|---|---|---|
| Henahena | A/M | 731 | NotBre avoidance of take |
| Hala pepe | A/M | 92 | ChrHaw avoidance of take |
| ‘Aiea | A/M | 291 | NotBre avoidance of take |
| Honohono | A/M | 5 | Only known population on State land and PEPP species |
| Solanum Kīpuka | A/M | 18 | Only known population on State land and PEPP species |
| Kauila Hala pepe | A/M | 375 | Avoidance of take of ColOpp and ChrHaw |
| Zanthoxylum II | A/M | 815 | Avoidance of take of ZanHaw |
| Anahulu I | A/M | 255 | Avoidance of take for NerOva, ZanHaw, SilLan, SteAng |
| Anahulu II | A/M | 124 | Avoidance of take for ZanHaw and NerOva |
| Stenogyne | A/M | 10 | Avoidance of take for SteAng |
| Uhiuhi 4 | A/M | 22 | Avoidance of take for MezKav |
| Pu‘u Loa | A/M | 530 | Avoidance of take for ChrHaw, MezKav, ColOpp |
| PWW CCA (remaining units) | Mit | 330 | Mitigation for 13 of 15 Cover Species |

[16] Exclosure size and exact location may vary depending on Covered plant locations, geography, roads, access, and surrounding exclosures. Exclosure size is based on GIS acres.

| Fencing Unit | Type | Size[16](acres) | Rationale |
|---|---|---|---|
| South Kīpuka | Mit | 42 | Outplanting site for lowland dry forest species (sites lacking) |
| Waihou II | Mit | 202 | Outplanting site for multiple Covered Species |
| Lama w/ Koki‘o | Mit | 382 | Last known KokDry at PWW. Avoidance of take for ColOpp, NotBre, ChrHaw. |
| Kileo | Mit | 533 | Outplanting site for AspPer, HapHap, NerOva, NotBre, PorScl, SilLan, SolInc, SteAng, and ZanHaw. |
| **Total Proposed Mitigation Acreage** | | **1,489** | **1.4% of the Plan Area** |
| **Total Proposed Avoidance/Minimization Acreage** | | **3,268** | **3.1% of the Plan Area** |
| **Total Proposed Fenced Acreage[17]** | | **4,757** | **4.5% of the Plan Area** |

[17] Exclosure size and exact location may vary depending on Covered plant locations, geography, roads, access, and surrounding exclosures.

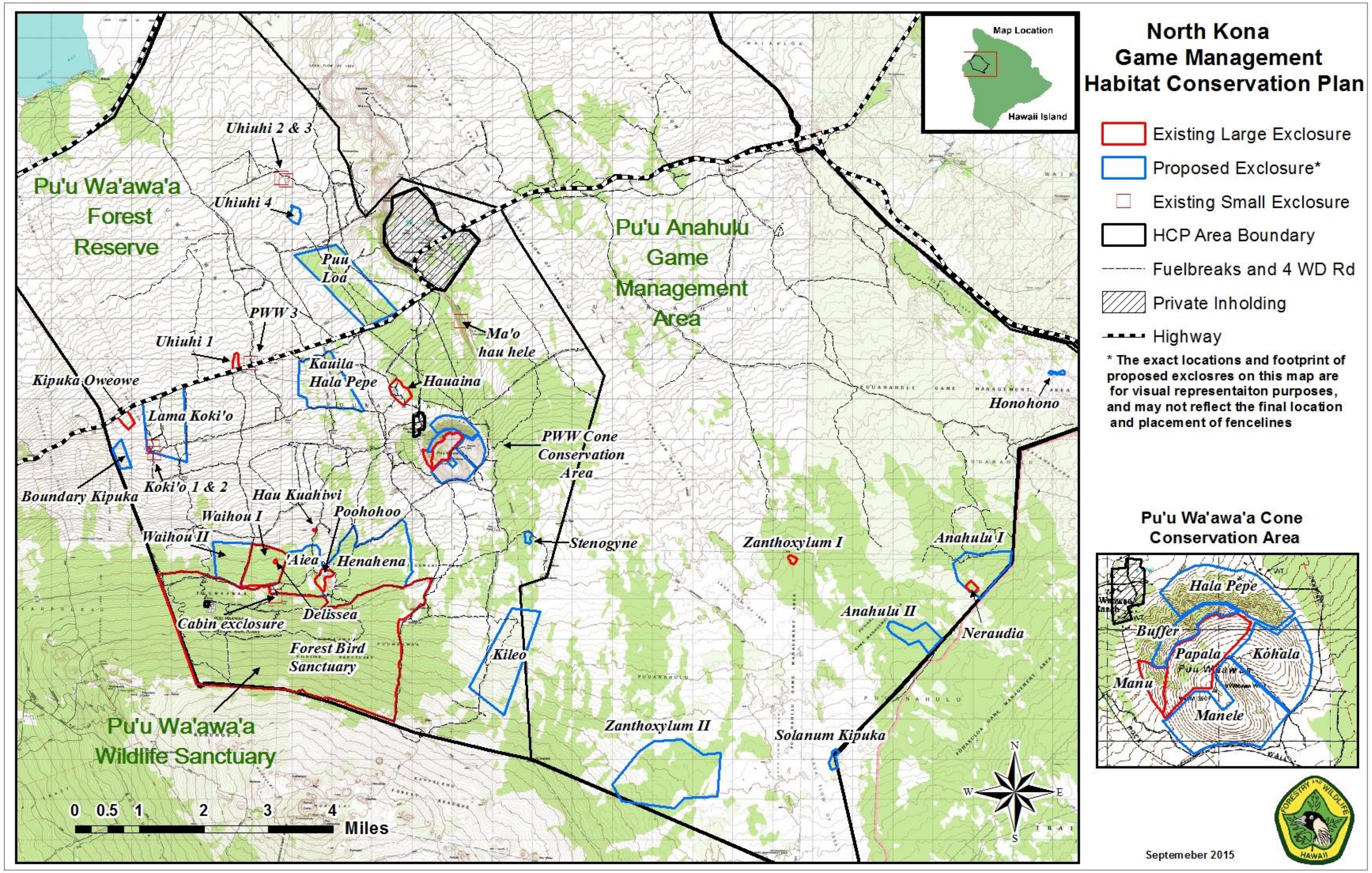


**Figure 4.1** Current and proposed exclosures in the Plan Area.

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### 4.3.6.2 Proposed Exclosures

The proposed exclosures were designed based on the following approach:

- To provide for the protection of the plant species included in the incidental take license.
- To avoid negative effects of game mammal management on Covered Species.
- To promote functional native dominated communities. The construction of large exclosures is intended to protect a larger and more diverse native plant community.
- Use of existing fences and exclosures, whenever feasible and effective for plant protection, is preferred over building new fences, both to minimize cost and to minimize effects on game mammal management.

**Henahena – 731 acres**

This area is also known historically as Henehene (Fujii 1995) and contains predominantly ʻŌhiʻa forest. This area also contains numerous sandalwood trees (ʻIliahi) and ʻAiea which are hosts for the endangered Blackburn's sphinx moth. Fencing of this area will protect remaining ʻŌhiʻa forest stands and the fragile lava tube ecosystems that occur underneath this forest type by preventing animals from damaging vegetation over the lava tube ecosystem.

**Puʻu Waʻawaʻa Cone Conservation Area (4 remaining units totaling 330 acres)**

- Buffer: 29 acres: This unit will be used for mitigation for 12 Covered species.
- Mānele: 121 acres: This unit will be used for mitigation for 12 Covered species.
- Kōhala: 88 acres: This unit will be used for mitigation for 12 Covered species.
- Hala pepe: 92 acres: This unit contains a large concentration of Hala pepe and one individual Aʻe (*Zanthoxylum dipetalum* var. *tomentosum).*

**ʻAiea – 291 acres**

This unit will incorporate a small concentration of the endangered ʻAiea that is also important habitat for the endangered Blackburn's sphinx moth. The forest here is dominated by ʻŌhiʻa, Koa, Māmane, and Naio and contains scattered individuals of the endangered ʻAiea, and the SOC ʻAkoko.

**Honohono – 5 acres**

This area contains the last known population of Honohono found on state land.

**Solanum Kīpuka – 18 acres**

Currently 8 individual fences occur in this kīpuka enclosing approximately nine Pōpolo kū mai plants. The entire kīpuka will be enclosed to further protect these remaining plants. The PTA boundary fence could be used as one side of the fence unit.

**Kauila Hala pepe – 368 acres**

This unit contains a large population of Kauila and Hala pepe.

**Zanthoxylum II – 815 acres**

This area contains the highest concentration and largest population of Aʻe (*Z. hawaiiensis*) in the area.

**Anahulu I – 255 acres**

This area contains some of the best remaining dry forest shrubland in the upper Puʻu Anahulu region. Puʻu Anahulu has been plagued by fires in recent years resulting in a drastically altered landscape. Without management actions including fencing to protect plants from ungulates, fire control, and invasive species management, this area will likely burn in the future resulting in the loss of many species including: Aʻe (*Z. hawaiiensis*), Hawaiian Catchfly, *Neraudia ovata*, and *S. angustifolia.*

**Anahulu II – 124 acres**

This area contains some of the best remaining dry forest shrubland in the upper Puʻu Anahulu region. Puʻu Anahulu has been plagued by fires in recent years resulting in a drastically altered landscape. Without management actions including fencing to protect plants from ungulates, fire control, and invasive species management, this area will likely burn in the future resulting in the loss of many species including: Aʻe (*Z. hawaiiensis*), Hawaiian Catchfly, *Neraudia ovata*, and *S. angustifolia.*

**Stenogyne – 12 acres**

This area contains some of the highest concentration of *S. angustifolia* in the Plan Area. The site is also suitable for the potential reintroduction of Hawaiian Catchfly, *Neraudia ovata*, and ʻAiea*.*

**Uhiuhi 4 – 22 acres**

This unit will protect nine Uhiuhi trees on the makai side of Puʻu Waʻawaʻa.

**Puʻu Loa – 530 acres**

This large unit makai of the highway contains individuals of Kauila, Hala pepe, and Uhiuhi.

**Boundary Kīpuka – 42 acres**

This unit is primarily a mitigation unit for lowland dry forest species but may also contain ʻAiea and Hala pepe.

**Waihou II – 202 acres**

The expansion of the Waihou forest fence will greatly increase the amount of protected area in which to recover both existing and recently extirpated endangered plant populations. This area contains numerous individuals of the endangered ʻAiea which are host to the endangered Blackburn's sphinx moth, at least two individuals of Aʻe (*Z. dipetalum* var. *tomentosum*) and the SOC, ʻAkoko.

**Lama Koki‘o – 382 acres**

This unit is primarily a mitigation unit for lowland dry forest species and also contains ‘Aiea and Hala pepe.

**Kileo – 533 acres**

This unit is a mitigation unit for *A. peruvianum*, Honohono, *Neraudia ovata*, ‘Aiea, Po‘e, *Silene lanceolata*, Pōpolo kū mai, creeping mint, and A‘e (*Z. hawaiiense*).

**Table 4.2** *In situ* individuals within exclosures. This table summarizes the presence of extant wild (*in situ*) individuals within proposed and current exclosures to be used for avoidance and minimization. Numeric values indicate the number of individuals of each species within each unit. Species codes are: AspPer = *Asplenium peruvianum*, ChrHaw = *Chrysodracon hawaiiensis*, ColOpp = *Colubrina oppositifolia*, HapHap = *Haplostachys haplostachya*, HibBra = *Hibiscus brackenridgei*, KokDry = *Kokio drynarioides*, MezKav = *Mezoneuron kavaiense*, NerOva = *Neraudia ovata*, NotBre = *Nothocestrum breviflorum*, SilLan = *Silene lanceolata*, SolInc = *Solanum incompletum*, ZanDip = *Zanthoxylum dipetalum*, ZanHaw = *Zanthoxylum hawaiiense*. *indicates fenced unit.

| Exclosure | Acres | Asp Per | Chr Haw | Col Opp | Hap Hap | Hib Bra | Kok Dry | Mez Kav | Ner Ova | Not Bre | Por Scl | Sil Lan | Sol Inc | Ste Ang | Zan Dip | Zan Haw | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **‘Aiea** | 291 | | | | | | | | | 33 | | | | | | | **33** |
| **Anahulu I** | 255 | | | | | | | | 4 | | 1 | 30 | | 15 | | 9 | **59** |
| **Anahulu II** | 124 | | | | | | | | 4 | | | | | | | 30 | **34** |
| **Uhiuhi 4** | 22 | | | | | | | 9 | | | | | | | | | **9** |
| **Hala pepe** | 92 | | 62 | | | | | | | | | | | | 1 | | **63** |
| **Honohono** | 5 | | | | 80 | | | | | | | | | | | | **80** |
| **Henahena** | 731 | | | | | | | | | 20 | | | | | | | **20** |
| **Kauila Hala pepe** | 375 | | 148 | 643 | | | | | | 6 | | | | | | | **797** |
| **Kīpuka Oweowe*** | 26 | | 1 | | | | | | | 6 | | | | | | | **5** |
| **Lama Koki‘o** | 382 | | 6 | 33 | | | 4 | | | 16 | | | | | | | **59** |
| **Pu‘u Loa** | 530 | | 30 | 5 | | | | 2 | | | | | | | | | **37** |
| **Neraudia*** | 12 | | | | | | | | 1 | | | | | | | | **1** |
| **Po‘ohoho‘o *** | 29 | | | | | | | | | 6 | | | | | | | **6** |
| **FBS*** | 3744 | 45 | | | | | | | | 3 | | | | | | | **47** |
| **Solanum Kīpuka** | 18 | | | | | | | | | | | | 13 | | | | **13** |
| **Stenogyne** | 10 | | | | | | | | | | | | | 43 | | | **43** |
| **Uhiuhi 1 *** | 13 | | | | | | | | | 1 | | | | | | | **1** |
| **Waihou II** | 202 | | | | | | | | | | | | | | 2 | | **2** |
| **Waihou I*** | 211 | | | | | | | | | 9 | | | | | 2 | | **11** |
| **Zanthoxylum I*** | 7 | | | | | | | | | | | | | | | 7 | **7** |
| **Zanthoxylum II** | 815 | | | | | | | | | | | | | | | 129 | **129** |
| **Total Plants** | | **45** | **247** | **681** | **80** | **65** | **4** | **11** | **9** | **100** | **1** | **30** | **13** | **58** | **5** | **175** | **1524** |

### 4.3.7 Preservation of natural plant communities and ecosystems

HRS §195-D-21(b)(1)(A) states: "*The plan will further the purposes of this chapter by protecting, maintaining, restoring, or enhancing identified ecosystems, natural communities, or habitat types upon which endangered, threatened, proposed, or candidate species depend within the area covered by the plan;*
Where:
*'Ecosystem' means all natural elements, physical and biological, of the habitat or site in which any aquatic life, wildlife, or land plant species is found, and upon which it is dependent.*
and
*'Natural communities' means a natural assemblage of plants or animals that occurs within certain elevation, moisture, and habitat conditions."*

The HCP focuses on the preservation, management, and restoration of remnant native or degraded habitats and forest with the goal of creating or enhancing habitat for rare or listed plant and wildlife species including the Covered Species. The Covered Species and their associated habitat types are listed in Table 4.3. Some species overlap with other species because they have wide ranges and can be found in multiple habitat types.

**Table 4.3** Listed species currently or historically found within the Plan Area categorized into plant clusters based on habitat type and range.

| |
|---|
| **Lowland Dry Forest** |
| *Mezoneuron kavaiense, Colubrina oppositifolia, Hibiscus brackenridgei* ssp. *brackenridgei, Kokia drynarioides, Neraudia ovata, Nothocestrum breviflorum, Chrysodracon hawaiiensis, Silene lanceolata, Solanum incompletum, Polyscias sandwicensis* |
| **Mixed Mesic/Dry Forest** |
| *Hibiscus brackenridgei* ssp. *brackenridgei, Kokia drynarioides, Nothocestrum breviflorum, Chrysodracon hawaiiensis, Silene lanceolata, Solanum incompletum, Zanthoxylum hawaiiense, Zanthoxylum dipetalum var. tomentosum, Euphorbia olowaluana, Melicope hawaiiensis, Polyscias sandwicensis* |
| **Mesic to Wet Forest** |
| *Phyllostegia velutina, Vicia menziesii, Nothocestrum breviflorum, Exocarpus gaudichaudii, Fragaria chiloensis, Melicope hawaiiensis, Sisyrinchium acre, Tetramolopium consaguineum* |
| **Upland/ Dry Shrubland** |
| *Haplostachys haplostachya, Neraudia ovata, Silene lanceolata, Solanum incompletum, Stenogyne angustifolia, Zanthoxylum hawaiiense, Euphorbia olowaluana, Eragrostis deflexa, Fragaria chiloensis, Sisyrinchium acre* |

**Table 4.4** Proposed and existing conservation units and exclosures categorized by habitat type.

| |
|---|
| **Lowland Dry Forest** |
| Kīpuka Oweowe, Hauaina, Uhiuhi 1, Maʻo hau hele, Kauila Hala pepe, Boundary Kīpuka, Lama Kokiʻo, Puʻu Loa, Uhiuhi 4 |
| **Mixed Mesic/Dry Forest** |
| Waihou I, PWW Cone Conservation Area, Waihou II, Henahena, ʻAiea, Poʻohohoʻo |
| **Mesic to Wet Forest** |
| Forest Bird Sanctuary, Poʻohohoʻo |
| **Upland Dry Shrubland** |
| Anuhulu I & II, Zanthoxylum I & II, Stenogyne, Honohono, Solanum Kīpuka, Kileo |

# 5.0 POTENTIAL IMPACTS

The issuance of an ITL requires establishing the number of individuals of (and habitat for) each Covered Species authorized for incidental take during a defined period. The following subsections describe potential direct and indirect impacts from the proposed Plan to the 15 federally and state listed plant species and the Blackburn's sphinx moth. Implementation of the measures described in Section 4.3 is expected to minimize the potential for take of species resulting from the proposed covered activities. Temporary impacts associated with maintaining fuelbreaks within the Plan Area are identified, as well as more permanent impacts resulting from game mammal management. The approach taken for estimating take levels for each species over a 25-year term is described in Section 5.3. Anticipated levels of take for the Covered Species are based on modeling and field surveys conducted within the Plan Area.

This section describes the activities within the Plan Area that will be covered by the incidental take license and for which the HCP provides avoidance, minimization, and mitigation for impacts to the Covered Species. Incidental take authorization is being sought for resource management, specifically game mammal management and associated hunting activities that are described in this section.

## 5.1 IMPACTS TO PLANTS

### 5.1.1 Grazing, Browsing, and Trampling

The only two mammals that are native to Hawai‘i are the Hawaiian hoary bat (*Lasiurus cinereus semotus*) and the Hawaiian monk seal (*Monachus schauinslandi*). Because of this, native Hawaiian plants evolved in the absence of browsing and grazing mammals, and they often lack physical and chemical defenses that would help protect them.

Potential negative impacts from game mammal management activities on Covered Plant species are primarily in the form of direct take from grazing, browsing, and trampling. Appendix C describes a study done within the Plan Area that investigated the effects of ungulates on a number of the Covered Plant species. The results of the study indicate that those individuals outside of fences were negatively impacted by ungulates. Those *in situ* individuals of Covered Species that will be not protected by ungulate proof fences are considered subject to take and are covered under this HCP.

## 5.2 IMPACTS TO BLACKBURN'S SPHINX MOTH

Potential negative impacts to Blackburn's sphinx moth in the Plan Area are possible through the loss of native host plants (‘Aiea) which are susceptible to ungulate browsing, grazing, and trampling, as well as loss of non-native host plants, such as tree tobacco, that now colonize roadsides and fuel-breaks across the Plan Area through road maintenance and clearing. Assessment of the cumulative impact of Plan actions on *M. blackburni* is discussed in this section.

### 5.2.1 Grazing, Browsing, and Trampling

Take of larvae on its native host plant, ‘Aiea, due to direct and immediate ungulate pressure is unlikely, because the impacts of ungulate pressure may take years to cause tree death, and Blackburn's sphinx moth egg laying and larval development is seasonal. It has also been suggested that adult moths will take their time in finding suitable host sites for eggs (Kitching and Cadiou 2000), and therefore would be unlikely to lay eggs on a dead or dying ‘Aiea. By the time an ‘Aiea tree has senesced due to ungulate grazing or trampling adult moths will no longer lay eggs on the tree.

### 5.2.2 Clearing and Maintaining Fuelbreak Roads

Roadside and fuelbreak maintenance within the Plan Area is critical for at least two major reasons. First, clearing reduces the quantity of fine fuels that can lead to fires as well as prevents the spread of fire into new areas. And second, clearing these roads provides continued access for fire control vehicles, natural resource management, hunting, hiking, and educational and research visits. One of the primary shrubs being cleared on the roads and fuelbreaks is the non-native tree tobacco, which is a host plant for the Blackburn's sphinx moth. Clearing of roads and fuelbreaks (if not timed correctly) could potentially lead to the direct take of Blackburn's sphinx moth through loss of eggs and larvae. However, provisions put forth in this HCP (*see Section 4.3*) will avoid and minimize take to the greatest extent feasible. Fuelbreak roads need to be maintained free of vegetation year-round in order to adequately reduce fire risk. Fuelbreaks are created and maintained around each exclosure to limit the risk of fire within fenced units. Vegetation is cleared mechanically and with herbicides. Equipment used for clearing includes, but is not limited to:

- Skid sprayers with a boom and wand
- All-terrain vehicle and utility vehicle (ATV) battery pump sprayers
- Backpack sprayers
- Weed whackers
- ATV tow-behind brush/grass mowers
- Tractors
- Pruners, clippers, loppers, hand saws, chainsaws
- Small plastic containers for treating stumps
- Bulldozers

Fuelbreak roads are sprayed with herbicide after precipitation events that lead to vegetation regrowth. Most rainfall in the Plan Area occurs between December and May. The number of spraying events varies based on label instructions (i.e. allowable quantities) and vegetative growth, and can range from near zero (e.g., such as in drought years like 2010), to eight times a year. If vegetation has already consumed a large portion of the road or fuelbreak, then the vegetation is initially cleared with an ATV tow-behind brush/grass mower, a weed whacker, or a tractor. Once this vegetation has been cleared and a new flush of green growth has appeared, then herbicides are applied to prevent regrowth.

An herbicide product with the active ingredient glyphosate is typically used for road and fuelbreak maintenance. Application quantities are based on label instructions. A concentration of 1.5 - 3 percent is usually used depending on the time of year, amount, and type of vegetation. Lower concentrations can easily kill grasses, but higher concentrations may be needed to kill small trees or shrubs. A blue dye is used at approximately one ounce per gallon to mark areas where the herbicide has been sprayed. Broadcast spray is not effective on larger woody shrubs, and instead the cut and treat method is used. Loppers, clippers, handsaws, and chainsaws are typically used to cut the shrub, and then the stump is treated with a product with an active ingredient of Triclopyr. The Triclopyr product is often mixed with 70 percent crop oil (a surfactant that makes the herbicide stick to the stump) and blue dye. The types and quantities of pesticides used for road and fire fuelbreak maintenance may vary depending on factors such as cost, availability, evolved plant resistance to herbicide, and density. Regardless of the herbicides used, all label specifications and all regulations for use of herbicides in forested and natural areas will be followed for all vegetation control required in this HCP.

### 5.2.3 Clearing Tree Tobacco within Exclosures

Tree tobacco found within conservation units will be removed as part of invasive species management. Prior to removal, all tree tobacco will be surveyed for Blackburn’s sphinx moth eggs and larvae. Unoccupied tree tobacco plants will be removed to prevent future use by the Blackburn’s sphinx moth. Plants less than one meter tall will be removed by pulling, while plants greater than one meter tall will be cut and treated with herbicide. Should any larvae be found just prior to plant removal or cutting, the larvae will be removed and relocated by trained, authorized staff to a nearby location outside the area of disturbance that contains suitable moth habitat to avoid direct take.

## 5.3 ESTIMATING PLAN RELATED IMPACTS

This section focuses on methods used for estimating populations within the Plan Area. For plant populations, a model has been developed to estimate plant species abundance in the unsurveyed areas, and we use the HCP survey data and model to calculate take estimates for each plant species covered under this HCP. For *M. blackburni*, the distribution of tree tobacco was documented with the goal of calculating the acreage of Blackburn's sphinx moth habitat affected by road clearing and fuelbreak maintenance. These estimates were used to create a mitigation strategy for each of the Covered Species (*See Section 7, Implementation, for more information*).

### 5.3.1 Estimating Rare Plant Population Size

In order to estimate the size of Covered Plant Species populations within the Plan Area, we used a method based on 1) the number of plants found during HCP surveys, 2) the amount of area surveyed, and 3) the types of physical environments within which surveys took place. Because the Area of Potential Impact (Figure 1.2) includes all areas within 2.25 km of Puʻu Waʻawaʻa and Puʻu Anahulu, we generated a 2.25 km buffer to reflect the entire action area (Figure 5.1). The Area of Potential Impact is defined as the Plan Area plus the buffer zone (*See section 1.3.1 for a full description of the Area of Potential Impact*). The buffer size was calculated using the home range data (see Appendix A) collected for pigs, sheep, and goats. Of the three game mammals that occur within the Plan Area, goats have the largest home range, 16.3 km. This 2.25 km buffer area is used to estimate the number of Covered Plant species potentially affected by game mammal management activities outside the boundary of Puʻu Waʻawaʻa and Puʻu Anahulu. These abundance estimates are used to create the take estimates for each Covered Species and no actual management will occur within the 2.25 km buffer as the lands do not belong to the state.

Extensive surveys completed between 2003 and 2007 were focused in areas where rare species had been found in the past, as well as areas with the best remaining native dominated habitat. The 2003 -2007 survey data was used to estimate the areas with the highest likelihood of harboring Covered Plant species within the Plan Area. Estimates were then used to focus new plant surveys in 2011 on select areas (see Figure 3.3). Both data sets were combined to create a new estimate of the number of Covered Species that may occur in the unsurveyed areas of the Plan Area.

First, all of the point location data for each Covered Plant species was collated into a single GIS coverage. Next, we estimated the approximate area that was surveyed using the following assumptions. All surveys were recorded as track files on GPS device, and additional plant locations located away from these tracks represent areas where surveyors went; while it is logical to assume areas were surveyed along the way to these points, we have no way of knowing where these are, and therefore have slightly underestimated the area surveyed. Next, assuming each surveyor can perform a thorough visual sweep of the area up to 50 m from the path for herbaceous species, 100 m for ground survey of woody species, and 200 m for helicopter surveys of woody species, we generated buffers around all tracks and plant location points to estimate the entire area surveyed (Figure 5.2 and Figure 5.3).

The Plan Area is characterized by a large elevational gradient, a moderate range of moisture (relative to other areas in Hawai‘i - see Figure 5.4), an array of different substrate ages, and some variation in the land use and fire history. While some imagery and vegetation maps are available for the area, these are very general and provide little information with which to associate species with potential habitat. Additionally, fire maps are inadequate and provide little information about areas that have burned (and are therefore potentially less likely to harbor rare plants). Therefore, we used GIS layers of geologic substrate age (Wolfe and Morris 1996) and general climatic moisture (Price et al. 2012) to subdivide the region into distinct habitat units; because the "Moderately Dry" moisture zone extended from 500 m elevation up to 2,000 m elevation, we used a digital elevation model to divide all combinations involving that moisture zone at 1,100 m. The result is habitat units with different combinations of moisture, age, and elevation. In total, 35 habitat units were recognized (Figure 5.5).

By overlaying the surveyed areas against each habitat unit, we can determine how much of each habitat unit was surveyed. Overall, we estimate that 14% of the action area was surveyed with a capacity for detecting herbaceous species and 29% was surveyed with a capacity to detect woody species (both trees and shrubs). Ten habitat units had greater than 20% of their areas surveyed; however, four habitat units had less than 1% of their areas surveyed (in these cases no extrapolation can be made). Overall, most habitat units had sufficient areas surveyed to determine the likelihood that a given species might occur there. Furthermore, since the moisture and elevation limits have been mapped for each species (Price et al. 2012), further analysis was restricted to areas where each species could feasibly occur; this avoids over-estimation of potential habitat in the action area.

For each species, the number of individuals outside the survey areas and outside proposed or current exclosures was estimated. To do this, we first calculated the number of individuals of each Covered Species within the surveyed portion of each habitat unit. Then the average density of individuals recorded within each habitat type was estimated by dividing the number of individuals by the area of each habitat type surveyed. The average density was then used to estimate the number of individuals of each species within the areas of the same habitat units that were not surveyed. For example, imagine a habitat unit occupies 1 $km^2$ total, of which 20% was surveyed. If 10 individuals were recorded in the surveyed portion of the unit we would calculate a density of 10 individuals divided by 0.2 $km^2$ equaling 50 individuals/ $km^2$. By using this same value for the unsurveyed portion of the unit (0.8 $km^2$), we would multiply the density of 50 individuals/ $km^2$ times 0.8 $km^2$, which equals 40 individuals. We obtained the total take estimate by summing the estimated number of individuals within the take area of each habitat, which in this example, totals 50 individuals.

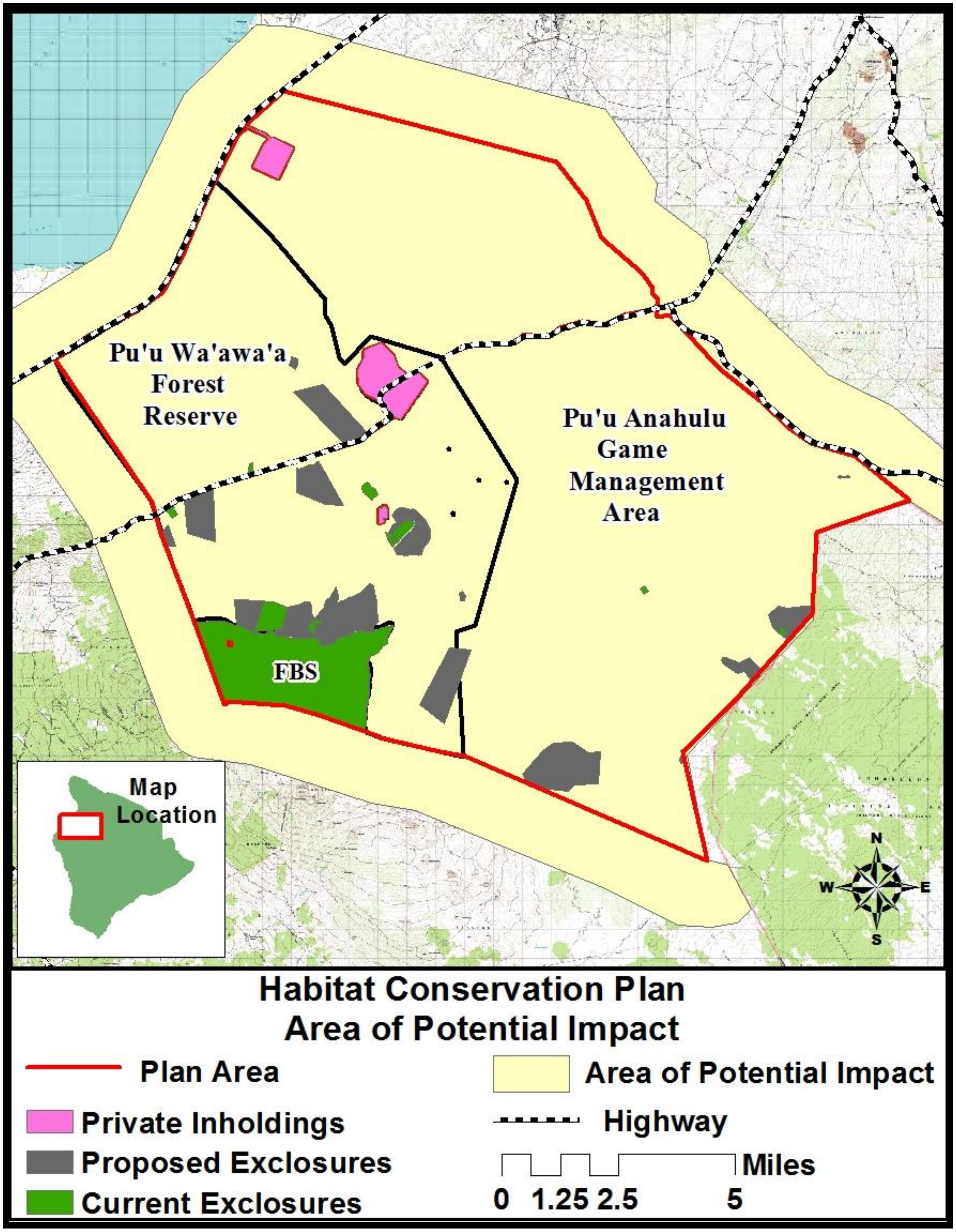


**Figure 5.1** The HCP Area of Potential Impact including the 2.25 km buffer around all boundaries with the exception of PTA where a boundary fence prohibits the movement of ungulates.

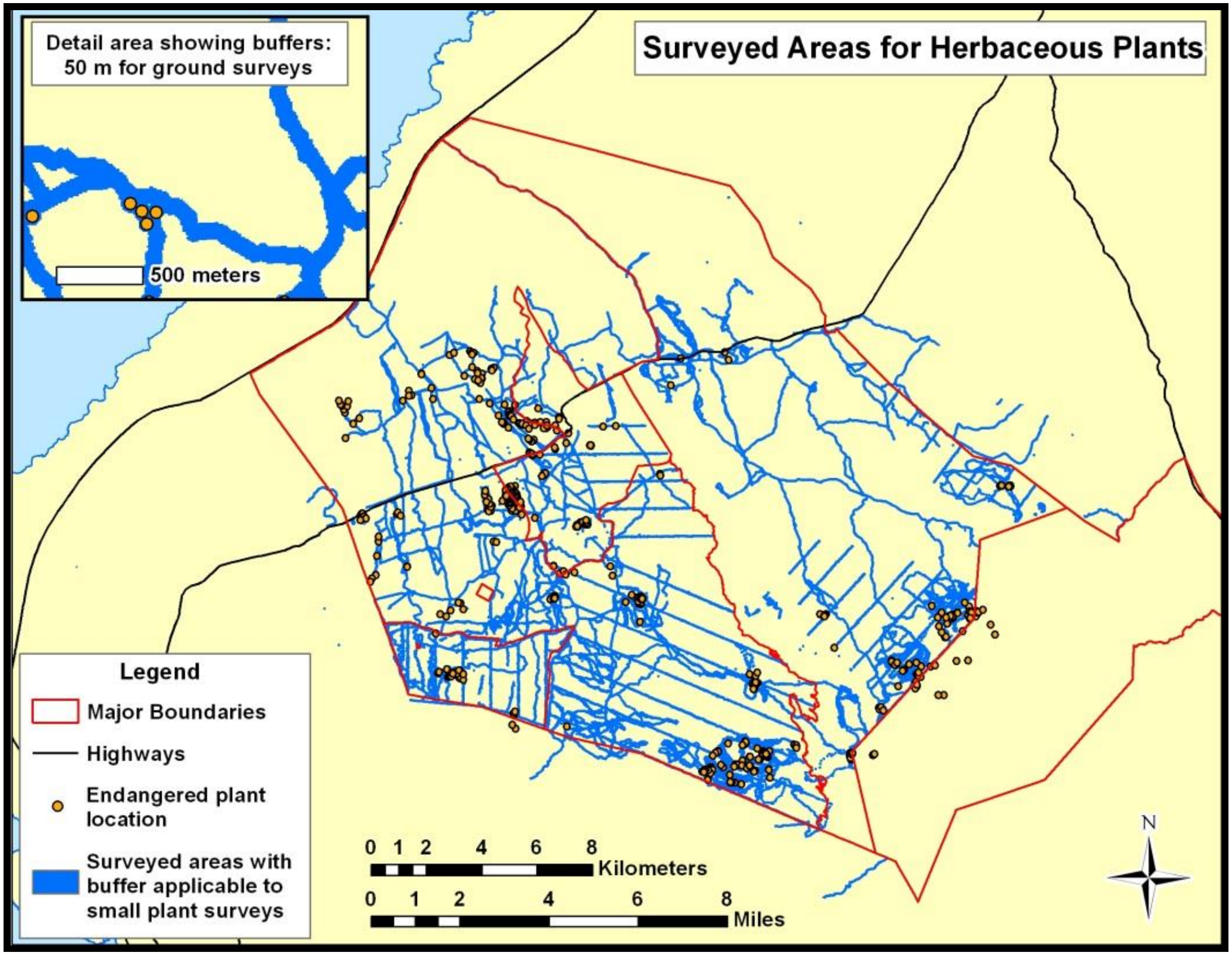


**Figure 5.2** Surveyed areas within the Action Area including all 4x4 roads and a 50 m buffer around all tracks and guided searches for herbaceous species.

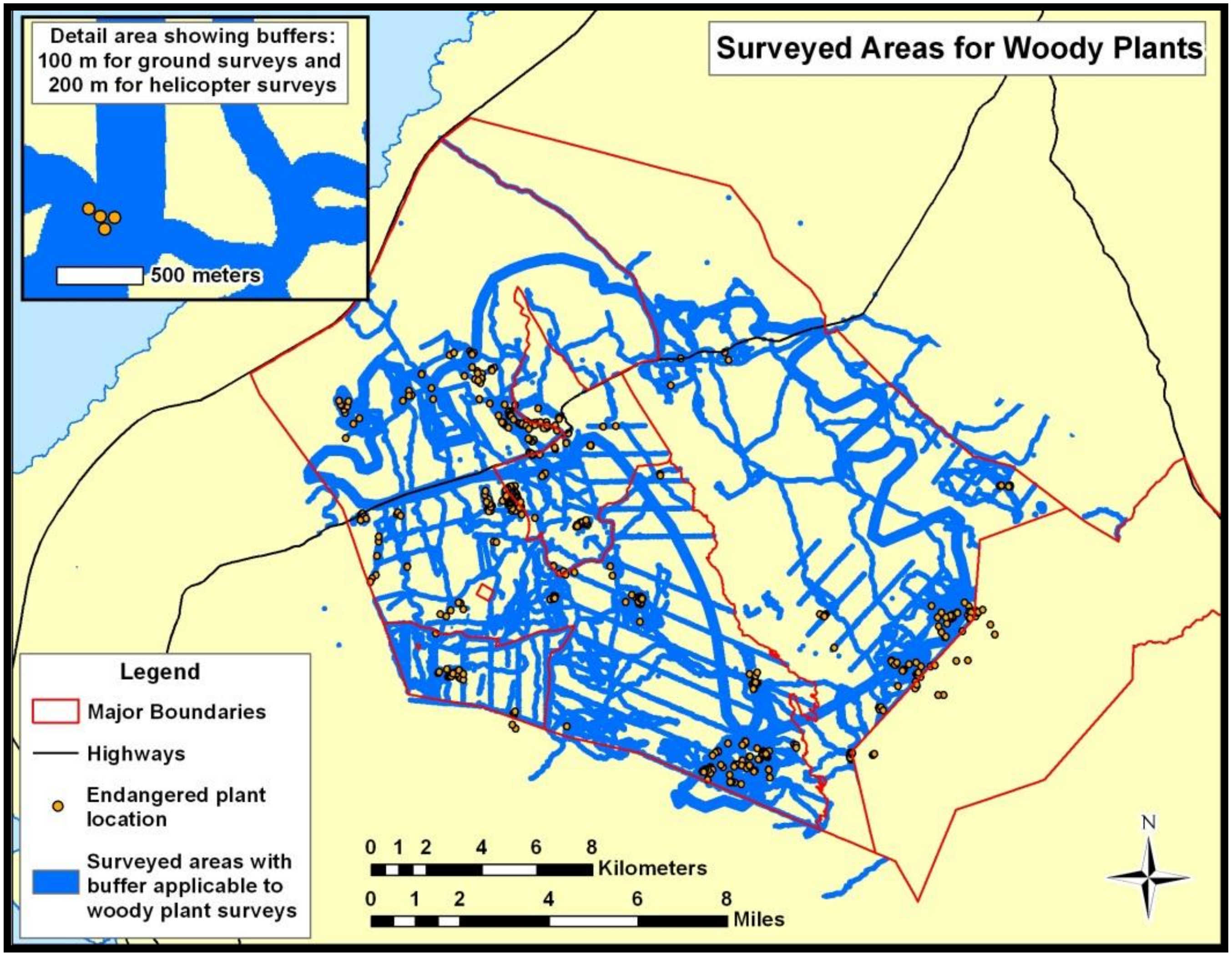


**Figure 5.3** Surveyed areas within the Area of Potential Impact including all 4x4 roads and a 100 m buffer for ground and 200 m for helicopter surveys all tracks and guided searches for surveys of woody species.

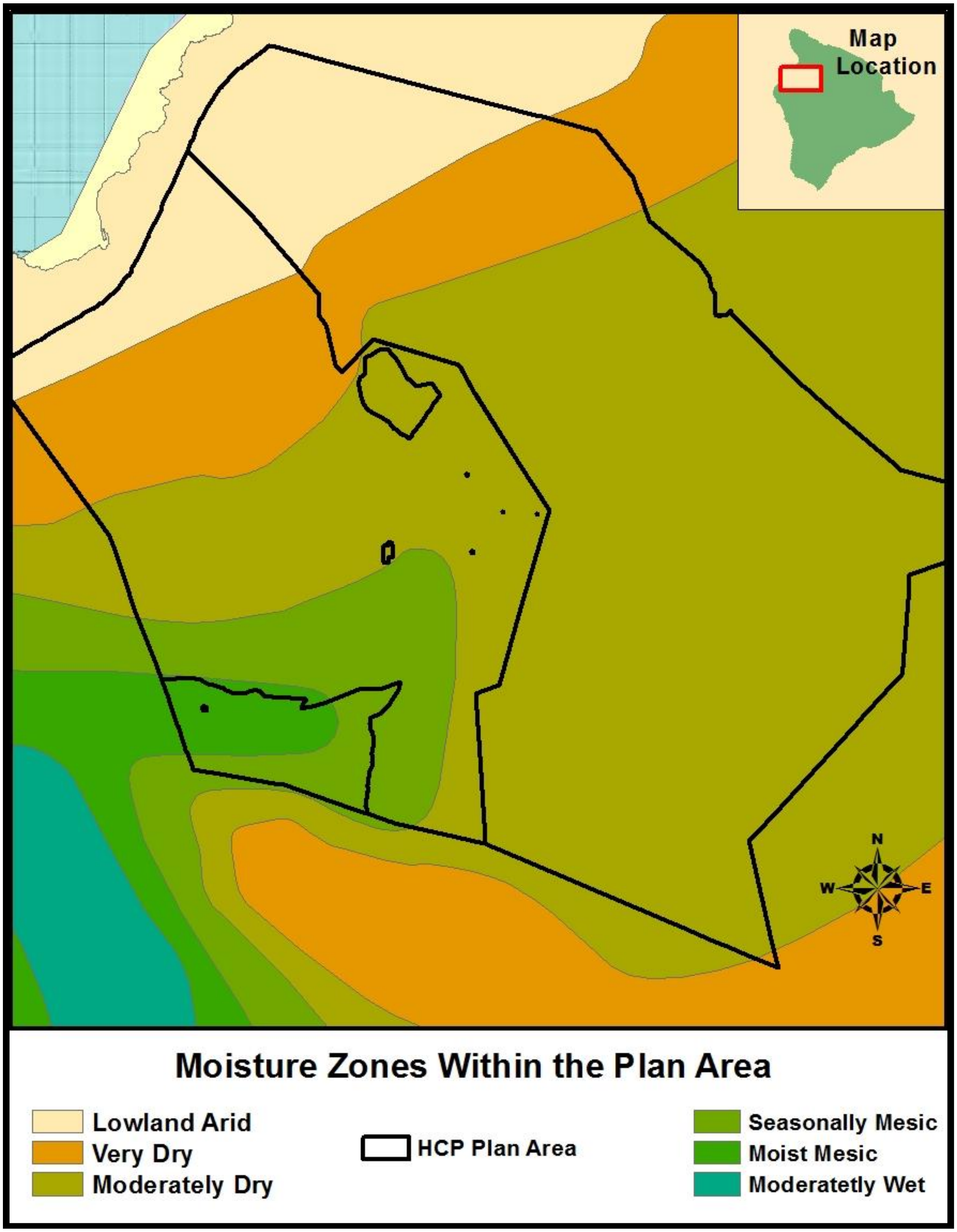


**Figure 5.4** Moisture zones found within the Area of Potential Impact. Moisture zones were used as a proxy for elevation in defining habitat types for developing the model used to estimate number of plant individuals found outside of surveyed areas.

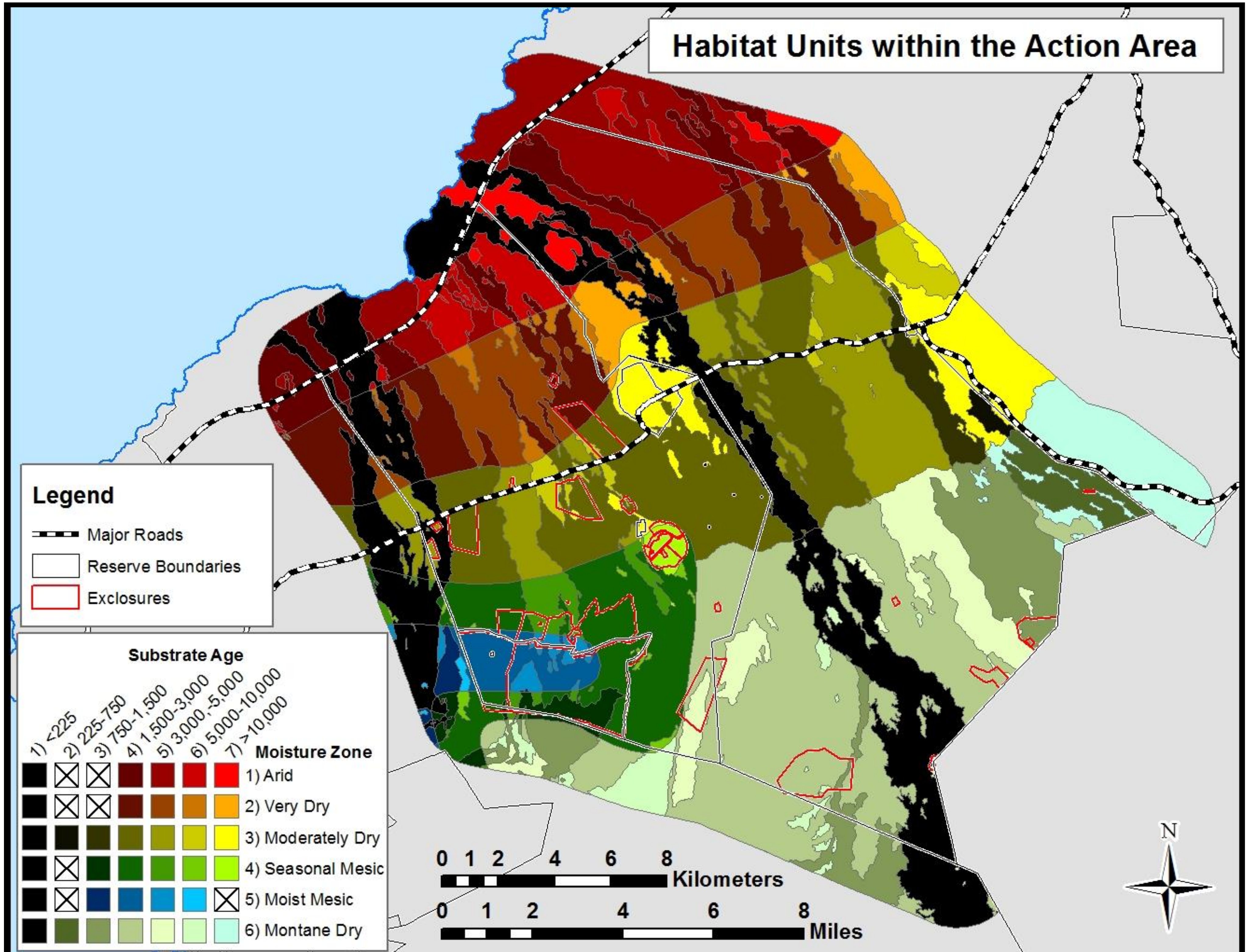


**Figure 5.5** Habitat types found within the Area of Potential Impact as defined by moisture zone and substrate type.

### 5.3.2 Estimating Take of Covered Plant Species

Take estimates were calculated for each of the Covered Plant species using the HCP survey data (Table 5.1), the estimates generated from the model, and the location and size of the proposed and current exclosures. The number of known (surveyed) individuals is added to the estimated number of individuals (based on model predictions) to give a total population estimate. This information is summarized in Table 5.2 and details for each Covered Species and the corresponding exclosures are described below. The final numbers used in the plant model are based on the most up-to-date plant survey values. During the 2011 botanical surveys, the area proposed for the Kauila conservation unit was completely censused. Because the 2011 survey was more comprehensive and more accurate than those done during the 2003-2007 surveys, the 2011 results were used for this area and the previous data (2003-2007) were removed (*please see section 3.5.3 for details on botanical surveys*).

**Table 5.1** Final plant numbers used for population modeling.

| Scientific Name | Common Name | Number of Individuals |
|---|---|---|
| *Chrysodracon hawaiiensis* | Hala pepe | 299 |
| *Colubrina oppositifolia* | Kauila | 739 |
| *Haplostachys haplostachya* | Honohono | 80 |
| *Hibiscus brackenridgei* | Maʻo hau hele | 65 |
| *Kokia drynarioides* | Kokiʻo | 4 |
| *Mezoneuron kavaiense* | Uhiuhi | 48 |
| *Neraudia ovata* | | 9 |
| *Nothocestrum breviflorum* | ʻAiea | 156 |
| *Silene lanceolata* | Hawaiian Catchfly | 235 |
| *Solanum incompletum* | Pōpolo kū mai | 13 |
| *Stenogyne angustifolia* | | 98 |
| *Zanthoxylum dipetalum* var. *tomentosum* | Aʻe | 13 |
| *Zanthoxylum hawaiiense* | Aʻe | 219 |

**Table 5.2** Estimated take of Covered Plant Species. Estimates were only made within habitat types where the species was documented, and only within the known geographical range of the species (as given in (Price et al. 2012)). The area documented as surveyed differed according to whether the plant species is woody or herbaceous. We considered detection of an individual to be any 10 by 10 meter grid square that contains at least one surveyed plant location (see main text for explanation). Density was calculated as the number of detections divided by the area surveyed for each habitat. Unsurveyed take area consists of areas that have not been surveyed and lie outside of proposed or existing conservation exclosures. Estimated numbers of undetected plants represent the density of individuals detected in a given habitat multiplied by the unsurveyed take area.

| Species | Habitat Type | % of habitat surveyed | Amount of habitat surveyed ($km^2$) | Number of individuals in habitat | Density of individuals (per $km^2$) | Unsurveyed take area ($km^2$) | Projected number of undetected plants in take area[18] | Number of individuals in take area | Total projected take |
|---|---|---|---|---|---|---|---|---|---|
| ***Chrysodracon hawaiiensis*** | 24 | 29.5 | 9.2 | 10 | 1.1 | 21.9 | 24 | 1 | 25 |
| | 34 | 49 | 30.5 | 212 | 7.0 | 24.8 | 173 | 42 | 214 |
| | 35 | 31.1 | 11.3 | 5 | 0.4 | 6.3 | 3 | 5 | 8 |
| | 36 | 21 | 1.7 | 7 | 4.1 | 15.7 | 65 | 1 | 66 |
| | 37 | 24.9 | 6.2 | 2 | 0.3 | 4 | 2 | 2 | 3 |
| | 44 | 50.9 | 4.7 | 1 | 0.2 | 4 | 1 | 1 | 2 |
| | 47 | 47.6 | 0.5 | 62 | 124 | 0.1 | 13 | 0 | 12 |
| | **Total** | **36.9** | 58.1 | **299** | **4.7** | **76.8** | **279** | **52** | **331** |
| ***Colubrina oppositifolia*** | | | | | | | | | |
| | 24 | 32.1 | 8.7 | 3 | 0.3 | 18.2 | 7 | 1 | 7 |
| | 34 | 49.8 | 29.5 | 723 | 24.5 | 28.6 | 701 | 51 | 752 |
| | 35 | 30.5 | 10.6 | 4 | 0.4 | 23.9 | 10 | 4 | 13 |
| | 36 | 21.0 | 1.7 | 8 | 4.7 | 6.3 | 30 | 1 | 31 |
| | 44 | 45.7 | 2.8 | 1 | 0.4 | 3.1 | 2 | 1 | 2 |
| | **Total** | **39.4** | **53.3** | **758** | **14.2** | **80** | **767** | **58** | **805** |

[18] In cases where a take of a partial individual is calculated, the values are rounded up.

| Species | Habitat Type | % of habitat surveyed | Amount of habitat surveyed ($km^2$) | Number of individuals in habitat | Density of individuals (per $km^2$) | Unsurveyed take area ($km^2$) | Projected number of undetected plants in take area[18] | Number of individuals in take area | Total projected take |
|---|---|---|---|---|---|---|---|---|---|
| ***Haplostachys haplostachya*** | | | | | | | | | |
| | 67 | 9.0 | 1.8 | 80 | 44.4 | 17.9 | 796 | 0 | 796 |
| | **Total** | **9.0** | **1.8** | **80** | **44.4** | **17.9** | **796** | **0** | **796** |
| ***Hibiscus brackenridgei*** | 34 | 51.5 | 25.3 | 65 | 2.6 | 22.7 | 59 | 0 | 58 |
| | **Total** | **51.5** | **25.3** | **65** | **2.6** | **22.7** | **59** | **0** | **59** |
| ***Kokia drynariodes*** | 34 | 92.6 | 20.3 | 4 | 0.2 | 1.3 | 1 | 0 | 1 |
| | **Total** | **92.6** | **20.3** | **4** | **0.2** | **1.3** | **1** | **0** | **1** |
| ***Mezoneuron kavaiense*** | 24 | 29.0 | 9.0 | 28 | 3.1 | 21.9 | 69 | 17 | 85 |
| | 25 | 34.1 | 9.3 | 20 | 2.2 | 18.0 | 39 | 20 | 59 |
| | **Total** | **31.4** | **18.3** | **48** | **2.6** | **39.9** | **107** | **37** | **144** |
| ***Neraudia ovata*** | | | | | | | | | |
| | 63 | 23.3 | 4.1 | 4 | 1.0 | 13.2 | 13 | 1 | 14 |
| | 64 | 25.7 | 13.7 | 4 | 0.3 | 39.1 | 12 | 0 | 11 |
| | 65 | 18.7 | 3.2 | 1 | 0.3 | 13.9 | 5 | 0 | 4 |
| | **Total** | **23.9** | **21.0** | **8** | **0.4** | **66.2** | **28** | **1** | **29** |
| ***Nothocestrum breviflorum*** | 24 | 29.5 | 9.2 | 1 | 0.1 | 25.1 | 3 | 1 | 4 |
| | 31 | 12.6 | 2 | 3 | 1.5 | 13.8 | 21 | 2 | 23 |
| | 34 | 49 | 30.5 | 43 | 1.4 | 30.6 | 44 | 22 | 65 |
| | 35 | 31.1 | 11.3 | 8 | 0.7 | 24.8 | 18 | 1 | 19 |
| | 41 | 1.9 | 0.1 | 2 | 20.0 | 3.8 | 76 | 2 | 78 |
| | 44 | 60.4 | 16.8 | 78 | 4.6 | 8.2 | 39 | 25 | 63 |
| | 45 | 37.2 | 2 | 6 | 3.0 | 2.5 | 8 | 0 | 8 |
| | 46 | 51.2 | 0.6 | 2 | 3.3 | 0.5 | 2 | 2 | 4 |

| Species | Habitat Type | % of habitat surveyed | Amount of habitat surveyed ($km^2$) | Number of individuals in habitat | Density of individuals (per $km^2$) | Unsurveyed take area ($km^2$) | Projected number of undetected plants in take area[18] | Number of individuals in take area | Total projected take |
|---|---|---|---|---|---|---|---|---|---|
| | 47 | 41.5 | 0.8 | 1 | 1.3 | 0.1 | 1 | 1 | 1 |
| | 54 | 70.4 | 5.4 | 10 | 1.9 | 0.3 | 1 | 0 | 1 |
| | 55 | 59.5 | 1.4 | 2 | 1.4 | 0.4 | 1 | 0 | 1 |
| | **Total** | **40.3** | **80.1** | **156** | **2.5** | **110.1** | **211** | **79** | **265** |
| ***Silene lanceolata*** | 61 | 6.6 | 1.8 | 79 | 43.9 | 25.8 | 1132 | 79 | 1211 |
| | 63 | 19.8 | 4.7 | 35 | 7.4 | 18.7 | 139 | 5 | 144 |
| | 64 | 26.2 | 19.1 | 121 | 6.3 | 53.1 | 336 | 121 | 457 |
| | **Total** | **18.6** | **25.6** | **235** | **9.2** | **97.6** | **1607** | **205** | **1812** |
| ***Solanum incompletum*** | 61 | 6.6 | 1.8 | 4 | 2.2 | 25.8 | 58 | 0 | 57 |
| | 65 | 21.1 | 4.1 | 8 | 2.0 | 15.3 | 30 | 0 | 30 |
| | **Total** | **27.7** | **5.9** | **12** | **2.0** | **45.3** | **87** | **0** | **87** |
| ***Stenogyne angustifolia*** | 63 | 19.8 | 4.7 | 15 | 3.2 | 18.7 | 60 | 0 | 60 |
| | 64 | 26.7 | 19.2 | 83 | 4.3 | 52.1 | 226 | 40 | 265 |
| | **Total** | **46.5** | **23.9** | **98** | **4.1** | **70.8** | **285** | **40** | **325** |
| ***Zanthoxylum dipetalum*** | 44 | 57.7 | 10.5 | 8 | 0.8 | 6.1 | 5 | 5 | 10 |
| | 45 | 35.9 | 1.7 | 4 | 2.4 | 2.5 | 6 | 3 | 9 |
| | 47 | 40.4 | 0.8 | 1 | 1.3 | 0.1 | 1 | 0 | 0 |
| | **Total** | **52.1** | **13.0** | **13** | **1.0** | **8.7** | **11** | **8** | **19** |
| ***Zanthoxylum hawaiiense*** | 61 | 18.8 | 4.1 | 3 | 0.7 | 17.6 | 13 | 3 | 16 |
| | 63 | 47.0 | 10.1 | 13 | 1.3 | 11.3 | 15 | 1 | 16 |
| | 64 | 49.5 | 33.9 | 203 | 6.0 | 24.4 | 147 | 40 | 186 |
| | **Total** | **43.1** | **48.0** | **219** | **4.6** | **63.3** | **176** | **44** | **218** |

### 5.3.3 Loss of Recruitment

Those individuals of Covered Species that occur outside of current and proposed fenced units are considered unprotected and will be included within the take estimate. Propagules from these individuals will be collected to ensure genetic representation in mitigation populations. In addition to the loss of these individuals, concern has been raised about the loss of recruitment from these unprotected individuals. In order to address this concern, one additional population (following stabilization criteria) will be created for each of the Covered Species to mitigate for this potential loss of recruitment. Monitoring will be done to estimate the level of potential take of seeds that germinate around unprotected plants and are harmed as a result of Covered Activities. For each of the Covered Plant Species, a minimum of 10 fenced individuals (where 10 individuals still exist) will be monitored on an annual basis (for five years) to count the number of recruited individuals and estimate an average recruitment for that species. An estimated rate of loss of recruitment will be calculated for each species. Should values calculated from monitoring data exceed those proposed for in the stabilization criteria, the additional values will be added to the overall take estimate (*For more detailed description of methods please see the Monitoring Section 7.2*).

### 5.3.4 Strategies for Stabilization of Covered Species

The focus for the stabilization of threatened and endangered species occurring within the Plan Area will be on restoration and protection of functional native plant communities. These communities should support not only stable Covered Species populations, but represent fully functional (in so far as possible), self-sustaining communities with eventual minimal dependence on human management. Measures of success for the purposes of the HCP are necessarily focused on specific protected species, but our management approach (per HRS §195 D-1, -4, and -21) recognizes that these species may never be truly stable and protected unless they are part of a functioning community.

The first step in developing our management strategy is to identify and use areas within the Plan Area that contain established native overstory tree species within which a matrix of rare and endangered species can be managed. Those populations of listed species located in areas with higher quality habitat will have priority and will be managed for stability. Those populations or individuals located in degraded habitat will be individually fenced and used primarily as propagule sources to maintain genetic diversity of outplanted areas. Within the first five years of HCP implementation, all propagule source plants will be mapped and database created to track what individuals have been collected from and which individuals still need genetic representation.

The U.S. Fish and Wildlife Service (USFWS) defines plant stabilization according to the recommendations put forth by the Hawai‘i and Pacific Plants Recovery Coordinating Committee (HPPRCC), a group of botanical experts gathered together by the USFWS to offer guidance on the recovery of listed plants in the Pacific (Army 2003b). The HPPRCC states that a species is considered to be stable if it meets the following three criteria: 1) it has sufficient numbers of regenerating individuals in a minimum number of populations (specified below); 2) its threats are controlled at these populations; and 3) these populations are fully represented in an *ex situ* collection (USFWS 1999). A population in this context is defined and used here as 1) a given number of individuals found less than 1,000 m apart, that 2) are presumably genetically similar and therefore capable of outcrossing, and 3) are equally affected by localized stochastic events such as fire (Army 2003b). It is important to note that the requirements for stabilization are far below those required for delisting or down listing, and that stabilization is <u>not</u> synonymous with recovery.

The HPPRCC (1994) recommends the following population stability goals: three populations of plants with a minimum of either 25 mature and reproducing individuals of long-lived perennials (>10 year life span), 50 mature and reproducing individuals of short-lived perennials (<10 year life span), or 100 mature and reproducing individuals of annual taxa per season (<1 year life span). The HPPRCC (1994) outlines that sustaining populations with these numbers of reproducing individuals over the short-term will ensure that there will be an adequate reservoir of younger individuals that can develop into mature, reproducing plants with each subsequent generation to prevent extinction. However, this approach is not adequate long-term to achieve full recovery of the taxon (Army 2003b).

Factors that will be considered when assessing mitigation goals for this HCP include threats that contribute to the decline of the target taxa and aspects of their biology (especially reproductive biology) that are pertinent to natural regeneration, as well as the state of knowledge regarding propagation, cultivation, and *in situ* care of wild individuals.

Reintroduction and augmentation of Covered Species will follow the guidelines set forth by the Hawaiʻi Rare Plant Restoration Group (HRPRG) (Army 2003a). By definition, reintroduction is the introduction of individual(s) of a given species into an area of known historical range where no individuals currently occur (Army 2003b, a). Augmentation is defined as the introduction of propagules or individual(s) of a given species into an area in which a population is currently extant (Army 2003b, a). In both cases a number of considerations must be taken, particularly relating to genetic integrity. Specific guidelines will be developed to ensure mitigation efforts will not harm or endanger current extant populations of listed species.

### 5.3.5 Factors Influencing Effective Population Size

Effective population ($N_e$) size is the average number of individuals in a total population (N) that actually contribute genes to succeeding generations. The following factors may influence the effective population size of plant species thereby requiring a larger number of individuals needed to reach an equivalent $N_e$. For this reason, these factors will be considered during mitigation planning on a species by species basis (Table 5.2).

1. <u>Obligate outcrossing:</u> The fertilization of a flower of a genetically distinct individual by the pollen of another genetically distinct individual is known as outcrossing. For taxa incapable of self-fertilization, outcrossing is obligatory, meaning if there is no outcrossing there will be no viable offspring produced. Once a population of an obligately outcrossing taxon becomes too small, or the distance between individual plants increases beyond the range of pollination mechanisms, the population's regeneration rate may decrease, leading to a decline

in the number of individuals recruited annually. **Therefore, for taxa that obligately outcross, the base population target should be doubled.**

2. Dioecy: Dioecy is the condition in which an individual plant produces only functionally staminate (male) or pistillate (female) flowers. Dioecious plants require the presence of both male and female individuals within pollination range that are flowering at the same time in order to effect fertilization and successful seed set. It is therefore much more difficult to ensure conditions for regeneration with dioecious taxa.

3. Vegetative reproduction: Plants that reproduce vegetatively produce clones of themselves, so that an area that appears to be composed of unique individuals may actually be composed of many genetically identical individuals. These groups of individuals are often more genetically similar within populations and more distinct between populations than taxa that reproduce sexually.

4. Infrequent or inconsistent flowering: Since flowering is a key component of reproduction, any inconsistency in flowering or reduction in the frequency of flowering reduces $N_e$ and therefore reduces the likelihood of maintaining population stability. For example, there are some cases where, although the great majority of individuals in a population flower, flowering occurs infrequently. The likelihood of environmental events (e.g., droughts, fires, storms) reducing mass flowering and successful fruiting is much greater for plants that flower sporadically or infrequently than for plants that flower more regularly or frequently. **In those taxa with known infrequent or inconsistent flowering, the population target is doubled.**

5. Large percentage of non-flowering or non-fruiting plants: This problem is similar to the infrequent or inconsistent flowering factor described above, but concerns populations in which, even during peak flowering times, the majority of individuals do not flower, or are not able to produce fruit or seed. **$N_e$ is much lower than N in this case, and the population target is doubled.**

6. Low seed set or poor seed viability: Low seed set or poor seed viability, whether due to seed predation, disease, pollination failure, or other factors, can potentially lead to decreases in reproductive potential. **For taxa with low seed set or poor viability, the target population goal is doubled.**

7. Tendency for large declines or fluctuations in population size: Large declines in population size, even if balanced by large increases at other times, reduce the stability of the population through a reduction in $N_e$. Any negative events during a major low point in a population fluctuation could extirpate the population. **For taxa prone to large declines or fluctuations in population sizes, the population target is doubled.**

8. Persistence of the seed bank: This factor does not warrant increasing the population target, but suggests that surveys of historical occurrences should be conducted to check for regeneration from the seed bank, even years after the last observation of mature individuals at the site. A persistent seed bank in a population of short-lived individuals could buffer fluctuations in population size.

For many of the listed species in the Plan Area basic life history information such as phenology, pollinators, and seed viability is lacking. For this reason, mitigation goals may be adjusted as new information becomes available. Utilizing the HCP plant survey data, those areas containing the highest quality habitat and greatest number of Covered Species will be selected and prioritized for conservation. For each species, we used the population estimates (Table 5.1) in conjunction with the identification of those factors that may influence effective populations size (Table 5.2) to determine mitigation goals for each covered plant species (*See section 6.3 for species specific mitigation goals*). Species stabilization guidelines will also be used to set goals for additional populations that must be established to provide a net benefit for each Covered Species. In addition, we identified sites for potential reintroduction (*see section 6.1*), as well as future augmentation needs for each species. Future plans include documenting the health and threats to plants within both proposed and current exclosures (i.e. weeds, compromised fences etc).

**Table 5.3** The life form (SP= short-lived perennial, LP= long-lived perennial) and factors affecting effective population size for Covered Species in the Plan Area.

| Scientific Name | Common Name | Life Form | Applicable Factors |
|---|---|---|---|
| *Asplenium peruvianum* | | SP | Unknown |
| *Mezoneuron kavaiense* | Uhiuhi | LP | Tendency for large declines or fluctuations in population size (wildfire) |
| *Colubrina oppositifolia* | Kauila | LP | Unknown |
| *Haplostachys haplostachya* | Honohono | SP | Tendency for large declines or fluctuations in population size (wildfire, drought) |
| *Hibiscus brackenrdgei* | Maʻo hau hele | SP | Unknown |
| *Kokia drynarioides* | Kokiʻo | SP | Infrequent and inconsistent flowering |
| *Neraudia ovata* | | SP | Dioecious |
| *Nothocestrum breviflorum* | ʻAiea | LP | Unknown |
| *Chrysodracon hawaiiensis* | Hala pepe | LP | Unknown |
| *Portulaca sclerocarpa* | Poʻe | SP | Unknown |
| *Silene lanceolata* | Hawaiian Catchfly | SP | Unknown |
| *Solanum incompletum* | Pōpolo kū mai | SP | Vegetative reproduction, infrequent/inconsistent flowering, large percentage of non-flowering/fruiting plants, low seed set/poor seed viability |
| *Stenogyne angustifolia* | | SP | Unknown |
| *Zanthoxylum dipetalum* | Aʻe | LP | Dioecious, large percentage of non-flowering/fruiting plants, low seed set/poor seed viability |
| *Zanthoxylum hawaiiensis* | Aʻe | LP | Dioecious |

**Table 5.4** Species stabilization goals for each of the Covered Species.

| Scientific Name | Common Name | Populations | Individuals | Threats to Mitigate |
|---|---|---|---|---|
| ***Aslpenium peruvianum*** | | 3 | 50 | fire, invasive species, ungulates |
| ***Mezoneuron kavaiense*** | Uhiuhi | 3 | 50 | fire, invasive species, ungulates |
| ***Colubrina oppositifolia*** | Kauila | 3 | 25 | fire, invasive species, ungulates |
| ***Haplostachys haplostachya*** | Honohono | 3 | 100 | fire, invasive species, ungulates |
| ***Hibiscus brackenridgei*** | Ma‘o hau hele | 3 | 50 | fire, invasive species, ungulates |
| ***Kokia drynarioides*** | Koki‘o | 3 | 100 | fire, invasive species, ungulates |
| ***Neraudia ovata*** | | 3 | 100 | fire, invasive species, ungulates |
| ***Nothocestrum breviflorum*** | ‘Aiea | 3 | 25 | fire, invasive species, ungulates |
| ***Chrysodracon hawaiiensis*** | Hala pepe | 3 | 25 | fire, invasive species, ungulates |
| ***Portulaca sclerocarpa*** | Po‘e | 3 | 50 | fire, invasive species, ungulates |
| ***Silene lanceolata*** | Hawaiian Catchfly | 3 | 50 | fire, invasive species, ungulates |
| ***Solanum incompletum*** | Pōpolo kū mai | 3 | 100 | fire, invasive species, ungulates |
| ***Stenogyne angustifolia*** | | 3 | 50 | fire, invasive species, ungulates |
| ***Zanthoxylum dipetalum*** | A‘e | 3 | 50 | fire, invasive species, ungulates |
| ***Zanthoxylum hawaiiensis*** | A‘e | 3 | 50 | fire, invasive species, ungulates |

### 5.3.6 Estimating Blackburn's Sphinx Moth Habitat Affected by Road and Fuelbreak Maintenance

In 2011 and 2012 the distribution of tree tobacco on roadsides and fuelbreaks was mapped across the Plan Area. Tree tobacco locations were recorded as HCP staff drove a subset of 4x4 roads expected to contain tree tobacco from previous observations. For each location logged, the number of trees within a 25 m x 3 m belt transect was recorded. Tree tobacco locations were recorded on both sides of the road. These locations were used to create a preliminary map of the distribution of tree tobacco across the surveyed area (Figure 5.6). We then used a subset of this data taken in Puʻu Anahulu, to calculate what proportion of the roads that are expected to contain tree tobacco actually are occupied by tree tobacco. For a stretch of road 37,402 m long and 7 m wide (261,814 $m^2$), 649 tree tobacco location survey points were recorded. Each survey point represents a 25 m x 3 m long belt transect that contains tree tobacco. For the subset of road used in this calculation, the total area actually occupied by tree tobacco was 48,675 $m^2$ or approximately 18.6% of the surveyed roads.

Next, a map of the Core Tree Tobacco Invasion Area (CTTIA) was created to indicate which roads in the Plan Area currently contain, have contained in the past, or may contain tree tobacco in the future (Figure 5.7). Based on this map, we estimate the CTTIA to be 839,486.38 $m^2$ or approximately 207 acres. If we assume that the coverage measured above in general characterizes the density of tree tobacco as a whole across the Plan Area (and this is likely a conservative estimate as Puʻu Anahulu tends to have high density), then we can apply this value to the CTTIA (839,486.38 $m^2$ x 0.186), to calculate the area occupied by tree tobacco (Occupied Area = 156,144.467 $m^2$ or 38.6 acres).

### 5.3.7 Tree Tobacco and Blackburn's Sphinx Moth Population Estimate in the Plan Area

We estimated the location and distribution of tree tobacco in the Plan Area based on a helicopter survey conducted in January 2015 (see Figure 5.7). During the helicopter survey, track files and waypoints were taken to map the outer edges of infestation areas as well as map individual tree tobacco locations in less colonized areas. Based on this survey, we estimate that approximately 6,462 acres of the Plan Area (outside of roads) contain tree tobacco (6% of the Plan Area). The winter 2012 off-road BSM survey data was then used to estimate BSM density. A total of 17 Blackburn's sphinx moth detections (larvae and un-hatched eggs) were found on 557 tree tobacco plants across 38 transects. One transect has an area of 75 $m^2$ (25 m x 3 m). Using these data, we calculated: the area surveyed as 2,850 $m^2$ (38 x 75 $m^2$) and BSM density as 0.006 BSM/$m^2$ (17/2850 $m^2$) or 24.1 BSM per acre. Based on the tree tobacco distribution estimated above, the population estimate for Blackburn's sphinx moth larvae and un-hatched eggs outside of roads is 155,734 BSM (24.1 x 6462 = 155,734.2).

An on-road estimate was calculated based on a total of 56 Blackburn's sphinx moth detections (larvae and un-hatched eggs) found on 1766 tree tobacco plants across 80 transects. One transect has an area of 75 $m^2$ (25 m x 3 m). Using these data, we calculated: the area surveyed as 6,000 $m^2$ (80 x 75 $m^2$) and BSM density as 0.009 BSM/$m^2$ (56/6,000 $m^2$) or 37.8 BSM per acre. Based on the Occupied Area calculated above (38.6 acres), estimated take for one winter clearing period rounds up to 1458 Blackburn's Sphinx moth individuals (37.77 x 38.6 = 1457.9 larvae plus un-hatched eggs). We then added the winter 2012 on-road population estimate (1,458 BSM) to the Off-road estimate for a total winter Blackburn's sphinx moth population estimate of 157,445 individuals (larvae plus un-hatched eggs).

### 5.3.8 Estimating Blackburn's Sphinx Moth Take (Based on (USFWS 2015e))

We are requesting take of Blackburn's sphinx moth based on following a schedule that allows DOFAW to clear the roads and fuel-breaks year-round, which is critical to reducing the risk of a catastrophic wildfire. Studies conducted in the Plan Area indicate that larvae and egg densities are highest in the winter months which tend to be the wettest months in the Plan Area. However, weather patterns may be unpredictable and increased rains may extend the larval season (similarly drought conditions may restrict the larval season). Whenever possible control and removal will be timed to reduce adverse effects to Blackburn's sphinx moth eggs and larvae; tree tobacco, especially over one meter tall, will be controlled during dry periods (summer months). In general, tree tobacco clearing will occur year-round at intervals designed to prevent new growth from exceeding one meter. This clearing schedule will reduce the number of eggs and larvae on roads and fuel breaks and minimize the amount of take anticipated to occur as a result of the Covered Activity.

The loss of tree tobacco within roads and fuelbreaks will not substantially reduce the amount of Blackburn's sphinx moth habitat in the North Kona region. There are an estimated 6,500 acres of tree tobacco in the Plan Area both on and off roads/fuel breaks. However, the density of tree tobacco differs between on and off roads/fuel breaks (Table 5.5), with more tree tobacco plants per meter on roads/fuel breaks. As calculated in Table 5.5, the loss of 38.6 acres of tree tobacco within the roads and fuel breaks constitutes 0.9 percent of the total number of tree tobacco plants that serve as Blackburn's sphinx moth habitat in the Plan Area. This does not include ‘Aiea within the Plan Area, nor thousands of acres of tree tobacco outside the Plan Area. Given the rate at which tree tobacco is spreading in the Plan Area, it is likely that these 38.6 acres lost will quickly be replaced by new growth of tree tobacco elsewhere.

Clearing tree tobacco from roads and fuel breaks will likely result in direct mortality of BSM eggs and larvae as tree tobacco is cut down. Incidental take of Blackburn's sphinx moth will be difficult to detect and impossible to accurately quantify for the following reasons.

First, take of Blackburn's sphinx moth is difficult to detect because of the small size and cryptic nature of its eggs and newborn larvae, as well as the density at which the larvae and eggs occur on the landscape. Blackburn's sphinx moth eggs and larvae are hard to find. Eggs are approximately 1.5 mm in diameter, newly hatched larvae are approximately one cm long and ~one mm wide, both are similar colors to the leaves of tree tobacco, and often loiter in cryptic areas on the undersides and folds of leaves. Furthermore, eggs and larvae can be present in very low densities. For instance, during the winter of 2012, which was during the wet part of the year when *more* BSM were present, there were still only 0.03 larvae/eggs per plant, or roughly 1 larvae/egg per 33 stems. Because some surveyed plants had multiple eggs and/or larvae, less than 3 percent of tree tobacco surveyed had eggs or larvae on them. Secondly, quantifying the anticipated amount of take is nearly impossible given the seasonal and annual variability of the species. The density of Blackburn's sphinx moth in the Plan Area fluctuates annually and seasonally by at least an order of magnitude, e.g. 20 egg/19.5 larvae per hectare in the winter of 2011 to 1.6 eggs/0.4 larvae per hectare in the summer of 2012. In addition, 2011 and 2012 were years of low rainfall in the Plan Area compared to 2014 and thus do not necessarily represent BSM densities and distribution in wetter years. However, 2011 and 2012 are considered wet years relative to 2009 and 2010.

The level of take of Blackburn's sphinx moth can be anticipated by the proportional loss of tree tobacco in the Plan Area. Surveys show that there is no significant difference between the density of Blackburn's sphinx moth eggs and larvae on tree tobacco *on* roads/fuel breaks (0.0312 larvae/eggs per tree tobacco) versus *off* roads/fuel breaks (0.0305 larvae/eggs per tree tobacco). Therefore, whatever proportion of tree tobacco is cut down in the Plan Area, the same proportion of Blackburn's sphinx moth eggs and larvae will experience take. One important note however, is that there is a difference in the density of tree tobacco plants on and off roads/fuel breaks, with higher densities being on roads/fuel breaks (Table 5.5). Taking those two factors into account, clearing roads/fuel breaks will account for 0.9 percent of the tree tobacco in the Plan Area. Therefore, given that 0.9 percent of the available tree tobacco will be cleared in the Plan Area, <u>we estimate that 0.9 percent of Blackburn's sphinx moth larvae and eggs will be taken</u> in the process. In reality the percentage of larvae and eggs taken in the Plan Area is almost certain to be less on an annual basis. Use of tree tobacco by Blackburn's sphinx moth correlates strongly with plant height; surveys found that only 1.9 percent of tree tobacco < one meter tall have Blackburn's sphinx moth eggs and/or larvae whereas 23.1 percent of plants 1-2 m and 67.3 percent of plants 2-5 m tall have eggs and/or larvae (See Appendix D). Given that DOFAW will clear roads and fuel breaks regularly year-round, the majority of tree tobacco regrowth will be less than one meter when cleared, which will minimize the number of eggs and larvae on roads and fuel breaks during subsequent maintenance, thereby reducing direct mortality of Blackburn's sphinx moth.

Improved access through routinely clearing four wheel drive roads, as well as vegetation free fuelbreaks, will have a beneficial effect to the moth by reducing the chances that a fire destroys its native or non-native habitats. Given the spread of readily ignitable fuels such as fountain grass (*P. setaceum*) throughout the Plan Area, projections of decreasing rain due to El Nino and climate change, and past fire history in and around the Plan Area, fire control is critical.

**Table 5.5** Densities of tree tobacco on and off roads/fuel breaks, and proposed proportional clearing of tree tobacco.

| Road/Fuel break | Tree tobacco Area (hectare) | Tree tobacco per hectare | Est. number of Tree tobacco | Percent of Tree Tobacco |
|---|---|---|---|---|
| On | 15.6 | 2,940 | 45,925.4 | **0.9%** |
| Off | 2,615.0 | 1,950 | 5,099,407.8 | **99.1%** |
| Total | 2,630.7 | NA | 5,145,333.2 | **100.0%** |

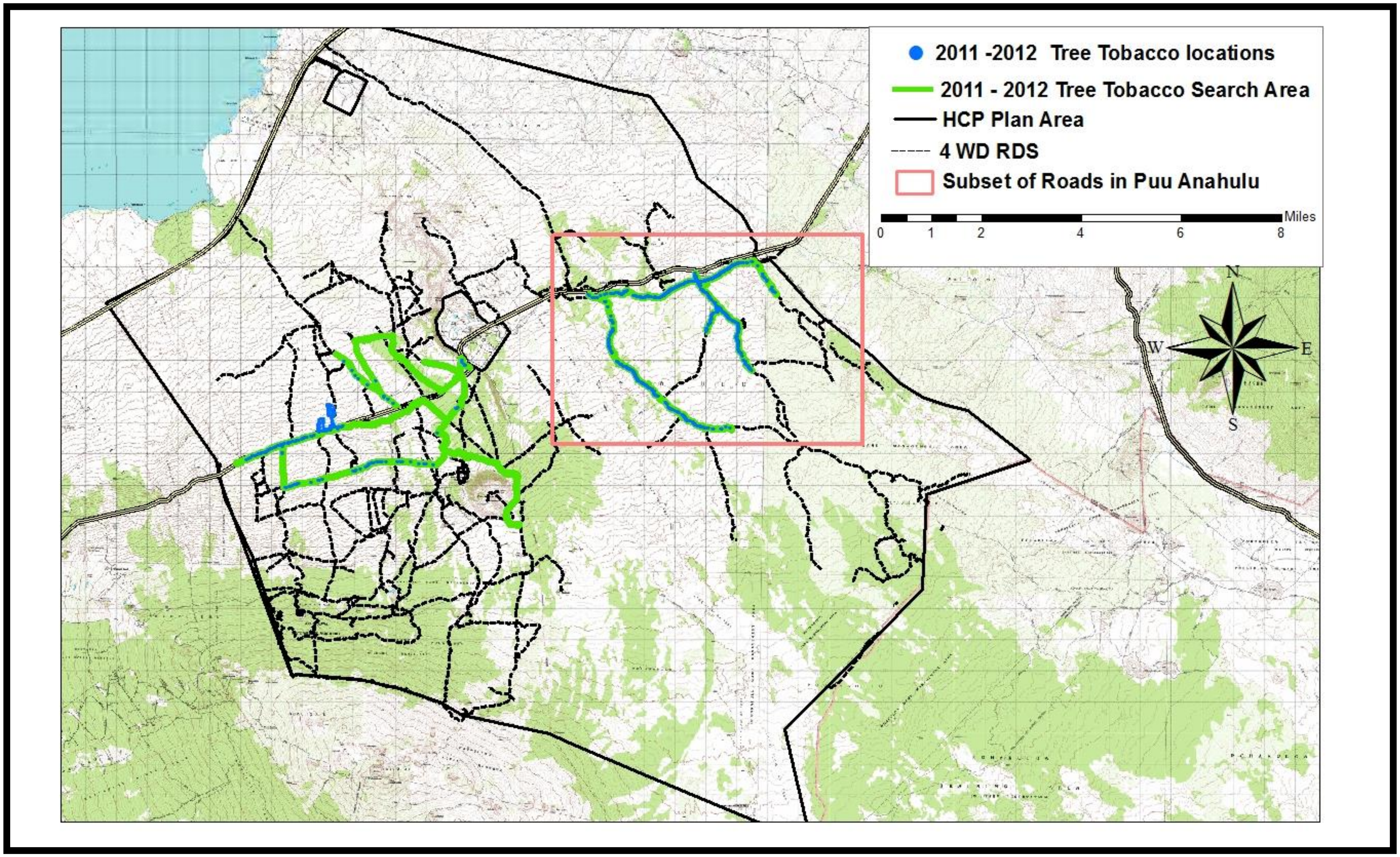


**Figure 5.6** 2011 and 2012 tree tobacco search area (green line) with mapped tree tobacco locations (blue dots). The area in the red/pink rectangle highlights the subset of roads used to calculate the proportion of occupied habitat.

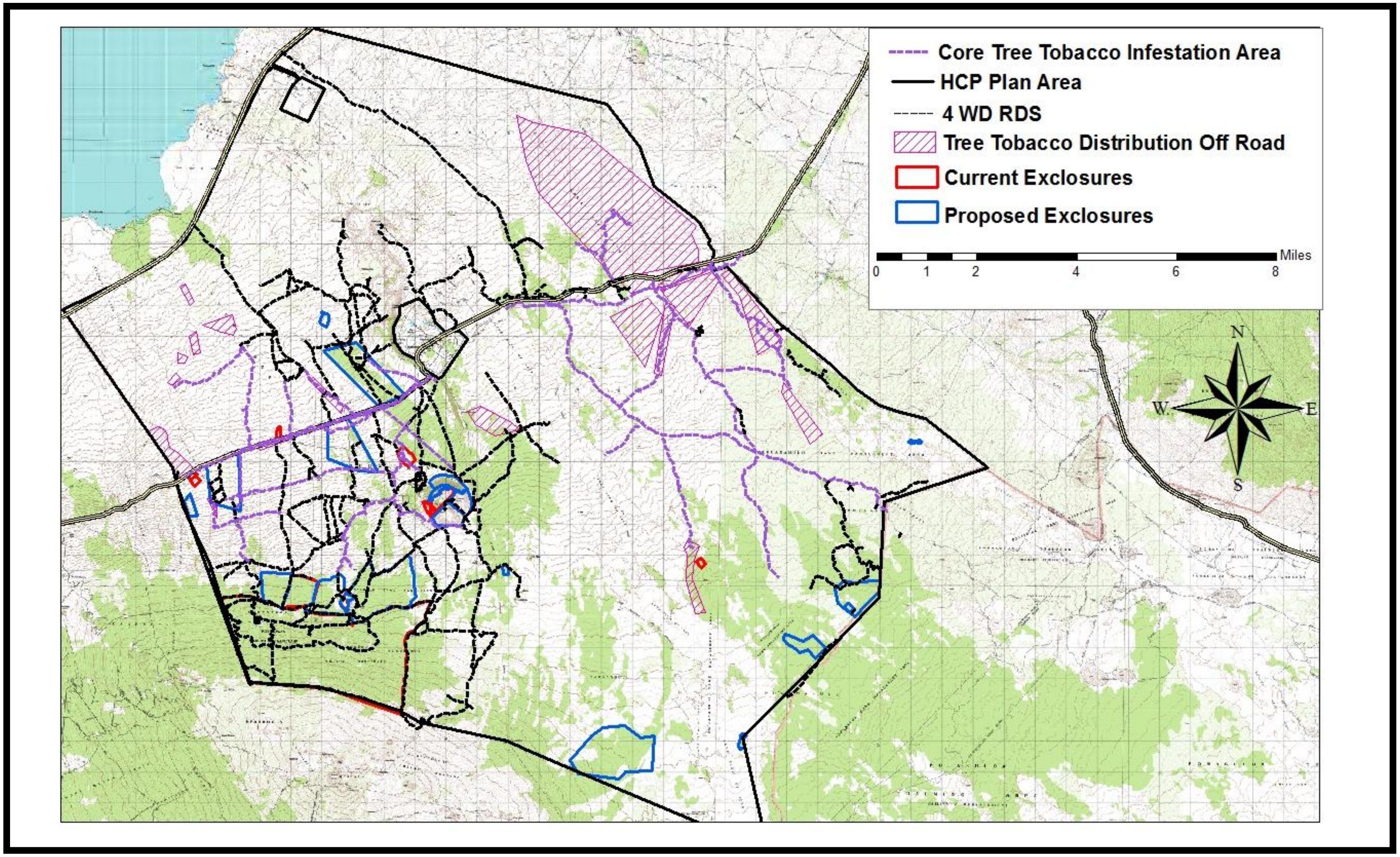


**Figure 5.7** Estimated tree tobacco distribution in the Plan Area based on the 2015 helicopter survey (pink hashed area). Roads in purple indicate the CTTIA.

# 6.0 MITIGATION

In addition to the need for avoidance and minimization measures, HRS Chapter §195-D-4 requires that an HCP describe the steps that will be taken to mitigate the effects of the taking authorized by the proposed ITL. Unlike incidental take avoidance and minimization measures (Section 4.3), which are designed to reduce the amount of take, mitigation measures are designed to offset or compensate for the actual effects of unavoidable incidental take that occurs under the HCP.

DLNR has worked with the ESRC to identify and select appropriate mitigation measures to compensate for the take of the Covered Species. Several criteria were considered in developing the proposed mitigation plan for this HCP, including:

- The mitigation program should be based on sound biological principles, be practical, and be commensurate with currently anticipated levels of take;
- Mitigation measures should have measurable goals and objectives that allow success to be assessed, and should have flexibility to adjust to higher or lower levels of anticipated take;
- Mitigation measures should be species-specific and should contribute to recovery (i.e., be consistent with recovery plan objectives) and have a net benefit to the species;
- Mitigation may include habitat enhancement or restoration of degraded or former habitats;
- Mitigation measures should be implemented prior to Plan impacts or the approval of this HCP to offset the time lag to achieve a net benefit for the slow growing woody species characteristic of many of the covered plant species.

The mitigation measures described below would meet the mitigation criteria required of HRS Chapter §195D, and would be complementary to other management activities that may be taking place for the benefit of the Covered Species. Over the term of the ITL, mitigation measures may be subject to modification in cooperation with the ESRC (*and in accordance with the Amendment procedures described in Section 7.1 of this HCP*) depending on the measured levels of take and the mitigation measures implemented.

## 6.1 MITIGATION LOCATIONS

Our main approach for mitigating the take of Covered Species in the Plan Area is through the management of conservation units, which includes large exclosures and small exclosures. Table 6.1 summarizes the existing and proposed exclosures, their sizes, and appropriate Covered Species to be planted in each exclosure. See Figure 4.1 for a map of both current and proposed exclosures. In general, exclosures greater than 100 acres allow for natural regeneration of forest and shrub land species within the exclosure, and may potentially provide a seedbank for adjacent areas. The unfenced exclosures outlined in the Puʻu Waʻawaʻa Management Plan and in this HCP target areas to provide protection for relatively good quality remnant dryland forest, mesic forest, and shrub land that are currently not under protection. Larger units allow for the restoration of ecological functions of natural communities and can serve as corridors or refugia for native wildlife and insects. However, larger units also have their limitations, including being more prone to ungulate ingress, which is more difficult to detect with larger fence lines, require larger fuelbreaks and weed management, and there may be a greater chance of damage to fence lines from tree falls or seismic activity.

In general, the following management practices will be effectively implemented within conservation areas and large exclosures:

- Management in conservation units will address not only listed plant species but also their more common and locally rare native community members. The potential benefits of community level restoration include creating habitat for native Hawaiian birds and insect pollinators (thereby potentially encouraging the pollination and dispersal of some plant species), and creating an assemblage of trees that allows for more contiguous habitat to facilitate gene flow between populations.
- Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawaiʻi Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawaiʻi* (DLNR 2007). Ungulate removal will depend on size and location of the exclosure and will include public hunting, animal drives, and if necessary, staff removal.
- Strict sanitation guidelines will be followed to prevent new introductions of invasive species. Weed infestations shall be addressed on a case by case basis, with follow-up if needed. As native communities become more vigorous, invasive species cover and treatment should decrease over time. Strict sanitation guidelines will be followed to prevent new introductions of invasive species.
- Research into factors beneficial to community restoration will be encouraged, including: ungulate ecology and behavior, pollination, phenology, mycorrhizae, dispersal, seed ecology, and macro invertebrates, etc.
- Education and outreach will be encouraged, and access to areas appropriate for traditional use of the area by native Hawaiians will be encouraged, in a way that minimizes negative impacts and maximizes appreciation for these resources. Direct access should be regulated to minimize impact to the species, as well as to minimize accidental introduction or re-introduction of invasive species.

### 6.1.1 Current Exclosures for Outplanting

**Pu‘u Wa‘awa‘a Forest Bird Sanctuary (FBS) – 3,744 acres**

Currently, the 3,744-acre Forest Bird Sanctuary Unit contains remnant mesic forest, high elevation native shrub land, and numerous sensitive lava tube ecosystems above 1,158 m elevation. The FBS contains an exceptional diversity of native flora and fauna, as well as some of the best remaining habitat for these species. The FBS supports several species of rare plants including two species covered under the HCP as well as offers opportunities for the re-establishment of a number of the of Covered Species now extirpated from the area.

Covered plant species currently found within this exclosure include the ‘Aiea and *A. peruvianum*. Species of concern that occur within this unit and were mapped during surveys include ‘Akoko (*Euphorbia olowaluana*), Mau‘u lā‘ili (*Sisyrinchium acre*), and ‘Ōhelo papa (*Fragaria chiloensis* var. *sandwicensis*). Opportunities exist for creating new populations of the following covered plant species: *Asplenium peruvianum*, Pōpolo kū mai, ‘Aiea, *Stenogyne angustifolia*, Hawaiian Catchfly, Po‘e, and both species of A‘e (*Z.dipetalum* var. *tomentosum* and *Z. hawaiiensis*).

**Waihou I – 211 acres**

Waihou forest was once transitional woodland that connected the moist montane mesic and lowland dry forests. Though highly degraded, it is still an important conservation link between the two forest types. At the turn of the last century, this mixed woodland was dominated by ‘Ōhi‘a, Koa, Māmane, Naio, and ‘Akoko. Vegetation was said to be so thick in places that it was almost impossible to pass through the forest (Rock 1913). Today, Waihou forest consists of remnant patches of native vegetation. There is good potential for recovery in this area, which includes some of the best mixed woodland remaining at Pu‘u Wa‘awa‘a. There is still substantial native tree cover and readily regenerating Koa, Māmane, and Naio, especially after seasonal rains.

Covered Plant Species currently found within the exclosure include A‘e (*Zanthoxylum dipetalum* var. *tomentosum*) and ‘Aiea. Species of concern include ‘Akoko (*Euphorbia olowaluana*), and ‘Anunu (*Sicyos macrophyllus*). Opportunities exist for creating new populations of the following covered plant species: ‘Aiea, Po‘e, Hawaiian Catchfly, Pōpolo kū mai, *S. angustifolia*, and both species of A‘e (*Z. dipetalum* var. *tomentosum* and *Z. hawaiiense*).

**Pāpala – 81 acres**

The Pu‘u Wa‘awa‘a cinder cone was formed 100,000 years ago. The cone is characterized by its many furrows created by rainfall run off that provide shade for a number of endangered and threatened species. It is the largest cinder cone on the island, and contains remnants of an uncommon forest type dominated by Olopua (*Nestegis sandwicensis*) and Mānele (*Sapindus saponaria*). The Hawaiian soapberry tree (Mānele) is only known on Hawai‘i island from Kīpuka Puaulu and Kīpuka Ki in Hawai‘i Volcanoes National Park and from one region at Pu‘u Wa‘awa‘a. Though this species is not considered rare, it is uncommon and deserves protection at this locale.

No Covered Species were found during HCP surveys within the Pāpala unit; however, a number of species have been outplanted in the unit, including: ‘Aiea, *Neraudia ovata*, Pōpolo kū mai, and A‘e (*Zanthoxylum dipetalum* var. *tomentosum*). This unit has potential for outplanting of additional Covered Species including: Hala pepe, Hawaiian Catchfly, *Stenogyne angustifolia*, A‘e (*Zanthoxylum dipetalum* var. *tomentosum*), and A‘e (*Zanthoxylum hawaiiensis).*

**Kīpuka Oweowe – Two fenced units totaling 26 acres**

This forest is dominated by Lama, but also contains the endangered Kauila, Hala pepe, and ‘Aiea trees. This area contains habitat that is important for the federally listed Blackburn’s sphinx moth (*Manduca blackburni*).

Covered Species that have been outplanted in this unit include: Kauila, Hala pepe, ‘Aiea, Uhiuhi, Pōpolo kū mai, and *Silene lanceolata.*

**Hauaina – 49 acres**

The overall objective within this unit is dryland forest restoration with special consideration for Nēnē habitat improvement. This exclosure also has potential as a reintroduction site for the following species: Kauila, Koki‘o, Hala pepe, Uhiuhi, ‘Aiea, A‘e (*Zanthoxylum dipetalnum* var. *tomentosum*), Ma‘o hau hele, *Neraudia ovata*, and Pōpolo kū mai. Other potential actions include upgrading the perimeter fence from small mammal exclusion to rodent-proof; a floating island over the shallow end of the reservoir for water bird refuge, surface area reduction, and native shrub planting.

**Po‘ohoho‘o – 29 acres**

The Po‘ohoho‘o cinder cone is at an elevation of 3,800 ft located just below the Forest Bird Sanctuary. In the 1960’s, under a previous lessee, this site was chosen for a water reservoir. Two rubber lined reservoirs were constructed along with a surface rain catchment. Currently, only a small component of the original catchment/storage system remains functional. There are plans to decommission this reservoir and to repair the liner of the smaller reservoir. Po‘ohoho‘o is an avoidance and minimization exclosure for ‘Aiea, as well as a potential outplanting site for additional covered species, including: *N. Ovata*, Po‘e, Hawaiian Catchfly, Pōpolo kū mai, *S. angustifolia*, and both species of A‘e (*Z. dipetalum* var. *tomentosum* and *Z. hawaiiense*).

### 6.1.2 Future Exclosures for Outplanting[19]

These proposed exclosures were described in the Section 4.3 Avoidance and Minimization and when constructed will be available for outplanting Covered Species.

**Waihou II – 202 acres**

An additional 202 acres of remnant forest and endangered species habitat adjacent to the currently fenced Waihou forest will be fenced. The expansion of the Waihou forest fence will greatly increase the amount of protected area in which to recover both existing and recently extirpated endangered plant populations. This area is considered a priority because it contains numerous individuals of the endangered ʻAiea, at least two individuals of the endangered Aʻe tree (*Zanthoxylum dipetalum* var. *tomentosum*), and the SOCs, ʻAkoko (*Euphorbia olowaluana*), and *Melicope hawaiensis*. Species appropriate for outplanting in this unit include: ʻAiea, *N. ovata*, Hala pepe, Poʻe, Hawaiian Catchfly, *S. angustifolia*, and Pōpolo kū mai.

**Henahena – 731 acres**

This fenced unit will provide protection to remaining ʻŌhiʻa forest and the fragile lava tube ecosystems that occur underneath this forest type. Forests of ʻŌhiʻa predominate in this area. The Henahena region contains numerous sandalwood trees (ʻIliahi) and numerous endangered ʻAiea trees which are host to the endangered Blackburn's sphinx moth (*Manduca blackburni*). Additionally this area contains lava tube systems that merit protection. Species appropriate for outplanting in this unit include: ʻAiea, *N. ovata*, both species of Aʻe (*Z. dipetalum* var. *tomentosum* and *Z. hawaiiense*), Poʻe, Hawaiian Catchfly, *S. angustifolia*, and Pōpolo kū mai.

**Kauila Hala pepe – 375 acres**

This unit will protect the remaining highest quality Kauila and Hala pepe dominated forest within the Plan Area. Reduction of fuel loads around and inside the fenced exclosure will be done using a combination of cattle (outside exclosure), bulldozers, weed eaters, and herbicide. Species appropriate for outplanting in this unit include: Uhiuhi, Kauila, *H. haplostachya*, Maʻo hau hele, Kokiʻo, *N. ovata*, ʻAiea, Poʻe, *S. lanceolata*, Pōpolo kū mai, *S. angustifolia*, and Aʻe (*Z. hawaiiense*).

**Lama Kokiʻo – 382 acres**

This forested area dominated by Lama on old substrate that contains the last remaining wild Kokiʻo (*Kokia drynarioides*) trees. This forest type is similar to the Kauila Hala pepe exclosure but has Lama as a co-dominant in the overstory. Species appropriate for outplanting in this unit include: Uhiuhi, Kauila, Honohono, Maʻo hau hele, Kokiʻo, *N. ovata*, ʻAiea, Poʻe, *S. lanceolata*, Pōpolo kū mai, *S. angustifolia*, and Aʻe (*Z. hawaiiense*).

**Anahulu I – 255 acres and Anahulu II – 124 acres**

This area contains some of the best remaining dry forest shrubland in the upper Puʻu Anahulu region. Puʻu Anahulu has been plagued by fires in recent years resulting in a drastically altered landscape. Without management actions including fencing to protect plants from ungulates, fire control, and invasive species management, this area will likely burn in the future resulting in the loss of many species including: Aʻe (*Z. hawaiiensis*), Hawaiian Catchfly, *N. ovata*, and

[19] Acreage for proposed exclosures is estimated and may change in the future based on fence-line ground surveys.

*S.angustifolia.* Species appropriate for outplanting in these units include: *A. peruvianum, H. haplostachya*, ʻAiea, Poʻe, and Pōpolo kū mai.

**Zanthoxylum II– 815 acres**
This area contains the highest concentration and largest population of Aʻe (*Zanthoxylum hawaiiensis*) in the area. Species appropriate for outplanting in this unit include: Hawaiian Catchfly, *N. ovata*, Pōpolo kū mai, and *S. angustifolia.*

**ʻAiea– 291 acres**
A concentration of the endangered ʻAiea that provides important habitat for the endangered Blackburn's sphinx moth (*Manduca blackburni*) will be fenced. This unit will enclose more than 30 ʻAiea trees and allow for systematic collection of seed from as many individuals as possible for outplanting in the Waihou exclosure. This fence will ensure the long-term survival of these rare trees that are being adversely affected by ungulates, invasive grasses, and insects. The forest here is dominated by ʻŌhiʻa, Koa, Māmane, Naio and the SOC ʻAkoko. Species appropriate for outplanting in this unit include: ʻAiea, Poʻe, Hawaiian Catchfly, Pōpolo kū mai, *S. angustifolia*, and both species of Aʻe.

**Boundary Kīpuka – 42 acres**
This unit will protect a portion of a kīpuka that is surrounded by lava flows from Hualālai. It is dominated by Lama and may contain the endangered tree species Kauila, ʻAiea, and Hala pepe (see description of Lama/Kauila forest above). This area also contains important habitat for the endangered Blackburn's sphinx moth (*Manduca blackburni*). Hualālai Ranch owns a portion of this kīpuka (although the fenced area will be restricted to state lands). Its isolation may make it a prime area for restoration as it has the Kaʻūpūlehu lava flow as a natural fuelbreak on one side. Species appropriate for outplanting in this unit include: Kauila, Honohono, Maʻo hau hele, Kokiʻo, *N. ovata*, ʻAiea, Hala pepe, Poʻe, Hawaiian Catchfly, Pōpolo kū mai, *S. angustifolia*, and Aʻe (*Z. hawaiiense*).

**Stenogyne– 10 acres**
This area contains some of the highest concentrations of *Stenogyne angustifolia* in the Plan Area. Species appropriate for outplanting in this unit include: Honohono, ʻAiea, Hala pepe, Poʻe, Hawaiian Catchfly, *N. ovata*, Pōpolo kū mai, and Aʻe (*Z. dipetalum*).

**Solanum Kīpuka – 18 acres**
Currently, eight individual plant fences occur in this kīpuka enclosing approximately nine Pōpolo kū mai individuals. The entire kīpuka will be enclosed to further protect these remaining plants. The PTA boundary fence may be utilized as one side of the fencing unit. Species appropriate for outplanting in this unit include: *A. peruvianum*, Honohono, Poʻe, *S. angustifolia*, *N. ovata*, and Hawaiian Catchfly.

**Puʻu Waʻawaʻa Cone Conservation Area (4 remaining sub-units) – 330 acres**

A number of tree species can be found within the the furrows of the cinder cone, including Hala pepe and Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*). This area is highly visible and provides a good opportunity for education and outreach to the public. Thirteen of the fifteen Covered Species are appropriate for outplanting on the cinder cone: Uhiuhi, Kauila, Honohono, Kokiʻo, *Neraudia ovata*, ʻAiea, Hala pepe, Hawaiian Catchfly, Poʻe, Pōpolo kū mai, *Stenogyne angustifolia*, Aʻe (*Zanthoxylum dipetalum*), and Aʻe (*Zanthoxylum hawaiiensis*).

**Uhiuhi 4 – 22 acres**
This unit will protect nine Uhiuhi trees on the makai side of Puʻu Waʻawaʻa. The protected Uhiuhi trees within the unit will serve as propagule sources for mitigation outplanting in adjacent areas in the future.

**Honohono – 5 acres**
This area contains the last known population of Honohono found on state land. The site is also suitable for the potential reintroduction of *Stenogyne angustifolia*, Hawaiian Catchfly, Pōpolo kū mai, and *Neraudia ovata*.

**Kileo** – **533 acres**
This area will protect a section of the oldest geologic kīpuka at Puʻu Waʻawaʻa and a unique cave system. Kileo is the oldest geologic area of Puʻu Waʻawaʻa containing a Naio, Māmane, and ʻAʻaliʻi woodland (a currently unprotected vegetation type at Puʻu Waʻawaʻa). The cave system runs from over 1,829 m elevation through the kīpuka to 1,280 m. Approximately 96 acres of this unit extends into DOFAW-managed lands of Puʻu Anahulu. Potential species to outplant at this outplanting site include: *Asplenium peruvianum*, Honohono, *Neraudia ovata*, ʻAiea, Hawaiian Catchfly, Poʻe, Pōpolo kū mai, *Stenogyne angustifolia*, and Aʻe (*Zanthoxylum hawaiiensis*).

**Puʻu Loa – 530 acres**
This forest is located makai of the highway and is dominated by ʻŌhiʻa. This unit will protect *in situ* individuals of Kauila, Hala pepe, and Uhiuhi. This forest also contains less common native tree species such as ʻAlaʻa *(Pouteria sandwicensis*) and Maua (*Xylosma hawaiiense*).

**Table 6.1** Potential mitigation sites for populations within current and proposed conservation units and exclosures. Species codes are: AspPer = *A. peruvianum*, ChrHaw =*C. hawaiiensis*, ColOpp = *C. oppositifolia*, HapHap = *H. haplostachya*, HibBra = *H. brackenridgei*, KokDry = *K. drynarioides*, MezKav = *M. kavaiense*, NerOva = *N. ovata*, NotBre = *N. breviflorum*, PorScl = *P. sclerocarpa*, SilLan = *S. lanceolata*, SolInc = *S. incompletum*, ZanDip = *Z. dipetalum*, ZanHaw = *Z. hawaiiensis*.

| | **Size (acres)** | **Asp Per** | **Chr Haw** | **Col Opp** | **Hap Hap** | **Hib Bra** | **Kok Dry** | **Mez Kav** | **Ner Ova** | **Not Bre** | **Por Scl** | **Sil Lan** | **Sol Inc** | **Ste Ang** | **Zan Dip** | **Zan Haw** | **# Species /Unit** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Current Units** | | | | | | | | | | | | | | | | | |
| FBS | 3,744 | 1 | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **8** |
| Po‘ohoho‘o | 29 | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **8** |
| Waihou I | 211 | | 1 | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **9** |
| Kīpuka Oweowe | 26 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **13** |
| Hauaina | 49 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **13** |
| Uhiuhi 1 | 13 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | **10** |
| Zanthoxylum I | 7 | | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **8** |
| Neraudia | 12 | | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **8** |
| **Proposed Units** | | | | | | | | | | | | | | | | | |
| ‘Aiea | 291 | | 1 | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **9** |
| Waihou II | 202 | | 1 | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **9** |
| Henahena | 731 | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **8** |
| Kauila Hala pepe | 375 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **13** |
| S. Kīpuka | 42 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **13** |
| Lama Koki‘o | 382 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **13** |
| Pu‘u Loa | 530 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | **11** |
| Uhiuhi 4 | 22 | | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | | | | | **9** |
| Anahulu I | 255 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **9** |
| Anahulu II | 124 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **9** |
| Zanthoxylum II | 815 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | | **8** |
| Stenogyne | 10 | | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **8** |
| Honohono | 5 | | | | | | | | | | 1 | | 1 | 1 | | | **3** |
| Solanum Kīpuka | 18 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **9** |
| PWW CCA | 330 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **14** |
| Kileo | 533 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | **9** |

## 6.2 OFF-SETTING TAKE PRIOR TO HCP APPROVAL

DOFAW has already begun outplanting to offset take for the covered plant species described in this HCP. See Table 6.2 for a list of Covered Species, the number of each species outplanted, and their general locations. DOFAW will be subtracting the number of surviving, mature, reproducing individuals from their anticipated take in order to substantiate a net benefit for each Covered Species.

**Table 6.2** Outplanted Covered Species from 2000 to 2014. Species codes are: ColOpp = *C. oppositifolia*, HapHap = *H.haplostachya*, HibBra = *H. brackenridgei*, KokDry = *K. drynarioides*, MezKav = *M. kavaiense*, NerOva = *N. ovata*, NotBre = *N. breviflorum*, ChrHaw = *C. hawaiiensis*, ZanDip = *Z. dipetalum*.

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHRHAW | | | 24 | 5 | 57 | | 8 | | | | 47 | 123 | | 24 | 319 | **607** |
| HAPHAP | | | | | | | | 2 | | | | | | | | **2** |
| HIBBRA | 30 | 5 | 5 | | 93 | | 7 | 31 | 6 | 1 | 1 | 21 | 4 | | | **204** |
| KOKDRY | 8 | 2 | 15 | | 12 | | | | 23 | 37 | 9 | 162 | 209 | 77 | 42 | **596** |
| MEZKAV | 6 | 2 | | 6 | 1 | | 25 | | 3 | | 39 | 87 | 37 | 17 | 207 | **430** |
| NEROVA | | | 11 | | | | | | | 15 | | 4 | | | | **30** |
| NOTBRE | 20 | 2 | 119 | 55 | 176 | 40 | 131 | | 22 | | 2 | 3 | | 39 | 68 | **677** |
| STEANG | | | | | | | | | | 16 | | | | | | **16** |
| ZANDIP | | | 2 | 10 | 1 | | 2 | | | 14 | 7 | | | | | **36** |
| **Total** | **86** | **47** | **194** | **76** | **340** | **40** | **179** | **33** | **54** | **83** | **106** | **401** | **88** | **203** | **946** | **3,039** |

## 6.3 SPECIES SPECIFIC MANAGEMENT GOALS

Each individual Covered Species has a mitigation goal based on take estimates and avoidance and minimization strategies. Goals for mitigation for each individual Covered Species are consistent with their associated approved federal recovery plan. Exclosure descriptions provide further detail on exclosure size, habitat type, and species composition. Whenever possible, mitigation exclosures are designed to provide mitigation opportunities for multiple species to increase management efficiency and benefit. Table 6.1 summarizes take estimates, avoidance and minimization strategies, and mitigation goals for each of the Covered Species.

### 6.3.1 *Asplenium peruvianum var. insulare*

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in the Avoidance and Minimization Section 4.3*).

2. DOFAW will propagate, as much as is feasible, complete genetic representation through spores from the known populations in the Plan Area. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** As discussed in Section 5.3.1, a take estimate is difficult to calculate for this species as it occurs in lava tubes and cave openings. The occurrence and location of this habitat type has not been mapped within the Plan Area. Because of this gap in knowledge, we defer to the species stabilization goals defined in the recovery plan (USFWS 1998b) and defined in Section 5.3.4. DOFAW will create and maintain **three populations of 50 individuals** each within fenced suitable habitat types. Table 6.3 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** (following stabilization criteria) which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1998b).

6. **Total Mitigation Goals:** In sum, DOFAW will create 5 populations with 50 mature and reproductive individuals (**for a total of 250 individuals**) within a population that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.3** Known *in situ* populations and potential reintroduction sites for *A. peruvianum* var. *insulare*. Exclosures in bold contain extant population(s). All other (non-bold) exclosures are potential sites for reintroduction.

| Potential Exclosures | Fenced | Management Type | # of Individuals | Unit Size (acres) |
|---|---|---|---|---|
| **FBS Unit** | Yes | Avoidance/minimization | 45 | 3,744 |
| Anahulu I | No | Mitigation | | 255 |
| Anahulu II | No | Mitigation | | 124 |
| Zanthoxylum II | No | Mitigation | | 815 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| Kileo | No | Mitigation | | 533 |

### 6.3.2 Hala pepe (*Chrysodracon hawaiiensis*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds from the known Puʻu Waʻawaʻa and Puʻu Anahulu populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a minimum of **three populations** within fenced suitable habitat types to total the take estimate (**331 individuals**). Table 6.1 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 25 individuals** (following stabilization criteria defined in the recovery plan (USFWS 1998a) which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 25 individuals** following species stabilization guidelines (USFWS 1998a).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 25 mature and reproductive individuals within each population (**for a total of 381 number of individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.4** Known *in situ* populations and potential reintroduction sites for Hala pepe.

| Exclosure | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Kauila Hala pepe | No | Avoidance/minimization | 148 | 375 |
| Puʻu Loa | No | Avoidance/minimization | 30 | 530 |
| Lama Kokiʻo | No | Avoidance/minimization | 6 | 382 |
| Hala pepe | No | Avoidance/minimization | 62 | 92 |
| Kīpuka Oweowe | Yes | Avoidance/minimization | 1 | 26 |
| Waihou I | Yes | Mitigation | | 211 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | | 13 |
| Waihou II | No | Mitigation | | 202 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Uhiuhi 4 | No | Mitigation | | 22 |

### 6.3.3 Kauila (*Colubrina oppositifolia*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Pu‘u Wa‘awa ‘a populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain **three populations** within fenced suitable habitat types to total the take estimate (**805 individuals**). Table 6.5 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 25 individuals** following stabilization criteria defined in the recovery plan (USFWS 1996b) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 25 individuals** following species stabilization guidelines (USFWS 1996b).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 25 mature and reproductive individuals within each population (**for a total of 855 number of individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.5** Known *in situ* populations and potential reintroduction sites for Kauila. Bold units contain extant population(s).

| Potential Exclosures | Fenced | Management Type | # of Individuals | Unit Size (acres) |
|---|---|---|---|---|
| Pu‘u Loa | No | Avoidance/minimization | 5 | 530 |
| Kauila Hala pepe | No | Avoidance/minimization | 643 | 375 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Koki‘o | No | Mitigation | 33 | 382 |
| PWW CCA | No | Mitigation | | 330 |
| Uhiuhi 4 | No | Mitigation | | 22 |

### 6.3.4 Honohono (*Haplostachys haplostachya*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in the Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Keamuku Puʻu Anahulu population. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a minimum of **three populations** within fenced suitable habitat types to total the take estimate (**796 individuals**). Table 6.6 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation: DOFAW will create and maintain one additional population of 50 individuals** following stabilization criteria defined in the recovery plan (USFWS 1993) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1993).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 896 number of individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.6** Known *in situ* populations and potential reintroduction sites for Honohono. Units in bold contain extant population(s).

| Potential Exclosures | Fenced | Management Type | # of Individuals | Unit Size (acres) |
|---|---|---|---|---|
| **Honohono** | No | Avoidance/minimization | 80 | 5 |
| Anahulu I | No | Mitigation | | 255 |
| Anahulu II | No | Mitigation | | 124 |
| Stenogyne | No | Mitigation | | 10 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Puʻu Loa | No | Mitigation | | 530 |
| Uhiuhi 4 | No | Mitigation | | 22 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| Kileo | No | Mitigation | | 533 |

### 6.3.5 Maʻo hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puʻu Waʻawa ʻa populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is 58 individuals because a population made up of such a small number of individuals is likely too small to become self-sustaining over time, we defer to the species stabilization guidelines. Based on species stabilization goals defined in the recovery plan (USFWS 1999) and defined in Section 5.3.4. DOFAW will create and maintain a minimum of **three populations of 50 individuals** within fenced suitable habitat types. Table 6.7 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** (following stabilization criteria) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1999).

6. **Total Mitigation Goal:** In sum, DOFAW will create 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 250 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.7** Known *in situ* populations and potential reintroduction sites for Maʻo hau hele. Bold units contain extant population(s).

| Potential Exclosures | Fenced | Management Type | # of Individuals | Unit Size (acres) |
|---|---|---|---|---|
| **Hib. Brackenridgei** | Yes | Avoidance/minimization | 65 | 1 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | | 13 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo | No | Mitigation | | 382 |
| Puʻu Loa | No | Mitigation | | 530 |
| Uhiuhi 4 | No | Mitigation | | 22 |

### 6.3.6 Koki‘o (*Kokia drynarioides*)

1. DOFAW will maintain outplanted individuals through maintenance of fences, monitoring, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. The four individuals documented during HCP surveys occur within small exclosures in the Plan Area. DOFAW will propagate a (as feasible) complete genetic representation through seeds and cuttings from plant stock that has been collected over the years from the few remaining Koki‘o at Pu‘u Wa‘awa‘a. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG guidelines (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is one individual. We defer to the species stabilization guidelines for our mitigation goals. Based on species stabilization goals defined in the recovery plan (USFWS 1994) and defined in Section 5.3.4, DOFAW will create and maintain **three populations of 100 individuals** each within fenced suitable habitat types. Table 6.8 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 100 individuals** (following stabilization criteria) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 100 individuals** following species stabilization guidelines (USFWS 1994).

6. **Total Mitigation Goals:** In sum, DOFAW will create 5 populations with a minimum of 100 mature and reproductive individuals (**for a total of 500 individuals**) within each population that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.8** Known *in situ* populations and potential reintroduction sites for for Kokiʻo.

| Potential Exclosures | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Kokiʻo 1 | Yes | Propagule | 2 | >1 |
| Kokiʻo 2 | Yes | Propagule | 2 | >1 |
| Waihou I | Yes | Mitigation | | 211 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | | 13 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo[20] | No | Mitigation | 4 | 382 |
| Puʻu Loa | No | Mitigation | | 530 |

[20] Kokiʻo 1 and Kokiʻo 2 will be incorporated into the Lama Kokiʻo exclosure.

### 6.3.7 Uhiuhi (*Mezoneuron kavaiense*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation as much as is feasible, through seeds and air layers from the known makai Puʻu Waʻawaʻa populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW tree nursery in Kamuela. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a minimum of **three populations** within fenced suitable habitat types to total the take estimate (**144 individuals**). Table 6.9 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation: DOFAW will create and maintain one additional population of 50 individuals**, following stabilization criteria defined in the recovery plan (USFWS 1994), which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1994).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 244 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.9** Known *in situ* populations and potential reintroduction sites for Uhiuhi. Bold units contain extant population(s).

| Potential Exclosures | Fenced | Management Type | # of Individuals | Unit Size (acres) |
|---|---|---|---|---|
| **Uhiuhi 4** | No | Avoidance/minimization | 9 | 22 |
| **Puʻu Loa** | Yes | Avoidance/minimization | 2 | 3 |
| **Uhiuhi 3** | Yes | Propagule | | 1 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Lama Kokiʻo | No | Mitigation | | 382 |
| Puʻu Loa | No | Mitigation | | 530 |

### 6.3.8 *Neraudia ovata*

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a (as feasible) complete genetic representation through seeds and cuttings from the known Puʻu Anahulu individuals. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is 29 individuals, because a population made up of such a small number of individuals is likely too small to become self-sustaining over time, we defer to the species stabilization guidelines. Based on species stabilization goals defined in the recovery plan (USFWS 1998a), and defined in Section 5.3.4, DOFAW will create and maintain **three populations of 100** individuals each within fenced suitable habitat types. Table 6.10 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 100 individuals** (following stabilization criteria) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 100 individuals** following species stabilization guidelines (USFWS 1998a).

6. **Total Mitigation Goals:** In sum, DOFAW will create 5 populations with a minimum of 100 mature and reproductive individuals within each population (**for a total of 500 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.10** Known *in situ* populations and potential reintroduction sites for for *Neraudia ovata*.

| Exclosure | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| NerOva 1 | Yes | Propagule | 2 | >1 |
| NerOva 2 | Yes | Propagule | 1 | >1 |
| Neraudia Unit | Yes | Propagule? | ? | 12 |
| Anahulu I | No | Avoidance/minimization | 6 | 255 |
| Anahulu II | No | Avoidance/minimization | 3 | 124 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Poʻohohoʻo | Yes | Mitigation | | 29 |
| PWW CCA | Yes | Mitigation | | 330 |
| Waihou I | Yes | Mitigation | | 211 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | | 13 |
| Zanthoxylum | Yes | Mitigation | | 7 |
| Waihou II | No | Mitigation | | 202 |

| Exclosure | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Henahena | No | Mitigation | | 731 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Pu‘u Loa | No | Mitigation | | 530 |
| Uhiuhi 4 | No | Mitigation | | 22 |
| Kileo | No | Mitigation | | 533 |

### 6.3.9 ‘Aiea (*Nothocestrum breviflorum*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Pu‘u Wa‘awa‘a populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain **three populations** within fenced suitable habitat types to total the take estimate (**265 individuals**). Table 6.11 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** following stabilization criteria defined in the recovery plan (USFWS 1996b) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1996b).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 365 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.11** Known *in situ* populations and potential reintroduction sites for ‘Aiea.

| Exclosure | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Henahena | No | Avoidance/minimization | 20 | 731 |
| Kauila Hala pepe | No | Avoidance/minimization | 6 | 375 |
| Kīpuka Oweowe | Yes | Avoidance/minimization | 6 | 26 |
| Po‘ohoho‘o | Yes | Avoidance/minimization | 6 | 29 |
| ‘Aiea | Yes-individual fences | Propagule | 33 | >1 |
| PWW CCA | Yes | Mitigation | | 330 |
| FBS | Yes | Mitigation | 3 | 3,744 |
| Waihou I | Yes | Mitigation | 9 | 211 |
| Waihou II | No | Mitigation | | 202 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | 1 | 13 |
| Neraudia | Yes | Mitigation | | 12 |
| Zanthoxylum | Yes | Mitigation | | 7 |
| Kauila Hala pepe | No | Mitigation | | 375 |

| Exclosure | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo | No | Mitigation | 16 | 382 |
| Puʻu Loa | No | Mitigation | | 530 |
| Uhiuhi 4 | No | Mitigation | | 22 |
| Anahulu I | No | Mitigation | | 255 |
| Anahulu II | No | Mitigation | | 124 |
| Zanthoxylum II | No | Mitigation | | 815 |
| Stenogyne | No | Mitigation | | 10 |
| Honohono | No | Mitigation | | 5 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| PWW CCA | No | Mitigation | | 330 |
| Kileo | No | Mitigation | | 533 |

### 6.3.10 Po'e (*Portulaca sclerocarpa*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a (as feasible) complete genetic representation from the individual(s) in the Anahulu I unit. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal**: As discussed in Section 5.3.1, a take estimate is difficult to calculate for this species as only one individual was found. Because of this gap in knowledge, we defer to the species stabilization goals defined in the recovery plan (USFWS 1996b) and defined in Section 5.3.4. DOFAW will create and maintain **three populations of 50 individuals** each within fenced suitable habitat types. Table 6.12 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation: DOFAW will create and maintain one additional population of 50 individuals** (following stabilization criteria) which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1996b).

6. **Total Outplanting Goals:** In sum, DOFAW will create 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 250 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.12** Known *in situ* populations and potential reintroduction sites for Poʻe. Exclosures in bold contain extant population(s). All other exclosures are potential sites for reintroduction.

| Exclosure | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| **Anahulu I** | No | Avoidance/minimization | 1 | 255 |
| Henahena | No | Mitigation | | 731 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Kīpuka Oweowe | Yes | Mitigation | | 22 |
| ʻAiea | No | Mitigation | | >1 |
| Poʻohohoʻo | Yes | Mitigation | | 29 |
| FBS | Yes | Mitigation | | 3,744 |
| Waihou I | Yes | Mitigation | | 211 |
| Waihou II | No | Mitigation | | 202 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | | 13 |
| Neraudia | Yes | Mitigation | | 12 |
| Zanthoxylum | Yes | Mitigation | | 7 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo | No | Mitigation | | 382 |
| Puʻu Loa | No | Mitigation | | 530 |
| Uhiuhi 4 | No | Mitigation | | 22 |
| Anahulu II | No | Mitigation | | 124 |
| Zanthoxylum II | No | Mitigation | | 815 |
| Stenogyne | No | Mitigation | | 10 |
| Honohono | No | Mitigation | | 5 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| PWW CCA | Partially | Mitigation | | 330 |
| Kileo | No | Mitigation | | 533 |

### 6.3.11 Hawaiian Catchfly (*Silene lanceolata*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puʻu Anahulu populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a **minimum of 3 populations** within fenced suitable habitat types to total the take estimate (**1,812 individuals**). Table 6.13 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** following stabilization criteria defined in the recovery plan (USFWS 1996c) which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those of forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1996c).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 1,912 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.13** Known *in situ* populations and potential reintroduction sites for Hawaiian Catchfly.

| Population Unit | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Anahulu I | No | Avoidance/minimization | 30 | 255 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Waihou I | Yes | Mitigation | | 211 |
| PWW CCA | Yes | Mitigation | | 330 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Poʻohohoʻo | Yes | Mitigation | | 29 |
| Hauaina | Yes | Mitigation | | 49 |
| Uhiuhi 1 | Yes | Mitigation | | 13 |
| Zanthoxylum | Yes | Mitigation | | 7 |
| Neraudia | Yes | Mitigation | | 12 |
| Waihou II | No | Mitigation | | 202 |
| Henahena | No | Mitigation | | 731 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo | No | Mitigation | | 382 |
| Puʻu Loa | No | Mitigation | | 530 |
| Uhiuhi 4 | No | Mitigation | | 22 |
| Anahulu II | No | Mitigation | | 124 |
| Zanthoxylum II | No | Mitigation | | 815 |
| Stenogyne | No | Mitigation | | 10 |
| Honohono | No | Mitigation | | 5 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| PWW CCA | No | Mitigation | | 330 |
| Kileo | No | Mitigation | | 533 |

### 6.3.12 Pōpolo kū mai (*Solanum incompletum*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a (as feasible) complete genetic representation through seeds and cuttings from the known Pu‘u Anahulu individuals. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is **87 individuals**. Because a population made up of such a small number of individuals is likely too small to become self-sustaining over time, we defer to the species stabilization goals outlined in the recovery plan (USFWS 1999) and defined in Section 5.3.4, DOFAW will create and maintain a **minimum of three populations of 100 individuals** each within fenced suitable habitat types. Table 6.14 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 100 individuals** (following stabilization criteria) which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those of put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal**: In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 100 individuals** following species stabilization guidelines (USFWS 1999).

6. **Total Mitigation Goals:** In sum, DOFAW will create 5 populations with a minimum of 100 mature and reproductive individuals within each population (**for a total of 500 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.14** Known *in situ* populations and potential reintroduction sites for Pōpolo kū mai. Exclosures in bold contain extant population(s).

| Population Unit | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| **SolInc** | 8 small units | Avoidance/minimization | 13 | 18 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Pāpala | Yes | Mitigation | | 74 |
| Po‘ohoho‘o | Yes | Mitigation | | 29 |
| Hauaina | Yes | Mitigation | | 49 |
| Zanthoxylum | Yes | Mitigation | | 7 |
| Neraudia | Yes | Mitigation | | 12 |
| Solanum Kīpuka[21] | No | Mitigation | 13 | 18 |
| Waihou II | No | Mitigation | | 202 |
| Henahena | No | Mitigation | | 731 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Koki‘o | No | Mitigation | | 382 |
| Anahulu I | No | Mitigation | | 255 |
| Anahulu II | No | Mitigation | | 124 |
| Zanthoxylum II | No | Mitigation | | 815 |
| Stenogyne | No | Mitigation | | 10 |
| Honohono | No | Mitigation | | 5 |
| PWW CCA | No | Mitigation | | 330 |
| Kileo | No | Mitigation | | 533 |

[21] Solanum incompletum 8 individual small units will be incorporated into the Solanum Kīpuka exclosure.

### 6.3.13 *Stenogyne angustifolia*

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puʻu Anahulu and Puʻu Waʻawaʻa populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a minimum of **three populations** (in addition to *in situ)* within fenced suitable habitat types to total the take estimate (**325 individuals**). Table 6.15 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** following stabilization criteria defined in the recovery plan (USFWS 1993) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines.

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 425 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.15** Known *in situ* populations and potential reintroduction sites for *Stenogyne angustifolia*. Bold units contain extant population(s).

| Population Unit | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Anahulu I | No | Avoidance/minimization | 15 | 255 |
| Stenogyne | No | Avoidance/minimization | 43 | 10 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| PWW CCA | Yes | Mitigation | | 330 |
| Poʻohohoʻo | Yes | Mitigation | | 29 |
| Hauaina | Yes | Mitigation | | 49 |
| Zanthoxylum I | Yes | Mitigation | | 7 |
| Neraudia | Yes | Mitigation | | 12 |
| Waihou II | No | Mitigation | | 202 |
| Henahena | No | Mitigation | | 731 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundary Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo | No | Mitigation | | 382 |
| Anahulu II | No | Mitigation | | 124 |
| Zanthoxylum II | No | Mitigation | | 815 |
| Honohono | No | Mitigation | | 5 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| Kileo | No | Mitigation | | 533 |

### 6.3.14 A‘e (*Zanthoxylum dipetalum* var. *tomentosum*)

1. DOFAW will maintain *in situ* individuals through individual fences, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*) to be used as propagule sources for mitigation outplanting.

2. DOFAW will propagate a (as feasible) complete genetic representation through seeds and air layers from the known Pu‘u Wa‘awa‘a individuals. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is **19 individuals**. Because a population made up of such a small number of individuals is likely too small to become self-sustaining over time, we defer to the species stabilization goals outlined in the recovery plan (USFWS 1998a) and defined in Section 5.3.4. DOFAW will create and maintain **three populations of 50 individuals** each within fenced suitable habitat types. Table 6.16 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** (following stabilization criteria) which will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal**: In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines.

6. **Total Mitigation Goal:** In sum, DOFAW will create 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 250 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.16** Known *in situ* populations and potential reintroduction sites for A‘e (*Z. dipetalum var. tomentosum*).

| Population Unit | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Waihou I | Yes | Avoidance/minimization | 2 | 211 |
| Waihou II | No | Avoidance/minimization | 2 | 202 |
| PWW CCA | No | Avoidance/minimization and Mitigation | 1 | 330 |
| Po‘ohoho‘o | Yes | Mitigation | | 29 |
| FBS | Yes | Mitigation | | 3,744 |
| Henahena | No | Mitigation | | 731 |

### 6.3.15 A‘e (*Zanthoxylum hawaiiense*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 4.3 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Pu‘u Anahulu populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal**: DOFAW will create and maintain **three additional populations** (in addition to *in situ)* within fenced suitable habitat types to total the take estimate (**218 individuals**). Table 6.17 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 50 individuals** following stabilization criteria defined in the recovery plan (USFWS 1996b) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal:** In an effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines (USFWS 1996b).

6. **Total Mitigation Goal:** In sum, DOFAW will create a minimum of 5 populations with a minimum of 50 mature and reproductive individuals within each population (**for a total of 318 individuals**) that are either a) in separate units, or b) at least 1000 m apart.

**Table 6.17** Known *in situ* populations and potential reintroduction sites for Aʻe (*Z. hawaiiense*)

| Population Unit | Fenced | Management Type | # of Individuals | Unit Size (acre) |
|---|---|---|---|---|
| Zanthoxylum II | No | Avoidance/minimization | 129 | 815 |
| Anahulu I | No | Avoidance/minimization | 9 | 255 |
| Anahulu II | No | Avoidance/minimization | 30 | 124 |
| FBS | Yes | Mitigation | | 3,744 |
| Waihou I | Yes | Mitigation | | 211 |
| Pāpala | Yes | Mitigation | | 74 |
| Poʻohohoʻo | Yes | Mitigation | | 29 |
| Kīpuka Oweowe | Yes | Mitigation | | 26 |
| Hauaina | Yes | Mitigation | | 49 |
| Zanthoxylum I | Yes | Mitigation | 7 | 7 |
| Neraudia | Yes | Mitigation | | 12 |
| Waihou II | No | Mitigation | | 202 |
| Henahena | No | Mitigation | | 731 |
| Kauila Hala pepe | No | Mitigation | | 375 |
| Boundar Kīpuka | No | Mitigation | | 42 |
| Lama Kokiʻo | No | Mitigation | | 382 |
| Stenogyne | No | Mitigation | | 10 |
| Honohono | No | Mitigation | | 5 |
| Solanum Kīpuka | No | Mitigation | | 18 |
| PWW CCA | No | Mitigation | | 330 |
| Kileo | No | Mitigation | | 533 |

**Table 6.18** Summary of Covered Species, avoidance and minimization measures, take estimates, mitigation goals, net benefit goals, and recruitment loss goals. Net benefit goals follow species stabilization guidelines.

| Species | Surveyed | Model Projection | Fenced Individuals | Avoidance & Minimization Exclosures | Take Estimate | Mitigation Goal | Net Benefit Goal | Recruitment Loss Mitigation | Total Mitigation Target |
|---|---|---|---|---|---|---|---|---|---|
| ***Asplenium peruvianum*** | 64 | n/a | 45 | FBS Unit | 19 | 3 populations of 50 plants each | 1 population of 50 plants | 1 population of 50 plants | **250 plants** |
| ***Chrysodracon hawaiiensis*** | 299 | 279 | 235 | Pu‘u Loa, Lama Hala pepe, Lama Koki‘o, Hala pepe, Kīpuka Oweowe | 331 | 3 populations totaling take estimate | 1 population of 25 plants | 1 population of 25 plants | **381 plants** |
| ***Colubrina oppositifolia*** | 758 | 767 | 692 | Pu‘u Loa, Lama Hala pepe | 805 | 3 populations totaling take estimate | 1 population of 25 plants | 1 population of 25 plants | **855 plants** |
| ***Haplostachys haplostachya*** | 80 | 796 | 80 | Honohono | 796 | 3 populations totaling take estimate | 1 population of 50 plants | 1 population of 50 plants | **896 plants** |
| ***Hibiscus brackenrdgei*** | 65 | 59 | 65 | Hibiscus brackenridgei | 59 | 3 populations of 50 plants each | 1 population of 50 plants | 1 population of 50 plants | **250 plants** |
| ***Kokia drynarioides***[22] | 4 | 1 | 4 | Lama Koki‘o | 1 | 3 populations of 100 plants each | 1 population of 100 plants | 1 population of 100 plants | **500 plants** |

[22] All known individuals are fenced in individual fences

| Species | Surveyed | Model Projection | Fenced Individuals | Avoidance & Minimization Exclosures | Take Estimate | Mitigation Goal | Net Benefit Goal | Recruitment Loss Mitigation | Total Mitigation Target |
|---|---|---|---|---|---|---|---|---|---|
| ***Mezoneuron kavaiense*** | 48 | 107 | 11 | Uhiuhi 4, Uhiuhi 1, Uhiuhi 2, Pu‘u Loa | 144 | 3 populations totaling take estimate | 1 population of 50 plants | 1 population of 50 plants | **244 plants** |
| ***Neraudia ovata*** | 8 | 28 | 8 | Neraudia, Anahulu I & II | 29 | 3 populations of 100 plants each | 1 population of 100 plants | 1 population of 100 plants | **500 plants** |
| ***Nothocestrum breviflorum*** | 156 | 211 | 123 | Henahena, Waihou I, Kauila Hala pepe, Kīpuka Oweowe, ‘Aiea, Lama Koki‘o, Po‘ohoho‘o | 265 | 3 populations totaling take estimate | 1 population of 50 plants | 1 population of 50 plants | **365 plants** |
| ***Portulaca sclerocarpa*** | 1 | n/a | 1 | Anahulu I | 0 | 3 populations of 50 plants each | 1 population of 50 plants | 1 population of 50 plants | **250 plants** |
| ***Silene lanceolata*** | 235 | 1607 | 30 | Anahulu I | 1812 | 3 populations totaling take estimate | 1 population of 50 plants | 1 population of 50 plants | **1912 plants** |
| ***Solanum incompletum*** | 12 | 87 | 14 | Solanum | 87 | 3 populations of 100 plants each | 1 population of 100 plants | 1 population of 100 plants | **500 plants** |
| ***Stenogyne angustifolia*** | 98 | 285 | 58 | Anahulu I, Stenogyne | 325 | 3 populations totaling take estimate | 1 population of 50 plants | 1 population of 50 plants | **425 plants** |

| Species | Surveyed | Model Projection | Fenced Individuals | Avoidance & Minimization Exclosures | Take Estimate | Mitigation Goal | Net Benefit Goal | Recruitment Loss Mitigation | Total Mitigation Target |
|---|---|---|---|---|---|---|---|---|---|
| ***Zanthoxylum dipetalum tomentosum*** | 13 | 11 | 5[23] | Waihou I&II, Hala Pepe | 19 | 3 populations of 50 plants each | 1 population of 50 plants | 1 population of 50 plants | **250 plants** |
| ***Zanthoxylum hawaiiensis*** | 219 | 176 | 169 | Zanthoxylum II, Anahulu I & II | 218 | 3 populations take estimate | 1 population of 50 plants | 1 population of 50 plants | **318 plants** |

[23] All known individuals for this species are indivually fenced.

### 6.3.16 Blackburn's Sphinx Moth (*Manduca blackburni*)

Fuelbreak creation and maintenance provides protection from fire for native habitat potentially used by *M. blackburni*. While removal of tree tobacco on fuelbreaks may reduce available non-native host plants, the overall result is a net benefit to the species. Mitigation of covered plant species will include the creation of large conservation units and exclosures for the outplanting of the native host plant ʻAiea, other covered plant species, and potential and known native nectar plant species. The USFWS is currently recommending a 5 to 1 offset ratio for loss of degraded habitat for Blackburn's sphinx moth. For every five acres of degraded habitat lost, one acre of native habitat will be restored. Approximately 38.6 acres of fuel break and 4x4 roads are currently occupied by tree tobacco and are actively cleared (through herbicide and/or manual cutting). By applying the 5 to 1 ratio suggested by the USFWS, we calculate that approximately 7.2 acres of habitat will need to be restored in order to mitigate for this loss of degraded habitat. In the case that tree tobacco colonizes all of the roads and fuel breaks within the Plan Area (totaling approximately 370 $km^2$ or 640 acres) we calculate that, using the same ratio as above, 128 acres will be need to be restored for mitigation. FIGURE 6.1 shows the Plan Area with overlays of ʻAiea range data and critical habitat for both ʻAiea and Blackburn's sphinx moth. The mitigation goal for ʻAiea is to have a minimum of three populations totaling 365 individuals. All of the proposed or current exclosures, (totaling approximately 9,000 acres), that will be used for mitigation purposes fall within the range of ʻAiea and far exceed the recommended ratio suggested by the USFWS. Mitigation for losses of Covered Plant species will also provide and enhance native habitat known to be used by Blackburn's sphinx moth.

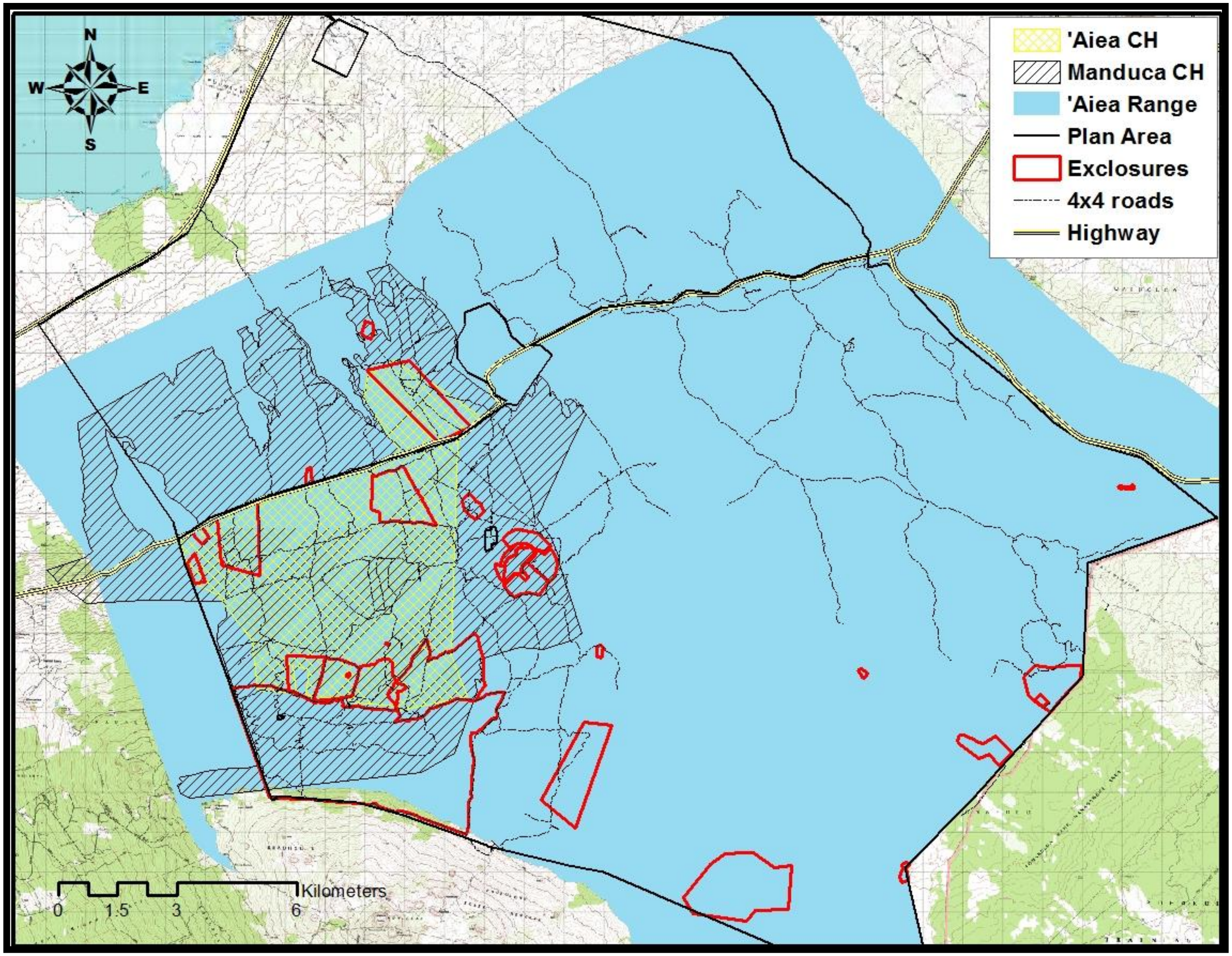


**Figure 6.1** Map depicting critical habitat for ‘Aiea and *Manduca blackburni*, exclosure locations, and species range for ‘Aiea within the Plan Area.

## 6.4 NET BENEFIT TO COVERED SPECIES

This HCP seeks to offset the potential impact of the proposed game mammal management activities on the listed species (i.e. Covered Species) with measures that protect and provide a net benefit to these species island-wide and statewide. Table 6.19 shows the number of known individuals and populations within the Plan Area, as well as the current island-wide and state-wide plant values (based on USFWS 5 year reviews) for each Covered Species. The combined number of protected (*in situ* and mitigation) plants after the HCP has been implemented compared to the current known and estimated plants in the Plan Area as well as the overall island-wide and state-wide values, show a marked increase in number of protected plants for each of the Covered Species (Figure 6.2). Mitigation targets are set at levels that account for levels of take as well as add additional plant populations to provide a net benefit to each of the covered species (Figure 6.3). The final number of protected individuals of each Covered Species (*in situ* and mitigation) far outweighs what is currently protected by fences through avoidance and minimization actions (Figure 6.4). Table 6.20 shows the percent increase in number of protected species after the HCP has been fully implemented. For all Covered Species there is at least a 100% increase in number of protected plants. While the activities in this HCP lead to to the incidental take of Covered Species, project actions will have an overall net benefit to the species covered under this HCP as well as to other non-covered species that occur in the Plan Area.

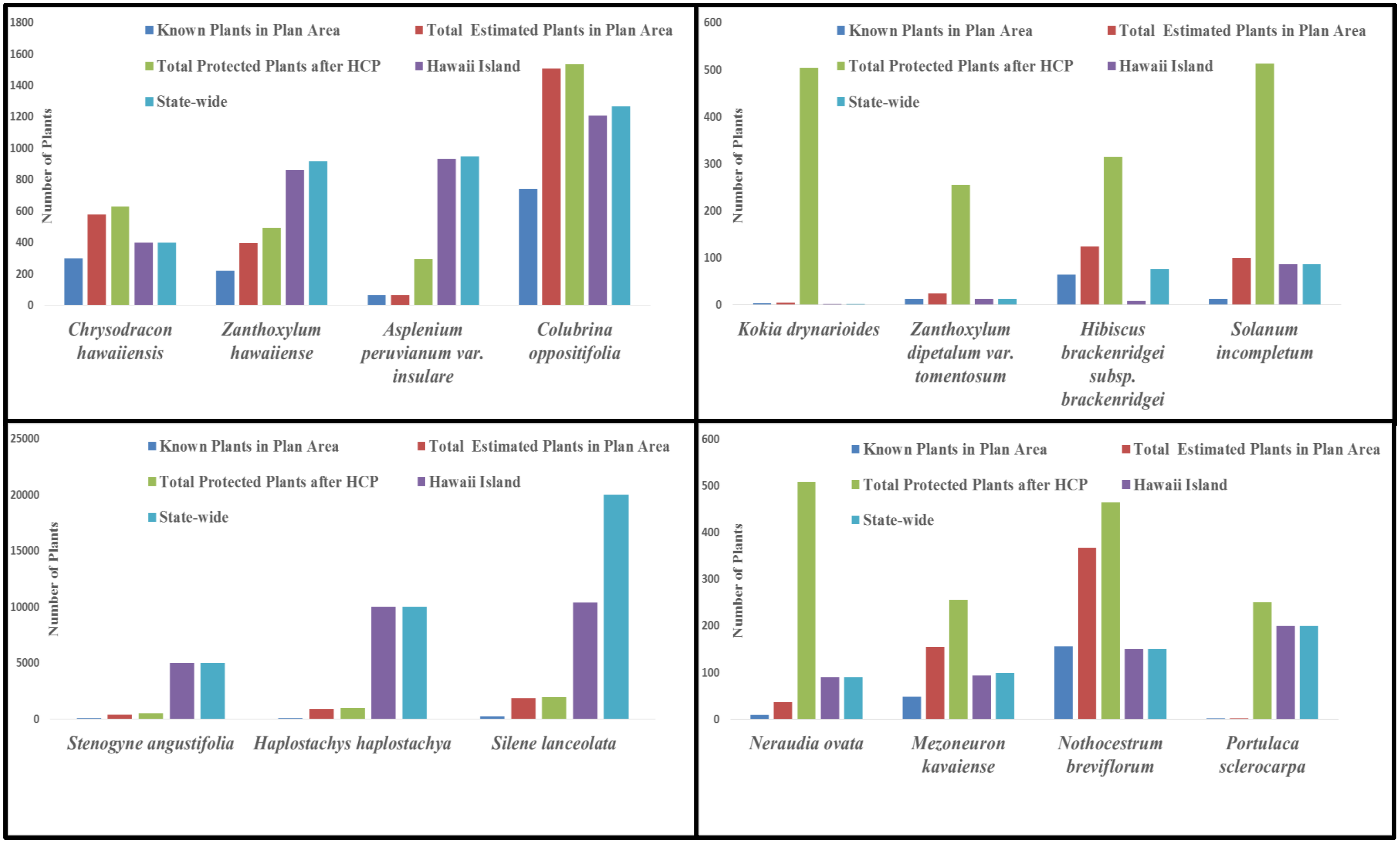


**Figure 6.2** A comparison of the number of plants in the Plan Area, with plant numbers from across the island and state. Known plants are those found during surveys, total estimated plants are known plants plus estimated plants from modeling, total protected plants after HCP are both *in situ* and mitigated fenced plants in the Plan Area after implementation. Island and State-wide values come from USFWS 5 year reviews.

**Table 6.19** Number of individuals of Covered Species in the Plan Area and across the state. A population is defined as a group of individuals within 1000m of one another. Values for number of individuals across the state come from the most recent USFWS 5 year review and summary evaluation reports for each of the covered Species.

| Species | Known Individuals in Plan Area | Populations in Plan Area | State wide | O‘ahu | Hawai‘i | Maui | Kaua‘i | Lāna‘i | Moloka‘i |
|---|---|---|---|---|---|---|---|---|---|
| *Asplenium peruvianum var. insulare* | 64 | 3 | 948 | | 931 | 17 | | | |
| *Chrysodracon hawaiiensis* | 299 | 5 | 400 | | 400 | | | | |
| *Colubrina oppositifolia* | 739 | 1 | 1265 | 54 | 1209 | 2 | | | |
| *Haplostachys haplostachya* | 80 | 1 | 10,000 | | 10,000 | X | X | | |
| *Hibiscus brackenridgei subsp. brackenridgei* | 65 | 1 | 76 | | 9 | 63 | | 4 | |
| *Kokia drynarioides* | 4 | 1 | 2 | | 2 | | | | |
| *Mezoneuron kavaiense* | 48 | 1 | 99 | 4 | 94 | X | 1 | X | |
| *Neraudia ovata* | 9 | 2 | 90 | | 90 | | | | |
| *Nothocestrum breviflorum* | 156 | 3 | 150 | | 150 | | | | |
| *Portulaca sclerocarpa* | 1 | 1 | 200 | | 200 | | | X | |
| *Silene lanceolata* | 235 | 3 | 20,000 | 189 | 10,394 | | X | | 622 |
| *Solanum incompletum* | 13 | 1 | 86 | | 86 | X | X | X | X |
| *Stenogyne angustifolia* | 98 | 3 | 5000 | | 5,000 | X | | | X |
| *Zanthoxylum dipetalum var. tomentosum* | 13 | 2 | 13 | | 13 | | | | |
| *Zanthoxylum hawaiiense* | 219 | 2 | 916 | | 860 | 51 | 2 | X | 3 |

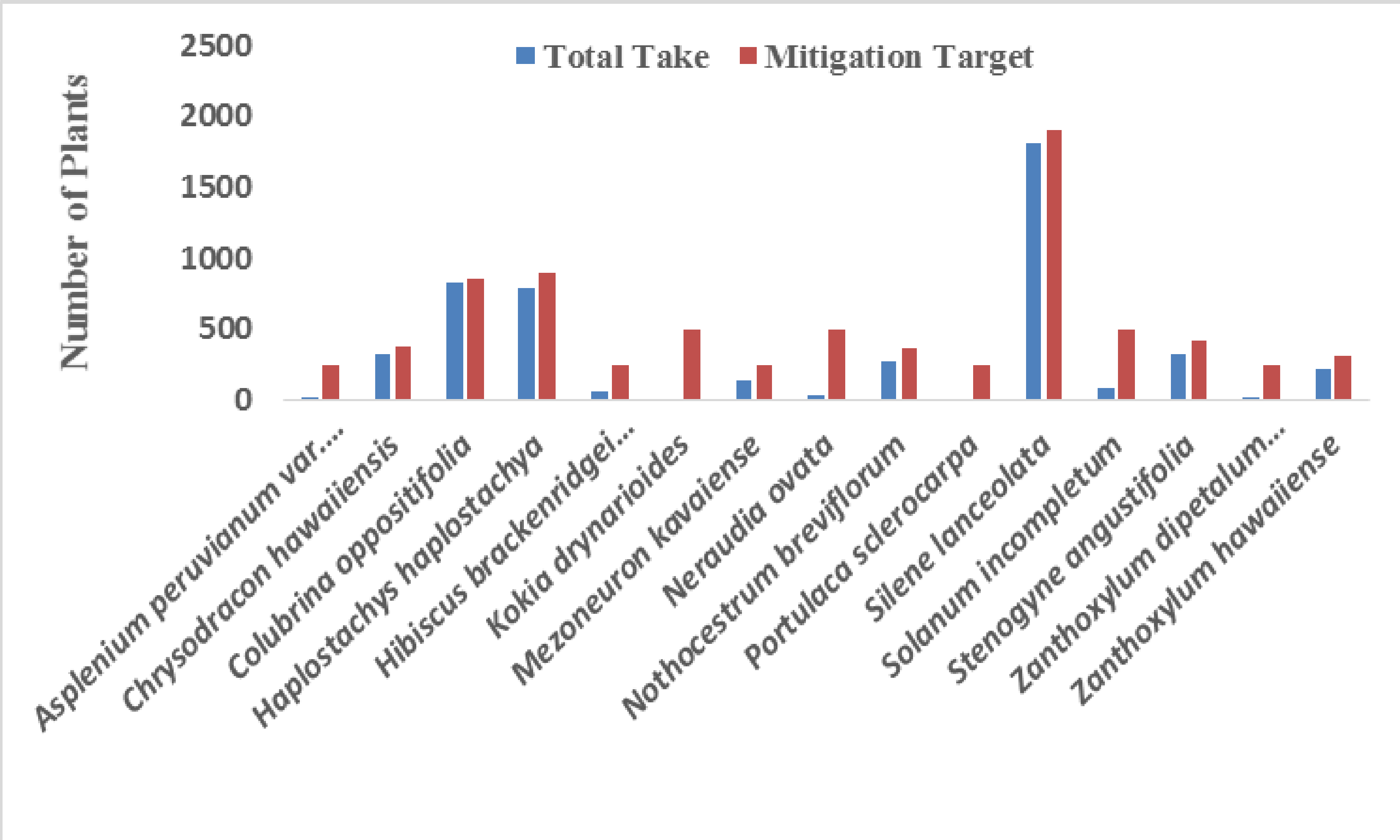


**Figure 6.3** Total take (blue bar) values compared to the mitigation target (red bars) for each Covered Species. Total take is calculated based on actual take of known unfenced plants and estimated plants outside of fenced areas.

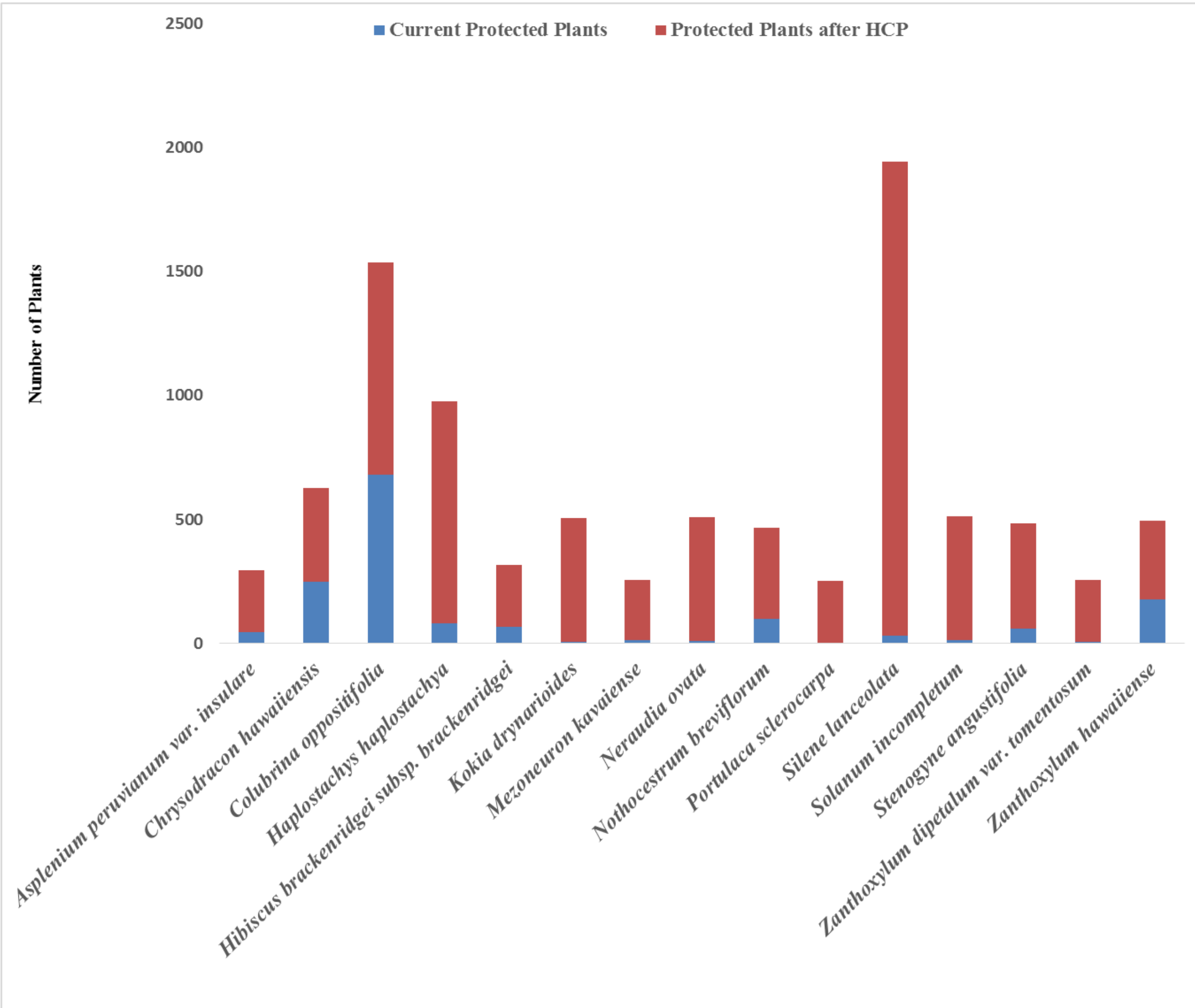


**Figure 6.4** Total combined number of protected (fenced) plants after HCP implementation. Blue bars are in situ plants within exclosures and red bars are mitigation (outplanted) plants.

**Table 6.20** Percent increase in number of protected plants after HCP implementation.

| **Species** | **% Increase** |
|---|---|
| *Asplenium peruvianum var. insulare* | 461 |
| *Chrysodracon hawaiiensis* | 109 |
| *Colubrina oppositifolia* | 102 |
| *Haplostachys haplostachya* | 111 |
| *Hibiscus brackenridgei subsp. brackenridgei* | 254 |
| *Kokia drynarioides* | 10080 |
| *Mezoneuron kavaiense* | 165 |
| *Neraudia ovata* | 1376 |
| *Nothocestrum breviflorum* | 127 |
| *Portulacca sclerocarpa* | 25100 |
| *Silene lanceolata* | 105 |
| *Solanum incompletum* | 513 |
| *Stenogyne angustifolia* | 126 |
| *Zanthoxylum dipetalum var. tomentosum* | 1063 |
| *Zanthoxylum hawaiiense* | 125 |

## 6.5 PROPAGULE COLLECTION, STORAGE AND PROPAGATION

Multiple methods for propagule collection and storage are available and are currently being used for *ex situ* conservation of many endangered plant species in Hawaiʻi. These methods take two basic forms, either collection of reproductive output (seeds), or the collection of plant vegetative materials. Collection of plant materials can be done as cuttings, air layering, or the collection of whole plants. In general, it has been argued that the collection of seed is preferable to the collection of plant materials (Guerrant et al. 2004). There are two main arguments for this; seed collection is seen as less damaging demographically than taking vegetative matter, and secondly, it is typically much easier and more economical to store seeds than continued maintenance of growing plants in botanical garden or nursery (Guerrant et al. 2004).

All of the plant species covered under this Plan have been or are currently in propagation. As previously discussed, some of the Covered Species are dioecious and individuals are isolated from one another by large distances. For dioecious species in particular, this may lead to long periods of time between seed set. For this reason, collection of plant vegetative material via cuttings or air layering will be used in conjunction with seed collection in order to have genetic representation from as many remaining individuals as feasible. Some individual trees may be senescing from ungulate pressure, competition with invasive species, or old age, therefore seed set may be reduced. The only recourse for the collection of genetic material from these individuals is to take cuttings or air layers. An onsite nursery, potentially located in Hauaina exclosure, will allow for air layers and/or cuttings to be outplanted onsite for future reproductive crosses and monitoring. Hauaina is located in a central area within the Puʻu Waʻawa ʻa Ranch, allowing for easy access on a 4x4 road. Water is available on site and can provide for the needs of a nursery. A small greenhouse has been built at the Puʻu Waʻawa ʻa baseyard for acclimatizing plants which are propagated elsewhere (e.g.Volcano Rare Plant Facility) to the Plan Area prior to outplanting. A qualified and trained technician will be onsite for nursery needs, as well as seed collection, and may provide additional assistance to field crews when necessary. In the first two years of implementation, a database and associated map will be completed for each Covered Species, that identifies all known plant locations and propagule collection needs. Within five years of implementation, propagules will be collected from each of the known populations within the Plan Area (*See* Table 3.5).

Individual plant exclosures are the smallest type of exclosure being used within the Plan Area. They are generally intended to protect only a single or few individuals of a single species that are very isolated and typically surrounded by invasive species. Because many of these fences are placed around individuals occurring in highly degraded habitat, they are not contributing to the perpetuation of the species in the wild and are not seen as a long-term management option. The fences do, however, provide protection for individuals of species that cannot be reproduced elsewhere, while cuttings, air layers, seeds, or seedlings are collected and propagated for outplanting in other locations. In addition, these small units can be put in place fairly quickly to protect individuals in locations where larger fencing units will be constructed in the future. Because of the small size of these units and limited grazing or watering opportunities, ungulates are rarely observed to enter the fences, therefore avoiding incidents of direct take from grazing and traffic. However, they offer little opportunity for recruitment of new individuals and population growth if left unattended. In cases where the number, location, or characteristics of a protected plant species is such that management in one of the functional community exclosures is infeasible, we have recommended smaller exclosures to protect the existing plants *in situ* for the purposes of propagule collection.

The following exclosures containing Covered Species will be used as a seed and/or cutting source for outplantings as well as Covered Species found in existing and proposed exclosures (described in Section 6.1.1 and 6.1.2):

- **Kokiʻo Unit 1 – <1 acre**: Contains Kokiʻo outplants.
- **Uhiuhi 2 – 3 acres**: Contains 2 individuals of Uhiuhi.
- **Uhiuhi 3 – 1 acre**: Contains 1 individual of Uhiuhi.
- **Kokio 2 – <1 acre**: Contains Kokiʻo outplants.
- **Puʻu Waʻawaʻa 3 – 1 acre**: A variety of lowland dry forest species.
- **Haplostachys Monitoring Exclosure**: 40 x 40 m fenced unit established by the HCP crew, contains about 40-50 plants.
- **Silene Monitoring Exclosure**: 40 x 40 m fenced unit established by the HCP crew, contains about 30 plants.
- **Stenogyne Monitoring Exclosure**: 40 x 40 m fenced unit established by the HCP crew, contains about 20 plants.
- **Zanthoxylum Unit – 12 acres**: Established in 2005 by Pono Pacific in coordination with USFWS.
- **ʻAiea Exclosures**: Eight individual exclosures with the proposed ʻAiea Conservation unit were established in 2008 and 2009.
- **Neraudia exclosures**: Three small exclosures, one that contains six plants, and two individual tree fences.
- **Aʻe exclosures:** All known individuals of *Z. dipetalum* var. *tomentosum* are individually fenced.
- **Pōpolo kū mai exclosures:** All known individuals of *S. incompletum* are individually fenced.

# 7.0 IMPLEMENTATION

## 7.1 HCP ADMINISTRATION

A DLNR-DOFAW Implementation Team (DDIT) on the island of Hawai‘i will be established to administer and implement the HCP after BLNR approval and ITL issuance. Other experts may be consulted as needed, including scientists or consultants from other agencies (e.g. USDA Forest Service, USFWS), conservation organizations, or academic institutions. HCP-related issues may also be brought before the ESRC for formal consideration when deemed appropriate by the DDIT and DLNR. Pursuant to HRS Chapter §195D-26, DLNR will provide annual updates to the ESRC on the status of all covered species and the effectiveness of implementation under this HCP. The purpose of the regular meetings will be to evaluate the efficacy of monitoring methods, compare the results of monitoring of the estimated take, evaluate the success of mitigation, and develop recommendations for future monitoring and mitigation. Regular meetings will also provide opportunities to consider the need for adaptive management measures. Additional meetings with the ESRC may be requested by the DLNR to address immediate concerns on the implementation of, or compliance issues related to the HCP. Additional meetings may also be requested by the ESRC at any time to address questions or concerns.

## 7.2 MONITORING AND REPORTING

Pursuant to Chapter 195D, monitoring and reporting by the DDIT will address both compliance with and effectiveness of monitoring and mitigation measures outlined in the HCP. Compliance monitoring will verify the Applicant’s implementation of the HCP terms and conditions. Annual reports and other deliverables as described below will be provided to the ESRC via DOFAW HCP staff and/or the DDIT to allow the committee to independently verify that required activities and tasks under this HCP are continuing and on schedule. Monitoring will document take relative to authorized levels and the success of the HCP’s mitigation program.

In order to meet the HCP requirements, and to provide an effective and efficient response to changing needs or circumstances, the DDIT will monitor avoidance and minimization measures, and mitigation efforts and results, assess impacts to covered species and compliance with obligations set forth under the HCP, and evaluate potential adaptive management measures. Roles and responsibilities are defined in this section, and the adaptive management strategy is explained as it pertains to regular evaluation of conservation measures and compliance requirements. The below monitoring information is a basic guideline for informational needs and does not constitute a complete monitoring plan. A final, detailed monitoring plan for each Covered Species will be created within three years of the Plans approval and implementation.

### 7.2.1 Avoidance and Minimization and Mitigation Monitoring

#### 7.2.1.1 Avoidance and Minimization

Each existing and proposed exclosure designated for avoidance and minimization loss, will be surveyed for baseline conditions. DDIT staff will monitor the survival of existing *in situ* populations. If population numbers drop 25% lower than the established baseline, additional management efforts will be initiated.

1. Establish baseline: A full survey of the Covered Species will be done within each of the proposed (upon completion of fencing) and existing exclosures (following HCP approval) with the exception of the FBS unit. Due to the density of vegetation and large size of the FBS unit, regular surveys will be limited to the known Covered Species populations and additional surveying for additional individuals will be done when staff time permits (*for full description of exclosures see Section 4.3.6*). Data to be collected include: location, life stage, vigor, phenological state, and any evidence of ungulate damage. Monitoring data to be collected will follow the recommendations of the HRPRG as closely as possibly (*see Appendix E*).
2. Exclosures will be surveyed annually to follow changes in the population of Covered Species over time. Demographic data by life stage including (growth, survival, reproduction, and recruitment will be analyzed to monitor changes in population abundance over time (declining, stabilizing, or increasing).

#### 7.2.1.2 Mitigation for Covered Plant Species

Each existing and proposed exclosure designated for mitigation and net benefit populations will be monitored to determine the effects of management (fencing, weed control, outplanting) on mitigation populations. If population numbers drop 25% lower than baseline outplanting goals, additional management actions (e.g. investigate causes, conduct additional outplantings, and provide supplemental watering) will be initiated. Additional environmental benefits expected above and beyond the requirements of this HCP will include outplantings of non-covered native plant species, enhanced forest structure for native species, and potential increase in native invertebrate and vertebrate abundance and diversity. Monitoring will include the following:

1. Monitoring survival of outplanted plants:
    a. A subset of the outplanted individuals will be monitored at 1 month, 3 months, 6, months, 12 months, and then annually.
    b. Data to be collected include: location, life stage, vigor, phenological state, and any evidence of ungulate damage. Monitoring data to be collected will follow the recommendations of the HRPRG as closely as possibly (*see Appendix E*).

2. At the end of each year, outplanting success will be evaluated and augmentation of ouplantings to reach mitigation goals will occur as needed. After year one, a subset of the outplanted population will be monitored to quantify survival rates over time. For herbaceous species, monitoring will begin for signs of reproduction and recruitment at the end of year one. For slow growing woody species, monitoring for reproduction and seedling recruitment will begin at year five, or as soon as marked individuals within the population show signs of reproduction. Detailed monitoring methods will be determined based on field observations and will likely be dependent on species identity and conditions. Possible methods include establishing seedling quadrats around randomly chosen individuals to investigate recruitment.

3. A baseline survey of plant community structure (species composition, abundance, and diversity) and other variables such as invertebrate and vertebrate composition may be

conducted directly after each avoidance and minimization, and mitigation exclosures is built.

#### 7.2.1.3 Invasive Plant Species Monitoring

Increased competition, threat of wildfire, and alteration of micro-site conditions have all been identified as potential negative impacts of alien plant invasions on native plants in Hawaiʻi. In order to minimize these risks, invasive species need to be controlled and introductions of new pest species avoided. In order to understand how to best mitigate the threat of invasive species, monitoring will be conducted. The goal for invasive species control for this HCP is to remove 90% of fountain grass and kikuyu grass[24] from within 3 meters of an individual (or cluster of ) Covered Species and, maintain a 25-50 m buffer of less than 50% invasive grass coverage around an individual (or cluster of) Covered Species.

Methods include:

1. Baseline monitoring: systematic transects with random quadrats will be used (concurrent with Covered Species monitoring) to establish and monitor the composition and abundance of alien plant species in the Plan Area. Monitoring will cover alien plant presence, frequency, cover, and density.
2. Baseline surveys will assist with identifying priority species for control. Initial work will rely on the results and experiences of previous restoration projects and experiments by professional managers and scientists. Pilot trials will also be done to assess the best method(s) of control for a given species.
3. After control is conducted, the presence, frequency, cover, and density of alien plants will be monitored semi-annually or annually to assess the efficacy and efficiency of previous control efforts.
4. Protocols to minimize and respond to introduction of new weed species will be developed within the first three years of HCP implementation.

#### 7.2.1.4 Fence line Monitoring

Fence checks will be done quarterly to ensure fence integrity and regular inspection of ungulate ingress occurs. In addition, fences will be checked more frequently if there are sufficient reasons to believe a fence may have been damaged (e.g. after a storm). If fences are found to be breached, fence will be repaired and any ungulates that have entered the fence unit will be removed.

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[24] Fountain (*Pennisetum setaceum)* and kikuyu (*Pennisetum clandestinum)* grass have been identified as the most damaging invasive plant species in the Plan Area. Additional weed species will be controlled on a case by case basis. Some alien species, such as kikuyu grass can hinder the encroachment of more aggressive weed species allowing for better outplanting conditions and can be left in place until outplants are near ready to be planted.

#### 7.2.1.5 Blackburn’s Sphinx Moth and Tree Tobacco Monitoring

Annual monitoring of ‘Aiea outplants for presence of Blackburn’s sphinx moth will begin 5 years post-outplanting. A minimum of three outplanting sites will be chosen to monitor for presence of larvae during the peak larval season (Dec-Feb).

Monitoring of tree tobacco will include biennial surveys of roadsides and fuel-breaks in the Plan Area. Roads will be surveyed annually either by driving, helicopter flight, or UAV (unmanned aerial vehicle). Dependent upon the methodology employed, a map and distribution and abundance estimate will be calculated after each survey. This data will be used to calculating area cleared in the Plan Area annually.

### 7.2.2 Monitoring Impact on Each Covered Species

The biological conditions associated with the HCP shall be monitored to determine if the species needs are being met. Monitoring impact to the species should include collection of quantitative and qualitative data needed to ensure that take is not likely to cause the loss of genetic representation of the affected population, that net benefit to the species and environment is being provided, and that mitigation activities are contributing to the recovery of the species. The effectiveness of monitoring will help the DLNR and ESRC to determine if the conservation strategy is functioning as intended and if the anticipated benefits to the species are being realized. Monitoring of mitigation efforts for Covered Species is intended to inform the DDIT, ESRC and DLNR whether these efforts are adequately compensating for take. If monitoring reveals that a particular mitigation effort is not achieving the necessary level of success, the DDIT will consult with ESRC and DLNR to develop and implement a revised mitigation strategy to meet mitigation requirements.

### 7.2.3 Compliance Monitoring

Compliance monitoring is intended to document implementation of mitigation activities in accordance with the HCP schedule and related agreements. Compliance monitoring is especially critical to ensure timely identification of site-specific conditions or problems that should be addressed through adaptive management or other measures. Monitoring should include collection of the required quantitative and qualitative data needed to assess the effectiveness of mitigation measures. Compliance monitoring may be conducted in concert with monitoring impact to the species.

Compliance monitoring will necessarily be site and management action specific, and depend on the goals and measures of success for that activity under the HCP. Specific protocols for compliance monitoring should be approved by the agencies and ESRC prior to, or as part of, approval of specific mitigation actions.

Generally, compliance monitoring will be conducted by the party or parties responsible for carrying out the mitigation activities, in accordance with the schedule set forth in the approved compliance monitoring protocol. DOFAW HCP administrative staff or their designees will also provide periodic on-site monitoring to ensure HCP-related activities are being performed in accordance with the HCP and related agreement(s) on at least an annual basis, but usually not more than semi-annually in order to minimize costs.

### 7.2.4 Annual Reporting

Annual reporting is required by state law (HRS §195-D). Additional reporting may be advantageous to address emergencies, special circumstances, or changes in condition that should be addressed more quickly than response to an annual report would deliver (e.g., a die-off event, drastic changes in funding or costs, or drastic changes in the level of impact or mitigation effectiveness).

Annual reports will be submitted by the DDIT by August 1 of each year, covering the 12-month period July 1 through June 30. The DDIT will confer with DOFAW HCP staff following the submittal of the annual report to review the results and discuss future HCP implementation issues. Annual reports will also be made available to the ESRC.

Annual reports should include:

1. A summary of HCP requirements (including requirements in the HCP, incidental take license, and other agreements or documents incorporated by the HCP and/or incidental take license), measures to ensure compliance with these requirements and schedule, and recommendations for actions and schedule needed to address any non-compliance issues that arise.
2. Adaptive management approaches and recommended changes for improvement under adaptive management, and the basis for such changes.

Annual review does not preclude other review or discussion. Discussion, review, and implementation of measures to address immediate, time-sensitive concerns, or as needed for the welfare of the species, or as required by the HCP, should be accomplished in a timely manner, as appropriate and feasible, and should not be delayed for completion of the annual review.

## 7.3 ROLES AND RESPONSIBILITIES

Annual reports will include a summary of avoidance and minimization measures and their schedule, monitoring methods and results, collaborative efforts with HCP staff, and identification of problems and solutions. Reports will also include if applicable: requests for technical advice and recommendations for changes through adaptive management. The report should identify any planned changes or additions to facilities or actions which have the potential to increase or decrease impact to protected species, proposed changes to avoidance and minimization measures, and/or monitoring in the following year. All raw data in electronic and/or hard copy form will be attached to the annual report.

Failure to submit adequate reports as required by the ITL is a violation of the permit and may lead to permit suspension or revocation**.** If a report required by the permit is not submitted or is inadequate, the DDIT will be notified in writing and offered at least 30 days to demonstrate compliance**.**

The annual report will include the following information:

1. A summary of all actions funded, planned, completed or not completed in the time period of the report.
2. Circumstances that triggered adaptive management and how the adaptive management was implemented.
3. Description of problems that occurred and how they were handled.
4. Description of cost expenditures and other information related to funding assurances.
5. An annual work plan including an implementation schedule and entities responsible for implementation.
6. Other pertinent information such as actions taken by any regulatory agencies related to implementation of the HCP.

The results of monitoring reports will be evaluated by the DLNR HCP administrative staff to determine the level of take that is occurring. Depending on these results, mitigation efforts may be increased or decreased accordingly. Any changes in mitigation will be done in concurrence with the ESRC and the DLNR. Regardless of the changes to mitigation however, the avoidance and minimization efforts will remain for the duration of the HCP.

## 7.4 ADAPTIVE MANAGEMENT

The concept of adaptive management was first applied to natural resource management by (Holling 1978), and is a concept summarized as “learning by doing,” where feedback from research would be explicitly incorporated into subsequent decisions regarding resource management. In its simplest form, adaptive management is an approach to moving forward in the face of inevitable uncertainties, and emphasizes the need to treat policies and decisions explicitly as hypotheses and opportunities for learning rather than as final solutions.

Under HRS Chapter §195D-21(b)(H) adaptive management in an HCP should specify the actions to be taken periodically if the plan is not achieving its goals. An adaptive management strategy would include a range of possible adjustments and the circumstances under which they would be triggered. Rather than delay the process while sufficient information is gathered to predict the outcome accurately, the DLNR administrative staff and DDIT should jointly develop the adaptive management strategy. Thus, all parties will be assured of an agreeable outcome. However, adaptive management should not replace crafting and implementing appropriate conservation measures up-front.

In the case of this HCP, some uncertainty exists from the estimated rates of take to the future success of the proposed mitigation measures. Adaptive management will ensure that the results of biological monitoring are integrated into future management decisions and actions and will enable annual evaluation of HCP requirements, management plans, goals and objectives. Adaptive management must be employed to achieve this HCP's biological goals and objectives and will rely heavily on feedback from the monitoring and reporting program.

### 7.4.1 Adaptive Management to Address Habitat Improvement

Management plans and guidelines prepared for this HCP will:

1. Identify the uncertainty and the questions to be addressed to resolve the uncertainty.

2. Develop alternative strategies and determine which experimental strategies to implement.

3. Integrate a monitoring program able to detect the necessary information for strategy evaluation.

4. Incorporate feedback loops linking implementation and monitoring to appropriate changes in management.

### 7.4.2 Adaptive Management for Covered Plant Species

As more information is learned about the plant propagation rates, outplanting success, and pest management within the Plan Area, avoidance, minimization, and mitigation measures will be adjusted accordingly. For example, we may find through monitoring and research that certain species of plants do better in certain exclosures or microsites and will need to adjust outplanting protocols or sites accordingly. Likewise, information gained on plant pest control methods may allow us to improve mitigation measures, thereby enhancing survival. New information and methods will be considered whenever brought to the attention of the DDIT or DLNR and will be considered in recommendations for changes through adaptive management. Adaptive management changes may address increased efficiency or effectiveness in assessment of impacts and net benefit, avoidance and minimization, as well as mitigation. Adaptive management recommendations should be reviewed promptly by the DLNR, and approved measures implemented in a timely manner.

### 7.4.3 Adaptive Management for Blackburn's Sphinx Moth

As more information is learned about the density, distribution, and biology of Blackburn's sphinx moth within the Plan Area, avoidance, minimization, and mitigation measures will be adjusted accordingly. For example, we may find through surveys that Blackburn's sphinx moth occur only at certain elevations, within certain plant communities, or at specific times of year. We can then utilize this information to improve removal methods for invasive tree tobacco, while encouraging native habitat. Likewise, information gained on predator or parasitoid interaction with Blackburn's sphinx moth may allow us to improve mitigation measures, thereby enhancing survival. New information and methods will be considered whenever brought to the attention of the DDIT or DLNR and will be considered in recommendations for changes through adaptive management. Adaptive management changes may address increased efficiency or effectiveness in assessment of impacts and net benefit, avoidance and minimization, as well as mitigation. Adaptive management recommendations should be reviewed promptly by the DLNR, and approved measures implemented in a timely manner.

### 7.4.4 Other Adaptive Management Methods

Adaptive management also may be used to update management strategies to 1) redefine conservation measures or 2) incorporate conservation measures recommended in future recovery plans for the Covered Species. If new techniques become available for more effective implementation of the conservation measures, then revisions in the HCP will be made as soon as practicable.

## 7.5 FUNDING

Sufficient funding will be made available to ensure that the proposed measures and actions in the HCP are undertaken in accordance with the schedule. An estimate of the costs of funding the proposed mitigation and avoidance and minimization plan is presented in Appendix H.

Funding for the implementation of the HCP will be provided by the DLNR as an annual operating expense paid *pari passu* with other operating expenditures (operation and maintenance costs, insurance, payroll, audit costs, and agency fee costs). The DLNR is committed to request funding in every biennial budget to support the proposed monitoring and mitigation measures for the life of the ITL. Any short-fall in funding will require consultation on whether the reduced funding will impact the success of the required measures outlined in the HCP, if adaptive management measures are appropriate, and if compliance with permit obligations are no longer upheld. The DLNR will work under the constraints of its program to ensure adequate funding for implementation of the HCP is provided.

## 7.6 CHANGED CIRCUMSTANCES PROVIDED FOR IN THE HCP

Circumstances may change during the life of an HCP, some of which can be anticipated and planned for. Possible changed circumstances that may be anticipated and planned for include: 1) climate change; 2) disease outbreaks in any of the Covered Species; 3) deleterious changes in relative abundance or composition of non-native plant species; 4) ungulate ingress into the mitigation or avoidance and minimization units for Covered Species; 5) hurricanes or other major storms or disturbances that may affect the Plan Area and/or mitigation sites; 6) the de-listing of any species covered in the HCP; and 7) the listing of one or more species that already occur on-site, not currently covered in the HCP.

The procedures to provide for these scenarios are described below:

**1) Global Climate Change Significantly and Negatively Alters Status of the Covered Species**

Global climate change within the life of the Plan (25 years) has potential to alter the current distribution of vegetation communities utilized by Covered Species through region-wide changes in weather patterns, sea level, average temperature, and levels of precipitation (IPPC 2007). In some instances, climate change may cause populations of Covered Species to decline. Covered Plant Species are especially likely to be affected by changes in precipitation. The Blackburn's sphinx moth is unlikely to be affected by any changes in climate over the life of the Plan due to its ability to utilize non-native habitats which are unlikely to decrease in availability during that time frame.

Studies have shown a trend of increasing frequency and intensity of hurricanes over the last 30 years, possibly linked to global climate (Webster et al. 2005, CCSP 2009), which may increase the risk of damage to the Plan Area. This is discussed in more detail below. Sea level is predicted to rise approximately one meter in Hawaiʻi by the end of the 21st Century (Fletcher 2009). Given this prediction, any rise in sea level experienced during the life of the Plan would likely be less than one meter. As the Plan Area ranges in elevation from approximately 20 m to 1700 m, these sites are unlikely to be impacted by sea level rise in the next 25 years (Plan life).

It has been predicted that wet season (winter) precipitation will decrease by 5% to 10%, while dry season (summer) precipitation will increase by about 5% (Giambelluca et al. 2009, Timm and Diaz 2009). This may result in altered hydrology at the Plan Area, with lower elevation units receiving reduced precipitation. To mitigate for this, fencing units at higher elevations may be used for outplanting a given Covered Species despite being outside of its current range.

Vegetation at mitigation sites may also change due to decreased precipitation or increased temperatures and wildfire occurrence. Although changes are expected to be small over the lifetime of the Plan, they are much less predictable in the long term. Should significant changes in vegetation occur, and it is demonstrated that there is a negative impact to Covered Species, other outplanting sites may be considered for continued mitigation. These sites will be chosen in consultation with DLNR administrative staff. In all cases, mitigation efforts will remain commensurate with requested take with a net benefit provided to each Covered Species as required by State law. Changes in the implementation of mitigation measures for any of the Covered Species due to climate change will be incorporated into management actions supporting this HCP so as to successfully meet the objectives outlined in this document.

**2) Deleterious change in relative abundance of non-native plant species, ungulates, parasites, disease outbreak, or predators occurring at the mitigation sites for Covered Species**

Should the proportion or coverage of non-native plant species, parasites, or predators increase at any mitigation site to a point where it is believed that this change is causing significant increases in mortality for the Covered Species and thereby resulting in a measurable decline of the species at the site, the DDIT will consult with DLNR to determine if measures to prevent the further spread of non-native plants, parasites, or predators are available, practical and necessary. If no such measures are available, mitigation measures for the affected Covered Species may be implemented at another site as determined by DLNR. These actions will be implemented if mitigation actions have not yet been fully achieved or if unmitigated take remains.

**3) Ungulate ingress into the mitigation or avoidance and minimization units for Covered Species**

Monitoring of exclosures for ungulate ingress will be conducted on a quarterly basis. Should ungulate ingress occur, animals will be removed and Covered Species populations will be evaluated for impacts. If it is deemed there has been a negative impact to mitigation or *in situ* Covered Species populations, mitigation efforts will be modified accordingly to ensure appropriate mitigation targets are achieved.

### 4) Natural Disasters Such as Hurricanes and Severe Storms

Natural disasters, including hurricanes and storms, have the potential to significantly affect the status of one or more of the Covered Species. Such disasters could also greatly hinder or disrupt mitigation efforts. Mitigation actions may be modified in order to meet outlined mitigation goals in the event of a natural disaster if mitigation actions have not been fully achieved or if unmitigated take remains.

It is not known how the Blackburn's sphinx moth or its habitat will respond to storms or hurricanes. However, we will implement changes in monitoring, reporting, or mitigation deemed appropriate by DLNR if necessary. The budget incorporates funding to enable mitigation objectives to be met in the face of anticipated natural disasters if mitigation actions have not been fully achieved or if unmitigated take remains.

### 5) De-listing of Covered Species

Should any of the species covered in the HCP be de-listed during the tenure of the permit, it is expected that the mitigation efforts provided by this HCP would have contributed in some part to the de-listing of the species. Therefore, mitigation actions for that species will continue to be performed in accordance with the HCP, unless and until the DLNR and ESRC agree that such actions may be discontinued.

### 6) Listing of One or More Species that Already Occur On-site

In the event that one or more species that occur on-site are listed pursuant to the ESA, DLNR will evaluate the degree to which the species is/are at risk of being incidentally taken by Plan operations. If take of the species appears possible, DLNR will then assess whether the mitigation measures already being implemented provide conservation benefits to the newly listed species and if any additional measures are needed to provide a net conservation benefit to the species. DLNR would then seek coverage for the newly listed species under an amendment to the HCP.

## 7.7 UNFORESEEN CIRCUMSTANCES AND "NO SURPRISES" POLICY

Unforeseen circumstances are "changes in circumstance surrounding an HCP that were not or could not be anticipated by HCP participants, DLNR, and ESRC, which result in a substantial and adverse change in the status of a Covered Species" (USFWS and NMFS 1996). Under the "No Surprises" policy, with a properly implemented HCP (HRS §195D-23), the Applicant will not be required to commit additional land, water, money or financial compensation, or be subject to additional restrictions on land, water or other natural resources to respond to such unforeseen circumstances beyond what has been already agreed upon in the HCP, without the consent of the Applicant. For the purposes of this HCP, changes in circumstances not provided for in Section 7.6 that substantially alter the status of the Covered Species are considered unforeseen circumstances.

The "No Surprises" policy assurances only apply to species "adequately covered" in the HCP. Species considered to be "adequately covered" are those covered by the HCP that satisfy the permit issuance criteria under HRS §195D-21. The species considered adequately covered in this HCP and therefore covered by the No Surprises policy assurances include the *Asplenium peruvianum* var *insulare*, Hala pepe (*Chrysodracon hawaiiensis*), Kauila (*Colubrina oppositifolia*), Honohono (*Haplostachys haplostachya*), Ma'o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Koki'o (*Kokia drynarioides*), Uhiuhi (*Mezoneuron kavaiense*), *Neraudia ovata*, 'Aiea (*Nothocestrum breviflorum*), Po'e (*Portulaca sclerocarpa*), Hawaiian Catchfly (*Silene lanceolata)*, Pōpolo kū mai (*Solanum incompletum*), *Stenogyne angustifolia*, A'e (*Zanthoxylum dipetalum* var. *tomentosum*), A'e (*Zanthoxylum hawaiiense*), and the Blackburn's sphinx moth (*Manduca blackburni*).

In the event that unforeseen circumstances occur during the term of the ITL and the DLNR concludes that any of the Covered Species are being harmed as a result, the DLNR may require additional measures from the DDIT where the HCP is being properly implemented, only if such measures are limited to modifications of the conservation program for the affected species and maintain the original terms of the HCP to the maximum extent possible. Additional conservation and mitigation measures will not involve the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water, or other natural resources otherwise available for development or use under the original terms of the HCP without the consent of the DDIT.

## 7.8 NOTICE OF UNFORESEEN CIRCUMSTANCES

DLNR HCP administrative staff will have the burden of demonstrating that unforeseen circumstances exist, using best available scientific and commercial data. The DLNR will notify the DDIT in writing should the DLNR believe that any unforeseen circumstance has arisen.

## 7.9 PERMIT DURATION

The HCP for North Kona Game Management is written in anticipation of the issuance of an ITL to cover the entire Plan duration of 25 years.

## 7.10 AMENDMENT PROCEDURE

Different procedures are present that allow for amendment to the ITL. However, the cumulative effect of any amendments must not jeopardize any listed species. ESRC and DLNR must be consulted on all proposed amendments and the amendment procedures are listed below.

### 7.10.1 Minor Amendments

Minor amendments include routine administrative revisions and changes to surveying or monitoring protocols that do not decrease the level of mitigation or increase take greater than 10%. A request for a minor amendment to the HCP may be made with written notice to the ESRC and DLNR HCP Administrative staff. The amendment will be implemented upon receiving concurrence from the DLNR.

### 7.10.2 Major Amendments

Major amendments are required when the Applicant wishes to significantly modify the Plan, activity, or conservation program already in place. Formal amendments are also necessary to add species to the HCP that were not originally covered or to implement adjustments required due to unforeseen circumstances. An amendment to the ITL requires prior written notification to the DLNR Administrative staff requesting an amendment to the HCP that addresses the new changed circumstance(s) and the adaptive measures that are proposed. Such applications typically require a revised HCP, a revised implementing agreement, and may require environmental review documents in accordance with Hawaii Environmental Policy Act (HEPA) as well as the approval of the BLNR. All major amendments will require consultation with the ESRC and the specific documents required may vary based on the nature of the amendment.

## 7.11 RENEWAL AND EXTENSION

This HCP proposed by the Applicant may be renewed or extended, and amended if necessary, beyond its initial 25-year term with the approval of the ESRC and BLNR. A written request will be submitted that will certify that the original information provided is still current and conditions are unchanged, or a description will be provided with relevant changes to the implementation of the HCP that will take place. The request will also provide species-specific information concerning the level of take that has occurred during the HCP's implementation. Such a request shall be made within at least 180 days of the conclusion of the 25-year term, and the HCP shall remain valid and in full force while the renewal or extension is being processed. The permit may not be renewed for levels of take beyond those authorized by the original permit.

# 8.0 APPENDIX A: MAMMAL TRACKING STUDY

## 8.1 INTRODUCTION

A study was initiated to understand the home range sizes of game mammals in the Plan Area in 2004. The primary objectives were to capture and monitor the movements of wild sheep, goats, and pigs and to establish the “Area of Potential Impact” of game mammals produced on or using the Plan Area (*See section 1.3.1 for a full description*).

## 8.2 METHODS

### 8.2.1 Capture and tagging techniques

Fifteen feral sheep (8 rams and 7 ewes) were captured and fitted with radio collars (Wildlife Materials model HLPM-31100 Magnum, Carbondale, IL, 2-year expected battery life) during September and October 2003. Five feral goats (4 billies and 1 nanny) were also captured and fitted with radio collars during this period.

A Hughes 500 helicopter was used to assist with capture of all sheep and goats. Initially a lasso attached to a pole was utilized to noose and capture the desired animal. One person held the rope in the helicopter while another person, the ‘mugger,’ jumped off the ship and controlled the animal. This method was somewhat successful and allowed for the capture of a specific animal. In practice, it proved somewhat difficult to get the helicopter close enough for the capture, and sometimes required repeated passes and prolonged chasing of the animal. No animals were stressed enough to preclude them from the study.

After the initial two days with the noose method, we switched to a net gun consisting of a modified 308 rifle firing a quad-weighted 12 x 12 ft parachute cord net. After the desired animal was netted, the mugger jumped out and restrained the animal until the helicopter could land and an additional person would assist in the tagging procedure. The net gun was the more efficient method, and allowed particular animals to be captured from within a herd.

Five feral pigs were captured in box traps at various locations in PWWFR during September and October 2004. The traps were baited for several weeks prior to being set. Traps were baited with expired produce and bakery products donated by a local grocery store in Kamuela. Macadamia nuts were also used in some instances. Following the attachment of radio collars, each animal was given a brief physical examination. Approximate age based on dental eruption patterns and horn length or physical size and sex were recorded.

**Selection of animals**

We intentionally captured only one sheep or goat from a particular herd in order to maximize information collected on the behavior, composition and movements of different herds. We targeted animals of different age classes and sexes. We attempted to select animals from all portions of the study area. This was fairly easy to accomplish with sheep, except in the makai areas below Māmalahoa highway, where sheep densities have been low in recent history. Goats tended to occupy more discrete areas within the study site, primarily on rough ‘a‘ā flows and near areas with numerous caves. The capture locations for goats reflect this distribution pattern. We also found that pigs were distributed in a clumped pattern, primarily in the wetter portions of the study area. For this reason, pigs were trapped only at three locations within the PWWFR. To determine how frequently and to what extent ungulates produced on or using portions of the Plan

Area affected resources on adjacent lands, we selected sheep and goats at PWWFR that were near borders with adjacent land owners.

**Tracking protocol**

For all ungulates that were radio collared, the goal was to track and obtain a visual observation once every two weeks. We used ground-based tracking almost exclusively in order to determine behavior, herd size and composition. Our specific approach was to begin tracking and get as close as possible in a truck or ATV. Then we followed the signal on foot and exercised caution to not spook the animal as we closed in on its location. A visual confirmation was nearly always obtained, except in several instances with pigs. After recording field notes we allowed the animal(s) to move off undisturbed, then walked to the location where the animal was seen and recorded a GPS location. This allowed for virtually no locational error in our data set. Occasionally (on three instances) several animals were tracked from a helicopter due to their remote location or if we had exceptional difficulty locating them from the ground.

Garmin 12XL handheld GPS units were used and the location was recorded in UTM WGS 84 format. The observations were compiled in a Microsoft Excel database and later imported into ArcView 3.2 and plotted as home ranges (95% and 50% kernels) and movement patterns. Routine radio tracking ended on April 12, 2005, at which time we had collected sufficient data to fulfill the objectives. To calculate home range size, we used the Animal Movements extension in ArcView 3.2. Home ranges were calculated as 95% adaptive kernels, and core areas were reported as 50% adaptive kernels (ad hoc smoothing parameter for both). We report average home range sizes within the present study.

## 8.3 RESULTS

### 8.3.1 Home Range

Ungulate descriptions, tracking data, and the fate of study animals followed during the tracking study are summarized in Table 8.1. Data gathered from game mammal home ranges was used to determine the geographic scope of the area of impact, hereafter "Area of Potential Impact (149,228 acres)". The calculated home ranges for mammals in the Plan Area are 9.35 $km^2$ for female sheep, 12 $km^2$ for male sheep, and 16.3 $km^2$ for goats. The largest of the three home ranges (16.3 $km^2$ for goats, or 2.25 km diameter) was used to calculate the area of potential impact. Figure 8.1 summarizes the current home range results for sheep, pigs, and goats in the region.

**Table 8.1** Female sheep tracking data results indicating age, date tagged, number of times the animal was located, and the 95% Kernel home range size ($km^2$).

| **Age** | **Date Tagged** | **Locations** | **95% Kernel HR size ($km^2$)** |
|---|---|---|---|
| 1 | 09/11/04 | 13 | 16.17 |
| 1 | 10/09/04 | 14 | 7.36 |
| 2 | 09/03/04 | 26 | 13.57 |
| 2 | 09/03/04 | 10 | 8.69 |
| 2 | 09/03/04 | 9 | 6.59 |
| 2+ | 09/02/04 | 11 | 11.65 |
| 3+ | 09/11/04 | 13 | 1.41 |
| **Average HR Size** | | | **9.35** |

**Table 8.2** Male sheep tracking data results indicating age, date tagged, number of times the animal was located and the 95% Kernel Home range size ($km^2$).

| **Age** | **Date Tagged** | **Locations** | **95% Kernel HR size ($km^2$)** |
|---|---|---|---|
| 1 | 09/02/04 | 6 | 9.18 |
| 2 | 10/09/04 | 11 | 3.79 |
| 2+ | 10/09/04 | 10 | 10.25 |
| 3+ | 09/11/04 | 11 | 21.28 |
| 3+ | 09/11/04 | 8 | 18.67 |
| 4+ | 09/02/04 | 13 | 8.92 |
| **Average HR Size** | | | **12.02** |

**Table 8.3** Goat tracking data results indicating sex, age, date tagged, number of times the animal was located and the 95% Kernel Home range size ($km^2$).

| **Sex** | **Age** | **Date Tagged** | **Locations** | **95% Kernel HR size ($km^2$)** |
|---|---|---|---|---|
| Female | 2 | 10/09/04 | 8 | 35.74 |
| Male | .75 | 10/09/04 | 8 | 19.21 |
| Male | 2 | 10/09/04 | 11 | 7.57 |
| Male | 2 | 10/09/04 | 9 | 13.34 |
| Male | 3+ | 09/11/04 | 12 | 5.65 |
| **Average HR Size** | | | | **16.30** |

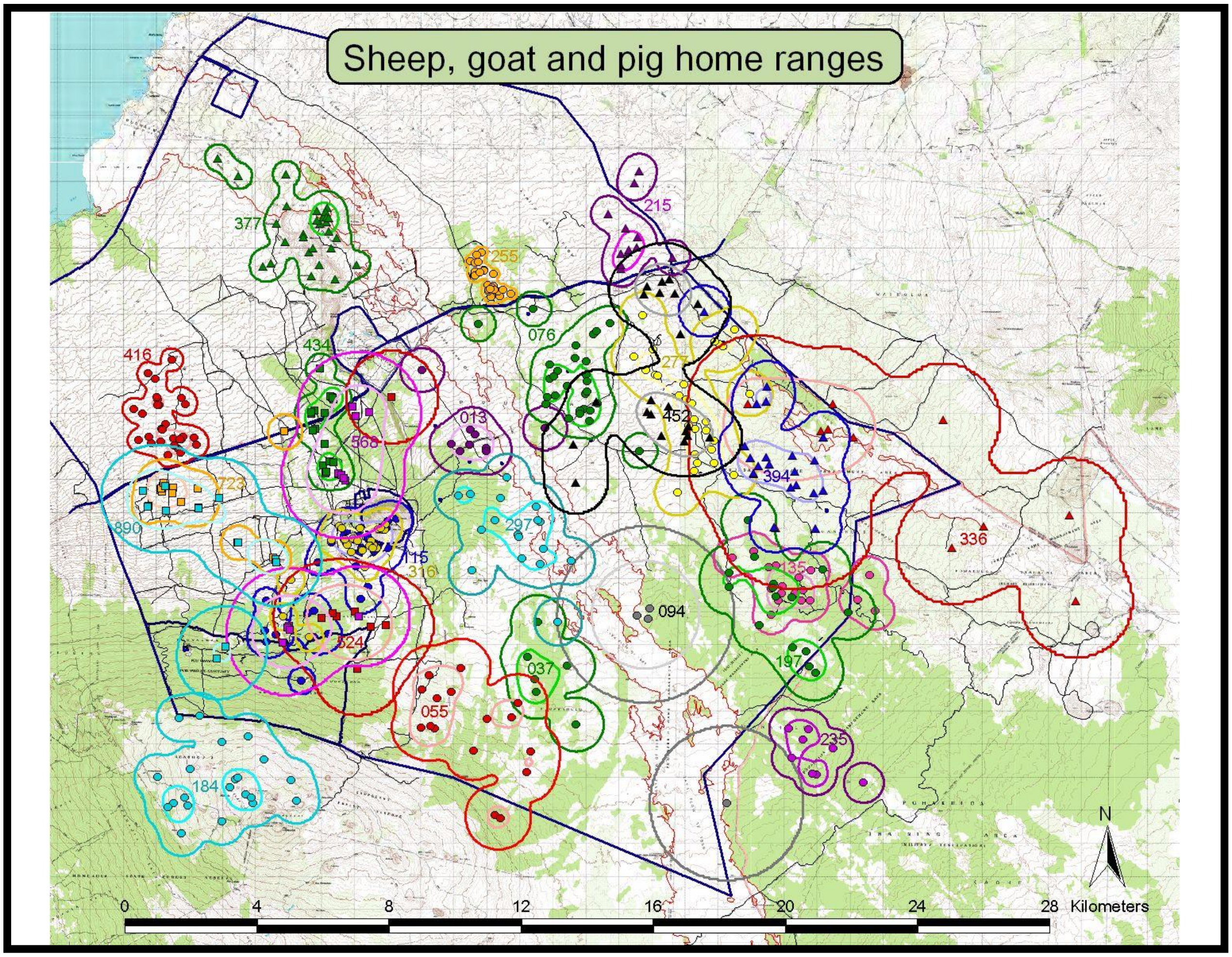


**Figure 8.1** Summary of the 95% kernel home range results (km$^2$) for sheep (circles), pigs (squares), and goats (triangles) in the region. Each color signifies an individual animal.

**Habitat Use**

The sheep in this study generally used well-defined ranges, characterized by repeated movements back and forth across their established ranges. There were no instances of clear dispersal from one area to another, though the majority of sheep radio-collared were >1 year in age. In fact, two sheep (Ram 184 and Ewe 115) were translocated 1 and 2 km, respectively, from their capture sites and released within the Forest Bird Sanctuary. However, both animals quickly left the Sanctuary and returned to their former home ranges. Sheep were found more frequently in open areas during the morning and late afternoon periods, feeding in small herds. On cloudy days, sheep tended to remain in more open areas for longer periods. During the hottest portion of the day sheep were often found bedded down beneath the shade of trees or shrubs.

Due to unusually high rainfall during our study, there was abundant grass and herbaceous vegetation for sheep to feed on. We detected some browsing on bark and woody vegetation, but apparently at lower levels than in the past, based on the condition and prevalence of past bark stripping that we observed.

**Herd composition**

Herd composition among sheep and goats was very fluid throughout the year, and from day to day. Some animals, especially goats, were found in large herds on several occasions. However, herd size and composition was nearly always changed from one observation to the next. Sheep showed some change in herd composition during the fall lambing season, with ewes breaking out of larger herds and forming into smaller herds composed of only ewes and lambs. During this period, small bachelor herds of rutting rams were occasionally seen. Pigs tended to be more solitary or associated with their littermates.

# 9.0 APPENDIX B: LIST OF SPECIES IN THE PLAN AREA

The Pu‘u Wa‘awa‘a Management Plan (2003) includes a list of threatened and endangered species currently known to exist within the area, as well as a list of species historically known to occur in the area, and those likely to be suited to the area. Endangered and threatened species currently existing in the Plan Area (modified from the Management Plan (2003a:63-65) to include Pu‘u Anahulu) are listed in Table 9.1. This list includes both plant and animal species. Note that not all of the listed plants are likely to be negatively impacted by covered activities, particularly those occurring in the Forest Bird Sanctuary portion of the Plan Area.

Protected species which were known to be in the Plan Area historically (from Management Plan (2003a:66), modified to include data from HCP surveys), are included in Table 9.2. A list of additional species that are likely to benefit from mitigation efforts under the Habitat Conservation Plan, but not included as Covered Species, are also listed in Table 9.3. Benefit gained for these species is considered a ‘net benefit’ for the purposes of this HCP, and contribute to the purposes of HRS §195D.

**Table 9.1** Endangered and threatened species currently existing in the Plan Area (modified from Management Plan 2003a:63-65 to include Pu‘u Anahulu species). *Indicates species not found during HCP botanical surveys.

| Scientific name | Common name | Status |
|---|---|---|
| **Plants** | | |
| *Asplenium peruvianum* var. *insulare* | | Endangered |
| *Chrysodracon hawaiiensis* | Hala pepe | Endangered |
| *Colubrina oppositifolia* | Kauila | Endangered |
| *Haplostachys haplostachya* | Honohono | Endangered |
| *Hibiscus brackenridgei* ssp. *brackenridgei* | Ma‘o hau hele | Endangered |
| *Kokia drynarioides* | Koki‘o | Endangered |
| *Mezoneuron kavaiense* | Uhiuhi | Endangered |
| *Neraudia ovata* | | Endangered |
| *Nothocestrum breviflorum* | ‘Aiea | Endangered |
| *Phyllostegia velutina* | | Endangered |
| *Portulaca sclerocarpa* | Po‘e | Endangered |
| *Silene lanceolata* | Hawaiian catchfly | Endangered |
| *Solanum incompletum* | Pōpolo kū mai | Endangered |
| *Stenogyne angustifolia* | Creeping mint | Endangered |
| *Vicia menziesii* | Hawaiian vetch | Endangered |
| *Zanthoxylum dipetalum* var. *tomentosum* | A‘e | Endangered |
| *Zanthoxylum hawaiiensis* | A‘e | Endangered |
| *Acacia koaia* | Koai‘a | Species of Concern |
| *Alphitonia ponderosa* | Kauila | Species of Concern |

| Scientific name | Common name | Status |
|---|---|---|
| *Capparis sandwichiana* | Maiapilo | Species of Concern |
| *Euphorbia olowaluana* | ‘Akoko | Species of Concern |
| *Eragrostis deflexa* | | Species of Concern |
| *Exocarpus gaudichaudii* | | Species of Concern |
| *Fragaria chiloensis* | | Species of Concern |
| *Melicope hawaiensis* | Manena | Species of Concern |
| *Polyscias sandwicensis* | ‘Ohe makai | Species of Concern |
| *Sisyrinchium acre* | Mau‘u lā ‘ili | Species of Concern |
| *Stenogyne macrantha* | | Species of Concern |
| *Tetramalopium consanguineum* | | Species of Concern |
| *Tetramalopium humile* | | Species of Concern |
| **Vertebrates** | | |
| *Branta sandvicensis* | Nēnē (Hawaiian goose) | Endangered |
| *Buteo solitarius* | ‘Io (Hawaiian hawk) | Endangered |
| *Eretmochelys imbricata* | Honu ‘Ea (Hawksbill turtle) | Endangered |
| *Himantopus mexicanus knudseni* | Ae‘o (Hawaiian stilt) | Endangered |
| *Lasiurus cinereus semotus* | ‘Ōpe‘ape‘a (Hawaiian hoary bat) | Endangered |
| *Loxops coccineus coccineus* | ‘Akepa | Endangered |
| *Oreomystis mana* | Hawai‘i creeper | Endangered |
| *Chelonia mydas* | Honu | Endangered |
| *Asio flammeus sandwichensis* | Pueo | Species of Concern |
| **Invertebrates** | | |
| *Manduca blackburni* | Blackburns’s sphinx moth | Endangered |
| *Drosophila heteroneura* | | Endangered |
| *Anomis vulpicolor* | | Species of Concern |
| *Caconemobius varius* | | Species of Concern |
| *Coleotichus blackburniae* | | Species of Concern |
| *Ectemnius rubrocaudatus* | | Species of Concern |
| *Hylaeus coniceps* | | Species of Concern |
| *Hylaeus difficilis* | | Species of Concern |
| *Hylaeus filicum* | | Species of Concern |
| *Hylaeus hula* | | Species of Concern |
| *Hylaeus kona* | | Species of Concern |

| Scientific name | Common name | Status |
|---|---|---|
| *Hylaeus laetus* | | Species of Concern |
| *Hylaeus pubescens* | | Species of Concern |
| *Micromus usingeri* | | Species of Concern |
| *Oliarus lorettae* | | Species of Concern |
| *Omiodes monogona* | | Species of Concern |
| *Plagithmysus mezoneuri* | | Species of Concern |
| *Plagithmysus elegans* | | Species of Concern |
| *Plagithmysus simplicollis* | | Species of Concern |
| *Rhyncogonus giffardi* | | Species of Concern |
| **Snails** | | |
| *Leptachatina lepida* | | Species of Concern |
| *Neritilia hawaiiensis* | | Species of Concern |
| *Vitrina tenella* | | Species of Concern |
| *Metabetaeus lohena* | | Species of Concern |
| | | |
| | | |

**Table 9.2** Endangered and threatened species historically found in the Plan Area (from Management Plan 2003a modified to include data from HCP surveys).

| Scientific name | Common name | Status |
|---|---|---|
| **Plants** | | |
| *Bidens micrantha* subsp. *ctenophylla** | Ko‘oko‘olau | Endangered |
| *Bonami menziesii* | | Endangered |
| *Delissea undulata* ssp. *undulata* | | Endangered |
| *Diellia erecta* | | Endangered |
| *Gardenia brighamii* | Nānū | Endangered |
| *Hibiscadelphus hualalaiensis* | Hau kuahiwi | Endangered |
| *Isodendrion pyrifolium* | Wahine noho kula | Endangered |
| *Ochrosia kilaueaensis* | Hōlei | Endangered |
| *Phyllostegia racemosa* | Kiponapona | Endangered |
| *Plantago hawaiiensis** | Laukahi kuahiwi | Endangered |
| *Crytandra menziesii** | Ha‘iwale | Species of Concern |
| *Dissochondrus biflorus* | | Species of Concern |
| *Nesoluma polynescium* | Keahi | Species of Concern |
| *Phytolacca sandwicensis** | Pōpolo kū mai | Species of Concern |

| Scientific name | Common name | Status |
|---|---|---|
| *Rubus macraei** | ‘Akala | Species of Concern |
| *Sicyos macrophyllus** | ‘Anunu | Proposed Endangered |
| **Vertebrates** | | |
| *Anas wyvilliana* | Koloa | Endangered |
| *Corvus hawaiiensis* | ‘Alalā | Endangered |
| *Hemignathus munroi* | ‘Akiapola‘au | Endangered |
| *Pterodroma phaeopygia sandwicensis* | ‘Ua‘u | Endangered |
| **Invertebrates** | | |
| *Partulina confusa* | | Species of Concern |

**Table 9.3** Endangered, threatened, and common species likely suited for restoration efforts in the Plan Area not covered under this HCP (Modified from Management Plan 2003a:67-68).

| **Scientific name** | **Common name** | **Status** |
|---|---|---|
| **Plants** | | |
| *Abutilon menziesii* | Koʻoloaʻula | Endangered |
| *Achyranthes mutica* | | Endangered |
| *Cyperus faurei* | | Endangered |
| *Fluggea neowawraea* | Mēhamehame | Endangered |
| *Gouania vitifolia* | | Endangered |
| *Hedyotis coriacea* | Kioʻele | Endangered |
| *Isodendrion hosakae* | Aupaka | Endangered |
| *Isodendron pyrifolium* | Wahine noho kula | Endangered |
| *Lipochaeta venosa* | Nehe | Endangered |
| *Pritchardia affinis* | Loulu | Endangered |
| *Sesbania tomentosa* | ʻOhai | Endangered |
| *Spermolepis hawaiiensis* | | Endangered |
| *Tetramolopium arenariun* var. *arenarium* | | Endangered |
| *Vigna o-wahuensis* | | Endangered |
| *Silene hawaiiensis* | | Threatened |
| *Ranunculus hawaiiensis* | | Candidate |
| *Bidens campylotheca* ssp. *Campylotheca* | | Species of Concern |
| *Bobea timonioides* | ʻAhakea | Species of Concern |
| *Dissonchondrous biflorus* | | Species of Concern |
| *Festuca hawaiiensis* | | Candidate |
| *Phyllostegia stachyoides* | | Candidate |
| *Acacia koa* | Koa | None |
| *Alyxia olivaeformis* | Maile | None |
| *Antidesma pulvinatum* | Hame | None |
| *Diplazium sandwichianum* | Hōʻiʻo | None |
| *Bidens menziesii* | Koʻokoʻolau | None |
| *Canavalia hawaiiensis* | ʻĀwikiki | None |
| *Charpentiera obovata* | Pāpala | None |
| *Cheirodendron trigynum* | ʻOlapa | None |
| *Chenopodium oahuense* | ʻĀweoweo | None |
| *Cibotium* spp. | Hāpuʻu | None |
| *Claoxylon sandwicense* | Poʻola | None |

| Scientific name | Common name | Status |
|---|---|---|
| *Clermontia clermontioides* | ʻŌha wai | None |
| *Cocculus trilobus* | Huehue | None |
| *Coprosma cymosa* | Pilo | None |
| *Diospyros sandwicensis* | Lama | None |
| *Dodonaea viscosa* | ʻAʻaliʻi | None |
| *Dryopteris spp.* | | None |
| *Dubautia linearis* | Naʻeneʻe | None |
| *Dubautia plantaginea* | Naʻeneʻe | None |
| *Eragrostis atropioides* | Lovegrass | None |
| *Eragrostis leptophylla* | | None |
| *Hesperocnide sandwicensis* | | None |
| *Lipochaeta subcordata* | Nehe | None |
| *Metrosiderospolymorpha* | ʻŌhiʻa | None |
| *Myrsine lanaiensis* | Kōlea | None |
| *Myrsine lessertiana* | Kōlea lau nui | None |
| *Nephrolepis exaltata* | Swordfern | None |
| *Nestegis sandwicensis* | Olopua | None |
| *Nototrichium sandwichensis* | Kuluʻi | None |
| *Peperomia cookiana* | ʻAlaʻalaʻwai nui | None |
| *Peperomia leptostachya* | ʻAlaʻalaʻwai nui | None |
| *Peperomia macraei* | ʻAlaʻalaʻwai nui | None |
| *Phyllostegia ambigua* | Mint | None |
| *Phytolacca sandwicensis* | Pōpolo | None |
| *Pisonia brunoniana* | Pāpala | None |
| *Pisonia sandwicensis* | Pāpala | None |
| *Pittosporum hosmeri* | Hōʻawa | None |
| *Pittosporum terminaloides* | Hōʻawa | None |
| *Plumbago zeylandica* | ʻIlieʻe | None |
| *Polystichum hillibrandii* | | None |
| *Pouteria sandwicensis* | ʻĀlaʻa | None |
| *Psychotria hawaiiensis* | Kōpiko | None |
| *Psydrax odoratum* | Alaheʻe | None |
| *Rauvolfia sandwicensis* | Hao | None |
| *Rumex giganteus* | Pāwale | None |

| Scientific name | Common name | Status |
|---|---|---|
| *Sadleria* spp. | ‘Ama‘u | None |
| *Santalum paniculatum* | ‘Iliahi | None |
| *Senna gaudichaudii* | Kolomona | None |
| *Sicyos lasiocephalus* | | None |
| *Sophora  chrysophylla* | Māmane | |
| *Streblus pendulinus* | A‘ia‘i | None |
| *Urera glabra* | Ōpuhe | None |
| *Wikstroemia* spp. | ‘Ākia | None |
| *Xylosma hawaiiense* | Maua | None |

# 10.0 APPENDIX C*:* EXCLOSURE STUDY

In September 2004, a study was initiated to quantify the effectiveness of exclosures in minimizing direct negative impacts from ungulates on plant species in the Plan Area, and to document the effect of browsing/grazing on plant performance (i.e. reproduction and growth). *Stenogyne angustifolia* is used here as an example to understand the effects game mammals have on native plant species.

## 10.1 METHODS

For each species, an exclosure (approximately 20 m by 20 m, four ft hogwire fencing) and a corresponding unfenced control site were established. For Hawaiian Catchfly and *Stenogyne angustifolia*, both the exclosure and the corresponding control sites were monitored at 0, 6, 12, and 24 months from initiation of the study, and Honohono and *Phyllostegia velutina* were monitored at 0, 6, 12, and 18 months from initiation of the study. The variation in monitoring intervals is the result of accessibility issues for the various field sites.

Each site was divided into four sampling quadrants and each of the four species were labeled and flagged. For each individual plant, the following attributes were measured and recorded: height (cm), width (cm), reproductive status (flowers present, fruit present, or n/a), age (seedling or mature), survival, vigor, and signs of ungulate damage (browse activity including evidence of broken stems or twigs, soil disturbance, and/or trampling).

## 10.2 RESULTS

### 10.2.1 Changes in Level of Browsing

A comparison of control (non-fenced) plants to populations of the *Stenogyne angustifolia* protected with game fencing showed a marked decrease in the amount of ungulate damage in the fenced populations over time (Figure 10.1). Browse activity was between 20-30% in both fenced and unfenced units at the beginning of the study. However, it is important to note that at the 18 months monitoring point, approximately 20% of the plants showed browse activity within the fencing unit, indicating ungulate ingress. This exemplifies the point that fences are not fool proof and need to be monitored for ungulate ingress.

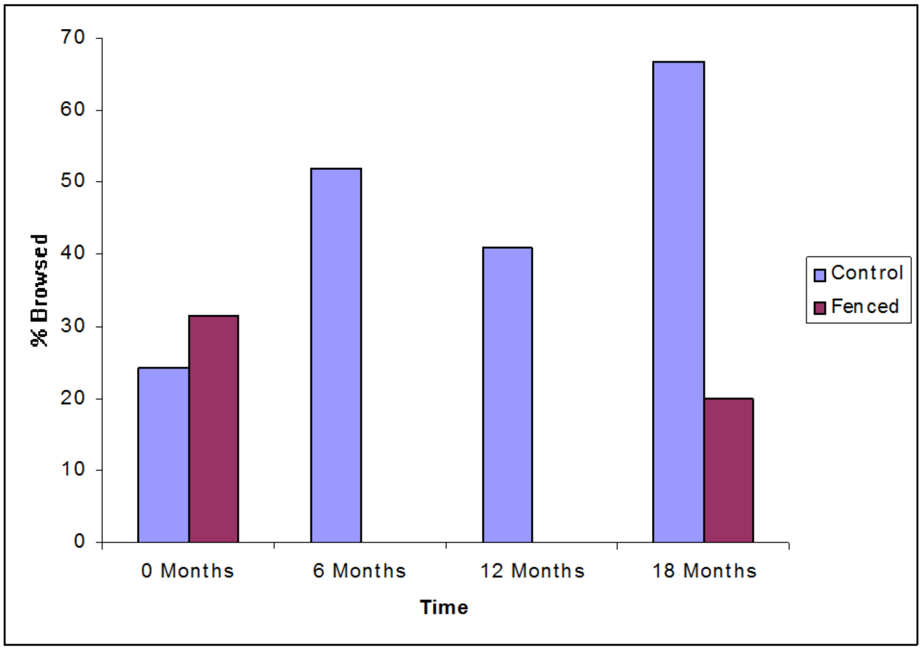


**Figure 10.1** Percent ungulate browse activity on *Stenogyne angustifolia* over the 18 month study period.

### 10.2.2 Changes in Plant Growth

Monitoring of growth (as measured by plant width) showed a similar positive impact within the exclosures, where plant growth is markedly higher in fenced individuals of *Stenogyne angustifolia* versus unfenced (Figure 10.2).

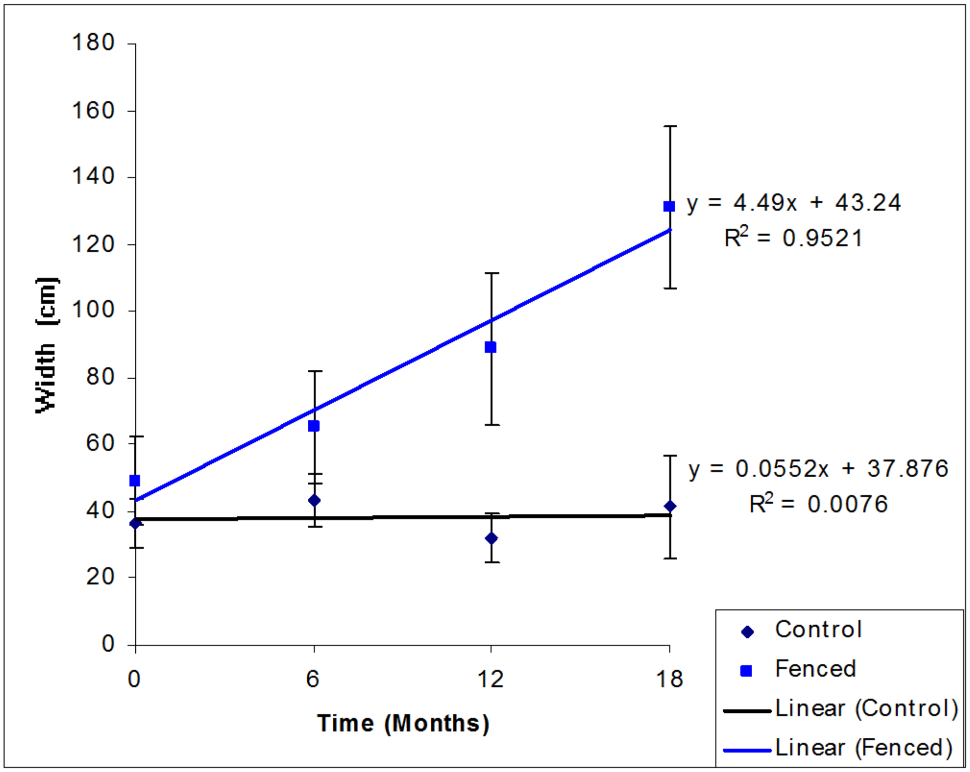


**Figure 10.2** Scatter plot of *Stenogyne angustifolia* plant width over time in both fenced and unfenced units.

### 10.2.3 Changes in Reproductive Rates

A comparison of the percent of reproductive individuals (plants with flowers, buds, or fruits) of *Stenogyne angustifolia* indicates over 70% of individuals in the exclosures were reproductive after one year, compared to 30% of individuals outside of exclosures (Figure 10.3).

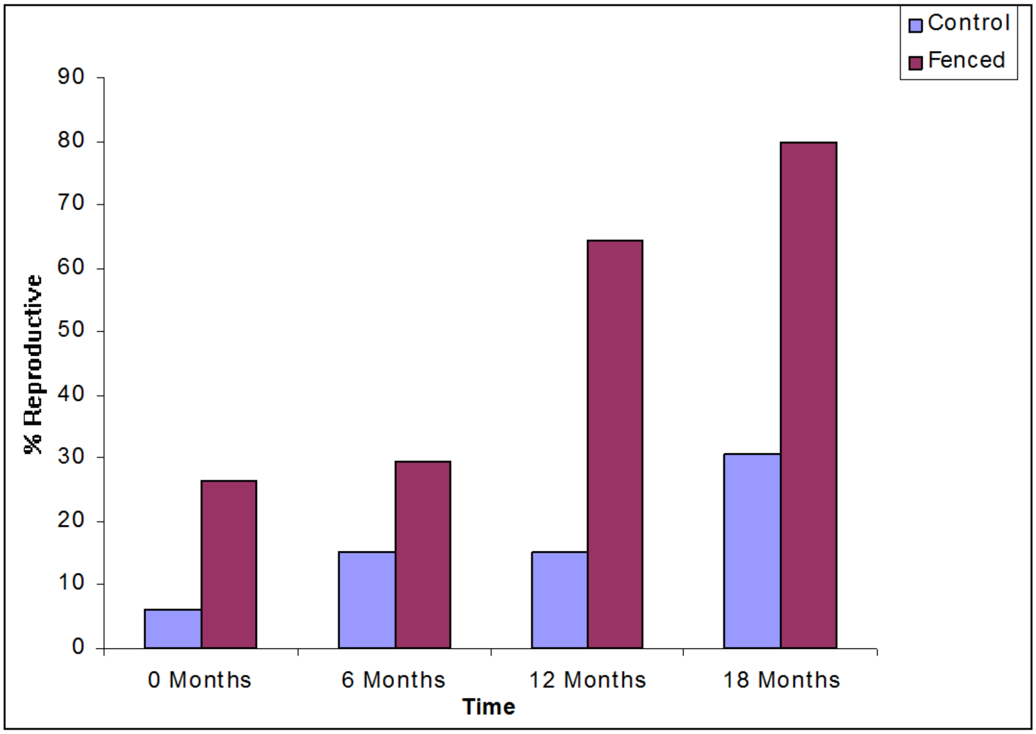


**Figure 10.3** Percent of *Stenogyne angustifolia* individuals reproducing over 18 months of the ungulate exclosure study.

### 10.2.4 Discussion and Conclusions

The study of the effects of exclosures on minimizing direct negative effects of grazing provides evidence that exclosures effectively minimize browsing, resulting in increased plant growth and reproduction.

Exclosure plants exhibited positive growth while the unfenced individuals showed no growth. Exclosure plants exhibited significantly greater reproductive rates compared to their non-protected counterparts. It is important to note, however, that some exclosures eliminated ungulate browse, but in other cases simply minimized browse because of ungulate ingress.

Results of this study suggest that exclosures are highly effective means of minimizing negative impacts from grazing mammals on native plants at Puʻu Waʻawaʻa and Puʻu Anahulu. The lower reproductive effort exhibited by control site plants suggests that replacement may not be sufficient to replace senescence in unprotected areas. Improved reproductive rates of plants in exclosure populations may be critical to population survival and species recovery.

# 11.0 APPENDIX D: BLACKBURN'S SPHINX MOTH SURVEYS AND RESULTS

## 11.1 SURVEY METHODS

In order to determine potential impacts to *M. blackburni* from Plan activities and minimize take, we initiated surveys for eggs, larvae, and adult moths and documented host plant use to estimate density and distribution of *M. blackburni* within the Plan Area. We also considered the surveys a way to contribute to our knowledge of the species, and to identify factors which could be manipulated to increase benefit and reduce threats to the species. Density and distribution of *M. blackburni* is known to vary within the Plan Area (E. Adkins and C. King, observation). The purpose of the surveys were to quantify *M. blackburni* density and distribution on tree tobacco (*Nicotiana glauca*), an invasive plant host, and attempt to identify significant factors affecting density and distribution such as plant density, leaf density, plant height, and elevation. Survey methods focused on determining the abundance of eggs, larvae, and adults because of potential differences in distribution, timing, and effective survey strategies for these different life stages. These data were used to determine estimated levels of take due to clearing of the invasive tree tobacco, to increase the effectiveness of mitigation efforts, and to estimate benefit from planned mitigation efforts. Field methods, analyses and results are described in this section.

### 11.1.1 Tree Tobacco Distribution on Roadsides and Fuelbreaks

To quantify the distribution of tree tobacco on roadsides and fuelbreaks across the Plan Area, locations of tree tobacco were recorded using Global Positioning System (GPS) technology as HCP staff drove 4x4 roads. For each location, we recorded the number of tree tobacco along a 25 m x 3 m belt transect with the following categories: low (1-9 plants), medium (10-19 plants), or high (> 20 plants). These locations were used to create a preliminary map of tree tobacco distribution across the Plan Area (Figure 11.1). While this method was not comprehensive in that it didn't cover all of the known roads within the Plan Area, the sampled area was large enough that it gave a general picture of the likely distribution and density of tree tobacco across the entire Plan Area. The initial survey was completed in 2010 and more comprehensive surveys were conducted again in 2011 and 2012.

We then used a subset of this data taken in Pu‘u Anahulu (Figure 11.1), to calculate what proportion of the roads that are expected to contain tree tobacco actually are occupied by tree tobacco. For a stretch of road 37,402 m long and 7 m wide (261,814 $m^2$), 649 tree tobacco location survey points were recorded. Each survey point represents a 25 m x 3 m long belt transect that contains tree tobacco. For the subset of road used in this calculation, the total area actually occupied by tree tobacco was 48,675 $m^2$ or approximately 18.6% of the surveyed roads.

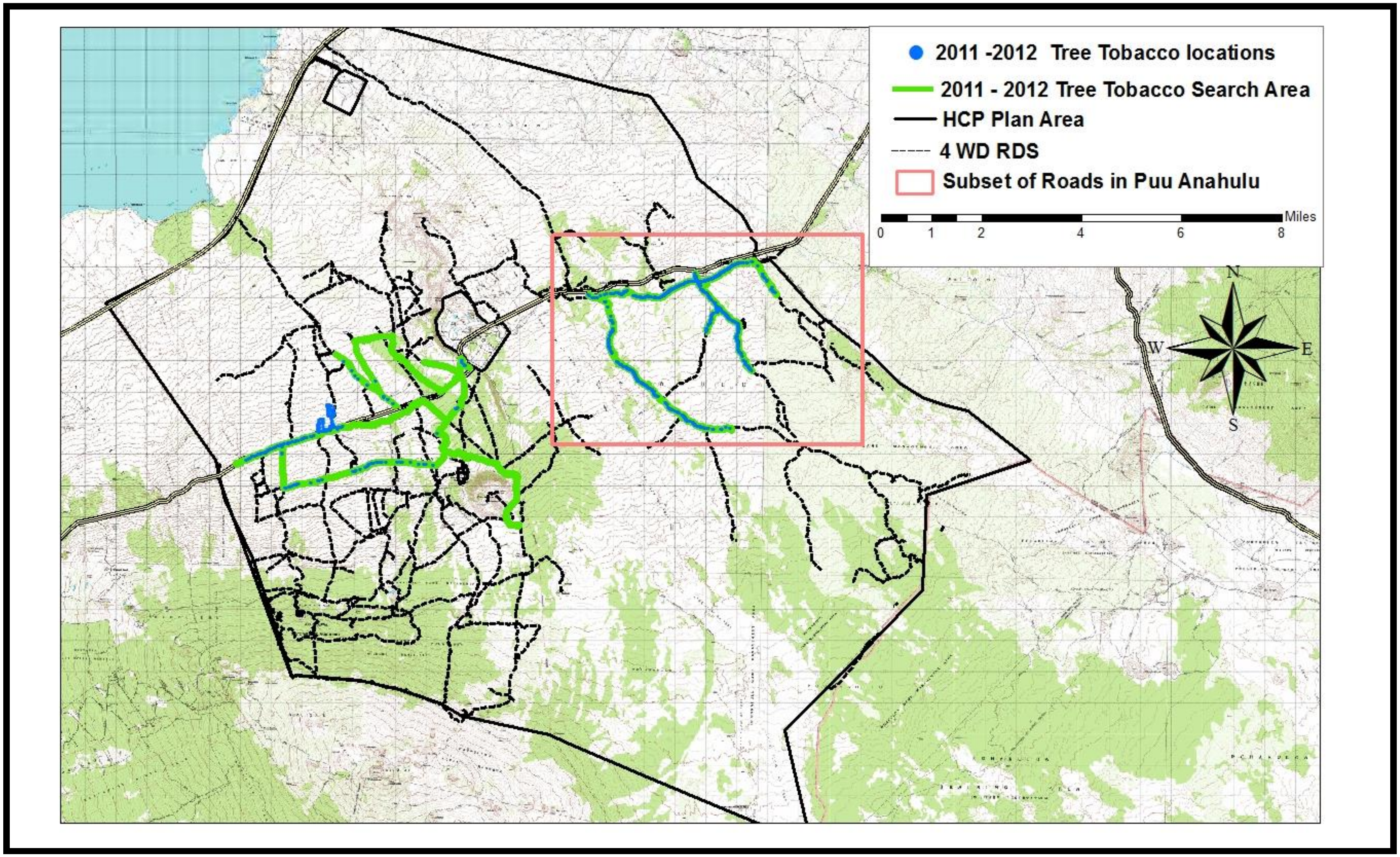


**Figure 11.1** 2011 and 2012 tree tobacco search area (green line) with mapped tree tobacco locations (blue dots). The area in the red/pink rectangle highlights the subset of roads in Pu'u Anahulu used to calculate the proportion of occupied habitat.

Next, a map of the Core Tree Tobacco Invasion Area (CTTIA) was created to indicate which roads in the Plan Area currently contain, have contained in the past, or may contain tree tobacco in the future (Figure 11.2). Based on this map, we estimate the CTTIA to be 839,486.38 $m^2$ or approximately 207 acres. If we assume that the coverage measured above in general characterizes the density of tree tobacco as a whole across the Plan Area (and this is likely a conservative estimate as Puʻu Anahulu tends to have high density), then we can apply this value to the CTTIA (839,486.38 $m^2$ x 0.186), to calculate the area occupied by tree tobacco (Occupied Area = 156,144.467 $m^2$).

### 11.1.2 *M. blackburni* Larval Density/Distribution on Tree Tobacco

We conducted *M. blackburni* surveys on a portion of the roads, fuelbreaks, and off road areas using visual surveys on belt transects. These belt transects were randomly selected from within areas of known tree tobacco distribution (based on the roadside surveys described above). Each belt transect consisted of a 25 m x 3 m area located on a randomly selected side of the road (left or right side). All individual tree tobacco that occurred within each belt transect were examined for 3 minutes each to search for *M. blackburni* eggs and larvae by trained staff. Data collected included: location (UTM coordinates), dominant vegetation description, elevation, tree tobacco height class (0-1 m, 1-2 m, 2-5 m, >5 m), and leaf density (low, medium, high). We chose to categorize surveyed tree tobacco plants into different height classes and leaf densities because these traits can correlate with factors that are selected for by certain insects as hosts for their offspring (e.g. leaf quality and quantity). In addition, we also recorded the percentage of each plant searched, reproductive status (flowering, fruiting), presence of larval feeding damage, additional insects present, number of *M. blackburni* eggs/host plant, number of larvae/host plant, approximate life stage (instar) of larvae ($1^{st}$ to $5^{th}$ instar), number and type of predators/parasitoids observed on host plants, and any damage to plant tissue (ungulate browse, trampling, cutting, vehicle, or herbicide spray), because those factors could also affect host site selection by adult moths through their effects on plant quality.

### 11.2.3 *M. blackburni* Larval Density/Distribution on ʻAiea

We plan to survey for *M. blackburni* eggs and larvae during HCP implementation on a subset of mapped wild ʻAiea (*Nothocestrum breviflorum*) throughout the Plan Area. Thorough surveys of ʻAiea are difficult because the wood is extremely brittle, making the plants impossible to climb, and thus leaving much of the tree inaccessible to searchers. Additionally, many of the trees in the Plan Area are in poor health with reduced foliage (likely due to many factors including drought, insect pests, and competition with invasive plants) which limits the available substrate for the larvae. Where possible, these threats will be controlled around individual ʻAiea trees (e.g. through removal of invasive weeds). Targeted surveys for *M. blackburni* eggs and larvae on ʻAiea will be completed during regularly scheduled intervals to be determined during HCP implementation to establish the presence or absence and distribution of the species on the native host plant. Reporting will include the total number and average density of *M. blackburni* eggs and larvae per host plant as well as distribution within the Plan Area.

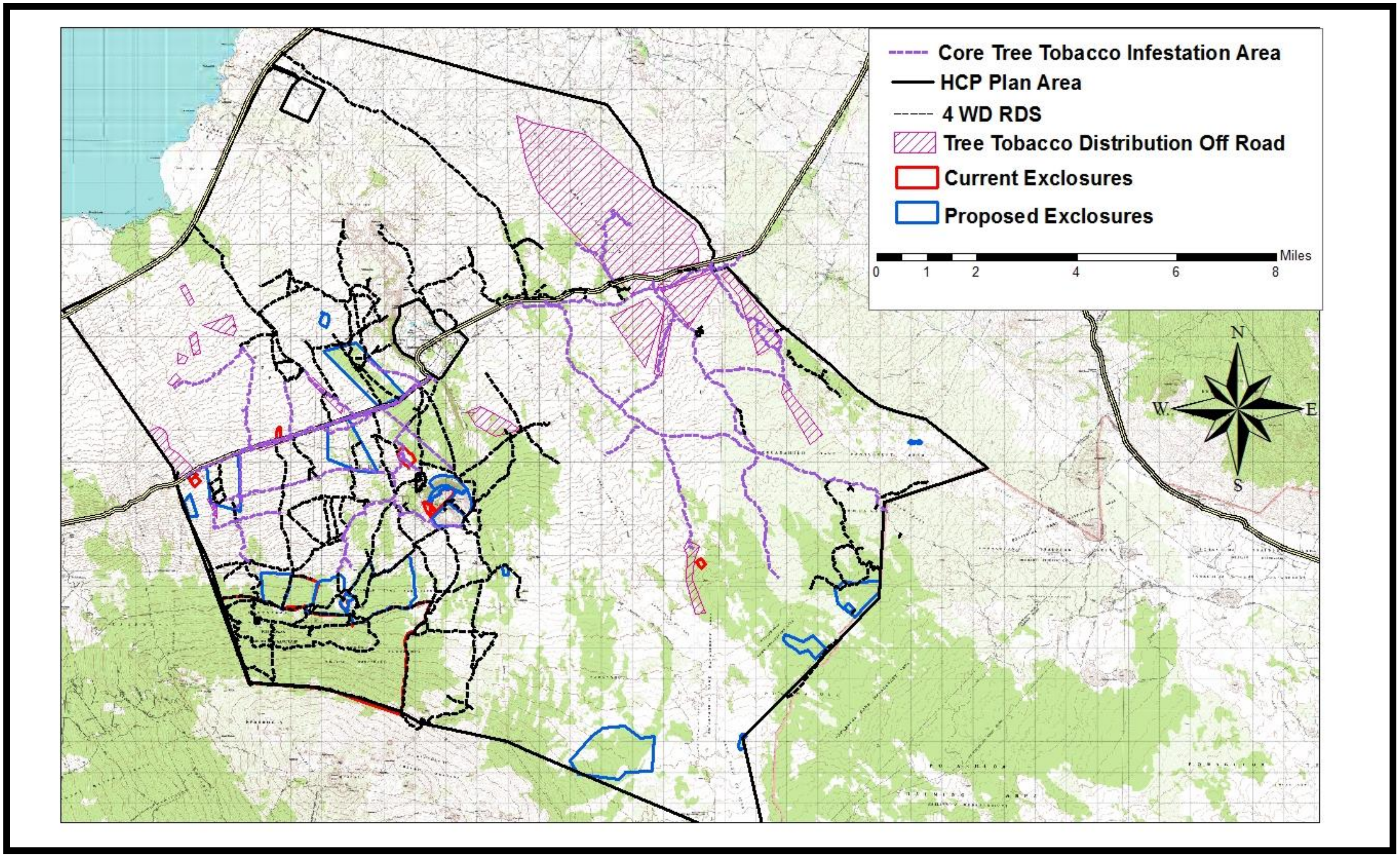


**Figure 11.2** Estimated tree tobacco distribution in the Plan Area based on the 2015 helicopter survey (pink hashed area). Roads in purple indicate the Core Tree Tobacco Infestation Area.

In addition, we will also record the number of each life-stage of *M. blackburni* observed, the number of host plants occupied, and the number and type of larval predators and parasitoids seen. Moreover, if we find significant associations between *M. blackburni* use and measured habitat or environmental variables (e.g. plant size and condition, location, substrate, plant community type, etc.), these results will be reported.

### 11.2.4 Adult *M. blackburni* Surveys:

We used black-light traps to survey for the presence of adult moths at five different locations within the Plan Area on four separate occasions. The vegetation at these survey locations varied between areas dominated by native plants and areas dominated by alien species. Light traps consisted of an 18 inch ultra-violet light bulb (powered by a 12-volt battery) placed in front of a white bed sheet suspended vertically from a clothesline. Individual moths that land on the sheet can be visually identified or photographed. The morphology of the adult *M. blackburni* is unique among moths in Hawaiʻi making them easy to identify in the field; they are Hawaiʻi's largest native insect with a wingspan of up to five inches, and they have distinctive spindle shaped bodies with five orange spots along each side of the abdomen (USFWS 2003b). In order to compare adult *M. blackburni* presence and density between various field sites, light trapping was conducted in comparable conditions, on nights with low wind, and during an early moon phase (i.e. new moon). Light traps were deployed for 8 hours following sunset at each trap site.

For future *M. blackburni* surveys conducted during HCP implementation, the total number and distribution of adult *M. blackburni* will be reported for each sampling location, plant community type, elevation, and as Plan cumulative totals.

## 11.3 RESULTS

### 11.3.1 Transect Surveys

Belt transect were surveyed for *M. blackburni* over multiple years (2010 – 2012). A total of 196 belt transects were surveyed for *M. blackburni* eggs, larvae and the other variables mentioned above. For all surveys combined, a grand total of 120 larvae, 91 hatched eggs (appears split or has an exit hole), and 101 un-hatched eggs were documented on tree tobacco (Table 11.1).

**Table 11.1** Number of transects and plants searched, and the number of larvae and eggs (un-hatched and hatched) found during *M. blackburni* surveys in 2010, 2011, and 2012.

| Survey Date | Transects Surveyed | Plants Surveyed | Larvae | Hatched Eggs | Unhatched Eggs |
|---|---|---|---|---|---|
| Feb 2010 | 14 | 436 | 55 | 28 | 11 |
| Feb 2011 | 43 | 1208 | 38 | 20 | 40 |
| Feb 2012 | 96 | 2323 | 26 | 43 | 47 |
| Aug 2012 | 43 | 1328 | 1 | 0 | 3 |
| Total | 196 | 5295 | 120 | 91 | 101 |


| Survey Date | Transects Surveyed | Plants Surveyed | Larvae | Hatched Eggs | Unhatched Eggs |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Feb 2010** | **14** | **436** | **55** | **28** | **11** |
| **Feb 2011** | **43** | **1208** | **38** | **20** | **40** |
| **Feb 2012** | **96** | **2323** | **26** | **43** | **47** |
| **Aug 2012** | **43** | **1328** | **1** | **0** | **3** |
| **Total** | **196** | **5295** | **120** | **91** | **101** |

## Environmental Variables

During February 2012, we were able to survey the greatest number of transects to date (a total of 96). Since this is the largest data set we currently have for one sampling period, a more in-depth analysis was performed. We considered whether four factors influenced the presence and absence of Blackburn's sphinx moth eggs and larvae: 1) sampling period 2) plant leaf density, 3) plant height, and 4) plant location (off road or on road). First, we found that the number of *M blackburni* eggs and larvae depended on the sampling period (Figure 11.3); the number of eggs and larvae found per acre decreased by 56% and 69% respectively between 2011 and 2012 showing that there is substantial year to year variation in abundance. Moreover, within 2012, egg and larvae abundance decreased by 82% and 93% respectively between the wetter (February), and dryer (August) 2012 months, showing that there is substantial variation in abundance between wet and dry seasons, and that dry seasons may be a good time to clear invasive tree tobacco plants off of roadsides and fuelbreaks.

We also found that while a smaller proportion of plants on the landscape fall in to the high leaf size category (only 24.5%), over half of all of the eggs and larvae found (53.8%) were on plants in this category, suggesting that Blackburn's sphinx moth are preferentially selecting plants with relatively large leaves (Figure 11.4). Large-leafed plants tend to be young, and large leaves also tend to be found on older plants that are damaged (such as re-growth from vehicle damage or cutting). Vegetation in re-growth and on young plants may have lowered levels of secondary defense chemicals rendering the leaves more palatable to larvae compared to older plants, or they may simply be selected to a greater degree because of larger surface area for consuming. Another possibility is that there is a greater probability of an adult moth finding plants that have larger leaves.

We also found a greater proportion of plant use by *M. blackburni* with increasing plant size (Figure 11.5); Blackburn's sphinx moth appear to be preferentially selecting plants of a larger size category, in particular those in the 2-5 m size class. In addition to on-road transects, areas perpendicular to the roadsides were also surveyed. We found that roughly the same proportion of plants being used by Blackburn's sphinx moth on the road as off of the road (Figure 11.6).

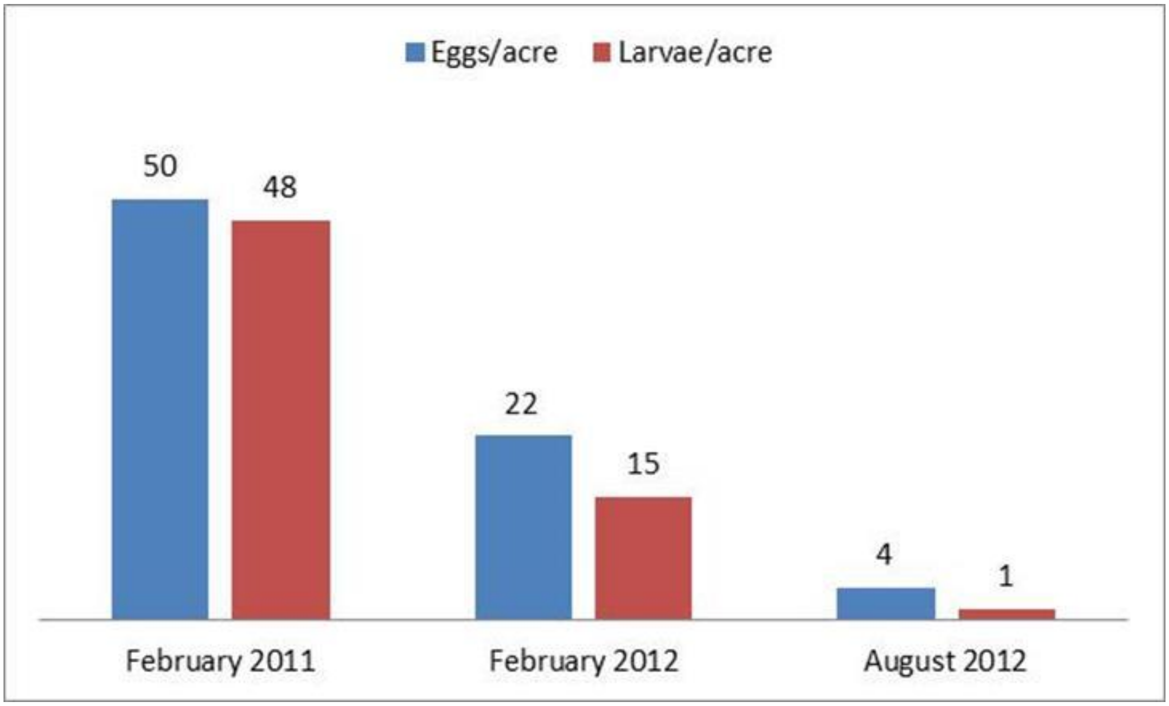


**Figure 11.3** Estimate of the number of eggs and larvae per acre of tree tobacco in the Plan Area. Larval surveys were done on transects containing a minimum of 10 trees per 75 $m^2$.

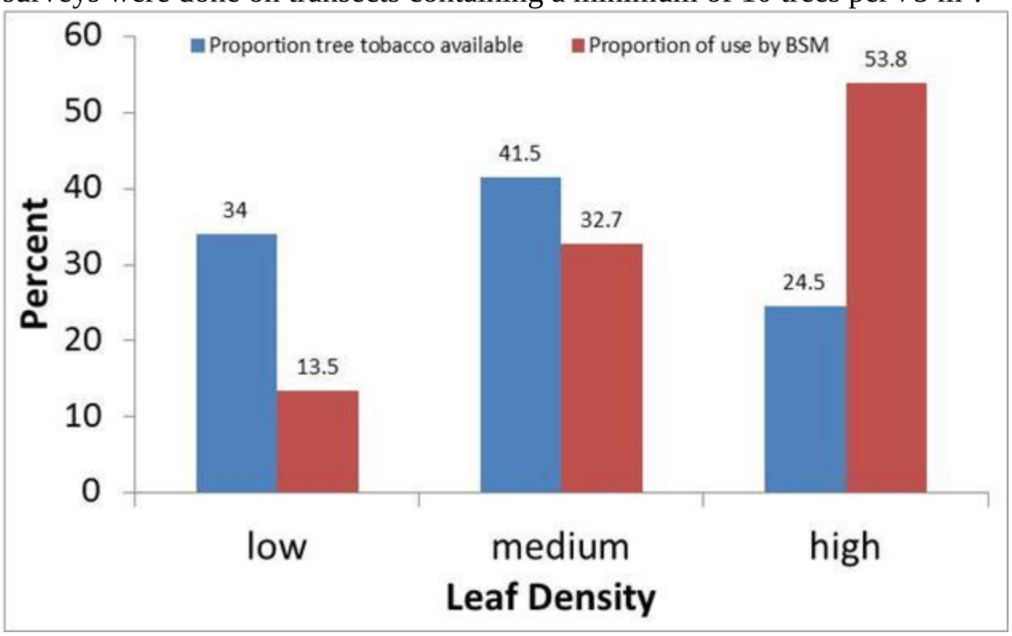


**Figure 11.4** Percent of plants containing Blackburn's sphinx moth eggs and larvae. Blue bars represent the proportion of plants that were available for use by Blackburn's sphinx moth of each leaf density category (low, medium, and high, all blue bars sum to 100%). Red bars represent the proportion of the plants actually containing eggs and larvae (all red bars sum to 100%).

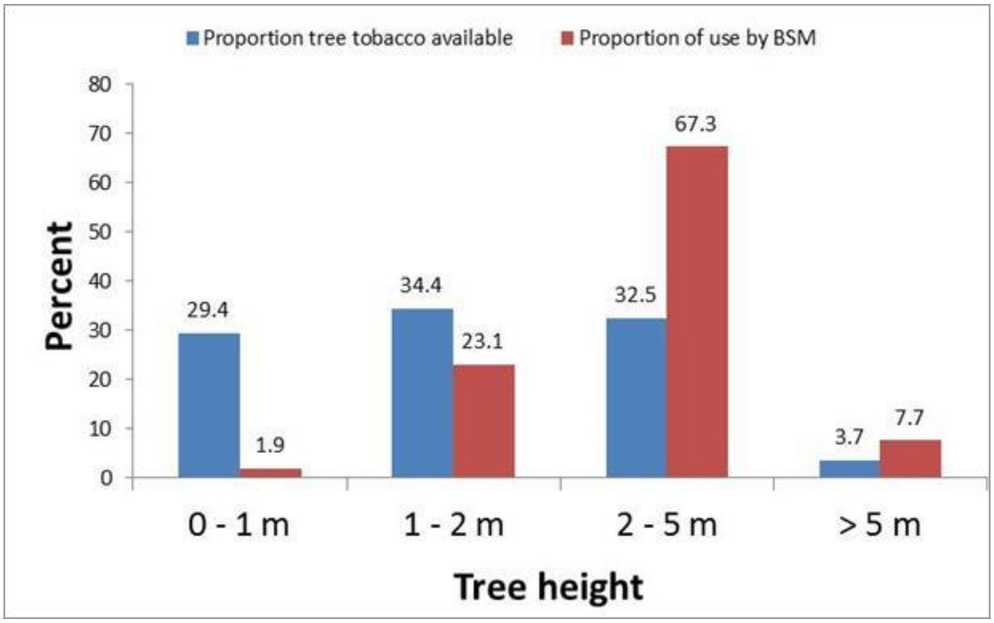


**Figure 11.5** Percent of plants in a given size class containing Blackburn's sphinx moth larvae and eggs. Blue bars represent the proportion of plants available of each of the size classes (blue sums to 100%). Red bars are the proportion of the plants that actually contained eggs and larvae (red sums to 100%).

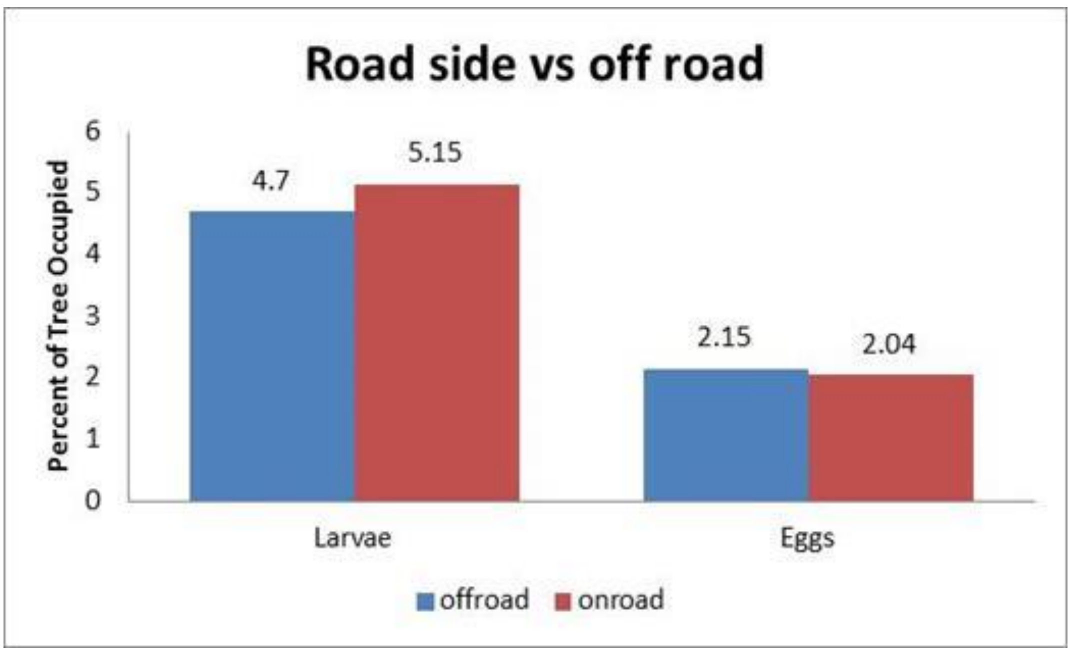


**Figure 11.6** A comparison of tree tobacco plants that were occupied by Blackburn's sphinx moth based on location (on road transects (red bars) or on perpendicular off-road transects (blue bars)).

### *Manduca blackburni* larval density/distribution on 'Aiea

To date, 17 'Aiea trees have been surveyed for *M. blackburni* use. Feeding damage was noted on all individuals surveyed. Larvae and eggs were documented on two individuals, one located makai of the highway in the 13 acre Uhiuhi 1 exclosure and the other in the proposed Henahena exclosure. There have been observations from DOFAW staff of larvae on 'Aiea on two other instances in recent years, one on a wild individual and the other on an outplant on the Pu'u Wa'awa'a cinder cone.

### *M. blackburni* adult density and distribution

Light trapping was conducted in the Plan Area on four occasions in 2009-2010. In September 2009, two light traps were deployed in a mixed silk oak (*Grevillea robusta*) and ʻŌhiʻa forest along the road side for 4 hours. One adult moth was documented visiting a trap at about 9:00 PM. From January 11-15, 2010, three light traps were deployed for about 5 hours each, however no adult moths were observed. These light traps were located in three habitat types, 1) a mixed native/alien forest with tree tobacco and ʻAiea present, 2) a predominantly native forest with ʻAiea present, and 3) a highly disturbed area dominated by *N. glauca*. Light trapping was conducted on the Puʻu Waʻawaʻa cinder cone, in native outplanted habitat with ʻAiea present in February 2011. Light traps were deployed on 2 nights for about 5 hours each, but no adult moths were observed. It is important to note that the absence of adult *M. blackburni* at light traps does not confirm absence of the species in a given survey area.

### Tree Tobacco and Blackburn's Sphinx Moth Population Estimate in the Plan Area

We estimated the location and distribution of tree tobacco in the Plan Area based on a helicopter survey conducted in January 2015 (see Figure 11.2). During the helicopter survey, track files and waypoints were taken to map the outer edges of infestation areas as well as map individual tree tobacco locations in less colonized areas. Based on this survey, we estimate that approximately 6,462 acres of the Plan Area (outside of roads) contain tree tobacco (6% of the Plan Area). The winter 2012 off-road BSM survey data was then used to estimate BSM density. A total of 17 Blackburn's sphinx moth detections (larvae and un-hatched eggs) were found on 557 tree tobacco plants across 38 transects. One transect has an area of 75 $m^2$ (25 m x 3 m). Using these data, we calculated: the area surveyed as 2850 $m^2$ (38 x 75 $m^2$) and BSM density as 0.006 BSM/$m^2$ (17/2850 $m^2$) or 24.1 BSM per acre. Based on the tree tobacco distribution estimated above, the population estimate for Blackburn's sphinx moth larvae and un-hatched eggs outside of roads is 155,734 BSM (24.1 x 6462 = 155,734.2).

An on-road estimate was calculated based on a total of 56 Blackburn's sphinx moth detections (larvae and un-hatched eggs) found on 1766 tree tobacco plants across 80 transects. One transect has an area of 75 $m^2$ (25 m x 3 m). Using these data, we calculated: the area surveyed as 6000 $m^2$ (80 x 75 $m^2$) and BSM density as 0.009 BSM/$m^2$ (56/6000 $m^2$) or 37.8 BSM per acre. Based on the Occupied Area calculated above (38.6 acres), estimated take for one winter clearing period rounds up to 1458 Blackburn's Sphinx moth individuals (37.77 x 38.6 = 1457.9 larvae plus un-hatched eggs). We then added the winter 2012 on-road population estimate (1458 BSM) to the Off-road estimate for a total winter Blackburn's sphinx moth population estimate of 157,445 individuals (larvae plus un-hatched eggs).

# 12.0 APPENDIX E: PROTOCOLS FOR COLLECTING & HANDLING NATIVE HAWAIIAN PLANTS (HRPRG)

**What do I need to provide to the propagation facilities when I submit my samples?**
1. Provide whenever possible the Rare Plant Field Data Form. If not, include with plant material sample descriptors such as:
- Genus, species, subspecies, etc.
- Collection organization
- Collector
- Date of collection
- Collection site (NAD 83 zone 5 UTM coordinates)
- Collection number
- Type of material
- Purpose of collection

2. Label all samples legibly and unambiguously. Make sure all samples are tagged.
3. If any special or significant sampling methods were used, note what was done.
4. Note any pest problems associated with the parent plant at the time of collection.
5. If possible, make arrangements with the propagation facility before sample collection.
6. Submit samples to the propagation facilities as soon as possible! Delays may have deleterious effects on sample viability.

**How do I handle my plant samples after I collect them?**

1. Insulate from heat. Keep at ambient of cool temperatures but do not freeze.

2. Try to cushion material so it won't be crushed.

3. Do not pack samples with excessive moisture or allow samples to sweat in the bags for an extended period of time. This promotes fungal and bacterial growth and accelerates the decline of sample quality.

4. Send to propagative facilities as soon as possible.

**Collecting and Handling of Seed Propagules**

Seed quality is primarily dependent upon the seed collector's methods and post-harvest handling of material. Knowledge of timing and habit of natural seed dispersal is helpful (though not always available) in seed collection. Attention to inflorescence structure and their seed maturity patterns are also important in determining what to harvest.

Loss of seed viability is due to:

1. Excessive temperature.

2. Development of anaerobic conditions around the seeds caused by their own respiration. This is due to storing in plastic bags or tight packing.

3. Prolonged time interval from collection of samples to propagative facilities under conditions conducive to fungal and bacterial growth. Samples of fleshy fruit stored in plastic bags should be aerated intermittently if immediate delivery is not possible.

**Dry dehiscent**

Only available before it disperses. Try to harvest just before dehiscing.

**Dry Indehiscent**

Collection and handling is dependent upon when and how they are dispersed. For example, wind dispersed, by animals or insects, etc.

**Fleshy fruits**

Need to know if recalcitrant (desiccation intolerant) or orthodox (desiccation tolerant).

**Recalcitrant Seed**

Recalcitrant seeds cannot withstand any drying, have some seed coats adapted to prevent excessive water loss while others have no such adaptation and are prone to rapid water loss post-harvest. In fleshy fruits, high seed moisture can be maintained by keeping the fruit intact. Their individual seeds can be stored in impermeable plastic bags, but must be aerated by opening the bag intermittently to compensate for the restrictive gas exchange environment. Insulate against heat and temperature extremes. Try to maintain a temperature as close to ambient as possible. In mature fruit, indicate if picked off the ground or parent plant. Try not to collect from the ground if possible, unless it is known that they have recently fallen.

**Orthodox Seed**

In general, the desiccation tolerance of orthodox seed varies throughout its development. They tend to be intolerant of drying during early development and become more tolerant as the seeds mature. If the fruits are immature, leave the seed within the fruit. Treat in the same manner as recalcitrant seeds. Mature seeds from dry indehiscent or dehiscent fruits can be kept in permeable containers such as paper or cloth bags.

**Collecting and Handling of Vegetative Propagules**

Successful propagation of vegetative propagules are dependent upon many different factors such as the vigor of the parent, the collection date and even the environmental conditions at the time of collection. Correct handling of vegetative material is also important.

1. Vegetative materials deteriorate quickly post-harvest and quick transfer from field to the propagative facility is imperative to ensure maximum viability.

2. Additional care must be taken during transport since they are easily damaged.

3. Place under cool conditions, such as a cooler with ice packs, as soon as possible after collecting and during transport to the propagation facility.

4. Try to collect samples that are insect and disease free.

5. Minimize damage during harvesting and transport.

6. In the case of vegetative cuttings, cut ends can be wrapped in damp towels or newspaper.

**Vegetative Cuttings (Herbaceous)**

The shoots harvested should be from the last mature flush of the plant. Cuttings should be long enough to allow for trimming and possible division.

If the plant species is known to be hard to propagate, small rooted plant suckers with some of the soil surrounding the roots could be taken if possible. Whole plants should not be removed at any time.

**Vegetative Cuttings (Woody)**

Propagation of mature trees is more difficult in general than their juvenile counterparts; but in many cases, juvenile forms are not available for collection. Whenever possible, the best material for propagation is the juvenile form. If only mature forms are available, material from their juvenile gradients may have a better chance of success.

**Roots and Tubers**

Timing of collection is important. The collection of immature or sprouting storage organs can result in significant losses in viability. In the case of plants that possess a dormant stage, a two-visit strategy may be required. One to identify individual clones and mark their location and another to collect the tubers or rhizomes once the top of the plant has died.

**Fern Fronds**

Fern fronds should be kept in plastic bags and not allowed to dry out during transport. If immediate delivery to the laboratory is difficult, place frond between 2 sheets of paper and allow to air dry flat within a plastic bag propped open. Spores will fall off frond as it dries. Seal the bag shut when completely dry and maintain a flat position to keep the spores on the paper surface.

**Flowering Shoots**

Some flowering shoots contain vegetative buds that do not develop but remain dormant. Sometimes the dormancy can be broken to produce juvenile vegetative shoots. Also, the immature flowers of a few tree species have been known to form adventitious shoots.

**Root Cuttings**

When lateral shoots are not available, such as in palms and other monocots, it is sometimes possible to produce vegetative shoots from root cuttings. Roots are often considered to be more juvenile in age than most of the tree. A juvenile gradient exists for roots, with the most juvenile material being closest to the trunk. Sprouts arising naturally from the roots of trees generally are juvenile in form. Store root cuttings in a moist sterile medium, such as peat moss.

**Decontamination of Collecting Tools**

Many of the Hawaiian endemic species have limited or non-existing *ex situ* collections, which necessitates the need for active *in situ* collecting. It is imperative that precautions be taken to keep the natural populations as disease free as possible. This is not only to maintain clean propagative stock material during collections, but also to ensure the integrity and overall health of the existing population and the surrounding flora. While absolute elimination of all pathogens is impractical and impossible, procedures should be directed toward preventing the introduction of serious foreign pathogens. The risk of disease transmission of viral, fungal, or bacterial origin is a realistic possibility through the cutting implements used in collection of plant samples. Whenever possible, plant cuttings should be made with a new, unused blade. This can be accomplished by using an implement such as a box knife fitted with a disposable razor blade. The used blade can be changed before cutting the next sample. Dr. Stephen Ferreira at UH Plant Pathology has also suggested that any cutting of plant propagules performed post collection should be done with disinfected tools. This is to prevent any disease contamination of the propagules before it goes to the propagation facility.

**Decontaminate tools**

Make a 5 % to 10% solution of household bleach (such as Clorox manufactured by The Clorox Co.) and soak tools. Let sit for 2-3 minutes then rinse well with water. Always use a fresh batch of bleach solution.

# 13.0 APPENDIX F: REINTRODUCTION GUIDELINES (HRPRG 1999)

These guidelines deal with the reintroduction of rare plants. Reintroduction should be a supplement to habitat management not a substitute. The final goal is not the success of an individual plant, but the establishment of a viable reproducing population where crosspollination can occur and in which genetic variation is maintained. An intermediate goal may be to establish a population for field stock or research reasons. It is expected that derivatives of the material in such field stocks will be outplanted more widely once appropriate habitat is secured and stabilized. These plants can be maintained as sources of seeds, cuttings or transplants for reintroduction efforts. Research activities may be intended to identify what factors are causing mortality/decline, to test methods to overcome these factors, or validate planting techniques. Ideally, successful research efforts will be permanent outplantings in their own right. Regardless of the intent of the planting, the process of reintroduction should consider the following guidelines. Many of the guidelines require coordination with other committees within the HRPRG as well as with agencies that may be collecting and propagating rare species. Included at the end of these guidelines is a list of contacts who may be contacted to consult on reintroductions. These guidelines have been broken into sections guiding actions prior, during, and following the actual transplanting of a plant.

### Prior

Prior to the reintroduction of a plant, there are some issues that must be considered to ensure the health of the species, the individual transplanted plant and the surrounding habitat. This must include considerations of the reproductive biology of the species to be reintroduced.

### Genetic Stock

The agency or individual that is reintroducing a plant must coordinate with the agencies or individuals responsible for the collection, and propagation of the plant. This must be done to ensure a healthy and balanced genetic composition. In addition a population geneticist may be consulted about strategies and alternatives when dealing with especially rare species or those with specific reproductive qualities. This is of course of special concern when dealing with depleted wild populations with remnant genetic stock. It should be the shared responsibility of all agencies and individuals involved to leave an easy-to-follow paper trail back to the source plant. (i.e. Rare Plant Monitoring Form, greenhouse accession numbers) Reintroduction is the last chance to make sure what we are propagating and planting represents a sufficient amount of the genetic composition of the species. Recalcitrant seed-producing plants may be taken as cuttings and helped into seeding in a greenhouse to increase the overall genetic base of the outplantings. Plants used in reintroduction should be as close to the collected field stock as possible. Plants that have been in the greenhouse for multiple generations may have been selected for different conditions than the reintroduction site and may have high attrition rates when planted. The pollination biology of each species must be researched and considered before reintroduction. Of special concern are pollen dispersal, autogamous (capable of self-pollination on a regular basis) and dioecious species, using propagules or plants from multiple year collections and mixing populations.

1. When reintroducing a species that is an outcrosser, one must consider the method of pollen dispersal. For example, wind pollinated species need to be planted close enough to ensure successful cross-pollination and species which require a pollinator must be planted in an area where an appropriate pollinator is known to exist. In a situation where one needs to keep a reintroduced population distinct from a wild population the site must be far enough to not allow cross-pollination. How far is enough is depends on the method of pollination (i.e. wind, insects, and birds).

2. One needs to determine if the species they intend to reintroduce is obligatively autogamous. Obligatively autogamous species tend to have genetically similar individuals due to their inability to outcross within a population. When collecting propagules for reintroducing an obligatively autogamous species, it is important to collect representatives from as many distinct populations as possible as opposed to getting representation from many individuals in one population as you would for an outcrossing species. If one intends to reintroduce an autogamous species it is important to maintain those distinct populations and not mix them when reintroducing. When reintroducing dioecious species one should plant equal numbers of male and female plants. If the plants are not yet mature and cannot be sexed, one should plant larger numbers of individuals to increase the effective population size.

3. When selecting the plants to be used in reintroduction, one must consider the age and year the stock was collected. Using propagules or plants from multiple years ensures better age class representation and possible genetic variety of stock.

4. Care should be taken not to mix gene pools that may be distinct and have local or microhabitat adaptations. A site with mixed stock should not be close to a population in which you seek to preserve representatives of geographically isolated subsets.

**Maps**

Prior to the reintroduction of a species, the area should be precisely mapped. Maps should include the historical and present range of the species, locations of known populations and proposed outplanting sites. A GIS database can also be used as a permanent record of the source of a particular population and to track the propagules. This will help ensure a genetic balance throughout the historical range.

**Threat Abatement**

Threats to a population should be noted on the Rare Plant Monitoring Forms used to monitor rare species. An entity involved with reintroduction must obtain copies of the Rare Plant Monitoring Forms to track the genetic composition of their plants. As always, consulting with anyone associated with the monitoring, collection and propagation of the species is necessary to get any other information. A management strategy addressing the threats compiled from the Monitoring Forms should be in place before plants are reintroduced. Strategies should include measures to control the most likely threats of ungulates and competition with non-native plants. Management activities must be conducted carefully as to not further degrade the habitat for reintroduction. All threat control techniques can be pathways for pathogens and other contaminants and must be executed properly. Weeding around an outplanting site may only proceed after careful considerations of the intent. Changing light regimes and soil composition can negatively impact the habitat for reintroduced plants. Also threats to a outplanted population may be different from those affecting the wild populations. For example, a wild population from which propagules are collected may be fenced and weeded but an ideal outplanting site existing off site within historical range may not have any management. Reintroduction should only proceed once a management strategy for the site has been established.

**Site Selection**

Once the historical range of the species is known and a management strategy is established, a suitable site for outplanting within the range must be selected. Again coordination with the collectors and propagators is essential. A site should be chosen according to the biotic and abiotic elements that comprise the habitat for the newly transplanted population. A careful review of the Rare Plant Monitoring Forms may provide all the information available on the source population. However, before outplanting, an agency or individuals should seek any additional information from anyone associated with the monitoring, collection, and propagation of the species. When interpreting historical range, one must consider that recent alterations of the habitats may have left the sites inhospitable for reintroduction. Invasion by alien species and other threats may have left the habitat within historical range unsuitable due to changes in moisture regimes and soil composition. In such cases reintroduction may be most successful in sites outside known historical locations that have maintained the critical biotic and abiotic elements necessary for successful reintroduction.

**Reintroduction scenario**

Sites for reintroduction can be placed in at least three categories each having special considerations.

**Reintroduction of a species within historical range**

Agencies must consider what distinguishes populations from one another for each species that is to be outplanted. The site must be able to support a distinct population or one is only augmenting the adjacent population which may have different ramifications. Specific information about the habitat characteristics of the source population must be matched as close as possible with the outplanting site to provide the best chance for survival. This should be done by consulting anyone associated with the collection and propagation of the species and referring to the RPMFs.

**Augmentations**

This involves introducing propagules or plants into existing wild populations. This type of reintroduction must be considered on a case by case basis for each species. This reintroduction must be done carefully as to not harm the existing population with contaminants or physically altering the soil structure or existing roots. Augmentation may negatively alter the genetic composition of the population with propagules or plants from a single source or ones that have been raised through multiple generations in the greenhouse if not carried out strategically. Alternative scenarios are preferred due to the difficulty in ensuring a successful reintroduction. The complex problems involved with preventing pathogens from invading the wild population lowers the desirability of this option. It is especially important to contact as many individuals or agencies as possible for comments before augmenting a population.

**Introduction of a species to a site outside the known historical range**

Agencies or individuals considering this type of introduction need also to consider the possible negative effects on the species. Establishment of a healthy viable population may be hindered by loss of genetic variation being at a site away from other populations. Possible hybridization may occur when bringing a species outside its historical range and into the range of another related species. A site outside the known historical range may lack the habitat characteristics necessary for establishing a healthy population. Contrarily a site outside of the known historical range of the species may be the only place safe from the threats that brought the species to the remnant state we find them in today. In some cases, these sites may also offer the best management option for a particular species. It is also possible that the historical range is incomplete or no longer contain the most appropriate habitat including suitable moisture and soil composition.

**Site Preparation**

Once a proper site has been selected there are steps the agency or individuals can take to prepare it for reintroduction. In accordance with the management strategy for the species and site, it may be initially necessary to construct a small scale exclosure and/or weed nonnative competitors around the site. These actions should be taken in concurrence with protection of the greater habitat, which is critical to the success of an established population. The season in which to plant must be considered. Generally mesic and dry plant species would face less challenges if planted during a wet season. If drought conditions persist for more than a year, it may be beneficial to wait for a better year if storage conditions allow. Techniques for preparing the soil to receive and support a new plant differ depending on the species. One should consider digging holes in advance and composting material on site to provide a favorable substrate. Composting materials should come from on-site and ideally be from native material. Soils may also be tested to guide soil preparation and future fertilization schemes. Coordination with the propagators is essential to ensure the fertilization and pesticide application schemes used in the greenhouse are adopted in the field. A catchment and watering system may also be considered.

**During**

The successful reintroduction from the greenhouse to the ground requires several issues to be taken into account.

**Sanitation**

Coordination with the propagator and collector is necessary to ensure that all aspects of rare plant handling is done with attention to sanitation. Collection should be done with sanitized tools and proper propagation techniques practiced to eliminate possible contaminants. Agencies and individuals involved with reintroduction need to coordinate with the propagator before the date of planting to make sure the propagules are prepared to go out. This may entail use of pesticides to ensure no foreign contaminants are transported to the site. The risk of spreading aliens via reintroduction activities must be adequately addressed and effectively eliminated. Seeds, slugs, disease, parasites, flatworms and other unintended inoculates must be prevented from being transported to the site by any aspect of the operation: protective management activities, materials, personnel and the plants themselves must all be completely free of contaminants. Care should be taken to clean all gear (boots, packs, planting tools, etc.) prior to arrival at the site to assure no contaminants are spread unknowingly.

**Transport**

Use caution when transporting fragile plants. Some species may need water or protection from the sun and wind during the transport. The most secure place in a vehicle for transporting plants is directly in back of the driver's seat.

**Planting**

Those involved in the planting of rare plants should be briefed before heading out to the site. Agencies and individuals directing reintroduction need to consider the techniques to be used in getting the plant from the container to the ground. Of special consideration is the decision to use a fertilizer in addition to any on site composting. In areas of low rainfall initial watering may be essential in easing the shock for the new plantings. Building up a pile of mulch around the base of a new plant can help to slow evaporation and keep water near the roots. A layer of cinder an inch thick placed around the base of a new planting can prevent slugs from reaching the plant.

**Post**

Following the reintroduction, monitoring is essential to maintain the health of the plant and the surrounding habitat.

**Monitoring**

Coordination with the agency or individual responsible for monitoring the existing populations may be necessary to see that a reintroduced population gets on a regular monitoring schedule. It is recommended that the site be monitored daily for a week after reintroduction. This close monitoring will insure that if there are problems with pests or other unforeseen threats such as drought, they can be addressed before they affect the plants. Use of the Rare Plant Monitoring Form (RPMF) will give important information pertaining to the location, phenology, population structure, habitat characteristics and threats to the new population. Individual plants may be labeled or tagged and tracked using the RPMF. The goal of a successful reintroduction is the establishment of a viable population that maintains the genetic variability of the species and produces successful offspring. Recruitment in the wild is necessary for the reintroduction to be deemed successful.

Monitoring a new population is essential to tracking the lineage of the population and to maintain local genotypes. A consistent monitoring schedule will also reduce the chance of a contaminant affecting the population or surrounding habitat. Recording the watering, fertilization and pesticide application schemes will help guide future reintroductions. CPC is currently working on a database to track safety net species including outplantings. Information on reintroduced populations should be transferred into the database.

**Maintenance**
Watering, fertilization and pesticide application may be necessary to ensure success. Supplemental watering especially in dry areas will greatly improve chances for a successful reintroduction.

**Management**
Actions after reintroduction must be taken in concurrence with a habitat management strategy. Reducing competition for resources with non-native plants by weeding may be necessary. A necessary ungulate exclosure may require maintenance.

**List of Contacts**
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# 14.0 APPENDIX G: DRAFT NORTH KONA WILDFIRE MANAGEMENT PLAN

## 14.1 Introduction

The Three Mountain Alliance (TMA) is a watershed partnership between Federal, State, and private landowners who wish to collaborate on land management issues affecting all of their lands. This group began as the ‘Ōla‘a Kīlauea Partnership, and after 10 years of success together they expanded their focus to include more of their lands that shared boundaries, values, and goals. This plan addresses wildland fire issues within the management area identified as North Kona. The North Kona Management Area (NKMA) landowners are Kamehameha Schools and the State of Hawai‘i. Although this landscape contains the interests of only two of the nine partners, they benefit from both the intellectual and physical resources available from all partners.

The purpose of this plan is to guide fire management programs that are responsive to TMA land management goals and objectives. The Three Mountain Alliance watershed partnership landowners share similar conservation goals and wish to coordinate their efforts across the landscape. One important rationale for creating such a large partnership, in respects to fire management, is that expensive resources can be shared between members.

The NKMA contains a large portion of lowland and montane dry forests and shrublands. Of all the TMA lands, this management area encompasses the largest area with the highest burn potential. This risk is coupled with the threat from invasive, fire-adapted grasses, which aggressively establish themselves following a wildland fire. Fountain grass is one such species which has increased its range by over 200% over a 40-year period. Due to the rough terrain and relative remoteness of much of the landscape, there are many intact remnant habitats that are threatened. Within State lands exists a small community posing a wildland urban interface hazard. Combining all of these issues highlights the importance of making fire protection a priority.

The wildland fire management plan discusses the characteristics of the landscape of the NKMA and its fire history. The plan describes all current fire assets, resources, and programs, and their current status. It also provides descriptions of the vegetation and fuel characteristics found on the landscape. Following a discussion of the current status of fire management, the plan will identify new prevention, pre-suppression, and suppression objectives, and provide cost estimates for their accomplishment.

The goal of the Three Mountain Alliance is to reduce the wildland fire occurrence and to minimize the impact wildland fires have on the ecosystem. The North Kona Management Area Wildland Fire Management Plan selects strategies towards accomplishing this goal.

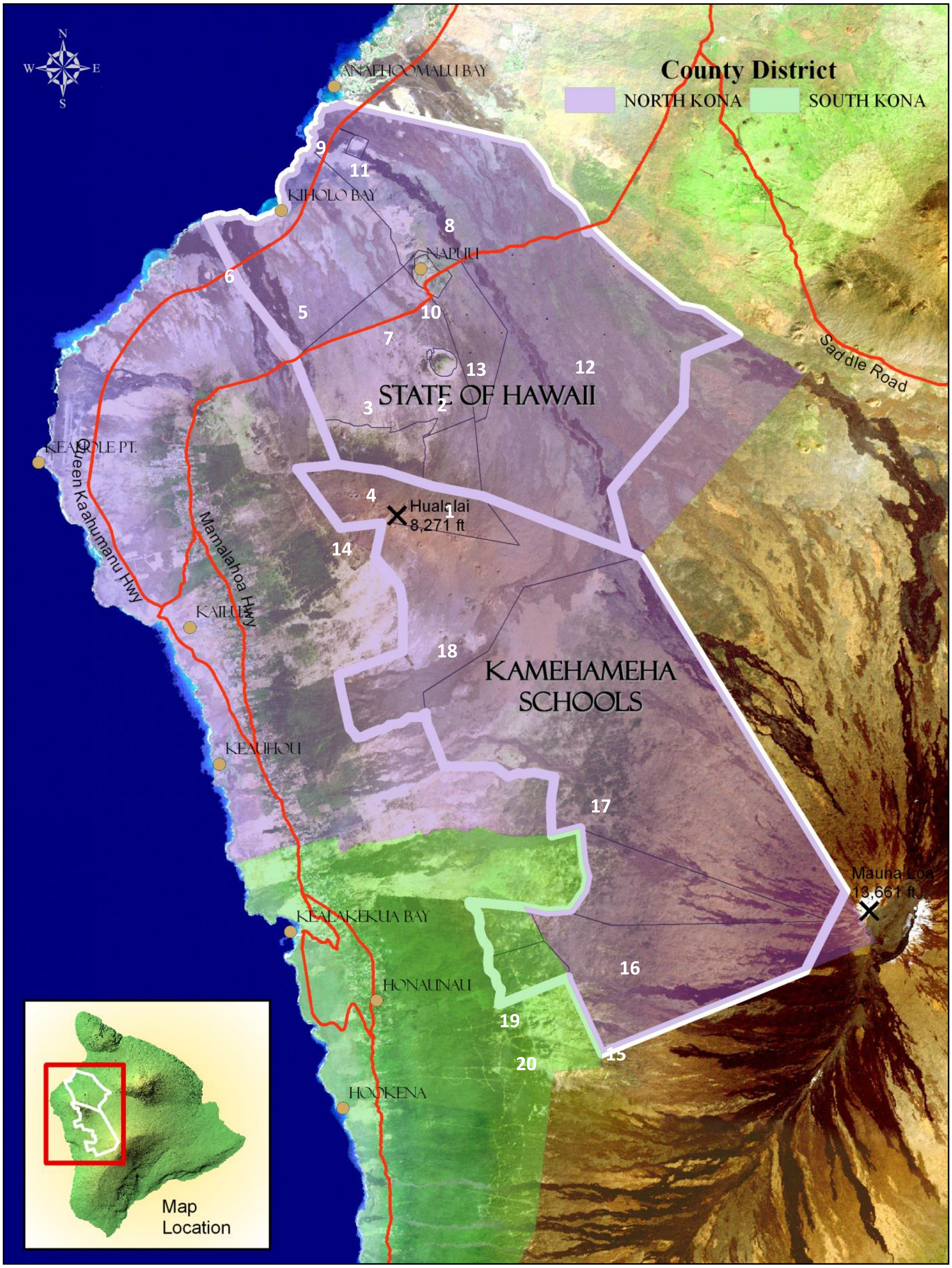


**Figure 14.1** North Kona Management Area land ownership.

## 14.2 Land Management

The land area of concern within this plan is 237,110 acres[25]. Of this, 98 % falls within the North Kona District jurisdiction of Hawai‘i County, and the remaining area (4,717 acres) is within the South Kona District. This tract, under the management guidance of the Three Mountain Alliance partners, is one of their four discrete management areas. The State of Hawai‘i and Kamehameha Schools are the two largest landowners which distinguish the land and its management. Although these two separate entities manage their lands by their precedence, the TMA has identified joint priorities on which to collaborate for resource management and research. The *Three Mountain Alliance Management Plan* (2007) summarizes the key threats which affect all partners' lands and proposes management actions that they can pursue within each of their four management areas.

There are five current land uses within the North Kona Management Area: 1) ranching 2) hunting 3) native forest restoration 4) recreation and 5) forestry. The two landowners manage these uses differently; however it is the type of use, location, and intensity that is of concern to this plan.

### 14.2.1 Historic Land Management

Historical land use should be compared with the historical fire occurrences described in this document, so that inferences can be made about how and why fires occurred. It is beyond the scope of this plan to provide a detailed land use history. Prior to the earliest date listed it, would be correct to deduce that land uses were based around pre-contact Hawaiian culture.

The most significant change in land use occurred in the second half of the 19th century. The introduction of ungulates, e.g. cattle, sheep, and goats, and the use of forest land for grazing, began altering the vegetation composition. The first land leases for grazing occurred in 1865 in Pu‘u Anahulu of the Northern section, owned by the State, and 1873 in Keauhou II of the Southern section, owned by Kamehameha Schools. Following this alternative type of land use, new non-native species became naturalized during the 20th century, continuing to alter the landscape.

Families moved into the rural landscape as jobs were created to care for the livestock. During the 20th century, the community of Pu‘u Anahulu began to grow and was soon followed by a main highway (Hwy 190), the large residential community of Pu‘u Lani Ranch, and a golf course. The coast quickly developed, and in 1975 Queen Ka‘ahumanu Highway was finished, designating a second main thoroughfare. The mounting transformation in vegetation composition due to increasing anthropogenic changes, contributed to the prevalence of wildland fires. Humans soon became the number one cause of fires, surpassing lightning strikes.

### 14.2.2 General Land Management Policies

Current land use is regulated by State of Hawai‘i, Hawai‘i Administrative Rules (HAR) and Hawai‘i Revised Statues (HRS). Under HRS Chapter 205 there are four approved land uses: 1) urban 2) rural 3) agricultural 4) conservation.The North Kona Management Area (NKMA) contains 93,329 acres in the agricultural district and 143,778 acres in the conservation district (Table 14.1). Additionally, the County of Hawai‘i designates its own zones on this land, yet bases them on control of housing density, and maintaining open space and forest cover.

Conservation districts are further divided into subzones, which are governed by Title 13, Chapter 5 of the HAR. The subzone designation limits the land use in order to protect the inherent conservation values found within a particular area. Most land uses are not allowed or highly regulated. For example, a wildfire fuels modification program may be implemented without permits or prior approval within agricultural land. However, if the same program was intended for conservation land, various procedures

[25] All acreages are calculated using ArcGIS software.

would need to be completed prior to implementation, based on the subzone classification. Figure 14.2 maps the governmental laws regulating the NKMA.

**Table 14.1** NKMA Land Use District and Conservation subzone acreage.

| | KS | | State | | Total | |
|---|---|---|---|---|---|---|
| Land Use | Area (ac) | Perimeter (mi) | Area (ac) | Perimeter (mi) | Area (ac) | Perimeter (mi) |
| Agriculture – total | 49,999 | 65 | 43,331 | 49 | 93,329 | 114 |
| Conservation - total | 76,903 | 114 | 66,875 | 116 | 143,778 | 230 |
| Conservation-General | 0 | 0 | 13,965 | 39 | 13,965 | 39 |
| Conservation-Resource | 51,528 | 73 | 51,275 | 68 | 102,803 | 141 |
| Conservation-Limited | 14,855 | 22 | 1,635 | 9 | 16,491 | 31 |
| Conservation-Protective | 10,519 | 19 | 0 | 0 | 10,519 | 19 |

### 14.2.3 The Northern Section – State of Hawaiʻi

The State of Hawaiʻi owns the land on the Northern aspect of Hualālai within a region known as Kekaha (Figure 14.1). The ahupuaʻa of Puʻu Waʻawaʻa and Puʻu Anahulu contain this land area and are significant boundaries to the guidance and management of the area. In January, 2002, the management responsibility was transferred from the State of Hawaiʻi Division of Land and Natural Resources-Land Division, to Division of Forestry and Wildlife, and Division of State Parks. This represented a significant land management change. It is notable that the land is further divided by management responsibility into three separate areas.

The first area is managed by the Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW). This area encompasses 103,987 acres. It begins at Queen Kaʻahumanu Highway at an elevation of approximately 100 feet, and continues mauka (upslope) toward the summit of Hualālai, ending at approximately 6,400 feet. In Figure 14.1, these areas are identified as numbers 1-5, 7, 8, and 11-13. Within this area are the communities of Puʻu Anahulu, Puʻu Lani Ranch, and Big Island Country Club (see #10 on Figure 14.1). There are a total of twenty-one Tax Map Key (TMK) parcels, eleven of which are smaller than 1 acre and insignificant for planning purposes due to their small impact.

The area managed by DOFAW includes Puʻu Waʻawaʻa Forest Reserve (numbers 1-5 & 7 in Figure 14.1), so designated in October, 2007; Hawaiʻi Experimental Tropical Forest (numbers 1-5 & 7 in Figure 14.1), established in March, 2007; Puʻu Waʻawaʻa Forest Bird Sanctuary (number 4 in Figure 14.1), set aside in May, 1998, and the Game Management Area of Puʻu Anahulu (numbers 8, 12 & 13 in Figure 14.1), set aside in April, 1999.

In March, 2007 the DLNR and United States Department of Agriculture (USDA) Forest Service Institute of Pacific Islands Forestry established the Hawaiʻi Experimental Tropical Forest (HETF). This experimental forest shares its boundary with the Puʻu Waʻawaʻa ahupuaʻa, including the Puʻu Waʻawaʻa Forest Bird Sanctuary and Kīholo State Park. The purpose is to create opportunities where scientists and students can conduct research projects that will benefit management, preservation, conservation, and restoration. The projects implemented here will improve management and provide new knowledge which can be shared throughout the NKMA.

The second area is managed by the DLNR, Division of State Parks and encompasses 4,484 acres makai (downslope) of Queen Kaʻahumanu Highway. This area is set aside as a State Park Reserve and includes such popular destinations as Kīholo Bay, Keawaiki Bay, Pueo Bay, and Weliweli (numbers 6 & 9 in Figure 14.1). There are a total of three parcels included in this area. This entire management area has received very little in the way of fire preparedness.

The third area has been transferred, by an executive order of the Governor, to the responsibility of the County of Hawaiʻi. This 293-acre single parcel is managed as the West Hawaiʻi Landfill. It is a "flag-lot" located mauka of Queen Kaʻahumanu Highway (designated as number 11 in Figure 14.1). Because this area is located entirely on a lava flow there is no fire threat whatsoever.

When the State transferred land management responsibility in 2002 to DOFAW, a change in land use philosophy also occurred. The State of Hawaiʻi intends, "to provide the basis and guidelines for managing Puʻu Waʻawaʻa and the makai lands of Puʻu Anahulu in a manner that emulates the concept of ahupuaʻa management" (State of Hawaiʻi, 2003). Guiding principles of land management, i.e. goals and objectives, can be referenced in *The Management Plan for the ahupuaʻa of Puʻu Waʻawaʻa and the Makai Lands of Puʻu Anahulu* (2003). The state manages its land uses for restoration, forestry, hunting, and recreation under the DOFAW Management Guidelines which are all determined in part by the State land use district designation.

### 14.2.4 The Southern Section – Kamehameha Schools

Kamehameha Schools owns the Southern land, and refers to this area as Mauka Kona (Figure 14.1). It covers the area above the town of Keauhou starting at 3,400 feet, up the Southern aspect of Hualālai, and encompasses the summit at 8,271 feet. It also stretches to the South above the area of Hōnaunau, beginning in elevation at 4,300 feet and ascending near the summit of Mauna Loa at 12,900 feet. The total land area covered is 126,902 acres, which encompasses seven TMK parcels.

Land use across Kamehameha Schools (KS) is managed by their Land Assets Division (LAD) which adheres to their strategic plan written in 2003. The land use here is roughly segregated by TMK parcels.

Map ID 17 in Figure 14.2 contains land used for hunting, ranching, and conservation. Ranching use since the Greenwell's departure in the 1980's has not been intensive. There are between 50 and 200 head of cattle which graze around Puʻu Lehua and below in an area named Koa Nui. Grazing occurs on only 10 % of the total area within the TMK.

Sheep hunting is the most intensive land use as assessed from the quantity of visitors. Concession hunts are run by allowing a licensee to hunt one to four days a week. Pig and goats are also hunted, though not as frequently as sheep. There are two cabins located on this parcel; Puʻu Keanui cabin and Hale Laʻau.

Native habitat restoration in this area has grown over the past decade and contains the largest area of māmane forest on the western slope of Mauna Loa. It is a possible site for pālila re-introductions, home to the largest remnant stands of ʻiliahi, and also home to several rare plants and insects. Restoration activities to date include invasive species control, ungulate management, and species monitoring. A 10,000 acre fence unit is schedule to be constructed in a few years through funding acquired by TMA.

Map ID 18 in Figure 14.2 has been leased to Palani Ranch since the 19th century. They use only a small portion for cattle pasture along the boundary of their fee simple land. However, unlike the Pulehua area, their operations are intensive. The rest of this parcel is unusable land covered in lava flows, and these areas are primarily used for hunting.

Map ID 16 in Figure 14.2 is licensed for sheep concession hunting and contains no infrastructure improvements. Recreational hunting here is typically one to three visits a week, by three to five persons.

Map ID 15, 19, and 20, in Figure 14.2, are also licensed for sheep hunting to an organized recreational group named Kahauloa Hunt Club, who only allow archery. The property's contains two cabins one is the Kahauloa Hunt Club cabin, the other is a semi-improved structure at Gaspar's Dairy.

Map ID 14 in Figure 14.2 contains the summit of Hualālai, Hainoa. This area is not encumbered and managed for conservation of the native habitat and restoration of degraded lands. Goats are not tolerated and sheep are well managed within this area. Hawaii Forest and Trail, an ecotourism company, provides guided day trips to Kaʻūpūlehu cinder cone on the Western end of the parcel. Hualālai is also a popular destination for hikers who wish to view the summit; although all hikers are considered trespassers.

There are two cabins on this parcel, Kipaheʻe and Duarte, located at 7,800 and 6,000 feet respectively. In addition to the cabins, there is one parcel owned by Hawaiʻi Electric Company located at Kaʻūpūlehu. This parcel contains various radio, television, and cell phone towers.

Kamehameha Schools' mission is to provide high quality educational opportunities for Hawaiian children within their schools and on their land, as well. KS LAD recognizes the cultural and forest resources found within Mauka Kona and seek to provide for education, preservation, conservation, and economy. Throughout the year, high school student groups travel mauka for education, and graduates and post-graduates implement research, all of which feedback to KS, their constituents, and the scientific community.

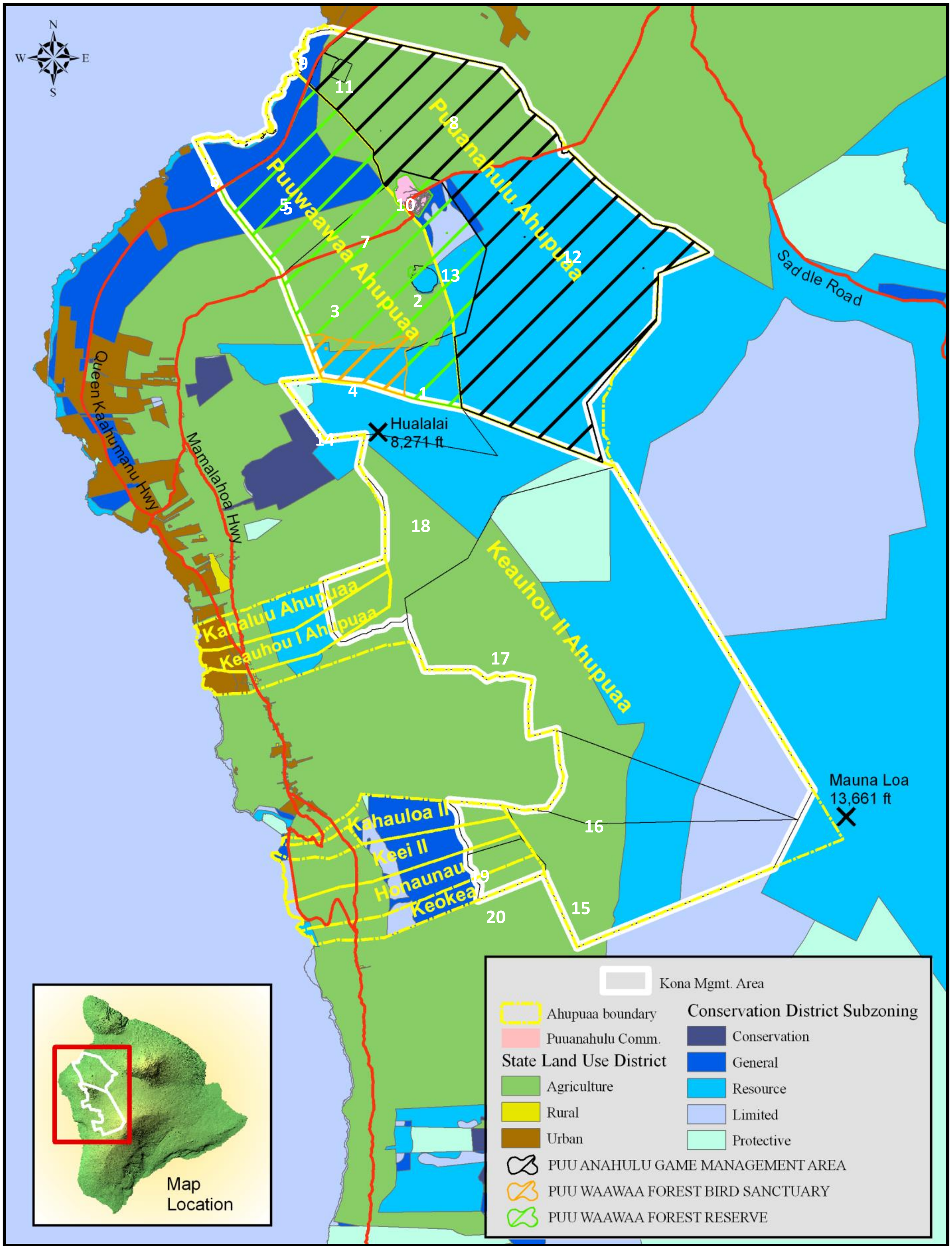


**Figure 14.2** North Kona Management Area Government regulated land uses and Ahupua‘a

### 14.2.5 Adjacent Land Ownership & Uses

Lands adjacent to the North Kona Management Area are owned by the State and Federal government, and large and small private landowners. The Kīholo State Park is bordered by the ocean, which provides unrestricted access to water.

Along the Northeast, East, and Southeast boundary, the land is owned by two departments of the Federal Government. Pohakuloa Military Training Area (PMTA) is owned by the Department of Defense and managed by the Army. On the East boundary is Volcanoes National Park managed by the Department of the Interior. Both of these neighbors manage their lands directly adjacent to NKMA for conservation and preservation, and are excellent neighbors in fire planning and preparedness.

Completely surrounded by State owned lands is the community of Puʻu Anahulu, the largest rural development and the most densely populated area. Within this boundary, 409 acres is a golf course managed by the Big Island Country Club, 272 acres is a private gated-community named Puʻu Lani Ranch, and 100 acres are various sized, privately owned lots (see Figure 14.3). Mamalahoa Highway is the only ingress and egress route for this community, which is cause for concern. Along the highway, and within the communities, are telephone and electric lines which are at risk to wildfire, as well. All homeowners are well educated to the risks from wildfire through the Firewise Communities program; however, their homes are still at risk to ignition from firebrands, radiation, and convection.

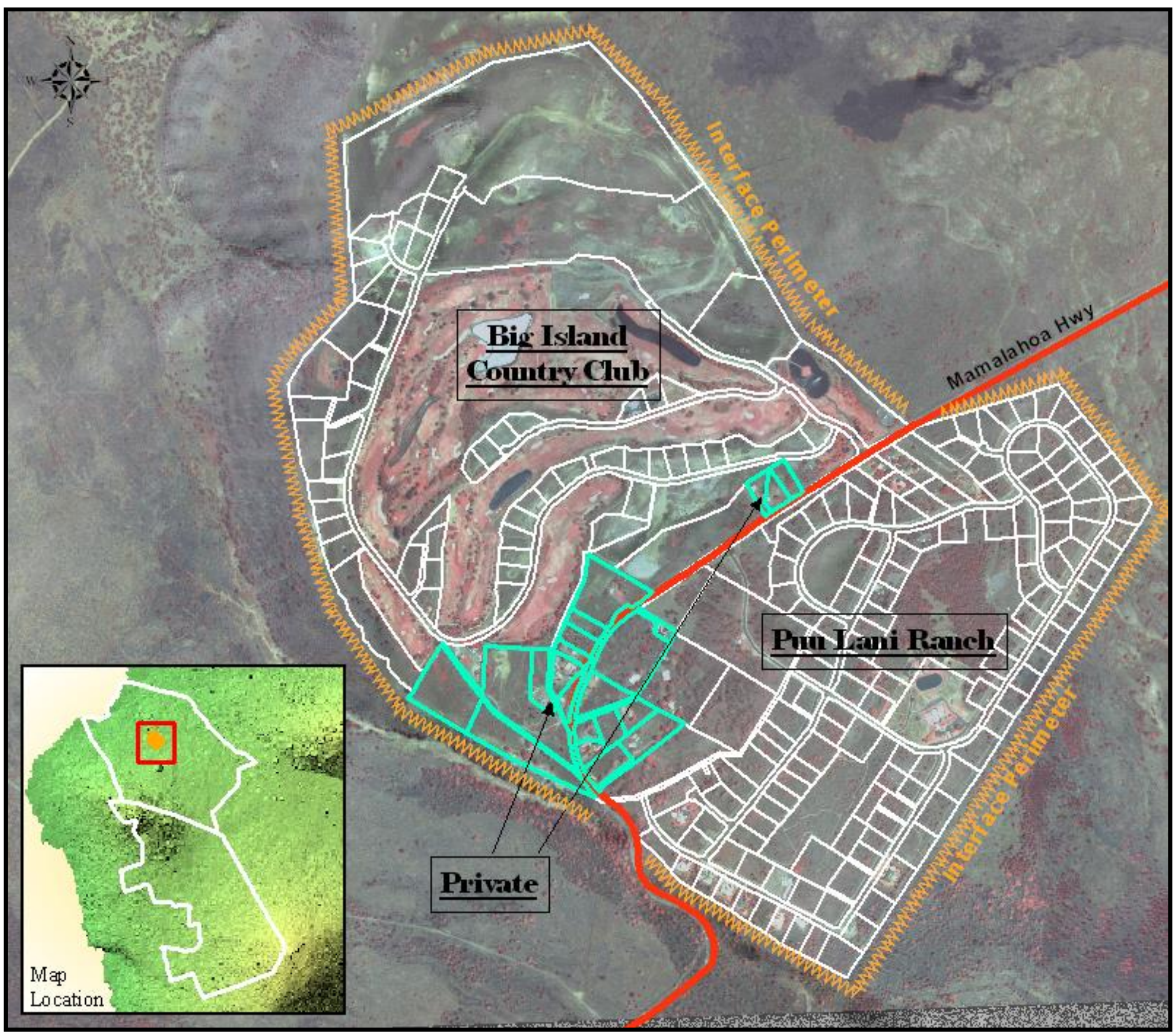


**Figure 14.3** Community of Puʻu Anahulu, Wildland Urban Interface (WUI).

On the makai side of Mamalahoa Highway, the interface between State land and the community is a perimeter of 2.7 miles, or 14,282 feet. The thirteen private home owners here are fortunate in being surrounded by a golf course which is an excellent fuel break. However, the golf course itself is at risk, because it is in the wildland interface. Mauka of Mamalahoa Highway, there is a much higher risk situation, because there are forty individual home owners directly on the wildland interface perimeter. This perimeter is 2 miles, or 10,500 feet, where fire breaks and defensible spaces need to be managed intensively.

There are fourteen privately owned parcels separate from the community, but still contained within State land (see Figure 14.4). There are eleven parcels makai of Queen Ka‘ahumanu Highway bounded by lands managed by the Division of State Parks. The total privately held area along the coast is 44 acres, or less than 1% of the coastal land area. All of these aforementioned residences represent a Wildland Urban Interface (WUI).

The remaining three privately held parcels are within the Pu‘u Wa‘awa‘a Ahupua‘a and the Pu‘u WaWa‘awa‘a Forest Reserve. One is owned by the Hawaii Electric Company, is insignificant in size at only a quarter acre, and has distinguished defensible space. However, due to the value and significance of the equipment (electric substation) within, it demands a high risk value. The other parcel is large, approximately 32 acres, and privately held. This property is a permanent residence and also has a high risk value. The last parcel is also within the same Ahupua‘a, but within the Pu‘u Wa‘awa‘a Forest Bird Sanctuary. It is privately held by the same owner as the 32-acre parcel, but is not a residence and only contains water catchment and storage space, and therefore it is of medium risk value.

**Table 14.2** Pu‘u Wa‘awa‘a Ahupua‘a private land owners.

| Parcel Owner | Acres | Defensible Perimeter (ft.) | Risk Value |
|---|---|---|---|
| Private | 32.1 | 5,589 | High |
| Private | 2.8 | 1,400 | Medium |
| Hawaii Electric Co. | .38 | 523 | High |

There are no small private residences directly adjacent to the NKMA lands owned by Kamehameha Schools in the Mauka Kona area. All of the land on the Southern border is agricultural land used for cattle ranching by the adjacent landowners. Cattle and sheep ranching have been a part of Mauka Kona for over a century, and there are four neighboring land owners still operating full-time, beef or cow-calf production, cattle ranches. Because their land is pasture, or grassland, it poses a high risk to wildfire because of the fine, flashy, grass fuels. Numerous fires are documented to have occurred in these pastures, and consequently pose wildfire threats to neighboring lands. A group like the Hawaii Wildfire Management Organization outreaching to assist these land owners in wildland fire planning would be highly beneficial.

Along the Western border there are also 2 Forest Reserves and open, unmanaged land (see Figure 14.5).

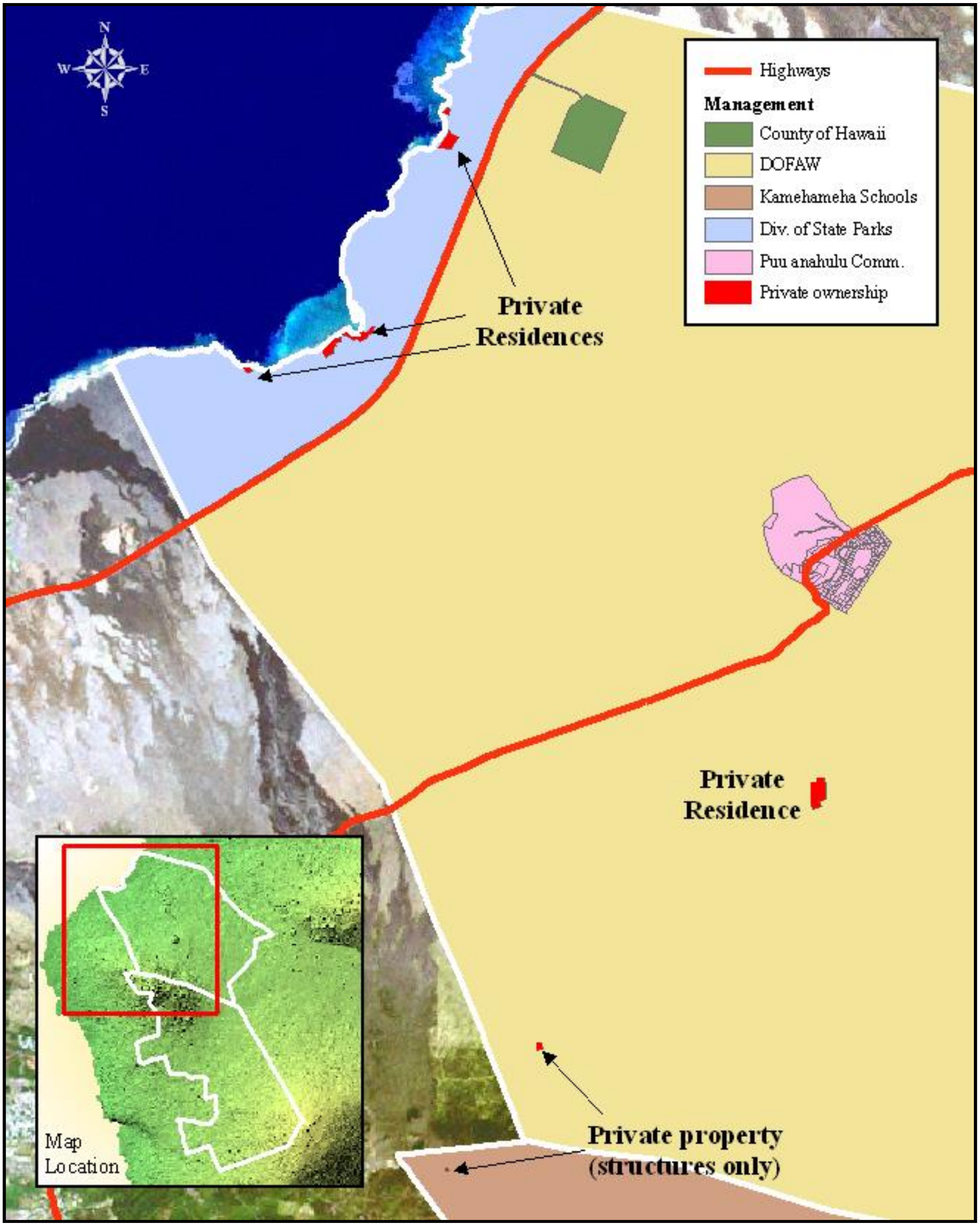


**Figure 14.4** Miscellaneous parcels land locked within the NKMA.

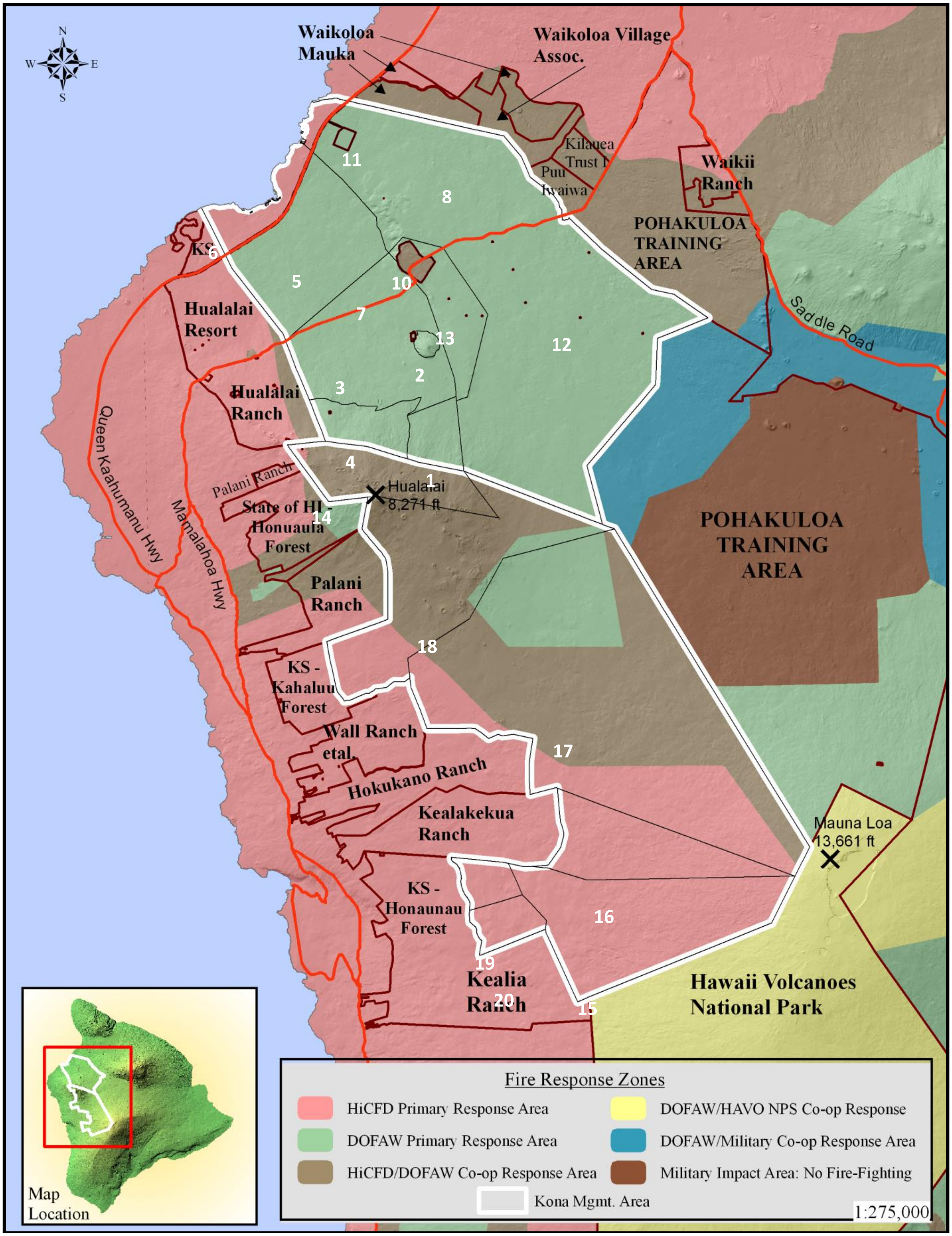


**Figure 14.5** Fire agency wildland fire jurisdictions and large neighboring land owners

## 14.3 Wildland Fire Risk Assessment

The following sections assess the wildfire risks within the NKMA. They include the following: wildfire occurrence, fuel hazards, habitat, infrastructure, culture, recreation, aesthetic sites, economic, and other specified values found on the land. The consequences of a wildfire are that some, or all, of these values may be partially or complete lost. Priorities need to be identified for proper allocation of available financial and human resources. Identifying these priorities before a wildfire and taking action to mitigate the risks must occur in order to preserve a natural landscape.

### 14.3.1 Wildland Fire Occurrence (History)

Hawaiian ecosystems, although established on lava flows, have not evolved with wildfire. Fires were infrequent in the natural landscape; their usual source being lightning strikes. Only one community type has been documented to thrive under frequent fire occurrence from anthropogenic sources: pili (*Heteropogon contortus*) grassland. Some plants, however, are able to withstand quickly moving fires, and some germinate better following a fire. Since fire was not common, ecosystems did not adapt to be able to deal with the present, unnatural, human induced, fire return intervals.

There is ample evidence of recent fires throughout the NKMA. Additionally, there is verbal history and government documentation covering the last forty years. The Hawaii Wildfire Management Organization helped to develop the first fire history map for State lands within the NKMA in 2003. Similar mapping efforts have taken place on Kamehameha Schools land for the Mauka Kona area. These fire history maps are continuously being updated by DOFAW and HWMO. The value and data they provide are instrumental in understanding and planning for wildfire on the landscape. They also highlight the relative importance of unburned areas.

Under natural conditions, one would expect to see a fire return interval of 100 years or more in the NKMA, yet because of the conversion of some woodland to grassland, and a larger human population frequenting the area, the interval has decreased to 7-10 years in the Northern areas of NKMA. This has direct threats to the adjacent remnant native forests.

On KS lands, wildfires most frequently occur at Pulehua and Puʻu Ikaʻaka. These two areas have heavy human use due to cattle ranching and past logging. The dominant land cover type is non-native grassland, which has adapted to the grass-fire cycle. Fire history illustrates that fire return intervals have been longer when the ignition source is natural. However, during the 20$^{th}$ century, human presence was frequent, and so were wildfires. A recent decrease in human presence has resulted in a sporadic return of fire.

Other areas within Mauka Kona have had fires over the past thirty years, but most of these were small, infrequent, and caused by lightning strikes. A significant note is the absence of documented fires in areas above 6,000 feet.

### 14.3.2 Geography

Volcanoes, cinder cones, lava tubes, and lava flows make up the NKMA landscape. Each landform has unique geology, topography, and associated vegetation. While there are steep slopes, geophysical features play only a small role in wildfire behavior. Instead, fire behavior is more heavily determined by vegetation composition, substrate, and weather conditions during the fire.

There are two large active volcanoes, Hualālai and Mauna Loa that have moderate slopes rising to their summits. Hualālai most recently erupted in 1800 - 1801 creating the Huehue lava flow, which headed in a Northwest direction roughly along the Southwest border of Puʻu Waʻawaʻa ahupuaʻa. The most recent eruption from Mauna Loa to influence the NKMA was in 1859 and runs along the Northern border of KS and PTA land, through Puʻu Anahulu ahupuaʻa, to the ocean. These two recent lava flows are sparsely vegetated which designates them as a natural fire break. However, fountain grass is slowly colonizing these flows. There are other un-vegetated or sparsely-vegetated lava flows throughout the NKMA which also would not sustain wildfire and should be identified as firebreaks on suppression maps. Since the NKMA contains two active volcanoes, it should be recognized that a wildfire threat can also come from an eruption, however unpredictable this may be.

The second largest prominent feature is Puʻu Anahulu ridge which extends makai from Puʻu Waʻawaʻa. This ridge was formed from a lava flow originating from Puʻu Waʻawaʻa and displays some of the steepest terrain covering a large area. The community of Puʻu Anahulu sits at the top of this ridge and is at risk from a wildfire which may ignite here. A wildfire could quickly ascend the ridge, through fuel pre-heating, and threaten homes.

Cinder cones and volcanic vents are numerous and have the most topographic relief. They are characteristic of a steep hill protruding from the surrounding flat area. The largest of these is Puʻu Waʻawaʻa, and due to its age, soil development, and complex topography, supports greater botanical diversity than the surrounding area (Giffin, 2003). There are several more predominant features such as Puʻu Lehua, Puʻu Oʻuo, Puʻu Keanui, Kuainiho, and Poʻohoʻohoʻo and smaller vents and cinder cones that are scattered throughout the NKMA with similar diversity.

Another relevant feature, and a very hazardous one, is the lava tubes, caves, and cracks which are strewn throughout the NKMA. These are found predominantly on pahoehoe lava flows. Vegetation growing within them has been shown to carry underground fires. Not only are these features dangerous, they are filled with important cultural and biological resources.

Soils are volcanic, either aʻa, pahoehoe, cinder, or ash derived, and originate from either of the two aforementioned volcanoes. The age and composition, as well as depth, influence the vegetation community found thereon. One characteristic of younger cinder soils is their ability to carry a smoldering fire because of the relatively large particles of organic matter mixed into the surface layer. Many times these fires appear to be extinguished because there is no obvious smoking, and yet the fire is still burning. This is cause for concern during fire suppression.

### 14.3.3 Weather

Throughout the year, Kona is influenced by sea breezes during the day, bringing in moisture from the ocean, and moving it upslope. This is the convective-uplift rainfall effect, resulting from the land warming. At night, wind direction changes and cooler winds, land breezes, come from Mauna Loa and Hualālai toward the ocean. It is usually dry and hot, however, with afternoon rain and mist at elevations of 1,000 to 3,000 feet. Above 4,000 feet, an inversion layer often occurs, which precludes cloud movement. It also effectively blocks moisture, brought by the sea breezes, from traveling to higher elevations. Above this blanket of clouds, the temperature can be quite variable without the effects of thermo-regulation. Often, the only moisture comes in the form of fog drip, to high elevations. This effect can supply approximately 25% of the moisture between 4,000 and 8,000 feet. Lower relative humidity is experienced at the upper elevations above the inversion layer where moisture is typically absent.

The summer is typically the wet season, although it is the dry season for most of the state. However, in Kekaha, the wet season can shift to be in the spring or fall. Therefore, fire season across NKMA is usually between November and March, but observations of fire conditions and weather should preclude any seasonal predictions.

There are three storm events that also contribute to the annual rainfall. The first is a summer tropical storm, depression, or hurricane. These are infrequent and result in heavy flooding and high winds. Second, are two types of winter storms, reoccurring several times during the months of September through March. They bring a significant amount of moisture and also bring change in wind direction. A Kona storm brings in moist air from the South and light South to West winds, which create hazy conditions throughout the island. The other winter storm results from a passing cold front moving from east to west and dropping down from the North. This type of storm brings heavy rains and uncharacteristically cold, gusty winds. Both winter storms bring in a great deal of moisture, and raise the relative humidity, resulting in weather not as conducive to fire. However, the associated thunder and lightning still has the potential to light fires. Winter is the fire season; however, during this time there can be more rain from winter storms, than during the entire summer wet season.

**Table 14.3** Temperature

| Location | (˚F) |
|---|---|
| Kīholo | 76 |
| Pu‘u Anahulu | 68 |
| PWWFBS Cabin | 60 |
| Hualālai | 50 |
| Hale La‘au | 59 |
| Pulehua | 60 |
| Ho‘olohe gate | 64 |
| Pu‘u O‘uo | 50 |
| Kahauloa cabin | 59 |

Another unique attribute of NKMA is that it can be influenced heavily by global climate patterns, particularly El Niño. During an El Niño period it is possible to experience long periods of drought that could increase the risk of wildland fires within NKMA and prolong a fire season throughout the year.

A large Hawaiian knowledge base exists about the winds of these areas. Various wind names are related to particular places throughout the NKMA and each are described in ethnostudies. The wind is an important factor in wildfire behavior, and knowledge of the Hawaiian winds can be useful during all stages of fire planning.

Minimum annual temperatures start at 30˚ Fahrenheit near the summits of Hualālai and Mauna Loa during the winter months. Winter frost will occur during these months near the summits and has been documented as low as 5,500 feet. Maximum annual temperatures can reach 85˚ Fahrenheit. Average annual temperatures can be found to the right in Table 14.3.

Vog, the sulfur-based pollutant released from Kīlauea and other island volcanoes is blown back in towards leeward Hawai‘i because of the daytime sea breezes (‘Eka). The vog will not directly affect wildfires, but it will contribute to air pollution when smoke from a wildland fire is also considered. A combination of pollution factors creates very poor visibility and health risks to personnel and the public.

### 14.3.4 Vegetation, Fuels, and Resources

Fuel characteristics are diverse across NKMA, but are consistent within ecological regions and substrate types. The horizontal arrangement of these fuels is also varied, and where characteristics can be consistent in certain areas the continuity will remain diverse.

The largest concern is the displacement of native forests with invasive fire-promoting alien grass species. Within Pu‘u Wa‘awa‘a ahupua‘a, alien grasses increased by 237% between 1954 and 1994 (Blackmore and Vitousek, 2000). Although no similar studies have been made in the adjacent areas of Keauhou II and Pu‘u Anahulu ahupua‘a, a quick land cover analysis would result in finding an increased percentage in alien grass cover also. The four priority alien grass species are fountain grass (*Pennisetum setaceum),* kikuyu (*Pennisetum clandestinum*), buffel grass *(Cenchrus ciliaris)*, and meadow rice grass (*Ehrharta stipoides*), they are all considered light or fine flashy fuels.

*Hawai‘i Volcanoes (HAVO) National Park Fire Management Plan* (2005) discusses in great detail the emerging fuel types and their characteristics. HAVO has the highest frequency of wildland fires in the most habitat types, and this has allowed them to become the leader in wildland fire research. Fuel types found at HAVO are similar to ones found within NKMA; therefore they should be consulted for the latest research on wildland fire.

The NKMA comprises 9% of the island of Hawaiʻi and within it exist some of the rarest and most valued biological, physical, and cultural resources. The resources found within Hawaii undergo continual stress from invasive threats, requiring anthropological mitigation for their survival.

Due to the degradation of these rare biological resources, one of the primary resource values being lost is the cultural and educational opportunities they provide to Hawaiians, Western science, and future generations. The island provided the necessary resources for Hawaiians, and still provides for the local community today. Off-shore and reef environments provided abundant marine fishery resources, inland agricultural zones used rich volcanic soils and ample rainfall to provide produce for island populations, and upland forested zones supplied materials used for canoes, house timbers, tools, and medicinal and ceremonial resources. These critical resources represent the essentials required to sustain island populations and were valued, protected, and preserved to ensure their sustainability (Three Mountain Alliance Management Plan, 2007). These uses and concepts are still relevant in modern society when recognizing the shifting reliance to local products and sustainability.

In the montane and lowland areas we find some of the largest ranges of high quality natural communities like grasslands and single species dominated forest, such as ʻiliahi and mamane. There also exist endangered birds, plants, and insects with restricted ranges. Sometimes these species are limited to their habitat, which can be as unique as lava tubes or caves like the ones commonly found throughout Puʻu Waʻawaʻa ahupuaʻa. Toward the coastal areas, there are resources such as anchialine ponds, wetlands, and marine life also struggling to remain viable in spite of non-point pollution sources and invasive species. Along the coastal lands, there are many places where ground water enters the ocean providing life and health to coastal systems.

Of particular note is the resource of Hualālai and Puʻu Waʻawaʻa. These two physical features are old and complex, making them as unique and valuable as the life they sustain. The head waters for Waiaha stream reside on Kamehameha Schools land; the only true intermittent stream on the West side of the island. Throughout these areas, there are recreational uses such as hunting and hiking, and land used for agriculture. There are also cultural and historical resources distributed throughout the land, such as temporary residential sites, coastal and inland villages, ceremonial construction (*heiau*) and interment sites, trail networks, and boundary markers (Three Mountain Alliance Management Plan, 2007).

The NKMA is also a major watershed for the North and South Kona districts. The forested land here helps to catch and sustain the water which eventually recharges the aquifer; the main source of water in Kona. A diverse and complex landscape is needed for flood control, sediment filtration, and to mitigate the current effects of climate change.

The plant communities here epitomize sensitivity to wildfire. The native ecosystem and culture contained within, evolved with little impact from fire, which is why the current grass-fire cycle has been so destructive and will continue to be if left unabated. The following is a list of the ecoregions found within NKMA (see Figure 14.6 Eco-region Map).

1. Subalpine Dry Forest and Woodland
2. Subalpine Dry Shrubland
3. Subalpine Dry Grassland
4. Montane Dry Forest and Woodland
5. Montane Dry Shrubland
6. Montane Dry Grassland
7. Montane Mesic Forest and Woodland

8. Montane Mesic Grassland
9. Lowland Dry Forest and Woodland
10. Lowland Dry Shrubland
11. Lowland Dry Grassland
12. Coastal zone

Within Puʻu Waʻawaʻa ahupuaʻa, 40 rare plants have been found, with 22 being listed as endangered or candidates (PWW Biological Assessment, 2003). The adjacent ahupuaʻa of Puʻu Anahulu has not been as extensively surveyed and no biological assessment exists for this area. A biological survey for Puʻu Anahulu ahupuaʻa is recommended. There are 4 endangered birds here: the nene (*Branta sandwicensis*), Iʻo (*Buteo solitarius*), Hawaiʻi ʻAkepa (*Loxops coccineus coccineus*), and Hawaiʻi Creeper (*Oreomystis mana*). Also one endangered land mammal the ʻopeʻapeʻa (*Lasiurus cinereus semotus*). The US Fish and Wildlife Service should be consulted for an up-to-date list of the threatened, endangered, SOC, and sensitive species. Critical habitat plans can also be obtained from them for land planning.

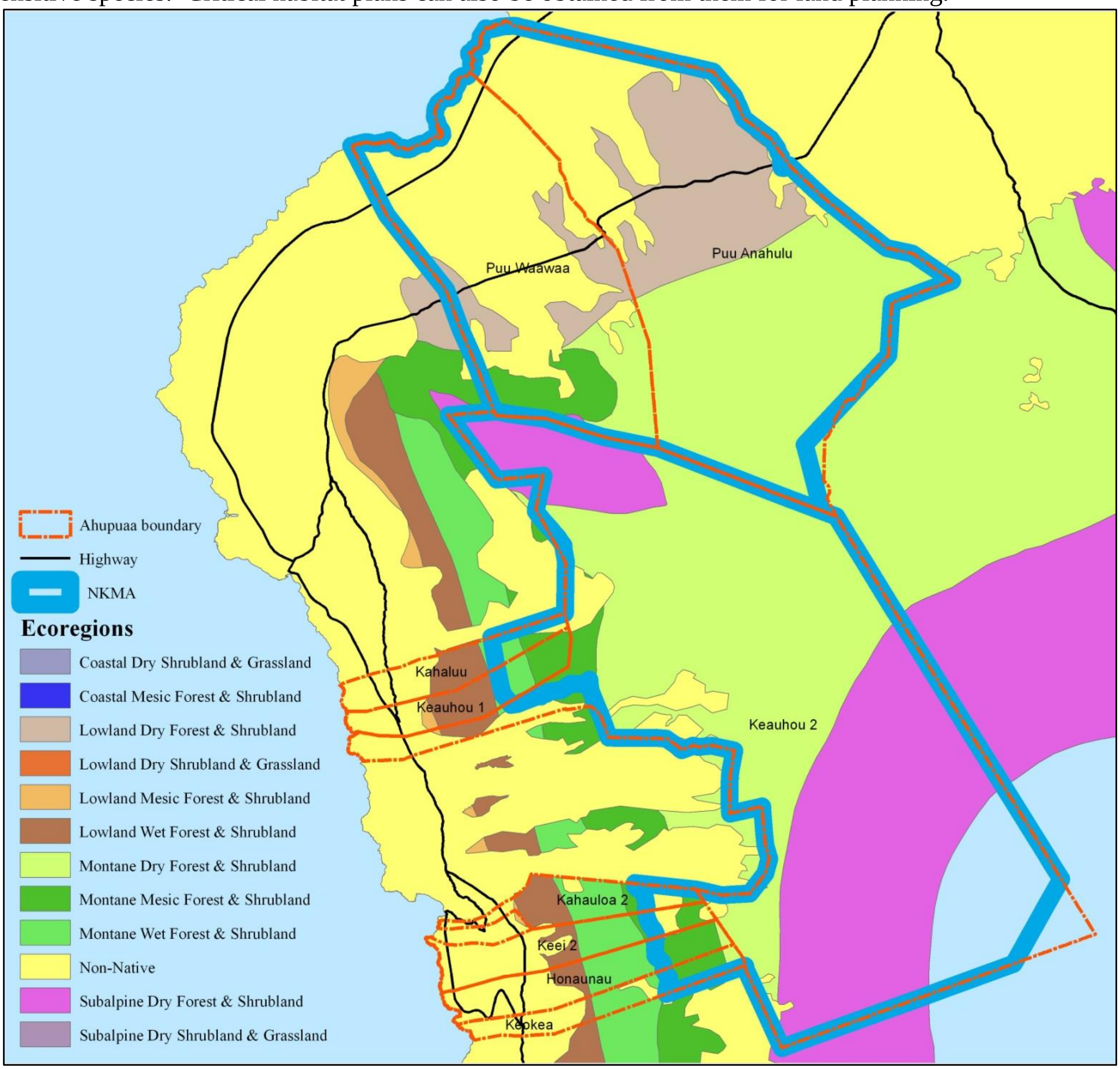

**Figure 14.6** Ecoregions of the North Kona Management Area

### 14.3.5 Infrastructure

The infrastructure in this section reviews the risks of the resources managed within the NKMA. As mentioned previously, there are numerous parcels within the NKMA, but not managed by TMA, that are considered adjacent landowners. The majority of these properties are considered to be at high risk although there are suppression resources and defendable interfaces.

**Structures**

The majority of the structures within the NKMA are at high risk to wildfire. These structures include houses, cabins, sheds, water tanks, reservoirs, and utilities. Although the cost of losing any structure would be high, there are few high-valued structures that would need to be saved at all costs. These high-valued structures would include private homes and utilities.

The existing structures have not been fully assessed and documented as to their level of risk for wildfires. It is assumed that they are all highly ignitable and have minimal maintained defensible space around their perimeters. A GIS point layer database should be created to track information.

There are numerous water sources across NKMA. They are generally well distributed across KS land but, on State lands they are concentrated within the mauka portion of Puʻu Waʻawaʻa ahupaʻa. Most catchment tanks designated for wildfire use are reliable because their use is minimal for other operations. The capacity of the tanks ranges from a few hundred gallons to many thousand. Most tanks have been equipped for drawing water in the event of a fire. On State lands, many tanks have been linked together, which allows the movement of water from one area to another. This benefits the total water capacity of a particular area. Again, a GIS point layer database should be created to gather and track information concerning water tanks that can be readily available to managers.

**Roads**

Vehicle travel is slow and arduous, and requires appropriate vehicles. Currently maintained roads within the NKMA are designated in four classes: 1) highway 2) main 3) secondary and 4) spur. Each class has an associated travel speed and ID, identified within a GIS. Some roads have been given names, and this should continue. Some signs have been installed along these roads to help navigation. Within State lands, there are 407 acres that are highway right-of-ways and thirty-eight miles of highway frontage where wildlands are adjacent to heavily travelled highways. There are no public roads on KS land.

**Utilities/Phone lines/Fence lines/Rock walls**

There are no utility or phone lines across KS land except for one utility line partly up Kaloko Summit road going to the Kaloko communications towers. On State land within Puʻu Waʻawaʻa and Puʻu Anahulu there is a utility line easement that parallels Queen Kaʻahumanu Highway and Mamalahoa Highway.

Cell phone service is unreliable. However, some areas do receive signals for various service providers. Radio transmissions are also untrustworthy, and therefore reliable communications within working areas must be established during a fire event.

There are numerous fence lines throughout NKMA. Some have wood infrastructure and others have steel. Many are in disrepair and not in use anymore, however some are still used.

Rock walls also exist in the same conditions. Rock walls can be used as firebreaks if appropriately prepared before a fire. Unfortunately, no current map exists of the rock walls in NKMA.

There is a consistent lack of information documented on paper and in a GIS database regarding infrastructure. Creating and updating a GIS database should be a priority for TMA.

## 14.4 Wildland Fire Management Programs

### 14.4.1 General Management Considerations

Wildland fire management includes the consideration of three management concepts; prevention, pre-suppression, and suppression. Wildland fire prevention is conducted by the land owner in conjunction with other resource management goals and objectives. The TMA can assist with wildland fire prevention planning by coordinating the exchange of information and cooperatively raising funds to support common management objectives. Pre-suppression and suppression deal directly with wildland fires and is therefore a job for professional firefighters.

On Hawaiʻi island, the Hawaii County Fire Department (HiCFD) responds initially to all wildland fires. They are the only full-time wildland fire-fighting agency that can respond to all calls (Hawaii Volcanoes National Park and Pohakuloa Military Training Area also keep full-time fire departments, but they are not initial responders). DOFAW, a State agency, is a wildland fire-fighting agency that is responsible for fire protection in Forest Reserves, public hunting areas, wildlife and plant sanctuaries, and Natural Area Reserves. DOFAW is better equipped than the HiCFD to fight fires in remote areas, and therefore shares fire-fighting responsibilities with them on a large portion of NKMA (see Figure 14.5).

There are several agencies on Hawaiʻi island that fight fire; HiCFD, DOFAW, Hawaii Volcanoes National Park, US Army (Pohakuloa Military Training Area), and the US Fish and Wildlife Service. They have formed a group called the Big Island Wildfire Coordinating Group (BIGWICG) to organize mutual aid agreements, response, planning, and resources between the Federal and State agencies to improve wildland fire protection. These agencies, both collectively and independently, organize the pre-suppression and suppression of all wildland fires.

The state currently follows their *Operational Policy Handbook for Wildfire Control*for activities related to prevention, pre-suppression, and suppression of wildfires. Additionally, four operational objectives were outlined in the *Management Plan for the Ahupuaʻa of Puʻu Waʻawaʻa and the Makai Lands of Puʻu Anahulu* (2003) to help wildfire mitigation within these areas.

Prevention lays out programs for education, fire analysis, training, fuel modification (engineering), and law enforcement. The pre-suppression program includes training/certification, planning, preparedness, air operations, communications, and logistical services. Suppression refers to extinguishing wildfires, which is based on the guidelines in the National Wildfire Coordinating Group's *Fireline Handbook*. The *Operational Policy Handbook for Wildfire Control* does not layout specific programs that occur on the landscape of DOFAW or Division of State Parks managed land.

In 2006, KS produced their first fire mitigation plan for the Mauka Kona area, meant to evaluate the wildfire risks, hazards, and suppression resources. This plan recommends actions to prepare KS in prevention, pre-suppression, and suppression. Each year, this plan is updated to include improvement in resources, fuel engineering projects, fire prevention, and employee training implemented during the prior yearOne primary task when planning is to create Fire Management Units which differentiate blocks of land and their unique wildfire regimes. The creation of Fire Management Units (FMUs) should result from identifying areas with similar problems through wildfire occurrence mapping and land cover mapping. This information should then provoke discussions on wildland fire management strategies. Information should address the following for each FMU:

- Location
- Topography and elevation
- Climate
- Ecoregion
- Fuels and fire potential
- At risk T & E species (e.g. plants)
- Not at risk T & E species (e.g. birds)
- Infrastructure at risk
- Values at risk
- Fire season

- Fire history
- Suppression strategies
- Wildland fire use strategies
- Prescribed fire use strategies
- Non-fire fuel treatment programs
- Rehabilitation and restoration

Planning FMUs should be a top priority for land managers. This is a task that can be completed in cooperation with TMA, but should only be at the expense of the landowners' time to create a plan. No funding should be required.

## 14.5 Wildland Fire Prevention

The National Wildfire Coordinating Group defines prevention of wildfire as the, "activities directed at reducing the incidence of fires, including public education, law enforcement, personal contact, and reduction of fuel hazards (fuels management)." Planning for wildfire prevention includes reviewing all the aforementioned topics with decision makers for involved agencies and interested parties. Within the NKMA, this needs to take place between groups such as TMA, BIGWICG, DOFAW, State Parks, Kamehameha Schools, and communities.

### 14.5.1 Public Information and Education

Since humans are the number one cause of wildland fires in Hawaiʻi, it is undeniable that the public needs to be continuously educated through outreach programs. Wildfire prevention education throughout the State occurs through the media and two National programs: Smokey the Bear and Firewise Communities.

A wildfire awareness brochure should be produced to hand out to those who wish to travel to NKMA. This can also be distributed along with additional wildfire education material at DOFAW offices in Waimea and Hilo. This brief handout should discuss fire prevention and what to do in case of a fire. It is usual for people to feel unthreatened by fire while in Hawaiʻi because it is a wet tropical environment. However, in dryland forest areas wildfire is a serious threat of which visitors need to be aware. On the opposite side of this brochure could be a discussion about limiting the spreading of invasive species.

Fire condition public notices and area closure procedures should make aware the current fire conditions and resultant prohibited actions for NKMA. Public service announcements can make aware the fire conditions via newspaper, radio, and television. This is most applicable to the State-owned land in the North due to the large area of wildland-urban interface. All neighbors should be notified of conditions by a staff employee in order to promote positive relationships and partnering.

Fire condition notices through signage may not be enough to prevent a fire. During certain times of the year, when public use and fire potential is high, it may be justified to have a Fire Coordinator to patrol parking lots and roads to aid informing the public. This Fire Coordinator should work closely with the Protection Forester for the State.

The NKMA can be conceptually expanded to include all of the adjacent landowners. The wildfire hazards for neighboring landowners directly affect the NKMA. Yearly meetings or friendly phone calls to discuss and understand fire preparedness and mitigation measures will help to protect these lands. Areas of mutual aid for discussion should be water, access, fuels, and fire-fighting equipment.

### 14.5.2 Wildland Fire Occurrence

To prevent the occurrence of wildfires, we must look at their common causes, frequency, and where they occur. The frequency and location of wildfires within NKMA has been documented on GIS by the DOFAW, HWMO, and Forest Solutions. The database exists as the Fire History Maps for North and South Kona with the HWMO. This information can be utilized within the planning mechanism to provide feedback on other prevention, pre-suppression, and suppression activities.

The data collected on wildfires identifies the two primary causes of wildfires; anthropogenic and lightning. It also states that the human started wildfires are ignited 90% of the time along roadsides (PWW, 2003).

To show success in controlling wildfire occurrence, we must document a decrease in the fire return interval for wildfires within NKMA. This is best tracked through a GIS database on wildfires, which tracks the following: size, location, ignition source, date, burn length, suppression costs, % native burned, and % non-native burned. The current database should be updated to include this information. Cost for historical research and editing should not exceed $15,000.

| Task | Rate | Amount | Cost |
|---|---|---|---|
| Researcher | $50/hr | 160 hours | $8,000 |
| GIS analyst | $50/hr | 120 hours | $6,000 |

A raster map showing fire frequency based on the number of wildfires occurring within any one cell can be created to show where wildfires are mathematically the most frequent. Updates to this GIS should not exceed $2,500 annually.

### 14.5.3 Non-Fire Fuels Treatment Activities

#### Hazardous Fuel Reduction and Modification Recommendations

There are many natural resource management projects being conducted by the landowners of the NKMA which provide multiple benefits. For example, cattle-grazing provides both land lease fees and reduces grass fuels. Eradication of the non-native fountain grass improves native plant habitat and also reduces the fire threat due to a decrease in fine fuels. This style of project should be the focus when planning fuel reduction and modification objectives. It is more likely to receive funding for projects when the benefits are manifold, and even more so when there is an impact on human safety.

The following is a list of the current projects within NKMA:

1. 12 miles of fire breaks mauka and makai of Mamalahoa Highway within Puʻu Waʻawaʻa (State)
2. 12.2 miles of interior mowing to maintain fire breaks makai of Mamalahoa Highway Puʻu Waʻawaʻa (State)
3. Grazing management plan development by University of Hawaii College of Tropical Agriculture (State)
4. 3.6 mile new firebreak road Lupea and Mizotas Kīpuka (KS)
5. Fountain grass (*Pennisetum setaceum*) control program
    a. Kīpuka Oweowe (24 ac) (State)
    b. Reservoir paddock (43 ac) (State)
    c. Mauka Kona (26,800ac) (KS)
6. Cattle grazing prescribed for fuel reduction at Pulehua (KS)
7. Cattle grazing prescribed for fuel reduction at Puʻu Waʻawaʻa (State)

Before any new projects are undertaken, maintenance and/or completion of existing projects should occur. The following list is proposed to work with existing projects, and also to help achieve landowner's natural resource goals and fire prevention.

| |
|---|
| **Project** |
| Remove all non-native fine fuels between highway 190 and paddock boundary (rock wall or fence) |
| **Location** |
| Pu‘u Wa‘awa‘a ahupua‘a Hwy 190 firebreaks |
| **Description** |
| The total area of this project is estimated to be less than 75 acres, however the width of this area is quite varied as the fences and rockwalls meander in their distance from Hwy 190. The area is very accessible for control work and contains primarily non-native species. Once control is established within Pu‘u Wa‘awa‘a ahupua‘a after year 2, funds should be available to expand work to Pu‘u Anahulu ahupua‘a in a manner consistent with current fuels management projects. |
| **Costs** |
| Total cost year 1 = $7,500 @ $100/acre (cost includes labor and Roundup herbicide)<br>Total cost year 2 = $3,750 @ $50/acre (cost includes labor and Roundup herbicide)<br>Total maintenance cost year 3+ = $2,250 @ $30/acre (cost includes labor and Roundup herbicide)<br>This work is estimated to take approximately 175 manhours |

| |
|---|
| **Project** |
| Pu‘u Anahulu biological assessment<br>**Location**<br>Ahupua‘a of Pu‘u Anahulu<br>**Description**<br>Design a biological assessment for the ahupua‘a of Pu‘u Anahulu that includes historical records and an in-field survey covering a minimum of 2% of the vegetated land area.<br>**Costs**<br>Costs will range dependent on who will complete the work. It is estimated to be between $90 and $140 per acre surveyed. Total project cost should not exceed $150,000. The cost of a field survey can be minimized by evaluating the historical records within the area. |

| Project |
| --- |
| Fountain grass compartmental control<br>**Location**<br>Pu‘u Wa‘awa‘a ahupua‘a |
| **Description**<br>Remove all fountain grass within fenced enclosures. Pu‘u Wa‘awa‘a ahupua‘a total 7,528 acres (fenced enclosures) & Keauhou II ahupua‘a total 10,000 acres (Lupea Habitat Management Area). Refine techniques with the goal of working towards control within select FMUs once they are designated.<br>**Costs**<br>Total cost year 1 = $100/acre (cost includes labor and Roundup herbicide)<br>Total cost year 2 = $50/acre (cost includes labor and Roundup herbicide)<br>Total maintenance cost year 3+ = $30/acre (cost includes labor and Roundup herbicide)<br>A yearly budget should be obtained to do a consistent amount of acres while allowing for resweeping and maintenance of previously controlled acreage. It is feasible to replace Roundup with Imazapyr during the first year of control to extend control period and act as a pre-emergent. Roundup should be used in subsequent years. |

| Project |
| --- |
| Pu‘u Lani Ranch WUI firebreak<br>**Location**<br>Mauka of Pu‘u Lani Ranch and at border of the Ranch and top of Pu‘u Anahulu ridge<br>**Description**<br>Remove all non-native fine fuels, ladder fuels, and thick brush between the community and state land – 10,500 ft distance at a minimum of 20 feet wide.<br>**Costs**<br>Brush clearance using a excavator with a large hydraulic masticating head @ $450-605/acre<br>Fine fuels control at $220/acre (cost includes initial weedwacker control followed with herbicide control one month later w/ Roundup). Total cost estimate $8,500 |

| Project |
| --- |
| Defensible space construction around all existing structures and cultural sites<br>**Location**<br>Entire North Kona Management Area<br>**Description**<br>Defensible zones should be created around all existing structures according to Firewise Communities guidelines<br>**Costs**<br>The responsibility of this work should be taken by the land manager, ie DOFAW, State Parks, KS, and private parties. However, assistance should be offered by TMA and consultants and TMA managers should take the lead on following-up with this task. |

### 14.5.4 Wildland Fire Law Enforcement

As stated earlier, humans are the primary cause of wildfires in Hawai‘i, and therefore authorities must make the public aware of the penalties that exist and follow through with prosecution. This should also be at the responsibility of the landowner on which the fire occurred. Fire law enforcement is carried out by the Division of Conservation and Resource Enforcement (DOCARE) under various laws (e.g. HRS Chapter 185, HAR 13.14-7, et al). Created public information signs should state that: “All violators may be prosecuted under HRS Ch. 185”, or something similar, to make them aware of the penalties for being irresponsible with fire in the open.

## 14.6 Wildland Fire Pre-Suppression

The National Wildfire Coordinating Group's definition of pre-suppression is: all activities in advance of fire occurrence to ensure effective suppression action. It includes planning the organization, recruiting and training, procuring of equipment and supplies, maintaining fire equipment and fire control improvements, and negotiating cooperative and/or mutual-aid agreements. Pre-suppression or preparedness actions are done by the agency in charge of suppression activities. On NKMA, this is the responsibility of HiCFD and DOFAW. The TMA and its partners, Kamehameha School, State Parks, and DOFAW, should still be responsible to work with these agencies via the BIGWICG to inform them of the resources on their land which can assist in wildland fire suppression. The following are a list of relevant issues:

- Land familiarity/Pre-attack planning
- Communications
- Knowledge of water resource
- Mapping (i.e. knowledge of roads, water sources, structures, species, fuels, topography, etc)
- Fire potential
- Hazards/Safety
- Training

The TMA can also coordinate funding to support the creation of more pre-suppression programs to help with the aforementioned.

- Training for private landowners could take place through grants and cooperation with Federal and State agency annual personnel training (e.g. Wildland Fire Behavior S-190).
- GIS data
    - Suppression assets and resources
    - Fuel potential/hazard
    - Fire/fuel breaks both natural and manmade
    - Fire suppression safety hazard mapping
    - Safety zone and staging area identification and mapping
    - Paddock map and waterlines in Pu‘u Anahulu
    - Rock wall mapping
    - Cracks, caves, tubes, and other fire fighter hazards mapping
    - Infrastructure mapping of coastal resources: roads, structures, etc.
    - Utilities mapping
- Road naming and signage to aid navigation
- Fire weather (identifying past fire ignition with the historical weather records could yield valuable information)
- Mutual aid agreements –Mutual aid agreements for water and other resources should extend beyond the partners of TMA to the neighboring landowners as well. Because many adjacent land owners operate ranches there is potentially many things they can assist with including water, heavy machinery, tools, and man power.

### 14.6.1 Pre-Attack Planning of Suppression Equipment

Through the BIGWICG, it is recognized that the NPS, DOFAW, and PTA possess fire suppression equipment which is stored and maintained in their respective fire caches. A list of supplies and equipment is not currently available to the TMA, and would be relevant to scrutinize for possible improvements if one was attained. The partners within the TMA should make aware, and request assistance for, any suppression equipment needs with which they can assist. TMA should prioritize and evaluate these requests for future funding.

Assisting with wildland fire suppression resources which are located in the field should be a priority objective for the TMA, i.e. water tanks, water lines, reservoirs, etc. The following are recommendations based on identifying wildland fire hazard areas; priority protection values and water resources. The map in figure 7 highlights areas in red which are more than three miles from a water source, have intact native forests with high biodiversity (an identified high value resource in the *Three Mountain Alliance Management Plan*, 2007), and are high fuel hazard areas.. Also highlighted on the map in green are areas that are more than three miles from a water source, have intact native forests with high biodiversity, but are <u>not</u> high fuel hazard areas.

Area 1 is 3,250 acres and located within an interface of lowland dry forest/shrubland and non-native grassland dominated by fountain grass. Area 2 is 31,900 acres and located in a very remote area dominated by montane dry forest and shrublands. A fire break, constructed by PTA, exists on the Eastern border of this area outside the NKMA. Area 3 is 39,000 acres and also very remote. This area is located within subalpine and alpine environments which have a very low burn potential because fuels are sparse.

The rest of the NKMA, outside of these “no water resource areas”, contains numerous water sources which can be utilized during suppression. The analysis also assumes that tankers can be provided along highway roadsides. Most water comes from rain catchment, which makes storage capacity an important pre-suppression planning item. Currently, there are 4 high priority projects for increasing water storage capacity within NKMA.

<u>Recently completed water resource improvements and capacity building</u>

1. Helicopter dip tank at Kīpuka Oweowe (State)
2. Waihou 1 new tank (State)
3. Puʻu Wa ʻawaʻa Cone new tank (State)
4. Reline Puʻu Waʻawaʻa lake house reservoir (State)
5. 100 gallon mobile pump for initial attack (State)
6. Pa laʻau new tank 20,000 gallons (KS)
7. Pulehua new tank 20,000 gallons (KS)
8. Pulehua tank repairs, improve capacity by 20,000 gallons (KS)
9. Duarte Cabin new tank 4,000 gallons (KS)

| **Project** |
| --- |
| Hale Piula Water Catchment improvements |
| **Description** |
| Jim Juvik and Lori Tango wrote an excellent report on the Hale Piula catchment area and tanks in 2003. All of their analysis still applies, however the prices need to be updated. They state that the current effective catchment area is 77,000 sq. ft. providing 2.1 million gallons/yr. Improvements to Tank 1 catchment area should be followed by improvements to Tank 2 catchment area, which currently has a larger intact surface catchment area. This will provide an additional 4.9 million gallons per year, while minimizing improvements.<br>Given the improvement in geosynthetics it is less cost effective and efficient to repair and/or install new bituminous pavement.<br><br>Tank 1 catchment area - line all bituminous paved surfaces with high density polyethylene (HDPE)<br>Tank 2 catchment area – line all bituminous paved surfaces with HDPE which drain directly into Tank 2 |
| **Costs** |
| Tank 1 - 95,000 sq.ft. @ $0.995/sq.ft ≈ $94,500 includes geomembrane, liner, sandbags, clearing, and install<br>Tank 2 – 90,250 sq.ft @ $1.002/sq.ft ≈ $90,500 includes geomembrane, liner, sandbags, clearing, and install |

| **Project** |
| --- |
| Poʻohoʻohoʻo reservoir improvements |
| **Description** |
| Again, please reference the 2003 report of Juvik and Tango for specifics on the Poʻohoʻohoʻo reservoir. Reservoir 1 should be improved first followed by improvements to reservoir 2 if sufficient water is still not available. A key and cost effective component would be to connect Poʻohoʻohoʻo to hale piula via a 2 inch high density plastic pipe to collect excess water from this, the wettest area within the ahupuaʻa. |
| **Costs** |
| Reservoir 1 – 86,000 @ $0.997/sq.ft. ≈ $85,750 includes geomembrane, liner, sandbags, clearing, & install<br>Water transfer line – 10,100 ft @ $1.00/ft ≈ $xx,xxx includes installation<br>Reservoir 2 – 165,000 @ $1.001/sq.ft. ≈ $165,155 includes geomembrane, liner, sandbags, clearing, & install |

| **Project** |
| --- |
| Lupea Habitat Area water storage |
| **Description** |
| Annually increase water resource infrastructure within the protected area via water catchment and storage. |
| **Costs** |
| 20,000 gallon corrugated steel tank ≈ $4,500<br>484 sq.ft. elevated catchment roof ≈ $9,500 |

| **Project** |
| --- |
| Hale Laʻau water storage |
| **Description** |
| One time installation of a water resource near the Greenwell Hale Laʻau Cabin |
| **Costs** |
| 20,000 gallon corrugated steel tank ≈ $4,500<br>484 sq.ft. elevated catchment roof ≈ $9,500 |

### 14.6.2 Fire Weather/Fire Danger (NFDRS)

Fire season in Hawai‘i can be year round due to localized weather patterns creating dry conditions. Extended periods of drought and fire weather should be assessed with the National Fire Danger Rating System for Hawai‘i, also known as the Hawai‘i Fire Danger Rating System, operated on the Internet at http://fireweb2a.pdc.org/ndfd/ by the Pacific Disaster Center. There are two Remote Automated Weather Stations (RAWS) located in Pu‘u Wa‘awa‘a ahupua‘a which collect real-time weather information. The National Oceanic and Atmospheric Administration (NOAA) also provides fire weather spot forecast upon request via their website at [http://www.prh.noaa.gov/hnl/pages/firewx.php](http://www.prh.noaa.gov/hnl/pages/firewx.php).

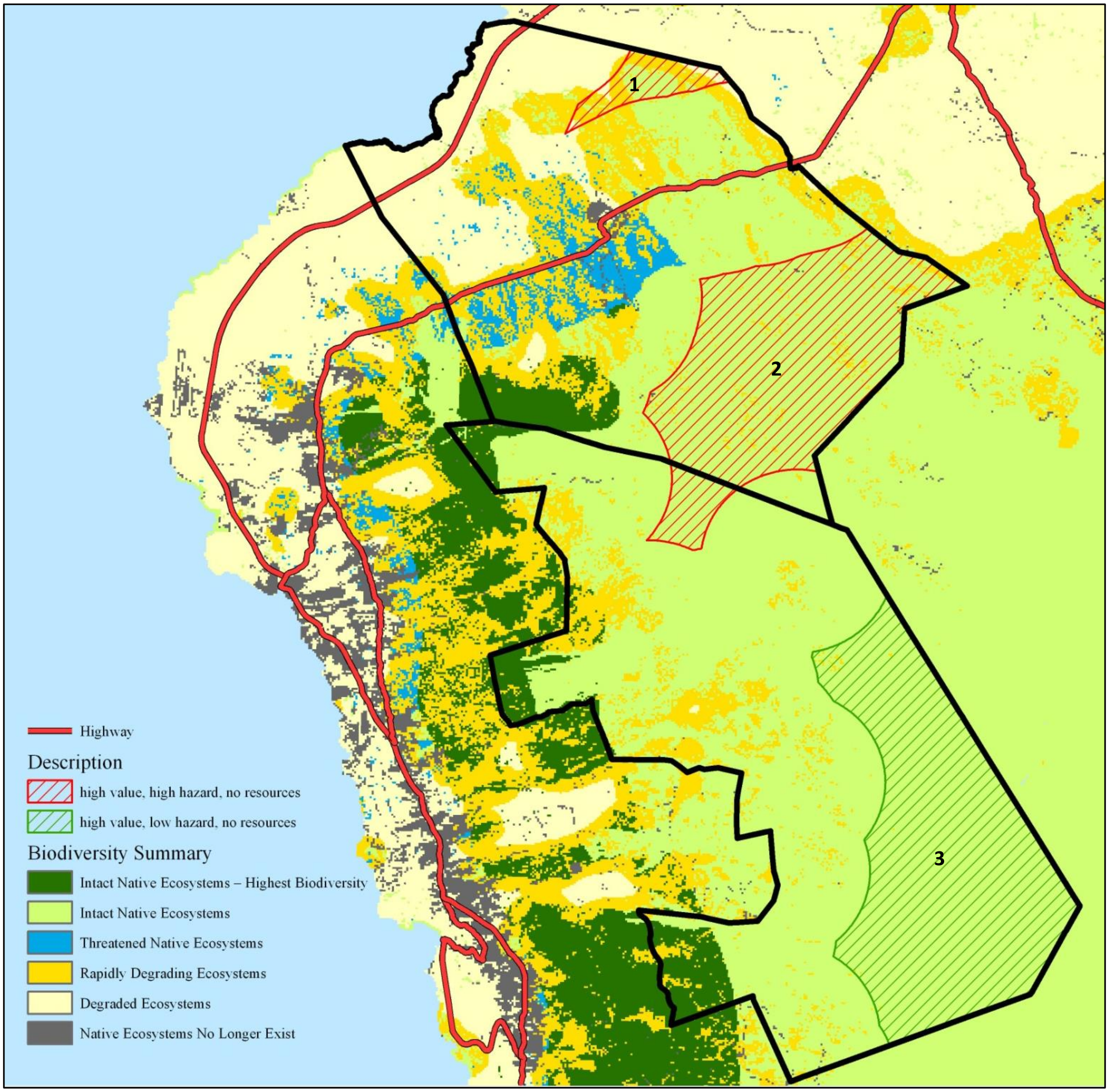


**Figure 14.7** Map of identified “no water resource areas” in NKMA.

## 14.7 Wildland Fire Suppression (Emergency Operations)

### 14.7.1 Incident Management and Reporting

Fire suppression and initial attack are carried out by the County of Hawaiʻi Fire Department or the State Division of Forestry and Wildlife on all NKMA lands. KS does not keep or train fire-fighting personnel. Agency response is well organized by the various State and Federal agencies under BIGWICG. This group has developed a fire response zone map (FIGURE 14.5), which details areas of responsibility for various agencies. They also have comprehensive Memorandums of Understanding (MOU) when requesting help from partnering agencies for suppression assistance. All requests must go through the County of Hawaiʻi Civil Defense.

Upon responding to a wildland fire, all agencies utilize the Incident Command System (ICS) to manage all incidents. An Incident Commander will be immediately recognized on scene and should be assisted by a resource manager, i.e. Kamehameha Schools land manager, State Parks staff, etc. NWCG Publication 310-1 should be referenced regarding requirements and qualifications for wildland and prescribed fire personnel. The following information should be evaluated by the IC and Resource Manager during an initial attack:

- Fire Report
    - Fire name
    - Reporting party
    - Date/time fire was first observed and name of observer
    - Possible cause
    - Location
    - Access
    - Terrain and fuels
    - Size of fire
    - Visitors of personnel in the area
    - Anticipated problems
    - Threatened Values
    - Cause
    - Weather
    - Resources on fire
    - Resources needed
    - Fire behavior

- Public and firefighter safety
- Communities in the Wildland Urban Interface
- Cultural and historic resources
- Natural resources such as threatened and endangered species, sensitive and important habitat, vegetation maps
- Available suppression resources
- Fire behavior as determined by fuels, weather, and topography
- Natural and manmade fuel or fire breaks

Information and knowledge held by the TMA which could assist with wildland fire protection should be made readily available during a fire. The TMA coordinator should confirm communication between parties affected by the fire and offer support where necessary.
If an initial attack does not contain the fire and/or continues to burn for longer than the initial operational consideration, an extended attack organization will be put into place under appropriate agency guidelines. At this point there is a federal resource called the Wildland Fire Decision Support System (WFDSS) which should be consulted by authorized personnel.
Dependent upon the location of the fire, and the prevailing weather, there can be air quality hazards to the public. The IC should be aware of the air pollution being caused by the fire and work with the State Department of Health when necessary.

## 14.8 Wildland Fire Use

Naturally ignited wildland fire should be considered for use in accomplishing management goals. When FMUs are designated, a prescription should be assigned to utilize wildland fire, if one were to occur. Kamahameha Schools' land is not a candidate for this management regime (unless future research proves different), however lowland and coastal State-owned lands that may support a pili grass fire management regime or similar, should be evaluated.

## 14.9 Prescribed Fire

The use of prescribed fire as a management tool should be considered over the long-term using reliable research data. Prescribed fire can be used to reduce fuel hazards, manage ecological processes, remove invasive species, cycle nutrients, remove unwanted debris, as well as other management goals, however very little research exists on the subject in Hawai'i. One research experiment used prescribed fire, herbicide, and cattle grazing in Pu'u Anahulu to manage fountain grass fuel loads. They found out that the best prescription is a combination of all three management techniques (Castillo, 2009).

Prescribed fire does not have any applications in the near term for NKMA lands because it has not been utilized enough to be a reliable management tool and the risk of escape is high. However, prescribed fire research should be supported in order to develop its use as another tool. Slash pile and debris burns should be managed as prescribed fires.

## 14.10 Rehabilitation/Restoration

Following the suppression of a wildland fire two things should be evaluated within the burn area; areas needing rehabilitation and restoration back to a natural state. These two items should conclude a fire, and they are not part of a long-term restoration or monitoring project. Both can be mitigated through good planning and low impact suppression.

Rehabilitation work should return disturbed areas, like campsites and fire lines, back to a state that will promote native plant regeneration and discourage erosion, runoff, and invasive species. Bulldozed firebreaks are a vector for invasive weed infestations and illegal access. These firebreaks should be rehabilitated unless they are determined to be future roads or permanent fire breaks.

Post fire restoration plans should be created and implemented quickly to capitalize on the bare ground in front of invasive species. Equally important to re-vegetation is the control of undesired species through herbicide control. The wildland fire/invasive grass cycle can be broken through rapid, intensive restoration. Funds to accomplish this restoration work should be acquired and set aside each year.

## 14.11 Monitoring and Evaluation

Wildland fire and environmental monitoring should take place to collect background information that will assist in decision-making. There are numerous agencies willing to be part of a monitoring program and they can rapidly respond if plans are already in place. The Hawaii Tropical Experimental Forest is one such entity. Monitoring of weather, fuel conditions, vegetation, and fire observation can all contribute to better land management by TMA.

The implementation of post-burn monitoring through a program such as *Fire Effects Monitoring and Inventory System* should be evaluated as part of the pre-suppression planning program.

# 15.0 APPENDIX H: FUNDING MATRIX

The following pages contain three tables outlining the funding matrix for this HCP. Table 15.1 covers years 0-8 (Avoidance and Minimization), table 15.2 covers years 9-15 (Mitigation), and table 15.3 covers years 16-25 (Maintenance).

# Table 15.1

| *Ungulate Exclosures (contracting and materials)* | Quantity | Units | Unit Cost | Total Cost | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 | YR 7 | YR 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Henahena | 3.3 | miles | 168,480.00 | 555,984.00 | 555,984.00 | | | | | | | |
| Hala pepe | 1.8 | miles | 168,480.00 | 304,748.57 | 304,748.57 | | | | | | | |
| ‘Aiea | 3.0 | miles | 168,480.00 | 503,656.94 | | 503,656.94 | | | | | | |
| Haplostachys | 0.6 | miles | 168,480.00 | 97,360.42 | | 97,360.42 | | | | | | |
| Solanum | 0.8 | miles | 168,480.00 | 139,602.27 | | 139,602.27 | | | | | | |
| Zanthoxylum II | 4.6 | miles | 168,480.00 | 773,544.20 | | | 773,544.20 | | | | | |
| Kauila Halapepe | 3.4 | miles | 168,480.00 | 576,415.53 | | | 576,415.53 | | | | | |
| Uhiuhi 4 | 0.8 | miles | 168,480.00 | 130,965.46 | | | 130,965.46 | | | | | |
| Anahulu I | 2.6 | miles | 168,480.00 | 441,471.90 | | | | 441,471.90 | | | | |
| Anahulu II | 2.2 | miles | 168,480.00 | 372,272.73 | | | | 372,272.73 | | | | |
| Pu‘u Loa | 4.2 | miles | 168,480.00 | 710,731.03 | | | | | 710,731.03 | | | |
| Stenogyne | 0.6 | miles | 168,480.00 | 93,801.00 | | | | | 93,801.00 | | | |
| PWW CCA buffer | 1.4 | miles | 168,480.00 | 230,210.27 | | | | | | 230,210.27 | | |
| Mānele | 1.8 | miles | 168,480.00 | 302,759.48 | | | | | | | 302,759.48 | |
| Kohala | 1.6 | miles | 168,480.00 | 262,140.30 | | | | | | | | 262,140.30 |
| Waihou II | 2.3 | miles | 168,480.00 | 395,827.67 | | | | | | | | |
| Boundary Kipuka | 1.2 | miles | 168,480.00 | 196,605.23 | | | | | | | | |
| Kileo | 4.2 | miles | 168,480.00 | 709,300.80 | | | | | | | | |
| Lama Kokio | 3.2 | miles | 168,480.00 | 544,171.44 | | | | | | | | |
| Fence checks and repairs for large exclosures | 837.38 | miles | 558.00 | 507,814.30 | 2,850.72 | 5,303.62 | 10,208.40 | 12,903.49 | 15,568.07 | 16,330.52 | 17,333.25 | 18,201.45 |
| Supplies for small spot fences | 100 | each | 500.00 | 50,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | | |
| Labor | | see full time labor crew | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Subtotal** | | | | **7,899,383.55** | | | | | | | | |
| *Fire pre-suppression for ungulate exclosures and fuel breaks* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 1** | **YR 2** | **YR 3** | **YR 4** | **YR 5** | **YR 6** | **YR 7** | **YR 8** |
| ATV with spray rig | | | | | | | | | | | | |
| Annual Maintenance | 2 | each | 500.00 | 25,000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 |
| Truck spray rig | 6 | each | 7,500.00 | 45,000.00 | | | | | | | | |
| Annual Maintenance | 6 | each | 250.00 | 1,500.00 | | | | | | | | |
| Backpack sprayers | 50 | each | 150.00 | 7,500.00 | 1500.00 | | | | 1500.00 | | | |
| Weed Whacker + PPE and supplies | 42 | each | 750.00 | 31500.00 | 10500.00 | | | | | | | 10500.00 |
| Herbicide + surfectant and dye | 500 | each | 1,000.00 | 10,000,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 |
| | | | | | | | | | | | | |
| **Subtotal** | | | | **10,140,500.00** | | | | | | | | |

| *Predator control* | Quantity | Units | Unit Cost | Total Cost | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 | YR 7 | YR 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good nature A24 Rat Trap | | | | | | | | | | | | |
| $CO_2$ cartridge refills | 250 | 10 pack | 45.00 | 11,250.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 |
| Rat lure replacement | 250 | 10 pack | 70.00 | 17,500.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 |
| Rodenticide (for large conservation units) | ? | ? | ? | ? | | | | | | | | |
| | | | | | | | | | | | | |
| **Subtotal** | | | | **177,500.00** | | | | | | | | |

| *Ungulate control in ungulate exclosures* | Quantity | Units | Unit Cost | Total Cost | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 | YR 7 | YR 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Game drives (helicopter) | | | | | | | | | | | | |
| Game traps | 138 | each | 180.00 | 24,840.00 | 16,200.00 | 3600 | | | | | | |
| Ungulate monitoring | | see full time crew | | | | | | | | | | |
| GPS tracking collars | 5 | set | 2,000.00 | 10,000.00 | 2,000.00 | | | | 2,000.00 | | | |
| Quarterly fence checks | | see full time crew | | | | | | | | | | |
| | | | | | | | | | | | | |
| **Subtotal** | | | | **122,840.00** | | | | | | | | |

| *Mitigation and Net benefit* | Quantity | Units | Unit Cost | Total Cost | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 | YR 7 | YR 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nursery Propagation (Volcano Rare Plant Facility) of covered species | | | | | | | | | | | | |
| On-site Green House | 1 | each | 6,500.00 | 6,500.00 | | | | | | | | |
| Green house maintenance and supplies | 25 | each | 2,500.00 | 62,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 |
| Green House labor | | See full time crew | | | | | | | | | | |
| Common species propagation | 150,000 | each | 6.00 | 900,000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 |
| Labor (seed collection and outplanting) | | see full time field crew | | | | | | | | | | |
| outplanting | | see full time field crew | | | | | | | | | | |
| pest control (ant/slug/aphid/etc) | | acre | 50.00 | 200,000.00 | | | | | | | | |
| | | | | | | | | | | | | |
| **Subtotal** | | | | **1,251,000.00** | | | | | | | | |

| *Permanent Field Crew* | Quantity | Units | Unit Cost | Total Cost | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 | YR 7 | YR 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project leader | | | | | | | | | | | | |
| Crew Leader (including fringe) | 1 | each | 59,000.00 | 1,475,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 |
| Field Assistants (including fringe) | 6 | each | 45,000.00 | 4,500,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 |
| Data management/nursery tech (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| Volunteer Coordinator (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| Vehicles for Crew | 4 | each | 40,000.00 | 160,000.00 | 80000.00 | | | | | | | |
| Annual maintenance | 2 | each | 2,500.00 | 62,500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 |
| ATV | 2 | each | 8,000.00 | 16,000.00 | 8,000.00 | | | | | | | |
| 2 Seater ATV | 2 | each | 15,000.00 | 30,000.00 | 15,000.00 | | | | | | | |
| | | | | | | | | | | | | |
| **Subtotal** | | | | **10,118,500.00** | | | | | | | | |

| *Monitoring* | Quantity | Units | Unit Cost | Total Cost | YR 1 | YR 2 | YR 3 | YR 4 | YR 5 | YR 6 | YR 7 | YR 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GPS units | | | | | | | | | | | | |
| field supplies | 25 | annual | 5,000.00 | 125,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 |
| **Subtotal** | | | | **132,000.00** | | | | | | | | |
| *Blackburn's sphinx moth research* | | | | | | | | | | | | |
| Post-doc position plus supplies | 3 | each | 100,000.00 | 300,000.00 | | 100,000.00 | 100,000.00 | 100,000.00 | | | | |
| **Subtotal** | | | | | | | | | | | | |
| | | | | 300,000.00 | | | | | | | | |

| *Ungulate Exclosures (contracting and materials)* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Henahena | 3.3 | miles | 168,480.00 | 555,984.00 | | | | | | | |
| Hala pepe | 1.8 | miles | 168,480.00 | 304,748.57 | | | | | | | |
| ‘Aiea | 3.0 | miles | 168,480.00 | 503,656.94 | | | | | | | |
| Haplostachys | 0.6 | miles | 168,480.00 | 97,360.42 | | | | | | | |
| Solanum | 0.8 | miles | 168,480.00 | 139,602.27 | | | | | | | |
| Zanthoxylum II | 4.6 | miles | 168,480.00 | 773,544.20 | | | | | | | |
| Kauila Halapepe | 3.4 | miles | 168,480.00 | 576,415.53 | | | | | | | |
| Uhiuhi 4 | 0.8 | miles | 168,480.00 | 130,965.46 | | | | | | | |
| Anahulu I | 2.6 | miles | 168,480.00 | 441,471.90 | | | | | | | |
| Anahulu II | 2.2 | miles | 168,480.00 | 372,272.73 | | | | | | | |
| Pu‘u Loa | 4.2 | miles | 168,480.00 | 710,731.03 | | | | | | | |
| Stenogyne | 0.6 | miles | 168,480.00 | 93,801.00 | | | | | | | |
| PWW CCA buffer | 1.4 | miles | 168,480.00 | 230,210.27 | | | | | | | |
| Mānele | 1.8 | miles | 168,480.00 | 302,759.48 | | | | | | | |
| Kohala | 1.6 | miles | 168,480.00 | 262,140.30 | | | | | | | |
| Waihou II | 2.3 | miles | 168,480.00 | 395,827.67 | 395,827.67 | | | | | | |
| Boundary Kipuka | 1.2 | miles | 168,480.00 | 196,605.23 | 196,605.23 | | | | | | |
| Kileo | 4.2 | miles | 168,480.00 | 709,300.80 | | 709,300.80 | | | | | |
| Lama Kokio | 3.2 | miles | 168,480.00 | 544,171.44 | | 544,171.44 | | | | | |
| Fence checks and repairs for large exclosures | 837.38 | miles | 558.00 | 507,814.30 | 20,163.57 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 |
| Supplies for small spot fences | 100 | each | 500.00 | 50,000.00 | | | | | | | |
| Labor | | see full time labor crew | | | | | | | | | |
| | | | | | | | | | | | |
| **Subtotal** | | | | **7,899,383.55** | | | | | | | |
| *Fire pre-suppression for ungulate exclosures and fuel breaks* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
| ATV with spray rig | 4 | each | 10,000.00 | 30,000.00 | | | | 15,000.00 | | | |
| Annual Maintenance | 2 | each | 500.00 | 25,000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 |
| Truck spray rig | 6 | each | 7,500.00 | 45,000.00 | | | | | | | |
| Annual Maintenance | 6 | each | 250.00 | 1,500.00 | | | | | | | |
| Backpack sprayers | 50 | each | 150.00 | 7,500.00 | | 1500 | | | | | 1500 |
| Weed Whacker + PPE and supplies | 42 | each | 750.00 | 31500.00 | | | | | | | |
| Herbicide + surfectant and dye | 500 | each | 1,000.00 | 10,000,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 |
| | | | | | | | | | | | |
| **Subtotal** | | | | **10,140,500.00** | | | | | | | |
| *Predator control* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
| Good nature A24 Rat Trap | 250 | 5 Pack | 595.00 | 148,750.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ cartridge refills | 250 | 10 pack | 45.00 | 11,250.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 |
| Rat lure replacement | 250 | 10 pack | 70.00 | 17,500.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 |
| Rodenticide (for large conservation units) | ? | ? | ? | ? | | | | | | | |
| | | | | | | | | | | | |
| **Subtotal** | | | | **177,500.00** | | | | | | | |
| *Ungulate control in ungulate exclosures* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
| Game drives (helicopter) | 110 | hours | 800.00 | 88,000.00 | 16,000.00 | 8,000.00 | | | | | |
| Game traps | 138 | each | 180.00 | 24,840.00 | 3600 | | | | | | |
| Ungulate monitoring | | see full time crew | | | | | | | | | |
| GPS tracking collars | 5 | set | 2,000.00 | 10,000.00 | | 2,000.00 | | | | | 2,000.00 |
| Quarterly fence checks | | see full time crew | | | | | | | | | |
| | | | | | | | | | | | |
| **Subtotal** | | | | **122,840.00** | | | | | | | |
| *Mitigation and Net benefit* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
| Nursery Propagation (Volcano Rare Plant Facility) of covered species | 10,250 | each | 8.00 | 82,000.00 | | | | | | | |
| On-site Green House | 1 | each | 6,500.00 | 6,500.00 | | 6,500.00 | | | | | |
| Green house maintenance and supplies | 25 | each | 2,500.00 | 62,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 |
| Green House labor | | See full time crew | | | | | | | | | |
| Common species propagation | 150,000 | each | 6.00 | 900,000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 |
| Labor (seed collection and outplanting) | | see full time field crew | | | | | | | | | |
| outplanting | | see full time field crew | | | | | | | | | |
| pest control (ant/slug/aphid/etc) | | acre | 50.00 | 200,000.00 | | | | | | | |
| | | | | | | | | | | | |
| **Subtotal** | | | | **1,251,000.00** | | | | | | | |
| *Permanent Field Crew* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
| Project leader | 1 | each | 65,000.00 | 1,625,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 |
| Crew Leader (including fringe) | 1 | each | 59,000.00 | 1,475,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 |
| Field Assistants (including fringe) | 6 | each | 45,000.00 | 4,500,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 |
| Data management/nursery tech (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| Volunteer Coordinator (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| Vehicles for Crew | 4 | each | 40,000.00 | 160,000.00 | | | | 80,000 | | | |
| Annual maintenance | 2 | each | 2,500.00 | 62,500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 |
| ATV | 2 | each | 8,000.00 | 16,000.00 | | | | 8,000.00 | | | |
| 2 Seater ATV | 2 | each | 15,000.00 | 30,000.00 | | | | 15,000.00 | | | |
| | | | | | | | | | | | |
| **Subtotal** | | | | | | | | | | | |
| | | | | **10,118,500.00** | | | | | | | |

| ***Monitoring*** | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GPS units | 20 | each | 350.00 | 7,000.00 | | 1400.00 | | | | | 1400.00 |
| field supplies | 25 | annual | 5,000.00 | 125,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 |
| | | | | | | | | | | | |
| **Subtotal** | | | | **132,000.00** | | | | | | | |

| *Blackburn's sphinx moth research* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Post-doc position plus supplies | 3 | each | 100,000.00 | 300,000.00 | | | | | | | |
| | | | | | | | | | | | |
| **Subtotal** | | | | | | | | | | | |
| | | | | 300,000.00 | | | | | | | |

| Item description | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Ungulate Exclosures (contracting and materials)* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| Henahena | 3.3 | miles | 168,480.00 | 555,984.00 | | | | | | | | | | |
| Hala pepe | 1.8 | miles | 168,480.00 | 304,748.57 | | | | | | | | | | |
| ‘Aiea | 3.0 | miles | 168,480.00 | 503,656.94 | | | | | | | | | | |
| Haplostachys | 0.6 | miles | 168,480.00 | 97,360.42 | | | | | | | | | | |
| Solanum | 0.8 | miles | 168,480.00 | 139,602.27 | | | | | | | | | | |
| Zanthoxylum II | 4.6 | miles | 168,480.00 | 773,544.20 | | | | | | | | | | |
| Kauila Halapepe | 3.4 | miles | 168,480.00 | 576,415.53 | | | | | | | | | | |
| Uhiuhi 4 | 0.8 | miles | 168,480.00 | 130,965.46 | | | | | | | | | | |
| Anahulu I | 2.6 | miles | 168,480.00 | 441,471.90 | | | | | | | | | | |
| Anahulu II | 2.2 | miles | 168,480.00 | 372,272.73 | | | | | | | | | | |
| Pu‘u Loa | 4.2 | miles | 168,480.00 | 710,731.03 | | | | | | | | | | |
| Stenogyne | 0.6 | miles | 168,480.00 | 93,801.00 | | | | | | | | | | |
| PWW CCA buffer | 1.4 | miles | 168,480.00 | 230,210.27 | | | | | | | | | | |
| Mānele | 1.8 | miles | 168,480.00 | 302,759.48 | | | | | | | | | | |
| Kohala | 1.6 | miles | 168,480.00 | 262,140.30 | | | | | | | | | | |
| Waihou II | 2.3 | miles | 168,480.00 | 395,827.67 | | | | | | | | | | |
| Boundary Kipuka | 1.2 | miles | 168,480.00 | 196,605.23 | | | | | | | | | | |
| Kileo | 4.2 | miles | 168,480.00 | 709,300.80 | | | | | | | | | | |
| Lama Kokio | 3.2 | miles | 168,480.00 | 544,171.44 | | | | | | | | | | |
| Fence checks and repairs for large exclosures | 837.38 | miles | 558.00 | 507,814.30 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 |
| Supplies for small spot fences | 100 | each | 500.00 | 50,000.00 | | | | | | | | | | |
| Labor | | see full time labor crew | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **7,899,383.55** | | | | | | | | | | |
| *Fire pre-suppression for ungulate exclosures and fuel breaks* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| ATV with spray rig | 4 | each | 10,000.00 | 30,000.00 | | | | | | | | | | |
| Annual Maintenance | 2 | each | 500.00 | 25,000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 | 1000.00 |
| Truck spray rig | 6 | each | 7,500.00 | 45,000.00 | | | | | | | | | | |
| Annual Maintenance | 6 | each | 250.00 | 1,500.00 | | | | | | | | | | |
| Backpack sprayers | 50 | each | 150.00 | 7,500.00 | | | | | 1500 | | | | | |
| Weed Whacker + PPE and supplies | 42 | each | 750.00 | 31500.00 | 10500.00 | | | | | | | | | |
| Herbicide + surfectant and dye | 500 | each | 1,000.00 | 10,000,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **10,140,500.00** | | | | | | | | | | |
| *Predator control* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| Good nature A24 Rat Trap | 250 | 5 Pack | 595.00 | 148,750.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 |

| Item description | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ cartridge refills | 250 | 10 pack | 45.00 | 11,250.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 |
| Rat lure replacement | 250 | 10 pack | 70.00 | 17,500.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 |
| Rodenticide (for large conservation units) | ? | ? | ? | ? | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **177,500.00** | | | | | | | | | | |
| *Ungulate control in ungulate exclosures* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| Game drives (helicopter) | 110 | hours | 800.00 | 88,000.00 | | | | | | | | | | |
| Game traps | 138 | each | 180.00 | 24,840.00 | | | | | | | | | | |
| Ungulate monitoring | | see full time crew | | | | | | | | | | | | |
| GPS tracking collars | 5 | set | 2,000.00 | 10,000.00 | | | | | 2,000.00 | | | | | |
| Quarterly fence checks | | see full time crew | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **122,840.00** | | | | | | | | | | |
| *Mitigation and Net benefit* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| Nursery Propagation (Volcano Rare Plant Facility) of covered species | 10,250 | each | 8.00 | 82,000.00 | | | | | | | | | | |
| On-site Green House | 1 | each | 6,500.00 | 6,500.00 | | | | | | | | | | |
| Green house maintenance and supplies | 25 | each | 2,500.00 | 62,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 | 2,500.00 |
| Green House labor | | See full time crew | | | | | | | | | | | | |
| Common species propagation | 150,000 | each | 6.00 | 900,000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 |
| Labor (seed collection and outplanting) | | see full time field crew | | | | | | | | | | | | |
| outplanting | | see full time field crew | | | | | | | | | | | | |
| pest control (ant/slug/aphid/etc) | | acre | 50.00 | 200,000.00 | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **1,251,000.00** | | | | | | | | | | |
| *Permanent Field Crew* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| Project leader | 1 | each | 65,000.00 | 1,625,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 |
| Crew Leader (including fringe) | 1 | each | 59,000.00 | 1,475,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 |
| Field Assistants (including fringe) | 6 | each | 45,000.00 | 4,500,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 |
| Data management/nursery tech (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| Volunteer Coordinator (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| Vehicles for Crew | 4 | each | 40,000.00 | 160,000.00 | | | | | | | | | | |
| Annual maintenance | 2 | each | 2,500.00 | 62,500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 | 2500.00 |
| ATV | 2 | each | 8,000.00 | 16,000.00 | | | | | | | | | | |
| 2 Seater ATV | 2 | each | 15,000.00 | 30,000.00 | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **10,118,500.00** | | | | | | | | | | |
| ***Monitoring*** | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |

| Item description | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GPS units | 20 | each | 350.00 | 7,000.00 | | | | | 1400.00 | | | | | |
| field supplies | 25 | annual | 5,000.00 | 125,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | **132,000.00** | | | | | | | | | | |
| *Blackburn's sphinx moth research* | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 16** | **YR 17** | **YR 18** | **YR 19** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** |
| Post-doc position plus supplies | 3 | each | 100,000.00 | 300,000.00 | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **Subtotal** | | | | | | | | | | | | | | |
| | | | | 300,000.00 | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| **TOTAL:** | | | | **30,141,723.55** | | | | | | | | | | |

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# APPENDIX B: ARCHAEOLOGICAL INVENTORY SURVEY REPORT

# FINAL—Archaeological Inventory Survey of Fenceline Corridors for Three Ungulate Exclosure Conservation Units in the Pu‘u Wa‘awa‘a Forest Reserve, North Kona District, Pu‘u Wa‘awa‘a Ahupua‘a, Hawai‘i Island, Hawai‘i

**TMKs (3) 7-1-001:004 and 7-1-001:006**

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## Management Summary

At the request of the Department of Land and Natural Resources, Division of Forestry and Wildlife, Garcia and Associates has completed an archaeological inventory survey of proposed fenceline corridors for three ungulate exclosure conservation units in the Puʻu Waʻawaʻa Forest Reserve, Puʻu Waʻawaʻa Ahupuaʻa, North Kona District, Island of Hawaiʻi. The undertaking consists of the installation of wire mesh fencing along linear corridors surrounding areas designated by DOFAW as the Aiea, Henahena, and Puʻu Waʻawaʻa Conservation Units. The Area of Potential Effect (APE) for the undertaking is located in the remote uplands of Puʻu Waʻawaʻa Ahupuaʻa, within the boundaries of historic Puʻu Waʻawaʻa Ranch (Site 7190). The APE consists of a series of linear corridors ranging between 50 and 250 meters wide covering a combined total area of 256 acres (103.6 hectares).

The survey identified six distinct sites within the project corridors as well as a variety of ranch infrastructure features (e.g., fences, roads, and waterlines) associated with historic Puʻu Waʻawaʻa Ranch (Site 7190). The six sites include a trachyte quarry, a modified outcrop, a chute and corral complex, a stone wall, a stone corral, and the overall historic ranch. Additionally, three sites (50-10-20-30309, 30305, and 30397) located just outside of the project area were documented. Descriptions of these are included in Appendix A of this report.

Four of the six historic properties retain integrity and are significant under Hawaiʻi Administrative Rules §13-275-6(b) and Section 106 criteria. Significance determinations are as follows:

- Site 50-10-19-7190: Historic Puʻu Waʻawaʻa Ranch, consisting of paddocks, fencelines, waterlines, roads, and various other structures. The site is significant under Criteria C and D.
- Site 50-10-20-30306: A trachyte quarry consisting of an office building, Quonset hut, quarry pit, scattered refuse, graded areas, roads, wire fences, and utility lines. The site is in very poor condition, does not retain historic integrity, and is not significant under Criteria A, B, C, D, or E.
- Site 50-10-20-30307: A modified outcrop consisting of an L-shaped mound on a natural outcrop. The site is interpreted as a Traditional Hawaiian temporary shelter. It is not significant under Criteria A, B, C, D, or E.
- Site 50-10-20-30308: A historic chute and corral complex consisting of a wooden corral, a cattle chute, two concentrations of concrete footings, galvanized waterline, and wire fencing. The site retains integrity and is significant under Criteria C and D.
- Site 50-10-20-30310: A dry-laid stone wall associated with historic Puʻu Waʻawaʻa Ranch. The site retains integrity and is significant under Criteria C and D.
- Site 50-10-20-30311: A historic stone corral constructed of well-faced stacked basalt cobbles and small boulders with core-fill interior. The site retains integrity and is significant under Criteria C and D.

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# 1.0 Introduction

At the request of the Hawaiʻi Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW), Garcia and Associates has completed an archaeological inventory survey (AIS) of proposed fenceline corridors for three ungulate exclosure conservation units in the Puʻu Waʻawaʻa Forest Reserve, Puʻu Waʻawaʻa Ahupuaʻa, North Kona District, Island of Hawaiʻi (Figure 1).

The primary goal of the survey was to evaluate the fenceline corridors for the presence or absence of historic properties and to determine the cultural affiliation, function, significance, and integrity of any identified properties.

## 1.1 Project Authority

This archaeological inventory survey was conducted to meet DOFAW's cultural resource compliance obligations on both state and federal levels. On the state level, the survey and resultant AIS report supports Chapter 6E-42 (Hawaiʻi Revised Statutes) compliance and will also be used to evaluate impacts to historic properties under the Hawaiʻi Environmental Protection Act. On the federal level, the inventory survey report will be used to facilitate consultation with Hawaiʻi's Historic Preservation Office, Native Hawaiian Organizations, and other consulting and interested parties under Section 106 of the National Historic Preservation Act of 1966, as amended. National Historic Preservation Act compliance is triggered by the use of federal funds for portions of the proposed exclosure fenceline.

All work was conducted in accordance with the Hawaiʻi Administrative Rules Chapter 13-276 *Rules Governing Standards for Archaeological Inventory Surveys and Reports*. It is also compliant with the Secretary of the Interior's Standards for Archaeological Documentation.

## 1.2 The Undertaking

The undertaking consists of the installation of wire mesh fencing along linear corridors surrounding areas designated by DOFAW as the Aiea, Henahena, and Puʻu Waʻawaʻa Conservation Units. These three conservation units will be fenced in an effort to exclude ungulates and thereby protect threatened and endangered native Hawaiian species and their habitat, as well as cultural resources. Major portions of the conservation units will utilize existing fence. The newly proposed fenceline is designed to tie in to this existing fence and complete the three conservation unit exclosures.

## 1.3 Area of Potential Effect

The Area of Potential Effect (APE) for the undertaking is located in the remote uplands of Puʻu Waʻawaʻa Ahupuaʻa, within the boundaries of historic Puʻu Waʻawaʻa Ranch (Site 7190). The APE consists of a series of linear corridors ranging between 50 and 250 meters (m) wide and covering a total area of 256 acres (103.6 hectares) (Figure 2). The corridors are situated around the base, along the slopes, and on top of Puʻu Waʻawaʻa cinder cone, as well as along portions of the Aiea and Henahena Conservation Units. The Aiea Unit is located approximately 3.5 kilometers (km) southwest of Pu‘u Wa‘awa‘a and the Henahena Unit is located approximately 1.5 km southwest of Pu‘u Wa‘awa‘a. The survey corridors total 15.4 kilometers in linear extent.

The APE includes all areas that might be subject to direct or indirect impact from the undertaking. Direct impacts will include fence and post installation. Indirect impacts may include staging and lay down areas for materials and vehicular transport of materials within the project area. Transport of materials to the conservation units will be on existing ranch roads and via helicopter drops. Helicopter drop zones will be within the APE survey corridor.

### 1.4 Project Schedule and Personnel

AIS fieldwork was initially conducted over a three day period between 9 December 2013 and 11 December 2013. The archaeological survey team included one senior archaeologist supported by three DOFAW staff members and two trained interns. The DOFAW staff and interns consisted of biologists who concurrently surveyed the corridor for plant, avian, and other sensitive resources. Patrick O’Day, Ph.D., served as the Field Supervisor for the project and DOFAW staff members included Elliott Parsons, Ph.D., Kealaka‘i Knoche, Tara Seely, and interns Kylen Damo and Justin Ramos. Additional fieldwork, including a site tour and interview with Mr. Mikio “Miki” Kato, was conducted on 22 September 2014 by the Field Supervisor. Two days of supplemental site recording and test excavation were also conducted on 9 and 10 June 2015 by Dr. O’Day and project Principal Investigator Michael Desilets, MA, RPA (Hawai‘i Permit No. 15-20).

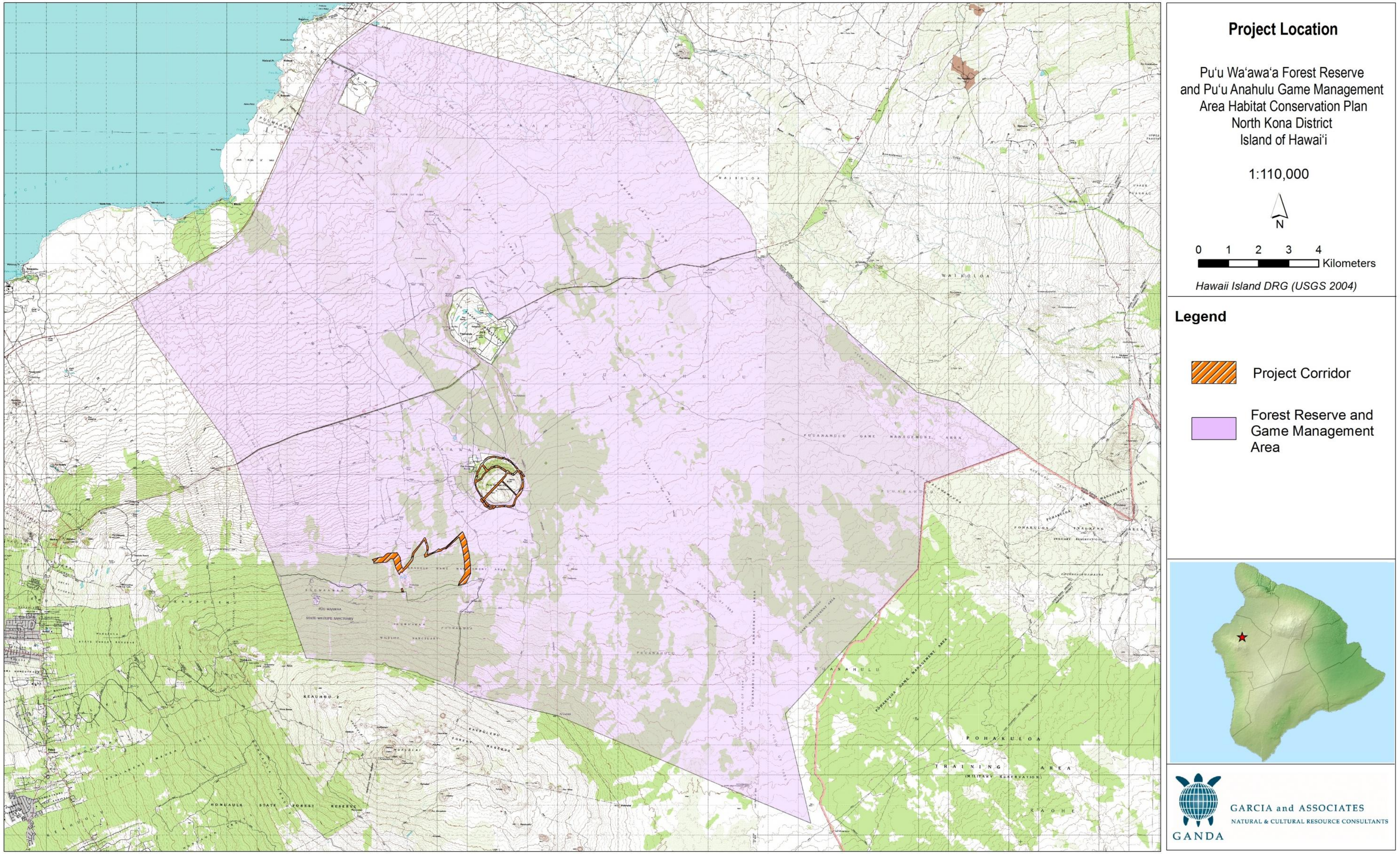


**Figure 1. Project area locator map.**

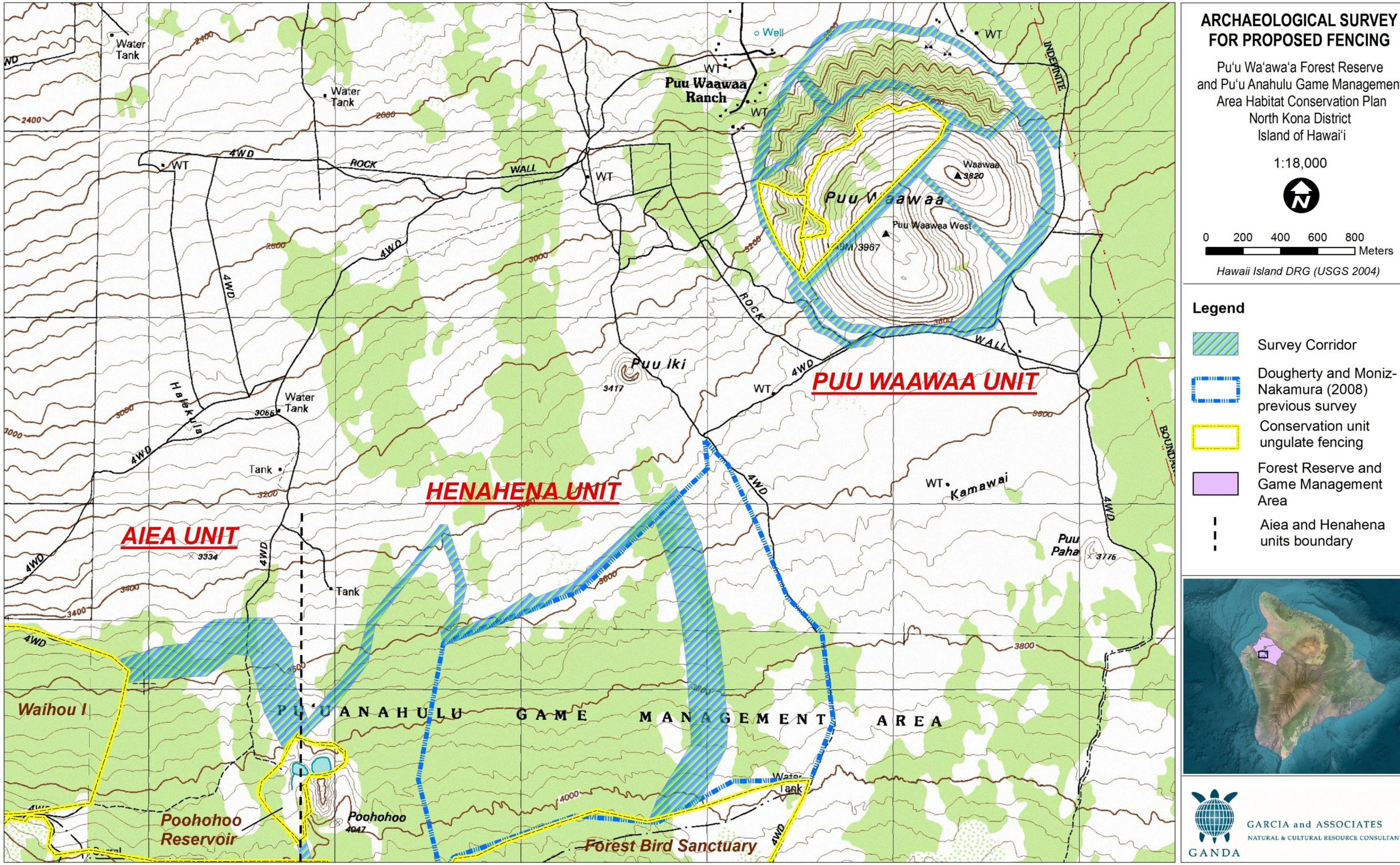


**Figure 2. Area of Potential Effect (Project Corridor) for proposed exclosure fencing.**

# 2.0 Background

The environmental setting, cultural context, and previous archaeology of the project area are presented in the following sections. A detailed account of the natural resources of the area can be found in the Puʻu Waʻawaʻa Biological Assessment (Giffin 2003).

## 2.1 Vegetation and Climate

The survey corridors cross-cut large portions of the Aiea, Henahena, and Puʻu Waʻawaʻa Conservation Units which contained numerous species of introduced and indigenous Hawaiian plants. Non-native grasses have replaced most native understory species and now cover most of the survey corridors. Silk oak (*Grevillea robusta*) was common throughout the project area. Various species of native trees were also observed during the AIS including mainly *ʻōhiʻa* (*Metrosideros polymorpha*) with some *ʻaiea* (*Nothocestrum breviflorum*), *koa* (*Acacia koa*), *māmane* (*Sophora chrysophylla*), and *ʻiliahi*, or sandalwood (*Santalum paniculatum*).

Puʻu Waʻawaʻa's climate is relatively dry. Mornings are clear and sunny with cloudy and/or rainy afternoons (Giffin 2003). Mean annual rainfall totals 683.7 millimeters (mm) with most precipitation occurring during the months of December and January (Giambelluca et al. 2013).

## 2.2 Soils and Terrain

Soils in the Aiea and Henahena Conservation Units consist of Puuiki-Lava flows complex with 10 to 20 percent slopes, Puuikaaka-Lava flows complex with 2 to 10 percent slopes, and Nawahine gravelly medial silt loam with 20 to 50 percent slopes (Figure 3). The Puuiki and Puuikaaka-Lava flows complexes consist of *pāhoehoe* lava (60%), *ʻaʻā* lava (35 %), and other minor components (5%). Nawahine gravelly medial silt loam is derived from basic volcanic cinders and ash and is associated with Poohohoo Cinder Cone, located in the southwest portion of the project area (Soil Survey Staff 2014). Various lava tubes were observed in the Aiea and Henahena portions of the AIS. These ranged in size from a few centimeters to over 6 feet in ceiling height. The cave openings consisted of collapsed sections of lava tube and are known to provide important habitat for rare invertebrates and plant species. They are also known to contain deposits of subfossil bird bones and land snail shells (Giffin 2003:7).

Soils in the Puʻu Waʻawaʻa Conservation Unit consist of Waawaa medial silt loam with 2 to 10 and 10 to 20 percent slopes and Waawaa medial silt loam with 40 to 70 percent slopes (Figure 3). These are derived from volcanic ash and cinders and are associated with the Puʻu Waʻawaʻa Cone (Soil Survey Staff 2014). This extinct volcanic vent and the associated Puʻu Anahulu ridge lava flow are the oldest geologic formations on Hualālai (>100,000 years old). Puʻu Waʻawaʻa is approximately one mile in diameter and 3,967 feet high. Erosion has formed multiple gullies and ridges on the side of the cone. Because of its high degree of soil development and complex topography, Puʻu Waʻawaʻa cone supports a more complex community of plants than surrounding areas (Giffin 2003:7). The soils of this cone also contain trachyte obsidian, also known as volcanic glass. The pebble and coble sized chunks of glass found in the soils of this cone were an important resource for pre-Contact Hawaiians and are the largest found in Hawaiʻi (McCoy et al. 2011).

## 2.3 Hawaiian Cultural Context

Puʻu Waʻawaʻa Ahupuaʻa is located in an arid region of North Kona District known as Kekaha. Puʻu Waʻawaʻa literally translates to "Furrowed Hill" and is named after a large fluted cinder cone located on the north slope of Hualālai (Kelly 1995:7).

> Puʻu Waʻawaʻa is one of twenty-three ancient *ahupuaʻa* within an *ʻokana* (sub-district) of North Kona called Kekaha wai ʻole (The arid region). Within Kekaha, is found the smaller sub-district of Nāpuʻu (The hills). Each of these names describe some facet of the natural environment in which we find Puʻu Waʻawaʻa. Traditional accounts, historical literature, and oral history narratives tell us that the *ahupuaʻa* of Puʻu Waʻawaʻa was one of the favored lands in this region. (Maly and Maly 2006:9)

Puʻu Waʻawaʻa Ahupuaʻa was noted for its abundance of natural resources which supported several Hawaiian villages. The coastal areas consisted of rich inshore fisheries and salt pans. Crops were cultivated in the forested uplands which also provided important resources for the construction of *heiau*, fishponds, and canoes. Regional narratives describe shifting patterns of seasonal cultivation and marine resource exploitation practices. Crops were planted in the uplands during the winter wet season and the focus shifted to the exploitation of coastal resources during the dry summer season. It was the knowledge and understanding of the seasons and the relationship between the land and ocean that sustained the residents of Puʻu Waʻawaʻa (Maly and Maly 2006:9–10).

## 2.4 Pre-Contact Hawaiian Settlement

Current theories of the traditional Hawaiian settlement sequence suggest that the expansion into the arid leeward and marginal zones of the islands, such as Puʻu Waʻawaʻa, occurred during the late expansion period (AD 1400–1650) (Kirch 2010). This period is characterized by the firm establishment of communities within the ecologically favorable and resource rich areas of the windward coast and valleys, substantial increase in population, and the resulting socioeconomic stress as these resource rich areas reached their carrying capacity. This period is also marked by an increase in social stratification, expansion into marginal zones of the islands, and the intensification of *mauka* dry land agriculture.

Puʻu Waʻawaʻa likely developed with the initial establishment of permanent habitation along the coast where marine resources could readily be exploited with subsequent expansion into the upper environmental areas of the *ahupuaʻa*. A regional settlement model proposed by Clark (1987) divides the region into four distinct environmental zones based on elevation. These include the Coastal Zone (0–150 feet), Intermediate Zone (150–1900 feet), Kula Zone (1900–2700 feet), and the Wilderness Zone which extends from the Kula lands to the top of the mountains.

The Puʻu Waʻawaʻa coast was an area of great economic importance and was noted for its abundant natural resources which included rich offshore fisheries, salt pans, and fresh water springs. Kīholo was known as the site of an important fishing village which was also the location of a large fishpond. Archaeological surveys conducted at Kīholo have identified numerous site

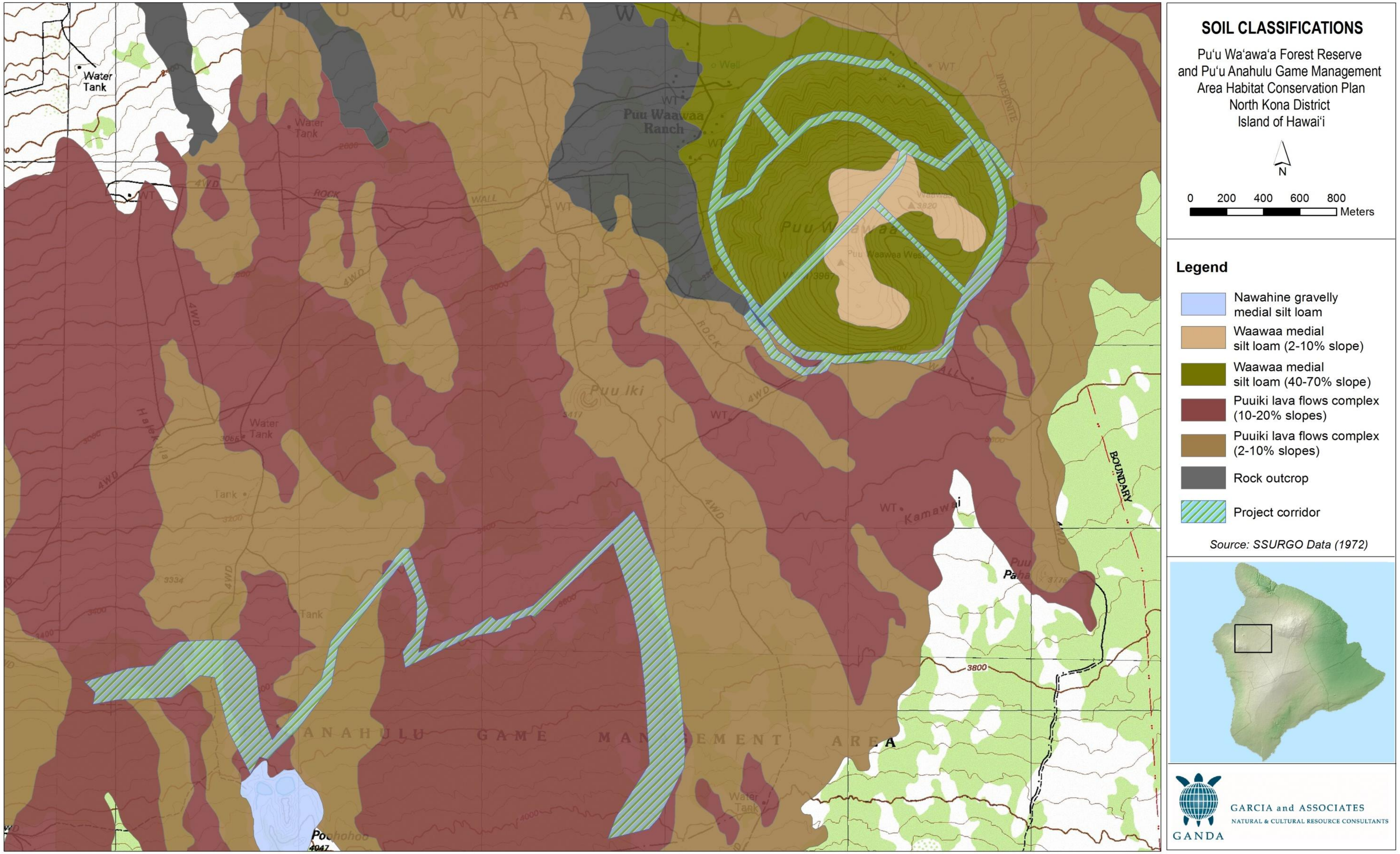


**Figure 3. Soil types in project area.**

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types associated with the procurement of coastal and marine resources (Ahlo 1982, Rechtman and Wolforth 1999). These site types included salt pans, temporary habitation shelters, enclosures, and a platform.

Puʻu Waʻawaʻa's Intermediate Zone is very dry and has been described as a volcanic desert. This area, however, likely supported temporary habitation and possibly seasonal agriculture.

> The lower *kula* lands receive only about 15–20 inches of rainfall annually, and it is because of their dryness, the larger region of which Puʻu Waʻawaʻa is a part, is known as "Kekaha." While on the surface, there appears to be little or no potable water to be found, the very lava flows which cover the land contain many underground streams that are channeled through subterranean lava tubes. (Maly and Maly 2006:9)

An archaeological study conducted in 1971 for the proposed Queen Kaʻahumanu Highway crossed through this section of Puʻu Waʻawaʻa (Ching 1971). A wide range of pre-Contact to Historic Period sites were recorded within these dry and desolate lava fields. These sites included caves associated with burial, habitation, and refuge as well as enclosures, cairns, petroglyphs, and surface midden.

The Kula Zone was primary agricultural area of the *ahupuaʻa*. Rainfall at this elevation was 30–40 inches annually and supported the cultivation of dry land *kalo* (taro), *ʻuala* (sweet potato), *ʻuhi* (yam), and *ulu* (breadfruit) (Kelly 1995:7).

> This region provided native residents with shelter for residential and agricultural uses, and a wide range of natural resources which were of importance for religious, domestic, and economic purposes. In Puʻu Waʻawaʻa, this region is generally situated between the 1,800 to 2,400 foot elevation, and is crossed by the present-day Māmalahoa Highway (which also generally follows portions of an ancient *ala loa*, or foot trail that was part of a regional trail system).
>
> Most notably in this area, the now endangered *kauila* (*Colubrina oppositifolia*) forests of Puʻu Waʻawaʻa were highly valued, and in ancient times provided the wood resource for many fishponds, temples and other ceremonial features throughout Kona. (Maly and Maly 2006:9)

There have been a number of archaeological studies conducted in Puʻu Waʻawaʻa's Kula Zone and in the northern adjacent *ahupuaʻa* of Puʻu Anahulu (Walker and Rosendahl 1990, McGerty and Spear 2000, Dye et al. 2002). Pre-Contact site types recorded in this area include habitation caves, burial caves, and agricultural sites; however, most sites are associated with nineteenth and early twentieth century ranching or homesteading (e.g. modified outcrops, enclosures, core-filled walls, house platforms, agricultural mounds, terraces, and historic petroglyphs).

The *mauka* areas beyond the *kula* lands also provided a wide range of natural resources. Use of these upper areas included the collection of wild plants for subsistence, medicinal, and ceremonial purposes, and the collection of wild fauna. This area was also noted as a locus for the collection of bird feathers, especially from the *ʻōʻō* (*Moho nobilis*), *ʻiʻiwi* (*Vestiaria coccinea*), and

*ʻapapane* (*Himatione sanguinea*). These species provided colorful features, a particularly powerful symbol of chiefly power. Ornately decorated goods with feathers including ʻ*ahu ʻula* (feathered capes), *mahiole* (helmets), and *akua hulu manu* (feathered gods) were a direct measure of a chiefs power and influence (Valeri 1985:246).

### 2.5 Historical Accounts of Puʻu Waʻawaʻa

By the arrival of foreigners in the late eighteenth century, the lands of Kekaha were under the control of two chiefly half-brothers Kameʻeiamoku and Kawakawa (Kamakau 1992:310). Kawakawa resided in Kiholo, Puʻu Waʻawaʻa, while Kameʻeiamoku lived in the adjacent southern *ahupuaʻa* of Kaʻupulehu (Kelly 1995:10). These lands were first given to the brothers during the reign of Kalaniʻōpuʻu and retained after the rise and succession of Kamehameha. These two powerful chiefs were known to have been among Kamehameha's strongest supporters.

During the early rein of Kamehameha I (1800–1801) Hualālai erupted and started to flow from the lower slopes of Huʻehuʻe. The lava flowed westward into Kaʻupulehu and the coastal area of Puʻu Waʻawaʻa. The impact of this significant natural event on the people and land was described by native historian Samuel Kamakau:

> Another important event which occurred in the fourth year of Kamehameha's rule, was the lava flow which started at Huʻehuʻe in North Kona and flowed to Mahaiʻula, Kaʻupulehu, and Kiholo. The people believed that this earthconsuming flame came because of Pele's desire for *awa* fish from the fishponds of Kiholo and Kaʻupulehu and *aku* fish from Kaʻelehuluhulu; or because of her jealousy of Kamehameha's assuming wealth and honor for himself and giving her only those things which were worthless; or because of his refusing her the *tabu* breadfruit of Kamehaʻikana which grew in the uplands of Huʻehuʻe where the flow started…The flow had been destroying houses, toppling over coconut trees, filling in fish ponds, and causing devastation everywhere. Upon the arrival of Kamehameha and the seer and their offering of sacrifices and gifts, the flow ceased; the goddess accepted the offerings.
>
> The reasons given for the flow may be summed up as: first, Pele's wanting the *aku* of Haleʻohiʻu and the *awa* fish of Kiholo; second, her anger at being denied the *ʻulu* (breadfruit) of Kamehaʻikana in upper Huʻehuʻe; third, her wrath because Kamehameha was devoting himself to Ka-heihei-malie and neglecting Ka-ʻahu-manu. (Kamakau 1992:184–186)

Early accounts by foreigners traveling through Puʻu Waʻawaʻa share similarities in their narratives. They place specific emphasis on the large fishpond at Kīholo and describe the surrounding area as dry and desolate.

In 1823, British missionary William Ellis visited several villages along the Puʻu Waʻawaʻa coast, stopping at Kapalaoa, Wainānāliʻi, and Kīholo. While in Kīholo, Ellis made a detailed description of the Kīholo fishpond.

> About four in the afternoon I landed at Kihoro, a straggling village, inhabited principally by fishermen. A number of people collected, to who I addressed a short discourse. . . This village exhibits another monument of the genius of

> Tamehameha. A small bay, perhaps half a mile across, runs inland a considerable distance. From one side of this bay, Tamehameha built a strong stone wall, six feet high in some places, and twenty feet wide, by which he had an excellent fish-pond, not less than two miles in circumference. There were several arches in the wall, which were guarded by strong stakes driven into the ground so far apart as to admit the water of the sea; yet sufficiently close to prevent the fish from escaping. It was well stocked with fish, and water-fowl were seen swimming on its surface. Just before sunset, I left Kihora. The men paddled the canoe past Laemano, a stretch of land formed by the last eruption of the great crater on Mouna-Huararai, which took place twenty years ago (Ellis 1963:294–295)

Rev. Lorenzo Lyons, a minister in Waimea, also provides an account of his travel along the coast through Puʻu Waʻawaʻa and Kīholo.

> Aug. 8, 1843. Took the road from Kapalaoa to Kailua on foot. Passed the great fish pond at Kiholo, one of the artificial wonders of Hawaii; an immense work! A prodigious wall runs through a portion of the ocean, a channel for the water, etc. Half of Hawaii worked on it in the days of Kamehameha. . . (Doyle 1953:137)

Charles Wilkes traveled through the Kekaha region in 1840–41 as leader of with the United States Exploring Expedition. His description of the area emphasizes the importance of coastal resources and trade with agricultural communities.

> . . . A considerable trade is kept up between the south and north end of the district. The inhabitants of the barren portion of the latter [i.e., Kekaha] are principally occupied in fishing and the manufacture of salt, which articles are bartered with those who live in the more fertile regions of the south [i.e.Kailua-Keauhou], for food and clothing. . . (Wilkes 1845, Vol. 4:95–97)

Mauna Loa began erupting in the 1850s, culminating in a 1859 lava flow destroying the villages of Wainānāliʻi and Kapalaoa in Kīholo before filling in Kīholo fishpond (Maly and Maly 2006:30). The impact of the event was reported by Lorenzo Lyons in his 1858 annual mission report:

> . . . Though this report is designed for 1858 only, yet I cannot close without mentioning a wonderful volcanic eruption.
>
> On Sabbath eve the 23rd of January we were called to gaze upon the most terrific & sublime volcanic exhibition we had ever seen. We had heard by the ear, we had seen the smoke, the reflection, & some of the fire of volcanic eruptions, but now we had the full view of the whole scene. The eruption took place on the North side of Maunaloa so near the top as to be in the region of the snow. As being the evening we could not determine the exact position. But the mountain top seemed to be in a blaze, & a flow of liquid fire passed out of the opening crater & rolled down the mountain side in a northwestward direction, lighting up the whole heavens. The light shone directly into our windows & made our rooms so light as the rays of the moon would make them.

> The succeeding day was cloudy – we could not see much of the volcano, but it was possible at night & we could discern that considerable progress had been made. The fiery stream rolled on increasing in length & presenting at night an exceeding grand yet awful spectacle. The process seemed to be 5 or 6 miles per day, till the whole distance from the crater to a hill that intercepted our vision [Puʻu Keʻekeʻe], became one long river of fire. On Monday morning a little over a week from the time of the eruption, the fiery stream reached the sea at Wainanalii on the border of Kona about 2 miles from the boundary of my field & and some 18 or 20 miles from our house. The whole stream cannot be far from 40 miles, more if anything. Wainanalii has a small village, but its houses, fishponds and salt beds are now a sea of fire. The inhabitants, doubtless fled ere the fire reached them. About 3 miles inland from this place there seems to be a new eruption from an old extinct crater, but I wait further information.
>
> Feb. 3rd. The inhabitants of the destroyed village & the isolated region above it but barely made their escape, the flowing lava came so suddenly upon them. They saved what they could contended with the all consuming fluid as long as they could & fled. The fire flowed some distance into the sea, destroying the precious canoe landing place. The last visitation of volcanic fires in that place is not within the memory of any now living. . . (from Maly and Maly 2006:30–31; ABCFM Collection, Houghton Library, Reel 808, Letter 197).

### 2.5.1 The Māhele

The 1948 Māhele abolished the traditional Hawaiian land tenure system in favor of a system based on the western concept of fee-simple ownership. All land in the Kingdom of Hawaiʻi was placed into one of three categories: Crown Lands, Government Lands, and Konohiki Lands. During the Māhele, the Hawaiian chiefs and *konohiki* were required to present their claims to the Land Commission and receive awards for the land quit-claimed to them by Kamehameha III. Until an award for these lands was issued, the title remained with the government. A land commission award (LCA) gave complete title to the lands with the exception of the government's right to commutation. Upon satisfaction of the commutation, which could be settled by a cash payment or through the exchange of land of equal value, a Royal Patent was issued by the minister of the interior. A Royal Patent quitclaimed the government's interest in the land and served as proof that the government's right to commutation no longer existed. The Act of August 10, 1854 provided for the dissolution of the Land Commission so that a LCA recipient was still protected if they had not obtained a Royal Patent (Chinen 1958:13–14). The Kuleana Act of 1850 provided a framework by which Hawaiians could apply for and be granted land to sustain their livelihood, however, the restrictions of the act made it difficult to receive a land award, thereby discouraging Hawaiians who did not actively cultivate land. No *kuleana* claims made by registered native tenants were awarded in Puʻu Waʻawaʻa. The land was claimed as Crown Lands and retained by the government.

### 2.5.2 Historical Overview of Ranching in Puʻuwaʻawaʻa

The introduction of cattle and ranching to Hawaiʻi during the mid to late nineteenth century dramatically altered the traditional cultural landscape and is one of many factors during the early historic period that contributed to the abandonment of the traditional Hawaiian settlement pattern, the depopulation of *ahupuaʻa* and migration to urban trade centers, and the economic change from a subsistence economy to a market economy. Cattle ranching was the primarily land use activity at Pu‘u Wa‘awa‘a until August 2000.

#### *2.5.2.1 The Establishment of Cattle in Hawai‘i*

British Naval officer Captain George Vancouver introduced the first cattle to Hawai‘i Island between 1793–1794 (Vancouver 1967 Vol. II:114). During this time, Vancouver made three voyages from California to Hawai‘i and landed a total of two bulls, two bull calves, six cows, seven ewes, and six rams (Henke 1929:9). This introduction of cattle and sheep to Hawai‘i was not done without considerable effort. Vancouver believed, however, that this new economic resource would not only be advantageous to the Hawaiian people, but would increase the value of the islands as a commercial center and depot in the Pacific (Kuykendall 1968:40–41). In order to allow the animals to propagate and flourish, Vancouver recommend that Kamehameha establish a *kapu* against the killing of cattle for 10 years with the exception of bulls, should they become too numerous (Henke 1929:9).

The *kapu* led to an immense proliferation of cattle and Kamehameha I eventually hired foreigners to help control the wild herds. An article published in 1859 in the *Pacific Commercial Advertiser* (PCA) reported that the *kapu* lasted 30 years.

> . . . becoming a flock, were removed to Waimea plains, from whence, breeding very fast, they spread inland and wandered off among the hills and valleys of Mauna Kea, and becoming so numerous, that, when the *tabu* was removed some thirty years ago, the interior plain and the three mountains of Hawaii were full of them, and they were in some seasons hard pushed for feed, though generally very fat. (PCA August 11, 1859, from Maly and Maly 2006:95)

By the 1820s, the emerging market for wild cattle grew as the commercial value of beef, hides, and tallow increased to meet the demand for provisions from foreign traders and whalers (Kuykendall 1968:313, 317). Cattle proved to be an important source of revenue for the kingdom since revenues from the sandalwood trade were rapidly declining due to a diminishing supply of trees. Hunting of cattle in the 1830s was so extensive that Kamehameha III placed a 5-year *kapu* on the killing of cattle in 1840 to allow the wild herds to recover their numbers (Morgan 1948:168). L.A. Henke reports that by 1851, there were approximately 20,000 head of cattle on Hawai‘i Island with 12,000 head being wild (Henke 1929:22).

#### *2.5.2.2 Pu‘u Wa‘awa‘a Ranch*

In 1863, the lands of Pu‘u Anahulu were leased to three Native Hawaiian lessees—G. Kaukuna, M. Maeha, and S. Kanakaole—to conduct ranching activities. The lease agreements were for a term of five years at the rate of $50.00 the first year and $100.00 each for the remaining four years (State Archives files – General Lease No. 106; DLNR2- Vol. 15). Two years into their lease agreements, the three Native Hawaiians sold their lease interests to Francis Spencer. Spencer incorporated the land holdings into the Waimea Grazing and Agricultural Company which continued to expand from 4,000 acres to more than 120,000 acres, including Pu‘u Wa‘awa‘a. During the 1880s, the Waimea Grazing and Agricultural Company pastured 12,000 to 14,000 goats in the Pu‘u Wa‘awa‘a and Pu‘u Anahulu areas (Giffin 2009:3).

The lease agreement held by Francis Spencer for the lands of Puʻu Waʻawaʻa and Puʻu Anahulu terminated in 1893. This prompted multiple parties (e.g., Francis Spencer, native Hawaiian residents, and partners Eben Low and Robert Hind) to apply for lease agreements for the land. Low and Hind secured the lease for the land of Puʻu Waʻawaʻa from public auction on August 16th, 1893 for the sum of $1,200 per year (HSA – Series 367, Minutes of the Crown Lands Commission). This was almost four times the initial bidding price which was set at $350 per year. There were also stipulations within the lease agreement that required that the tenant be responsible for $3,000 of improvements of permanent character within three years of the commencement of the lease, preserve the forest substantially in status quo, and prevent Lantana from spreading further (HSA – Series 367 Minutes of the Crown Lands Commission, pages 65–66). A year into their lease, Low and Hind sent an address to the Commissioners of Crown Lands requesting the reduction of the yearly rent from $1,200 to $500 citing the expenditures due to the conditions of the lease. By July 20, 1894 the ranch supported 1,000 head of cattle, 135 mules, and seven horses. Improvements to the value of $3,000 were made including construction of watersheds, stables, dwelling quarters, water tanks, and 10 miles of fence. The ranch also had 209 *kiawe* trees, 150 silk oak trees, 50 peach trees, and 2 Eucalyptus trees growing. In 1898, Low and Hind acquired the lease for Puʻu Anahulu (Lease No.517) for 21 years under similar conditions to their existing lease agreement.

In 1884, the Homestead Act was passed in an effort to get more native tenants in possession of fee simple property so they could cultivate crops or graze animals on their own land. The granting process for homestead lots was slow and the homesteaders often competed for lands that Puʻu Waʻawaʻa Ranch also wanted to acquire. Ironically, the first recipients of fee simple title to property in Puʻu Anahulu were James Hind (brother of the primary lessee), Eben Parker Low, Elizabeth Napoleon-Low (wife of Eben P. Low), and Sanford Dole (the adoptive father of Elizabeth Napoleon-Low). The conditions for homesteaders made it difficult for native tenants to keep their lots. The applicants for homestead lots had to live on the land they requested and they had to prove they had jobs and a secure income. The only employment in the region available to them was from Puʻu Waʻawaʻa Ranch.

Robert Hind became the sole proprietor of Puʻu Waʻawaʻa Ranch in 1903 when he bought out the land title and interest held by Eben Low. In 1914 Hind continued to expand his ranch holdings by acquiring the land titles of the homestead lots from the native residents. By 1919, most of the homestead lots acquired by the ranch were used to cultivate corn for cattle feed (Kelly 1995:19). By the late 1920s, Robert Hind consolidated his interest in the Puʻu Waʻawaʻa Ranch and his homestead holdings and formed the corporation Robert Hind, Ltd.

L.A. Henke wrote a detailed narrative of Puʻu Waʻawaʻa Ranch in a "Survey of Livestock in Hawaii," University of Hawaiʻi Research Publication No. 5, in 1929. It is an excellent description of the ranch land tenure, operations, and breeding, and is quoted at length:

> Puuwaawaa Ranch in North Kona, with the ranch headquarters beautifully located three miles above the government road, consists of a total of about 128,000 acres, but about 100,000 are waste lands covered with lava flows. Of the remaining 28,000 acres only 1,500 are really good grazing lands. About 100 acres are planted to cultivated crops. All but 300 acres held in fee simple are government leased lands. These lands run from sea level to an elevation

of 6,000 feet. Some of the best grazing lands are found at 5,000 feet elevation.

For many years there was practically no water on the ranch other than what the cattle could get from the dew and succulent vegetation. However, as the vegetation became scarcer water was required in all but a few paddocks well supplied with cactus where the cattle still grow to maturity without ever having access to free water. The limited water now available is secured from roofs, and a pipe line from Huehue Ranch.

A total of about thirty miles of fences, half stone and half wire, are found on the ranch. At present, the ranch carries about 2,000 Herefords. All the bulls and thirty of the females are purebred. About 500 head, ranging between two and three years of age and dressing out at 500 pounds are marketed annually,—practically all are sent to Honolulu, being loaded on the steamers at Kailua.

Only rarely are the bulls left with the breeding herd throughout the year. Usually they are turned out only during the seasons when grazing conditions are good, for the owner does not like to risk losing valuable bulls during adverse seasons. The good and bad seasons do not follow the same schedule year after year, so a definite pre-arranged breeding schedule, which would be preferable to get calves at the same time, is impossible.

Calves are weaned at about six months of age, depending on the season. In bad seasons they are weaned earlier and taken to the best paddock, which helps both the calf and the cow. An 85% calf crop was secured in 1928, but such a good percentage is not always secured.

When bulls range with the cows throughout the year they average about one bull to thirty cows. For restricted breeding seasons more bulls are needed.

The ranch carries about sixty light horses and raises about ten mules per year. Practically no swine and no sheep are kept.

About two hundred dairy cattle of the Holstein and Guernsey breeds, ranging in age from four months to about two years can be found on the ranch at all times. These are the young calves from the Hind-Clarke dairy in Honolulu which are carried to the calving age at Puuwaawaa Ranch and then sent back to the dairy in Honolulu again.

Bermuda grass (*Cynodon dactylon*) is considered one of the best grasses. Other grasses that do well are *Kukaipuaa* or crab grass (*Panicum pruriens*), Kentucky blue grass (*Poa priatensis*), Spanish needles (*Bidens pilosa*), Rhodes grass (*Chloris gayana*), Mesquite or Yorkshire fog (*Holcus lanatus*) on high elevations, orchard grass or cocksfoot (*Dactylis glomerata*), *Paspalum compressum*, bur clover (*Medicago denticulata*) and red top (*Agrostis stolonifera*). Native weeds supply some forage and in droughty seasons the cactus (*Opuntia* spp.) is a great asset for the cattle eat not only the young leaves but also manage to break off the spines with their feet and survive. Rat tail or New Zealand Timothy (*Sporobolus elongatus*) has also been introduced and seems to be spreading.

> The real beginning of Puuwaawaa Ranch was about 1892 when Robert Hind and Eben Low leased about 45,000 acres from the government and purchased about 2,000 head of cattle, —a mixture of Shorthorned, Angus and Devon breeds, from Frank Spencer, who had previously leased the lands of Puuanahulu, consisting of approximately 83,000 acres from the government. In 1893 Hind and Low acquired the lease on 12,000 acres of this area and in about 1917 Hind acquired the lease on the other 71,000 acres formerly in the Spencer lease. No cattle were carried on these 71,000 acres during the period 1893–1917, but the land was pretty well overrun with goats… Since 1902 Robert Hind has been the sole owner of Puuwaawaa Ranch and he is still general manager of the ranch. (Henke 1929:43–44)

By 1940, ranch operations were at their peak with 15,000 head of cattle pastured on government leased acreage (Kelly 1995:23). Most ranching paddocks in Pu‘u Wa‘awa‘a were demarcated by rock walls or barbed wire fences and were established by the 1940s. In 1948, Charles Murray was contracted by the ranch to compile a map of the ranch paddocks and fencing projects (Maly and Maly 2006:121). This map (Figure 4 and Figure 5) includes the names of the paddocks.

Robert Hind, Ltd. continued cattle ranching through the 1950s until the conclusion of the lease agreement in 1958 at which point the Hind family could no longer justify the continuation of the ranch due to the high operating costs (Maly and Maly 2006:121). The Commissioner of Public Lands reported:

> Robert Hind, Limited, the lessee of these lands up to June 30, 1958, was able to operate a reasonably successful cattle operation on the Puuanahulu and Puuwaawaa lands prior to and including 1949. Due to periodic drought to which the area is subject and to increased operating costs the company suffered losses on cattle operations each year thereafter. Recognitions that only by greater beef production could the company meet increased operating costs and only by a large investment in water systems and range improvements could a greater production be achieved, were compelling factors in Robert Hind, Limited’s decision to sell its Kona interests to Dillingham Investment Corporation and its wholly owned subsidiaries.
>
> Robert Hind, Limited was not in financial position to undertake the heavy investments necessary to effect more intensive use of its Kona lands. There being no prospect of either the County of Hawaii or the Territory of Hawaii being able to provide water supply for the widespread grazing areas, the only out for the owners of Robert Hind, Limited was sale to companies better able to finance extensive improvements. (G.L. No. 2621; State of Hawaii Land Division)

In 1958, the Dillingham Ranch, Inc., purchased all of the fee-simple holdings owned by Robert Hind, Ltd., which included properties in the Pu‘u Wa‘awa‘a Ranch and Pu‘u Anahulu Homesteads. Dillingham Ranch, Inc. secured a forty year lease for the Pu‘u Wa‘awa‘a Ranch holdings at auction in 1960. Dillingham continued ranching operations until 1972 when F. Newell Bohnett purchased the interest in the state lease that was set to expire August 14, 2000.

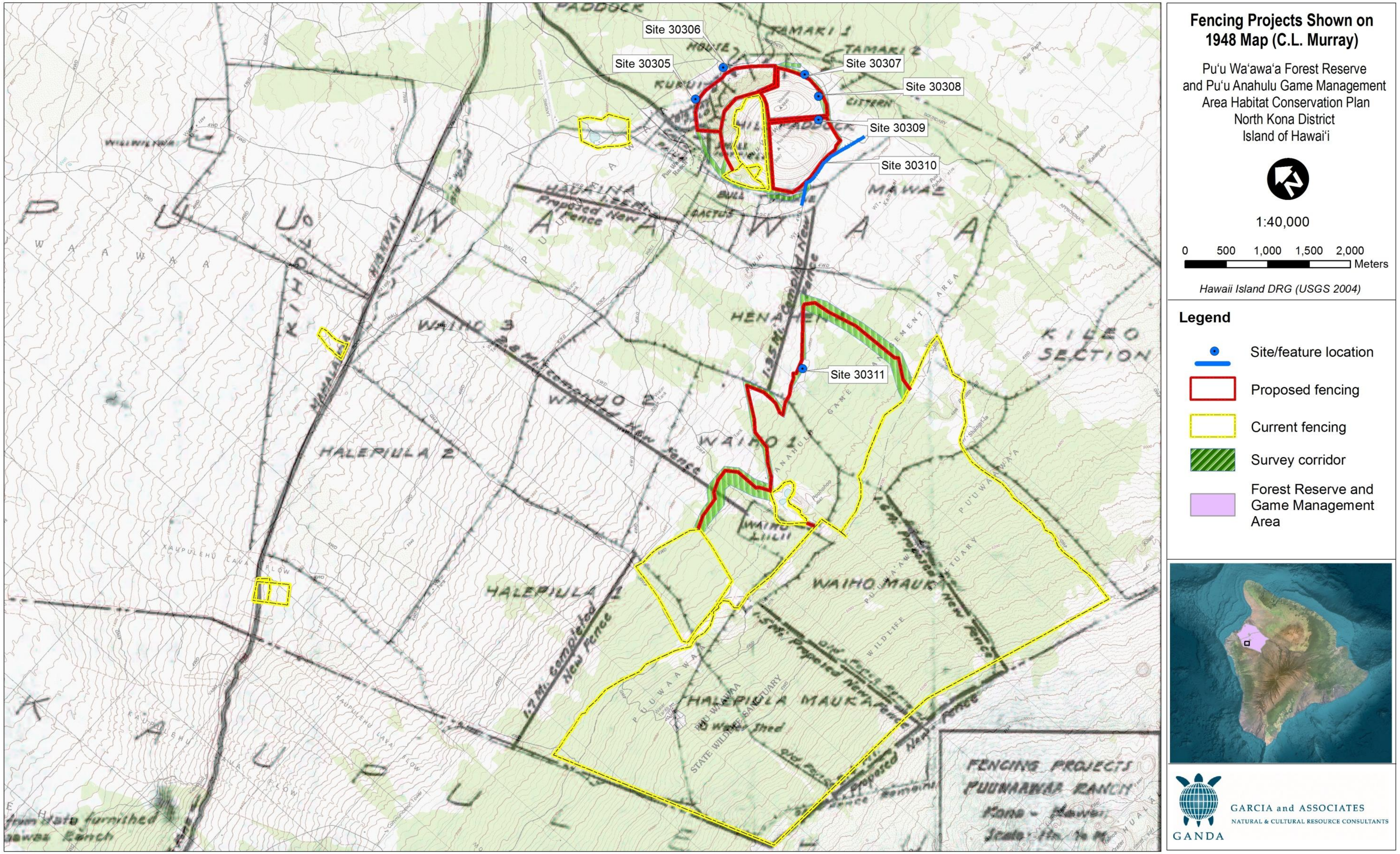


Figure 4. 1948 map of Pu'u Wa'awa'a Ranch paddocks.

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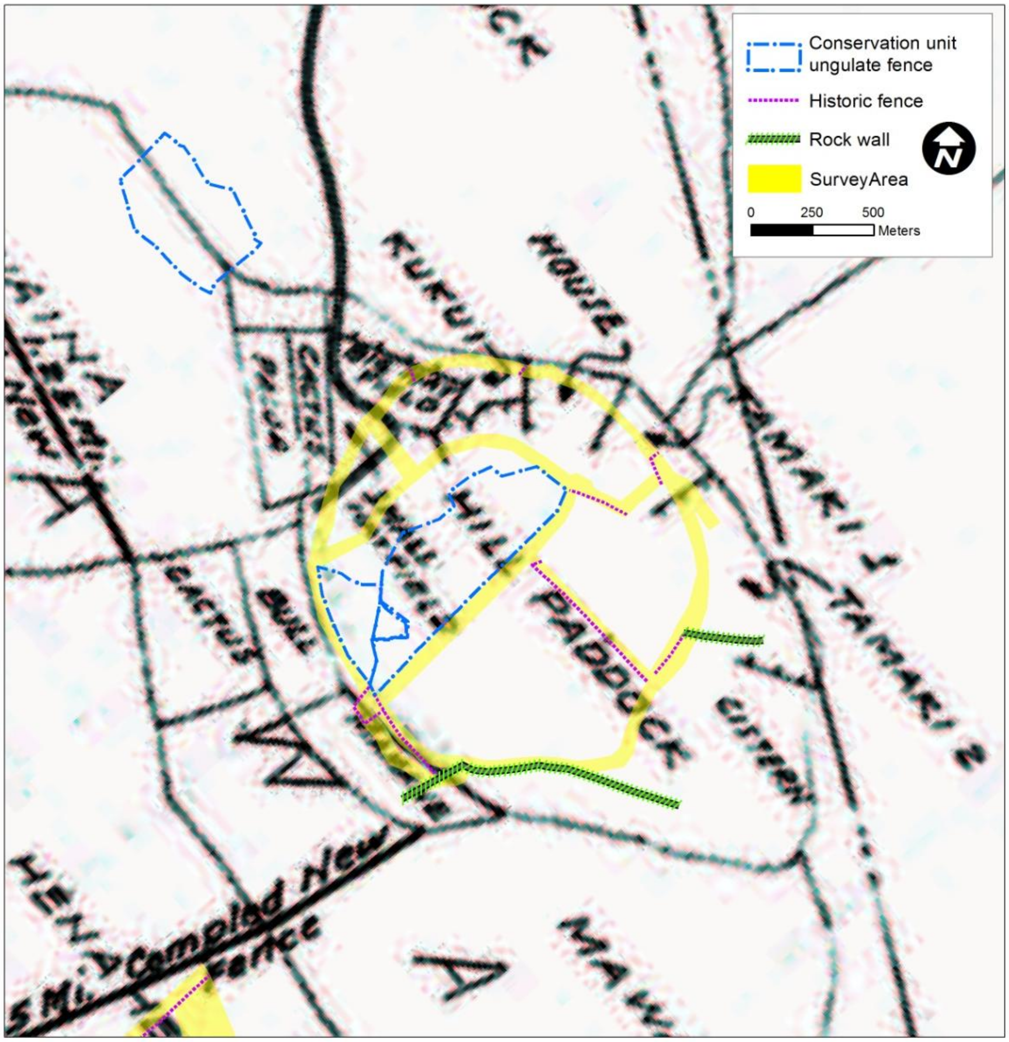


**Figure 5. Close-up of 1948 paddock map showing Pu‘u Wa‘awa‘a.**

The following summary of the Pu‘u Wa‘awa‘a Ranch operations and the improvements made to the ranch during the tenure of Dillingham and Bohnett was sourced from the extensive and detailed informant interviews conducted by Kepā Maly and Anna Ilima Loomis of cattle ranchers that were employed by the ranch.

Former ranch employees indicate that Dillingham took over Pu‘u Wa‘awa‘a Ranch operations in 1956, even though the Hind fee-simple holdings weren’t transferred until 1958 and the government lease was not secured until 1960. Pu‘u Wa‘awa‘a Ranch was one of a number of ventures owned by Dillingham on the Big Island which included cattle ranches in Hōlualoa and Honomolino, and a coffee company and Ford dealership in Captain Cook. Ranchers noted that Pu‘u Wa‘awa‘a Ranch was strictly a cattle operation. Other livestock kept during the tenure of

Robert Hind, Ltd., such as turkeys and dairy cows, were no longer raised. Dillingham authorized numerous improvement projects to update the ranching operation which included the construction of new dirt roads that ran to the *mauka* areas, the repair of cattle fences, the construction of a water catchment system and reservoir, a system of water pipelines, and the construction of six ranch homes. Due to arid environmental conditions on the ranch and the fear of drought, Dillingham started importing Santa Gertrudis bulls which were known to be hearty animals under dry and harsh conditions. These would be cross-bred with existing stock. Fire prone areas, especially near the highway, were of great concern. Bulldozers cut paddocks in the area into 600–700 acre grids to act as fire breaks. The ranch always kept one bulldozer on fire station and a tanker truck on stand-by in the event a fire broke out. After 16 years of operation, Dillingham sold the remainder of his lease to Bohnett. According to the ranchers, Bohnett didn't change the day to day ranching operations and kept the system established by Dillingham in place. Bohnett did, however, make a number of improvements. Bohnett quickly realized that during times of drought the ranch would have to haul water from Waimea since the catchment reservoir would be empty. After an aquifer was discovered under the ranch, Bohnett, had a fresh-water well drilled (1974–75). A unique system was also developed to rotate cattle herds through a five paddock system instead of three. The system was designed to alleviate environmental stress and overgrazing by ensuring that one paddock remained unused for five years. Other improvements included the construction of another reservoir, the construction of a guest house and community facility, and a private airstrip.

As of 2000, the majority of Puʻu Waʻawaʻa is still government owned and under the jurisdiction of the State of Hawaiʻi Department of Land and Natural Resources. Roughly 35,000 acres of land is managed as a State Forest Reserve. In 2002, the Puʻu Waʻawaʻa Advisory Council was established to discuss long-term land use strategies and the development of certain areas of Puʻu Waʻawaʻa Ahupuaʻa for conservation, recreational hunting, and business.

### 2.5.3 Puʻu Waʻawaʻa Quarry

The majority of volcanoes in Hawaiʻi are composed predominately of basaltic lavas that contain only small volumes of other mineral types (MacDonald et al. 1982). Hualālai is unique among volcanoes in Hawaiʻi as it contains a high volume of trachyic lavas which are exposed at the northern slope of Puʻu Waʻawaʻa (Cousens et al. 2003). Trachyic-pumice is commonly used in the manufacture of concrete products.

Concurrent with the Puʻu Waʻawaʻa Ranch operations during the 1950s, Volcanite Ltd., (also known as Hawaiian Ornamental Concrete Products) obtained the lease and mining rights, at auction, to approximately 500 acres of land on the north side of the Puʻu Waʻawaʻa cinder cone, in 1955, under General Lease No. 3528. The lease agreement and stipulations of the lease outlined in (Maly and Maly 2006:123) are presented below.

General Lease No. 3528 was for a period of 21 years and allowed Volcanite, Limited:

> a. to dig, excavate and quarry trachyte-pumice, for the primary purpose of utilizing of selling the same for concrete aggregate or for the manufacture of clay products…but not for the primary purpose of extracting mineral of any sort except trachyte-pumice.

b. to construct, maintain and operate a plant (together with camps and other structures appurtenant thereto) for the purpose of crushing materials; and

c. to remove, use and sell trachyte-pumice, pursuant to the provisions of paragraph (a) above, and also soil and quarry waste incidentally derived from digging, excavating, blasting and quarrying…(General Lease No. 3528)

The lease included a number of conditions, one of which regarded the protection of "the triangulation stations located on Puuwaawaa Hill." Another dealt with defacement of the cinder cone:

> 9. That the Licensee shall in no way deface the northwest half or rim of said Puuwaawaa Hill, and shall not unduly deface any of the remainder of said Hill…above the Rim, which Rim, for the purposes herein is that irregular line ranging from the 3350-foot to 3600-foot contours… Further, the Licensee shall level and fill all pits and other excavated areas to the end that there will be a slope to enable the proper drainage of water and to prevent the stagnation of water… (General Lease No. 3528)

Volcanite Ltd., held the mining rights to the quarry through a number of land licenses until the conclusion of their final license in March 31, 1988. It is important to note that although complaints were filed during the 1950s and 1960s against the Puʻu Waʻawaʻa mining operation and environmental infractions were clearly made contrary to the lease agreement, mining continued unabated leaving impact scars visible to the present day.

## 2.6 Previous Archaeology

Archaeological investigation conducted in Puʻu Waʻawaʻa and Puʻu Anahulu have predominantly been limited to areas from 300 feet elevation to the coastline. This is largely a consequence of coastal development and highway construction. In contrast, the remote upland portions of Puʻu Waʻawaʻa and Puʻu Anahulu are largely undeveloped. Consequently, relatively little archaeological work has been performed in the region.

A literature review and search of the State Historic Preservation Division (SHPD) report database revealed that the majority of the archaeological studies conducted in the upland areas have been concentrated around the development of Puʻu Anahulu's residential subdivisions. The information from these studies provide important archaeological context for the area and helped develop project expectations. Discussed below are archaeological studies conducted at elevations above 1800 feet in the vicinity of the Conservation Units investigated in this study. Figure 6 shows the locations of some of these studies.

An archaeological survey was conducted by Paul Rosendahl, Ph.D., Inc. of 462 acres for the development of the Royal Vistas Estates and Big Island Country Club Estates and resulted in the identification of 18 sites (Walker and Rosendahl 1989, 1990; Jimenez 1994). Sites recorded during the survey include platforms, rock mounds, walls, terraces, a boulder alignment, and modified outcrops.

Archaeological investigations conducted for the development of the Puʻu Lani Ranch and Puʻu Nana Estates subdivisions, located north of the current project area, yielded 46 sites with the majority of sites representing Hawaiian homestead and ranching activities (Barrera 1997; Dye and Maly 2001; Kouneski et al. 2006; Gregg et al. 2006; Elison et al. 2007). Sites recorded during these archaeological investigations include burials, mounds, enclosures, fire pits, petroglyphs, modified outcrops and one platform. Subsurface deposits of volcanic glass were also recovered from two fire pits and one cave shelter.

Archaeological reconnaissance survey of a subsample of 22,000 acres in the upland areas of Puʻu Anahulu Ahupuaʻa and Puʻu Waʻawaʻa Ahupuaʻa by Scientific Consultant Services Inc. resulted in the identification of 32 sites. Site types included C and U-shape shelters, rock mounds, stone walls, modified outcrops, and a historic dairy (McGerty and Spear 2000).

The National Park Service conducted an archaeological inventory survey at the request of the Division of Forestry and Wildlife within the uplands of Puʻu Waʻawaʻa Ahupuaʻa. Six sites were identified with the majority representing historic ranching activities. Sites included a water storage tank, a rock wall, an enclosure, and a cave shelter (Dougherty and Moniz-Nakamura 2008). The enclosure is located on the project area boundary in the Henahena Unit and is discussed in Section 5.0.

Rechtman Consulting, LLC conducted an archaeological inventory survey of a 32.5 acre parcel (TMK (3) 7-1-001:002 por. and 006 por.) and a 2.7 acre parcel (TMK (3) 7-1-001:003) within Puʻu Waʻawaʻa Ahupuaʻa. Two historic properties were identified during the survey. These included the historic Puʻu Waʻawaʻa Ranch buildings (Site 26170) and Hale Piula water catchment area (Site 26171). Both sites consist of architectural elements dating to the late nineteenth century (Ketner et al. 2008).

Rechtman Consulting, LLC conducted an archaeological inventory survey and cultural impact assessment of a 2.7-acre parcel located in the Puʻu Waʻawaʻa State Wildlife Sanctuary. One historic property consisting of two corrugated roof structures and several metal flumes were identified as a water catchment area associated with Puʻu Waʻawaʻa Ranch (Rechtman and Musie 2009).

McCoy conducted a pedestrian survey of Puʻu Waʻawaʻa cinder cone to identify and collect geologic samples in an effort to better define this major source of volcanic glass. As mentioned in Section 2.2 above, Puʻu Waʻawaʻa is the only known source of large pieces of volcanic glass in Hawaiʻi (McCoy 2011:41–42). This survey did not find signs of permanent habitation nor formal quarry sites, however, and it was found that the natural distribution of the glass nodules is limited to the *puʻu* itself. It was also discovered that the large pieces of glass were easily mined from exposed beds of pumice which were easiest to access in the gullies on the north face of the hill (McCoy et al. 2011:2549).

ASM Affiliates, Inc conducted an assessment survey of approximately two acres next to Puʻu Waʻawaʻa Ranch. No cultural resources were observed. It was also concluded that due to the type of substrate in the project area, there is a low probability for the presence of subsurface deposits (Rechtman 2014a). ASM Affiliates, Inc. also conducted an archaeological study in compliance with Section 106 of the National Historic Preservation Act for proposed drainage improvements to

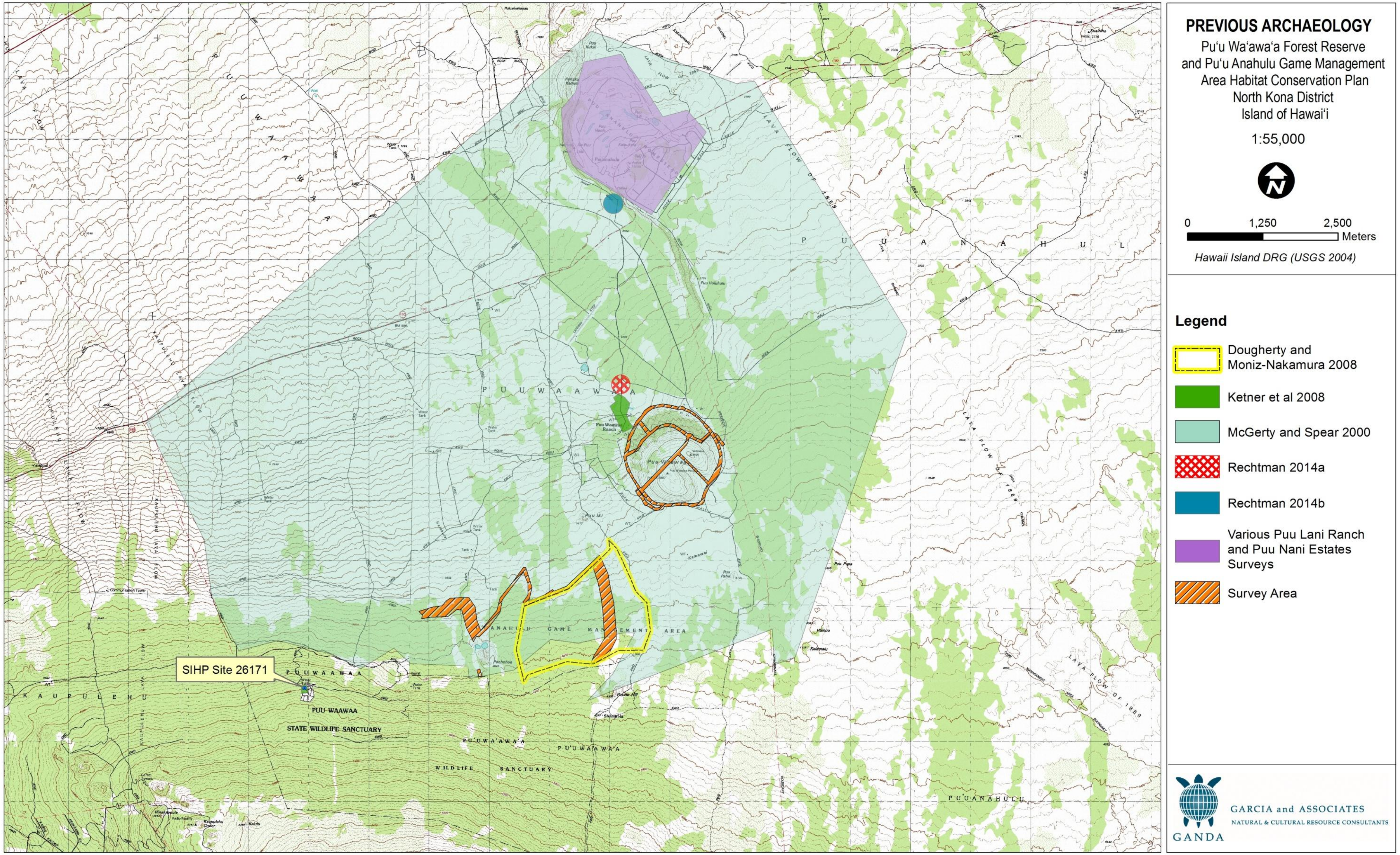


**Figure 6. Map of previous archaeological work in vicinity of the project area.**

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Māmalahoa Highway. This survey consisted of systematic archaeological work and consultation with Puʻuanahulu and Puʻu Waʻawaʻa community members. Fieldwork identified remnant features of the old Waimea-Kona Belt Road (Site 20855) (Rechtman 2014b).

### 2.6.1 Historic Puʻu Waʻawaʻa Ranch (50-10-19-7190)

Since the inception of Puʻu Waʻawaʻa Ranch in 1893 to its closure in 2000, the ranch was the sole proprietor of Puʻu Waʻawaʻa Ahupuaʻa, consisting of some 40,000 acres. By 1917, the ranch was also utilizing 83,000 acres of the adjacent northern *ahupuaʻa* of Puʻu Anahulu. A systematic archaeological inventory survey of all of the land used by Puʻu Waʻawaʻa Ranch has never been conducted.

Puʻu Waʻawaʻa Ranch was initially documented in 1973 during the Department of Land and Natural Resources, State Parks Division, statewide archaeological inventory survey of Hawaiʻi Island. The brief site description of the ranch defines the site as consisting of 19,000 acres and, although it is not specified in the site record, presumably includes the ranching facilities and surrounding paddock system.

Subsequent archaeological studies conducted at the inventory level within the former Puʻu Waʻawaʻa Ranch lands have focused on relatively small portions of land in Puʻu Waʻawaʻa and Puʻu Anahulu. These studies were in support of regional development and ecological initiatives including infrastructure improvements, residential construction, wildlife conservation, and habitat restoration. The archaeological investigations detailed in the previous section have documented and evaluated a wide range of site types interpreted to be associated with the operation and infrastructure of Puʻu Waʻawaʻa Ranch. These historic ranching sites include the core ranch buildings (Site 26170), the Hale Piula water catchment area (Site 26171), the paddock system, core-filled walls, building foundations, water tanks and delivery lines, road-beds, enclosures, temporary shelters, cairns, mounds, and terraces. It is important to note, however, that while all of these historic ranching sites have been assigned individual site numbers, they are all inter-related components of Site 7190.

# 3.0 Methodology

This section presents the methods and techniques used to complete pedestrian survey, test excavation, and consultant interviews. It also includes discussion of site and feature classification protocols and the site boundary delineation rationale.

## 3.1 Survey

AIS fieldwork consisted of a pedestrian survey of proposed fenceline corridors for all three Conservation Units (Figure 2). This involved walking systematic 10-m-wide transects parallel with the long axis of the corridors. Transects were surveyed by a crew of six individuals including one archaeologist and five biologists. The biologists were familiar with the types of cultural resources expected within the project area due to their extensive history of work on the parcels. They were briefed by the Principal Investigator on identification of archaeological sites and features and participated in the archaeological survey, concurrent with their survey for biological resources.

Standards of documentation and recording were in accordance with HAR §13-276 and were also in accordance with the Secretary of the Interior’s Standards for Archaeological Documentation. Site locations and survey corridor boundaries were recorded using a sub-meter accurate Trimble GPS.

## 3.2 Test Excavation

One 1 x 1 m test excavation was dug during this project. Test excavation methods consisted of systematic hand excavation with trowel and shovel in 20 cm arbitrary levels. This level thickness was chosen due to the very rocky nature of the soil. Smaller 10 cm levels would have been very difficult to maintain, given that individual cobbles were often 10 to 15 cm in diameter. Furthermore, the likelihood of stratified deposits was considered very low for this feature type (possible temporary shelter), making the finer increment unnecessary. If the soils had turned out different than expected, a shift to 10 cm levels was planned.

All sediment was sifted through 1/8$^{th}$-inch screen. Screen lag was inspected for cultural remains, including charcoal. The top and base of the excavation unit were mapped to scale and photographed. One stratigraphic profile was recorded. Stratigraphy was described using standard Munsell color notation and U.S. Department of Agriculture technical nomenclature. Following excavation, the unit was backfilled to as near its original state as possible.

## 3.3 Consultation with Knowledgeable Individuals

Two consultations were conducted for this project. One consultation was conducted with a person knowledgeable about the ranching history of the project area, Mr. Mikio “Miki” Kato, on 22 September 2014. Mr. Kato has worked at Puʻu Waʻawaʻa Ranch since 1956. The consultation consisted of an informal ‘talk story’ style interview (i.e., no recording or transcripts) as well as a site tour. Mr. Kato was questioned specifically about the history of land use in the area and information on the various sites recorded during the survey. A follow-up interview was conducted on 28 May 2015 to verify features which had been annotated by Mr. Kato on a historic map, and also to get information on twentieth century paddock construction and transformation.

In addition to Miki Kato, Kuʻulei Keakealani, a long-time resident and local cultural expert, was interviewed regarding Hawaiian and ranch-era sites in the project area. Two other local experts, Ms. Deborah Chang and Ms. Hannah Springer, were also contacted via email and phone concerning the possible presence of Hawaiian cultural sites or cultural places in and around the project area. Maps of the project area were provided to each consultant as well as a description of the proposed project. Of particular interest were Hawaiian sites or places that may not have been recorded in the published *moʻolelo* or in the archaeological literature.

## 3.4 Site and Feature Classification

As discussed in the background section, the entire project area is within Site 7190, Historic Puʻu Waʻawaʻa Ranch. This site number encompasses the entire ranch landscape and includes a number of sites that have been individually documented and assigned their own site numbers (e.g., 26170 and 26171). Most components of the ranch, however, have not been systematically documented. For these undocumented components, it is an open question as to whether they should be assigned site numbers or be considered features within the existing Site 7190. SHPD administrative rules do not provide guidance on this point, so we have chosen to employ a pragmatic classification methodology that is consistent with previous archaeological work conducted at the ranch, but that does not result in a proliferation of new sites with limited analytical or management utility. Under our classification method, we group ranch features into two categories: 1) interconnected, systemic infrastructure features, and 2) discrete features associated with specialized activities. Features in the latter category are most often aggregation points (i.e., features or areas in which cattle are concentrated and human-cattle interactions are most intense), such as corrals or watering troughs. Infrastructure features, by contrast, are large-scale interconnected arrangements such as paddock fencelines, water distribution systems, and ranch road networks. It is problematic to subdivide these types of features and assign them site numbers. It is also unwieldy to assign an entire ranch-wide system a single site number. The fact that these systems span almost the entire breadth and width of the ranch makes it reasonable to simply consider them features of the Historic Ranch. In a very real sense, they are the ranch. Importantly, infrastructure elements encountered during the survey were not assigned individual feature numbers during this project. Again, making arbitrary divisions for such continuous features is problematic and could result in a proliferation of small features (e.g., a feature number for every fence segment). To prevent this, we recommend that Puʻu Waʻawaʻa land managers and SHPD work together to develop a system for feature number assignment, if such a system is desired. For present purposes, it was sufficient to simply enumerate and describe the individual ranch infrastructure components that were intersected by the survey corridor.

### 3.4.1 Site Boundaries

Closely related to site/feature classification is the question of site boundaries. In keeping with the above classification methodology, we considered site boundaries of discrete features to be their actual physical extent. This is self explanatory for cobble platforms or a cistern. For features that are integral to ranch infrastructure, such as corrals or chutes, we sometimes include small segments of fenceline in order to show this connection. These segments are only intended to be illustrative of the site's larger association. Finally, sites that encompass a specific land-use area, such as the historic quarry, are delineated by their legal boundaries as found in lease documents and shown on period maps.

### 3.5 Organization of Results

The AIS covered multiple conservation units, each of which consists of long, narrow, and somewhat complex arrangements of fenceline corridors (Figure 2). To facilitate presentation of the survey findings, the results are reported in three major chapters, one for each conservation unit: Aiea, Henahena, and Puʻu Waʻawaʻa. Additionally, because each unit contains widely dispersed historic properties, each conservation unit is further subdivided into sections or quadrants.

## 4.0 AIEA UNIT RESULTS

For ease of discussion, the Aiea Unit is divided into two survey sections. Section 1 extends from the Forest Bird Sanctuary Boundary in the west (Figure 8) to what is locally referred to as the “Forest Bird Sanctuary Access Road.” Section 2 runs from this access road southeast to terminate at the Poohohoo Reservoir boundary fence. Both termini of the proposed Aiea Unit ungulate fence will attach to modern fences previously installed by DLNR. There are, however, several historic properties within the survey corridor. These consist of ranch (Site 7190) infrastructure and include historic fencelines, defunct galvanized waterlines, and ranch roads. Additionally, an historic water tank base and wooden trough (Site 50-10-20-30397) were observed outside the survey corridor, but close enough to warrant reporting and reconnaissance-level recordation. Descriptive information for the water tank base and trough is presented in Appendix A. Results for each of the Aiea Unit sections are as follows:

### 4.1 Section 1

Section 1 of the Aiea Unit survey corridor is 700 m long, averages 200 m in width, and runs along a 250 degree bearing (Figure 7). Survey of Section 1 produced two historic fencelines, the Forest Bird Sanctuary Access Road, and one possible waterline feature that is only visible on aerial imagery. The western terminus of this section is in close proximity to the historic water tank site mentioned above. The locations of these features are shown in Figure 7 below. All of the features are easily identifiable on the aerial imagery.

#### 4.1.1 Fence 1: Waiho 1 Waimea-Waiho 1 Kona Paddock Boundary

Fence 1 runs *mauka-makai* on a roughly north-south orientation. It is comprised of a combination of steel t-posts and wooden posts hung with galvanized woven wire fence with hinge joints (also known as ‘ringlock’) (Figure 9). The fence is topped with a single strand of barbed wire. The barbed wire is a modern twisted two strand with a four-point barb. It is similar to, and likely a descendant of, the “Ross Four Point” (Glover 1972:Entry No. 22). This style of barbed wire was originally patented June 10, 1879 by Noble G. Ross of Chicago, Illinois and has been in continuous use since that time. The hogwire is only minimally corroded and may post-date the top barbed wire strand which is highly corroded.

Some stretches of the fence are supported completely by t-posts while others consist of strings of wooden posts (Figure 10). It has the appearance of a line that was originally mostly wood but has been progressively replaced with t-posts over time. This conclusion is based on the presence of significant stretches of wooden posts. Use of strictly wooden posts pre-dates the modern approach of using t-posts interspersed with wooden posts at prescribed intervals. The wooden posts are used to provide support for the line. This style can be seen at Fence 2 (below), an intra-paddock fence of more recent date.

Although correspondence with historic maps is somewhat problematic, Fence 1 clearly demarcates the historic boundary between Waiho 1 Waimea and Waiho 1 Kona Paddocks. Subdivision of Waiho 1 Paddock occurred around 1948, as shown on Murray’s Puʻu Waʻawaʻa Ranch map (see Section 2.0, Figure 4). Fence 1 runs in a *mauka-makai* direction for 2.8 miles

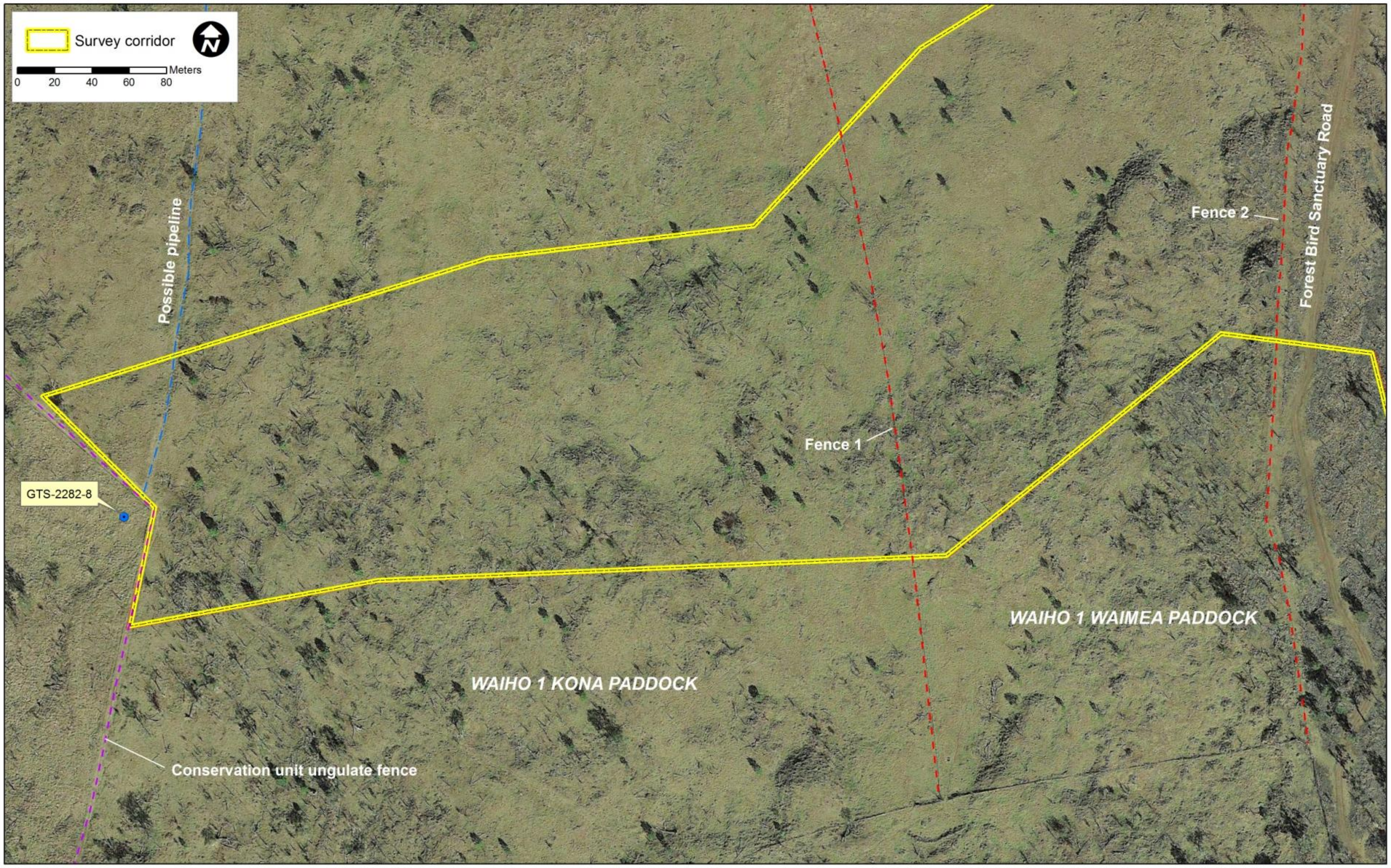


**Figure 7. Aerial image showing Aiea Unit, Section 1 survey corridor and identified historic resources.**

**Figure 8. Western terminus of Section 1 of Aiea Unit corridor. Proposed ungulate fence tie-in point is at the tall post at far left.**

**Figure 9. Aiea Unit Fence 1, t-post hung with woven wire and a single top-strand of four-point barbed wire.**

**Figure 10. Aiea Unit Fence 1, *makai* of ungulate fence centerline showing wooden posts and t-posts (view to north).**

and bisects Waiho 1, Waiho 2, and Waiho 3 Paddocks. This fence alignment corresponds to a major phase of paddock subdivision in the middle of the century. Although the woven wire fence is clearly recent, the wooden posts are likely remnants of the original fenceline.

#### 4.1.2 Fence 2: Waiho 1 Waimea Intra-Paddock Fence

Fence 2 runs *mauka-makai* on a roughly north-south orientation, paralleling Fence 1. It is constructed of four strands of barbed wire hung primarily on t-posts (Figure 11). Wooden posts are present but are widely spaced at approximately 40 meter intervals (Figure 12). The wire is Ross-style with four barbs on two twisted strands. The barb ends are notably elongated and the spans between posts are reinforced with paired twisted wire stays.

This fenceline is very close to the *mauka-makai* access road, a road which appears to be quite old. A road at this location is shown on a map annotated by former ranch hand Miki Kato (Figure 13). However, there is no fence near the road on the historic maps. It appears that this is an internal paddock fence that is not shown on the various ranch paddock maps. Importantly, this indicates that while historic paddock maps are useful for identifying major fencelines, they lack information on the intra-paddock cattle management infrastructure, at least in this instance.

**Figure 11. Aiea Unit Fence 2; t-posts hung with four strands of barbed wire. Interior paddock subdivision fence within Waiho 1 Waimea Paddock.**

**Figure 12. Aiea Unit Fence 3; example of widely-spaced wooden posts. View to north.**

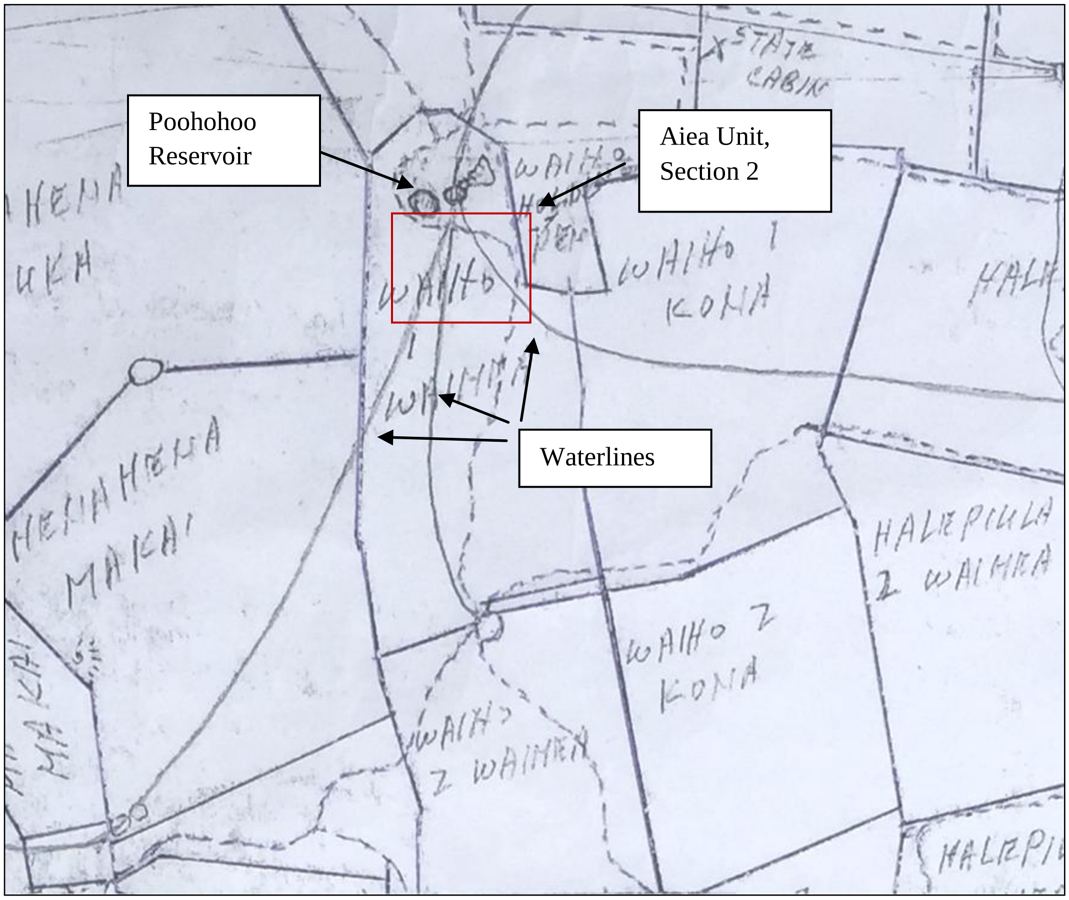


**Figure 13. Detail of Pu‘u Wa‘awa‘a Ranch map by Miki Kato.**

### 4.1.3 Forest Bird Sanctuary Access Road

Immediately east of Fence 2 is the Forest Bird Sanctuary Access Road (Figure 14). The road has been graded historically and is four meters wide with variable shoulder widths. According to DOFAW personnel, the road is graded about once every ten years.

This access route may have been in continuous use for as long as 92 years, possibly much longer. A 1923 USGS Puu Anahulu Quadrangle map shows a horse trail near this location (Figure 15). Its position relative to Poohohoo Reservoir and Henahena Paddock fenceline indicates that the trail is somewhat east of the current road. However, given the challenges of accurately mapping such a feature at this early date, it remains a distinct possibility that this trail was actually at the location of the current road. A later USGS quad from 1959 shows a jeep trail that corresponds very well with the current road (Figure 16). By this time, the trail had become accessible by off-road vehicles and was likely used to access the upper elevation Waiho 1 paddocks and, eventually, the reservoir at Poohohoo. It is still used for these purposes, in addition to providing access to the Forest Bird Sanctuary.

**Figure 14. Forest Bird Sanctuary Access Road.**

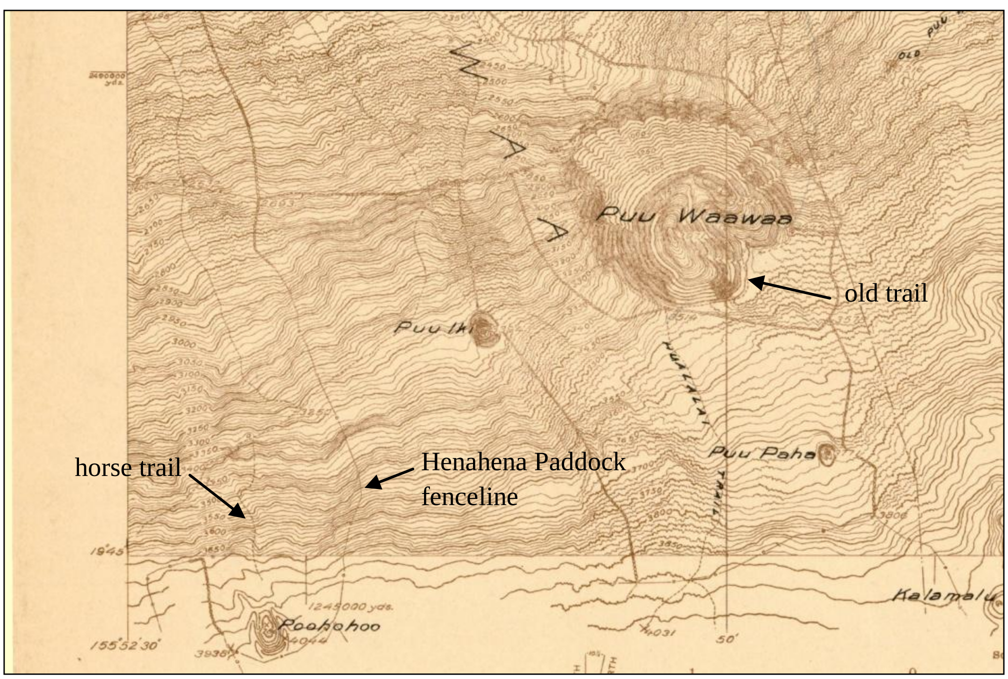


**Figure 15. Detail of 1923 USGS Puu Anahulu Quadrangle showing historic trail to Poohohoo. Note also Henahena Paddock fenceline.**

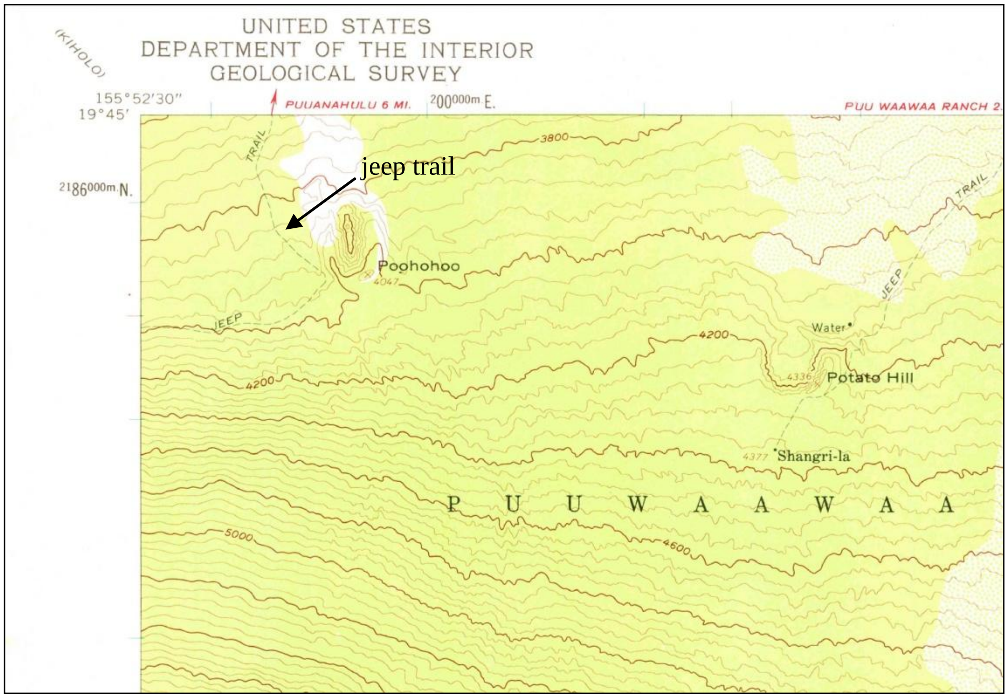


**Figure 16. Detail of 1959 USGS Hualalai Quadrangle showing jeep trail west of Poohohoo.**

### 4.1.4 Waterline/Road

One feature was identified on aerial imagery but could not be identified on the ground. The waterline and/or road feature is located at the western terminus of the Aiea corridor and runs north-northeast downslope (Figure 7). Close inspection of the aerial imagery shows that the road was likely created with a bulldozer, as berms border the road. The fact that it leads directly to the water tank base (Site 30397) just west of the project area suggests that there may be a waterline associated with the road. This road is part of a radial network of identical features centered on the intersection between Waiho 1 Waimea, Waiho 1 Kona, Waiho 2 Waimea, and Waiho 2 Kona Paddocks. The function of these roads is unclear and they do not appear on historic quadrangles or maps of Pu‘u Wa‘awa‘a Ranch. Although there is no empirical evidence, it seems likely that they date to the period of paddock subdivision and irrigation expansion in the 1950s and 1960s. They are no longer maintained and were not discernible at the time of survey. The road/waterline should be in the right side of the frame in Figure 8, but is not visible. This feature may be more apparent downslope from the survey area where more substantial berms are present.

## 4.2 Section 2

Section 2 of the Aiea Unit survey corridor is 600 m long, averages 200 m in width, and runs along a 340 degree bearing (Figure 17). Section 2 runs from the Forest Bird Sanctuary Road upslope to the northeast corner of the modern fence surrounding Poohohoo Reservoir (Figure 18). This section is entirely within Waiho 1 Waimea Paddock. Survey identified a ranch road and

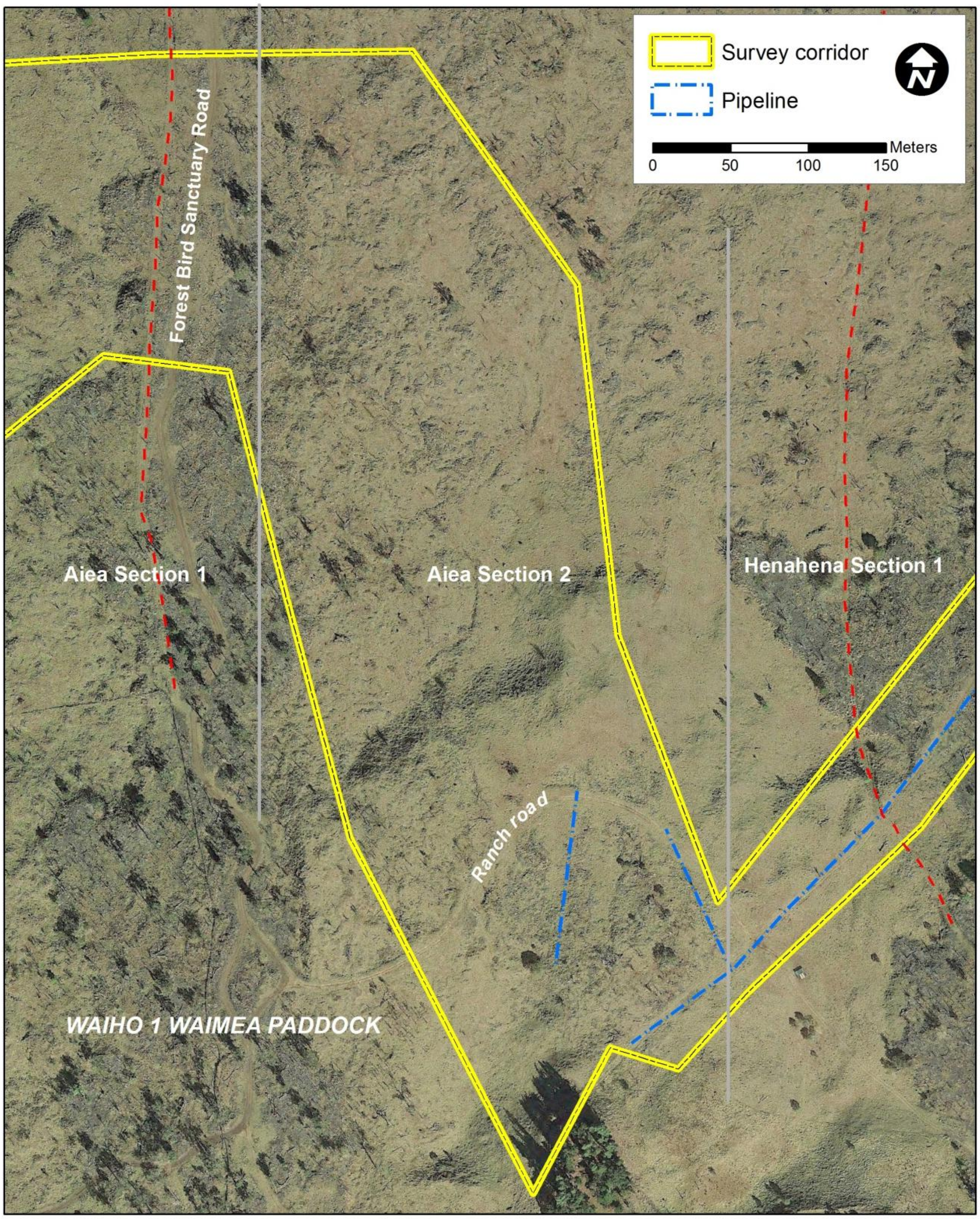


**Figure 17. Aerial image showing Section 2 of Aiea Unit and identified historic ranch features.**

**Figure 18. Terminus of Aiea survey corridor and Section 2. Proposed ungulate fence attaches at this corner.**

numerous segments of galvanized pipe associated with the former ranch waterline system. All of these historic resources are infrastructure features associated with historic Pu‘u Wa‘awa‘a Ranch (Site 7190).

### 4.2.1 Waterline

Galvanized pipe associated with the former ranch water distribution system was identified in multiple locations, although much of the lines are under grass and therefore not visible. The piping originally delivered water from Poohohoo Reservoir to watering locales in the lower paddocks. A major line (now defunct) is clearly visible along the Henahena fire break and extends northeast in that direction (see Section 5.1.2), paralleling a newer polyethylene waterline (Figure 19). The main line is 1½ or 1¾-inches in diameter and splits at a series of valves (Figure 20). At this point, a smaller ¾-inch line runs downslope through Waiho 1 Waimea and Henahena Makai Paddocks to a corral or water tank in the northeast corner of Henahena Makai Paddock. This line was largely obscured and is only within the survey corridor for a short length. Note that the smaller lateral pipe was originally connected to the mainline galvanized pipe, but was later shifted to tap the polyethylene replacement pipe. It may therefore still be in use.

A third waterline, ¾-inches in diameter, was also identified in the survey corridor. This small line runs from Poohohoo Reservoir downslope at a 354 degree angle to the large corral at the junction of Waiho 1 Waimea and Waiho 2 Waimea Paddocks. This line was also highly obscured by grass but was observable in a few places (Figure 21). This line and the other lateral line are both shown on a ranch map annotated by former ranch hand Miki Kato (Figure 13).

**Figure 19. Irrigation lines running toward Henahena Unit along *mauka* side of fire break.**

**Figure 20. Lateral line splitting and running to Waiho 2 Waimea corral.**

**Figure 21. Three quarter inch galvanized irrigation pipe running through Waiho 1 Waimea Paddock.**

### 4.2.2 Poohohoo Reservoir Access Road

Section 2 contains one ranch road (Figure 22). This road section splits off from the Forest Bird Sanctuary Road to access Poohohoo Reservoir from the northeast side. This road segment is not shown on the 1923 or 1959 maps referenced in Section 4.1. Nor does it appear on the current 1996 USGS Puu Anahulu Quadrangle. The road is, however, shown as a dashed line on Miki Kato's map (Figure 13). It appears to be a relatively new road associated with the development of Poohohoo Reservoir and the Pu'u Wa'awa'a Ranch water distribution system in the middle part of the century. The road is notably less developed than the Forest Bird Sanctuary Road and does not appear to have been graded, although this is difficult to discern due to the grass cover.

## 4.3 Discussion

The Aiea Unit survey corridor produced examples of all three major classes of ranch infrastructure—paddock fencing, water distribution lines, and access roads. In the western part of the unit, two major fencelines were recorded including 1) the Waiho 1 Waimea-Waiho 1 Kona Paddock boundary and 2) an intra-paddock fenceline within Waiho 1 Waimea Paddock. Moving east, two small lateral irrigation lines were identified as well as a major line running toward Henahena Unit. Finally, two historic ranch roads were identified. These include the current Forest Bird Sanctuary Road and a minor offshoot running to the northeast side of Poohohoo Reservoir.

**Figure 22. Minor road in Waiho 1 Waimea Paddock.**

All of the features identified in the Aiea Unit survey corridor are constituent elements of historic Pu‘u Wa‘awa‘a Ranch (Site 7190). They are important parts of the historic ranch landscape and contribute to the significance of the ranch complex as a whole. Within this understanding, however, some distinctions can be made regarding the relative antiquity of the features. Most of the features identified are associated with the post-World War II expansion and intensification of ranch operations under Spencer. These include the irrigation features, paddock fencing, and the Poohohoo Reservoir access road. One feature, however, may date to an earlier period of ranch operations. The Forest Bird Sanctuary Road appears to be on or near the location of a horse trail dating to 1923. Although improved to support vehicle travel since at least the 1950s, this route may have been used for ranch circulation as far back as the turn of the century. Finally, it is important to note that the intra-paddock line within Waiho 1 Waimea is not shown on any available paddock maps. These maps show only the broad outlines of the stock management system and do not account for additional subdivisions in the recent historical period. The intra-paddock fence is of a distinctly different construction than the paddock boundary fencing.

### 4.4 Project Effects

Proposed ungulate fencing within the Aiea Unit will intersect numerous infrastructure features associated with historic Pu‘u Wa‘awa‘a Ranch (Site 7190). These include two historic fencelines, two ranch roads, and at least one waterline. No features associated with traditional Hawaiian occupation were identified in the Aiea Unit survey corridor.

Although the proposed fence will undoubtedly impact the infrastructure features recorded above, impacts will be very minimal and will not rise to the level of ‘adverse’ effect. Descriptions of specific actions and expected effects are as follows:

1. *Historic Fencelines*: Ungulate fences will intersect existing paddock and intra-paddock fencing (Fences 1 and 2) at approximately right angles. The historic fences will be intersected between fence posts and no wooden posts will be removed. The fence wire will be cut and then retied to the newly installed fence to maintain paddock integrity. Original historic fence tension will be maintained in order to prevent excessive pull and potential adverse impact to posts. Circulation and access to the ungulate exclosures will be facilitated by gates in the new ungulate fence.

2. *Ranch Roads*: The Forest Bird Sanctuary Road and the Poohohoo Reservoir access spur will remain functional and will not be adversely impacted by fencing. Gates will be installed at ranch road crossings to permit access and circulation consistent with present and historical ranch usage patterns.

3. *Waterlines*: Waterlines originating at Poohohoo Reservoir and running along the ground surface within the project APE will be avoided during fence construction. Since the waterlines are largely obscured by grass, geophysical methods (e.g., metal detector or Schonstedt magnetic pipe locator) will be used, if necessary, to locate them. Fences will then be constructed over these lines.

If these practices are followed, there should be no adverse effect to historic resources. One might argue that cutting the fencelines constitutes an adverse impact. However, given the scale and extent of fencing at Puʻu Waʻawaʻa Ranch, this impact is considered negligible. There is an impact, but it is not adverse since paddock integrity will be maintained. There may be an issue with cumulative impact if historic fences are intersected by new fencing on a regular and ongoing basis. Potential cumulative impact to the historic ranch and possible mitigation actions need to be weighed by land managers and regulators against DOFAW’s conservation goals and public hunting and recreational uses. Under current plans, however, historic ranch infrastructure will be very lightly impacted by ungulate fence installation.

# 5.0 HENAHENA UNIT RESULTS

Henahena Unit consists of 4.24 km of proposed ungulate fence corridor. For organizational purposes, the unit is divided into three sections. The sections basically follow the major angle changes of the corridor, although Section 1 contains two major orientations.

## 5.1 Section 1

Section 1 of the Henahena Unit runs downslope for 1270 m along a 215 degree bearing, then makes a sharp turn to the south, running along Henahena Makai Paddock's western boundary for an additional 615 m (Figure 23). The proposed fence centerline ties in to the Poohohoo Reservoir fence enclosure and then runs along the *mauka* side of a fire break road. Corridor width is consistently 60 m.

Section 1 contains numerous elements of Puʻu Waʻawaʻa Ranch's (Site 7190) historic infrastructure including paddock fencing, one gate, a defunct waterline, and a ranch road that runs along the fire break. The features are presented below in the order in which they occur, moving from southwest to northeast along the survey corridor. Henahena historic fence numbering is continued from Aiea Unit fence numbering.

### 5.1.1 Fence 3: Waiho 1 Waimea Intra-Paddock Fence

Section 1 intersects one historic intra-paddock fenceline. This fenceline runs *mauka-makai* within Waiho 1 Waimea Paddock. The fence is comprised almost entirely of metal t-posts hung with four strands of barbed wire and interlaced with stays (Figure 24). The barbs are Ross-style four point barbs on two twisted wires, very common across the ranch. Only one wood post was observed within sight of the corridor intersection. At least two t-post styles are present, although the great majority are of one type and display white tops. The second post in Figure 24 is of the second, less common type and, given its spacing relative to the *mauka* wooden post mentioned above, may be a replacement for a similar wooden post once in its location. This line style is very similar to the intra-paddock fence recorded in the Waiho 1 Kona Paddock in the Aiea Unit and may constitute a standard type for intra-paddock fencing.

#### *5.1.1.1 Gate*

One fabricated steel gate was recorded along Fence 3. It is located immediately *makai* of the ungulate fence centerline (Figure 25). The gate is made of welded steel tubing and has the appearance of a custom manufactured item. Its hinges and locking plate are clearly custom cut and welded.

### 5.1.2 Waterline

A galvanized pipeline (1½ or 1¾-inch) runs along the *mauka* side of a ranch road and fire break (Figure 23). This line once delivered water from Poohohoo Reservoir to the lower Henahena Makai Paddock and eventually to the base of Puʻu Waʻawaʻa. This line is no longer functional and large sections have been removed. The original line was observed intermittently along both sides of the fire break (Figure 26).

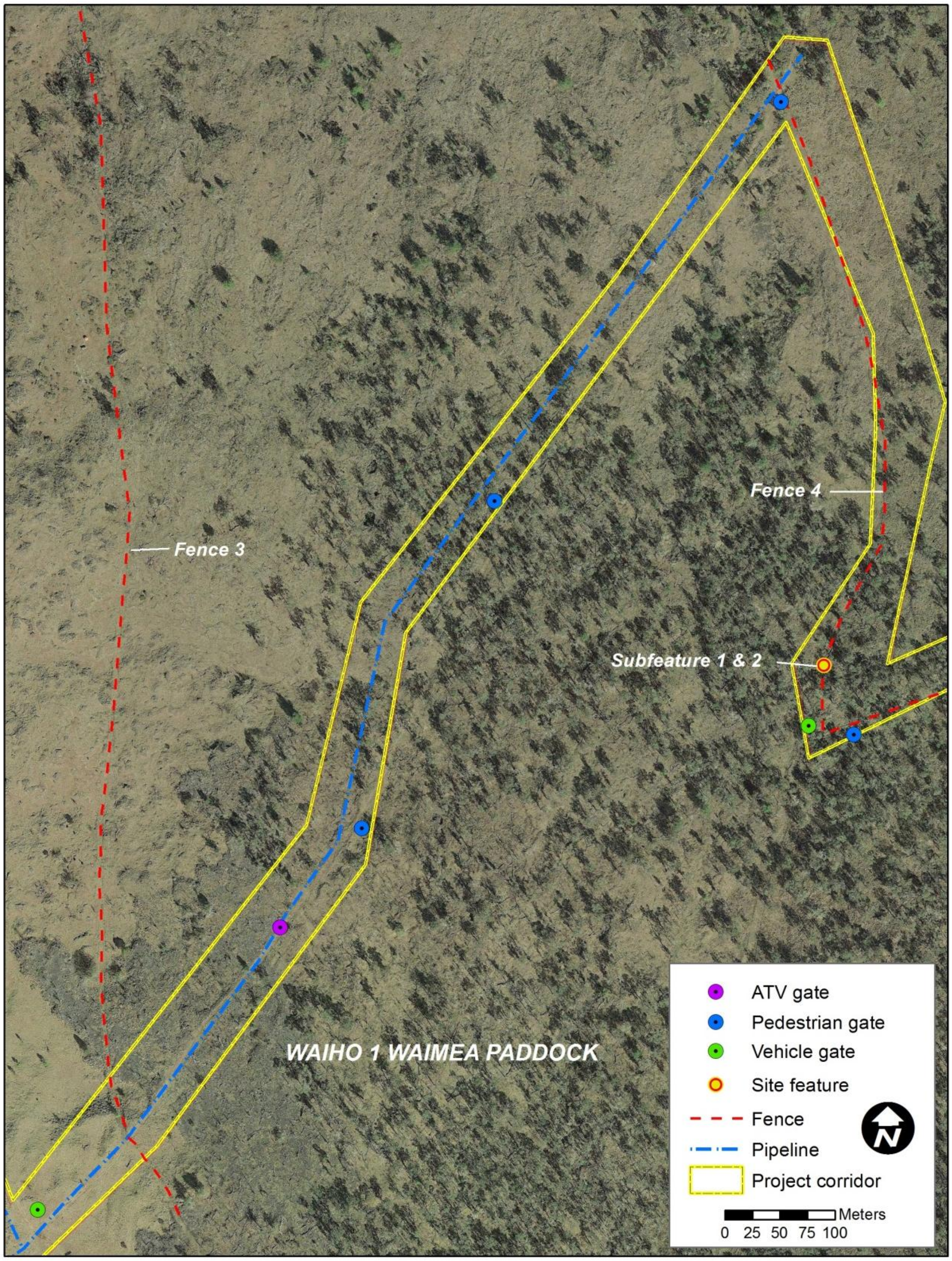


**Figure 23. Aerial image showing Section 1 of Henahena Unit and identified historic resources. Note: the water pipeline is discontinuous. The continuous dashed blue line is to show the general alignment.**

**Figure 24. Intra-paddock fence in Waiho 1 Waimea Paddock. View to southeast.**

**Figure 25. Steel gate in Waiho 1 Waimea Paddock. Detail: custom fabricated gate hardware.**

**Figure 26. Remnant pipe along Henahena Unit corridor, Section 1. Modern polyethylene pipe visible at far right.**

Water from Poohohoo Reservoir is still used for ranching and DOFAW operations at Pu‘u Wa‘awa‘a. Only the smaller of the two reservoirs is still functional. The original metal pipeline has since been replaced with polyethylene line.

### 5.1.3 Ranch Road

A ranch road runs alongside the irrigation line (Figure 26) and extends from the Poohohoo Reservoir fence to an intersection at Henahena Makai Paddock. The road does not occur on the 1959 Hualalai Quadrangle (see Figure 16, Aiea Unit). Note that there is no fencing along Section 1. The road was therefore likely built to assist construction and maintenance of the pipeline. Like the pipeline, the road was constructed following completion of Poohohoo Reservoir. It continues to provide access to the current polyethylene pipeline and DOFAW’s conservation fire break.

### 5.1.4 Fence 4: Waiho 1 Waimea-Henahena Makai Paddock Boundary

At approximately 1.1 km northeast of Fence 3, the irrigation line and jeep trail intersect with Fence 4, the western boundary of Henahena Makai Paddock. The proposed ungulate fence centerline makes a sharp turn just prior to this and runs west of Fence 4 for 510 m. Most of Fence 4 does not fall within the survey corridor. However, it is later intersected by the proposed ungulate fence where the survey corridor enters Henahena Makai Paddock.

Fence 4 is one of the oldest fence alignments at Puʻu Waʻawaʻa Ranch and is clearly identifiable on the 1923 Puu Anahulu Quadrangle (see Figure 15, Aiea Unit). Fencelines are continuously maintained, repaired, and occasionally replaced during normal ranch operations, and it is unclear if any of the 1923 elements remain intact. However, the design and construction elements of this line are notably different from the paddock boundary fencing and intra-paddock fencing observed elsewhere in the project area. This indicates that Fence 4 followed a distinctive evolutionary trajectory, likely related to its much greater antiquity.

Fence 4 is comprised of woven wire fencing on its lower half, and three strands of heavy-gauge wire on its top (Figure 27). The woven wire is of a different, older style than the woven wire recorded at Fence 1 in the Aiea Unit. This older style is identifiable by its more elongate panels and has been observed on older fencelines on other ranch landscapes by the Principal Investigator (e.g., Keamuku Sheep Station). The addition of the three upper heavy-gauge wires is even more distinctive and was not observed anywhere else during the survey. The strands appear to have been tensioned using a crimping technique, likely to correct sagging (Figure 28). This technique is only possible with heavy gauge wire. Smaller gauges would not maintain their shape and standard twisted barbed wire would certainly need to be restretched.

Posts for Fence 4 are a mix of metal t-posts and wooden posts. The t-posts provide primary structural support with the older wooden posts being secondary. The spacing of the wooden posts, however, indicates that this fenceline was originally comprised entirely of wood posts. The t-posts were likely added around the middle of the 1900s as a longer-lived alternative to wood. In some cases, staples associated with missing wooden posts are still visible on the fence wire (Figure 29). The t-posts on Fence 4 are of the older style, as previously observed on the paddock boundary fence in the Aiea Unit. They are distinctly larger and taller than the t-posts supporting intra-paddock fencing (Figure 30). Another notable feature of this alignment is the presence of cobble chinking along the base in certain areas, mainly at the southern end of the fence (Figure 31 and Figure 32). These features function to stabilize the posts in areas where the bedrock substrate is at the surface, and also to maintain a level line where there are substantial dips in the topography. These amendments can be found throughout the line, and are particularly prevalent along Fence 4 and Fence 5 (see Section 5.2.2) due to the rugged and irregular topography in this area.

Fence 4 is clearly one of the oldest alignments at Puʻu Waʻawaʻa ranch and its current fence contains element that may date to the early 1900s. Although use of plain wire predates barbed wire by many decades, it seems unlikely that barbed wire was unavailable at the time the fence was constructed. Barbed wire was widely available by the 1880s and was certainly widely used in Hawaiʻi by the turn of the century. The selection of plain, heavy gauge wire in this case may have simply been a case of ranchers using whatever was inexpensive and convenient at the time. Finally, it should be noted that the wire is clearly galvanized and only minimally rusted. How long galvanizing would preserve the wire in this environment is open to question. The woven wire below, which may or may not have been galvanized, is highly rusted.

In any case, this distinctive fence style may be diagnostic of the very earliest of Puʻu Waʻawaʻa fencelines. Further investigation of other fence alignments shown on the 1923 Puu Anahulu Quadrangle is recommended to verify this proposition.

**Figure 27. Boundary fence between Waiho 1 Waimea and Henahena Makai Paddocks.**

**Figure 28. Example of line crimping to correct sagging in heavy gauge wire.**

**Figure 29. Remnant staples from previous wooden posts.**

**Figure 30. Complete view of older t-post type, including base plate.**

**Figure 31. Substantial cobble chinking at base of Fence 4. View to northeast.**

**Figure 32. Cobble chinking along base of Fence 4. View to north.**

## 5.2 Section 2

Section 2 of the Henahena Unit runs 600 m at a 240 degree bearing from the western boundary of Henahena Makai Paddock northeast along the paddock's *mauka* boundary fence (Figure 33). The ungulate fence centerline on this section runs parallel to and *makai* (north) of the existing historic fenceline that separates Henahena Makai and Henahena Mauka Paddocks. The proposed ungulate fence only intersects the historic paddock fence where it enters and exits Henahena Makai Paddock at the western and eastern ends of Section 2, respectively. The survey corridor is 50 m wide.

Section 2 contains two historic resources: 1) the Henahena Makai Paddock boundary fence (Fence 4), and 2) an historic stone-walled corral (Site 50-10-20-30311).

### 5.2.1 Fence 4: Crossing Point

The proposed ungulate fence intersects Fence 4 immediately south of a large *ʻōhiʻa* tree and a gate leading into Henahena Mauka Paddock (Figure 34). Fencing at this location consists of woven wire at the base and three heavy gauge wires at the top. The tree functions as an anchor point for the various lines and is wound with a variety of wires, many of which have become embedded in the tree itself. Two wooden posts, of clearly different dates, are immediately against the tree on the *makai* side (Figure 35).

### 5.2.2 Fence 5: Henahena Makai-Henahena Mauka Paddock Boundary

After crossing Fence 4, the proposed ungulate fence corridor runs along the *makai* (northern) side of Fence 5 within Henahena Makai Paddock for 600 m. The proposed fence runs very close to Fence 5, sometimes as close as one meter (Figure 36).

Fence 5 is the boundary between Henahena Makai and Henahena Mauka Paddocks and is comprised of relatively galvanized new woven wire topped with a single strand of Ross-style four point barbed wire (Figure 37). The barbed wire strand is notably corroded, but the woven wire is not and appears much newer. The fencing is hung on a combination of metal t-posts and wooden posts. Fence 5 is very similar in design and construction to Fence 1 in the Aiea Unit. Like Fence 1, Fence 5 is shown as a completed fence (1.35 miles) on Murray's 1948 map of the Puʻu Waʻawaʻa Ranch Paddocks. Also like Fence 1, Fence 5 was likely originally constructed with all wooden posts, with metal t-posts added over the years. A few segments of the fenceline display long, continuous strings of the older wooden posts with their original spacing (Figure 38). The more recent t-posts, however, now comprise the majority of the line for long stretches (Figure 39 and Figure 40).

To compensate for the irregular lava substrate it runs over, Fence 5 exhibits a number of small modifications intended to make the line more secure and prevent escape or harm to livestock. These fence modifications consist of cobble chinking in spots where the fence does not meet the ground or where substantial void spaces (e.g., sinkholes, lava tube ceiling collapse) present a hazard. Five examples of these stacked rock subfeatures were recorded during the survey (Table 1). Most were built to block gaps where the fence crossed collapsed lava tubes (Figure 41 and Figure 42), to anchor wires which strengthen fence panels and fence posts (Figure 43), and to anchor the base of the fence and block gaps at depressions (see Section 5.1.4, Figure 31). Other minor chinking can be found along the line, but these are the best examples observed.

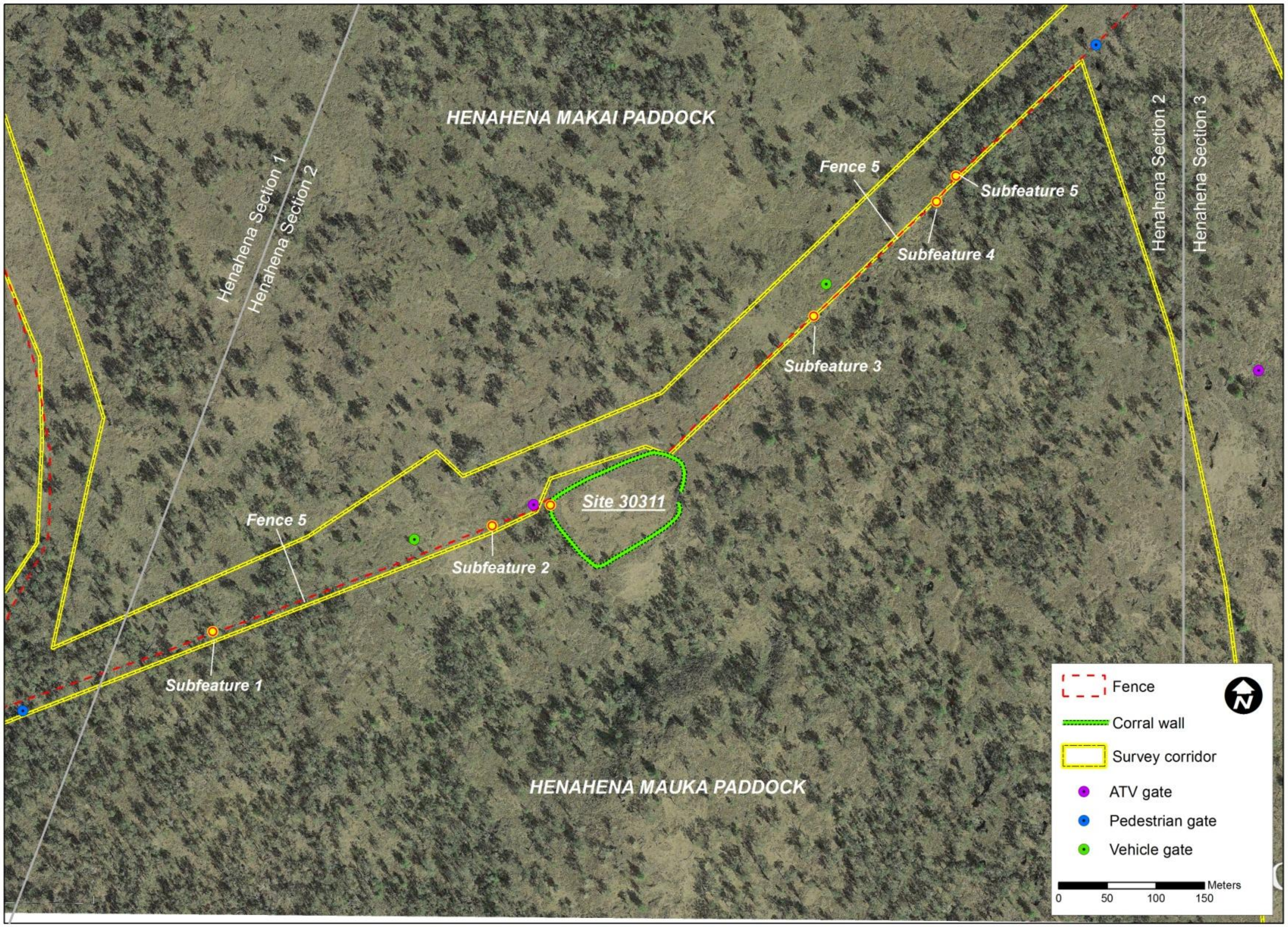


**Figure 33. Aerial image showing Section 2 of Henahena Unit and identified historic resources.**

**Figure 34. Gate into Henahena Mauka Paddock. Proposed ungulate fenceline is just left of the large *‘ōhi‘a* tree. Scale bar in 10 cm increments. View to east.**

**Figure 35. *‘Ōhi‘a* tree marks boundary between Henahena Mauka (right) and Henahena Makai (left) Paddocks. Proposed ungulate fenceline is just left of the *‘ōhi‘a* tree. Scale bar in 10 cm increments.**

**Figure 36. Proposed ungulate fence centerline at white stake. Fence 5 immediately to right (north). View to east.**

**Figure 37. Fence 5 in Henahena Unit, Section 2. View to southwest.**

**Figure 38. String of remnant wooden posts on Fence 5, Henahena Unit, Section 2. View to south.**

**Figure 39. Long string of t-posts on Fence 5, Henahena Unit, Section 2.**

**Figure 40. Two types of t-post on Fence 5. Older style on left, newer style on right.**

**Table 1. Rock Subfeatures along Fence 5 in Section 2 of Henahena Unit**

| Subfeature Number | Description |
|---|---|
| 1 | Stacked rock anchoring wooden fence posts and base of wire fence |
| 2 | Stacked rock anchoring base of fence |
| 3 | Stacked rock anchoring base of fence |
| 4 | Stacked rock blocking lava tube under wire fence |
| 5 | Stacked rock blocking lava tube under wire fence |

**Figure 41. Fence 5, Subfeature 1. Stacked rock under fence blocking lava tube, facing south.**

**Figure 42. Fence 5, Subfeature 2. Stacked rock under fence blocking lava tube, facing south.**

**Figure 43. Fence 5, Subfeature 3. Rocks anchoring base of fence, facing south.**

### 5.2.3 Caves

Various caves formed from collapsed lava tubes were observed throughout Section 2 of the Henahena Unit survey corridor. Some were very large (Figure 44), although many consisted of small overhangs with little depth. All of the caves were investigated during the survey and none contained evidence of human occupation or use, including the presence of artifacts or features.

### 5.2.4 Stone Corral (Site 50-10-20-30311)

At 624 m east-northeast of the Fence 4 crossing point, Fence 5 ties in to a historic stone-walled corral (Site 50-10-20-30311) (see Figure 33). This site was originally recorded as Temporary Site 3 by Dougherty and Moniz-Nakamura in 2008 during an archaeological survey of proposed ungulate exclosure fencelines (Dougherty and Moniz-Nakamura 2008:19). The corral is constructed of well-faced stacked basalt cobbles and small boulders with core-fill interior. The wall is 70 cm wide, on average, and 80 to 120 cm high. It measures 140 m east to west and 85 m north to south (Figure 45). Total length of the corral wall perimeter is 378 m and it encloses approximately 2.5 acres.

The wall has three ingress-egress features. One is along the wall section that runs in line with Fence 5. This opening originally had a gate, but now only exhibits the remnant support posts. A second gate on the opposite side, opening into Henahena Mauka Paddock, still sports its wooden gate. A third opening is present on the western end of the corral. This is a large opening, possibly to channel cattle into the corral. There is also a small section near this opening that is double-walled. The function of the second wall section is unknown.

**Figure 44. Example of collapsed lava tube on Section 2, Henahena Unit.**

#### *5.2.4.1 Conclusion*

The corral's date of construction is unclear. Its dry-stone style matches that of early walls constructed prior to 1923. While other stacked rock walls, trails, waterlines, and tanks are illustrated on the 1923 Puu Anahulu Quadrangle, the corral is not shown. The scale of the quad map does not appear to be an issue as the corral is large and is approximately a third the size of Pu'u Iki, located northeast of the site (Figure 46). Given the size of this feature, if it was present prior to 1923, it seems likely that it would have been included on the 1923 Puu Anahulu Quadrangle. A USGS aerial photograph shows that the corral was built at least by 1954 (Figure 47). Importantly, Henahena Paddock was divided into Henahena Makai and Henahena Mauka around 1948. The corral may date to this period of paddock construction and subdivision.

The proposed ungulate fenceline corridor runs parallel to the north wall of the corral, but is offset some 20 m to avoid the site (Figure 48). The proposed fence centerline comes closest at the northeastern end of the corral where Fence 5 ties in and resumes its northeasterly progression (Figure 49). At this point, the centerline is only about 2 m from the corral.

### 5.2.5 Ranch Road

Section 2 contained access roads along the entire length of the corridor. The road adjacent to Fence 4 clearly provides access to the ranch fenceline and extends south past the project area, paralleling the west perimeter of Henahena Mauka Paddock. The access road also makes a right angle turn and enters Henahena Makai Paddock and parallels Fence 5 for its entire length, though

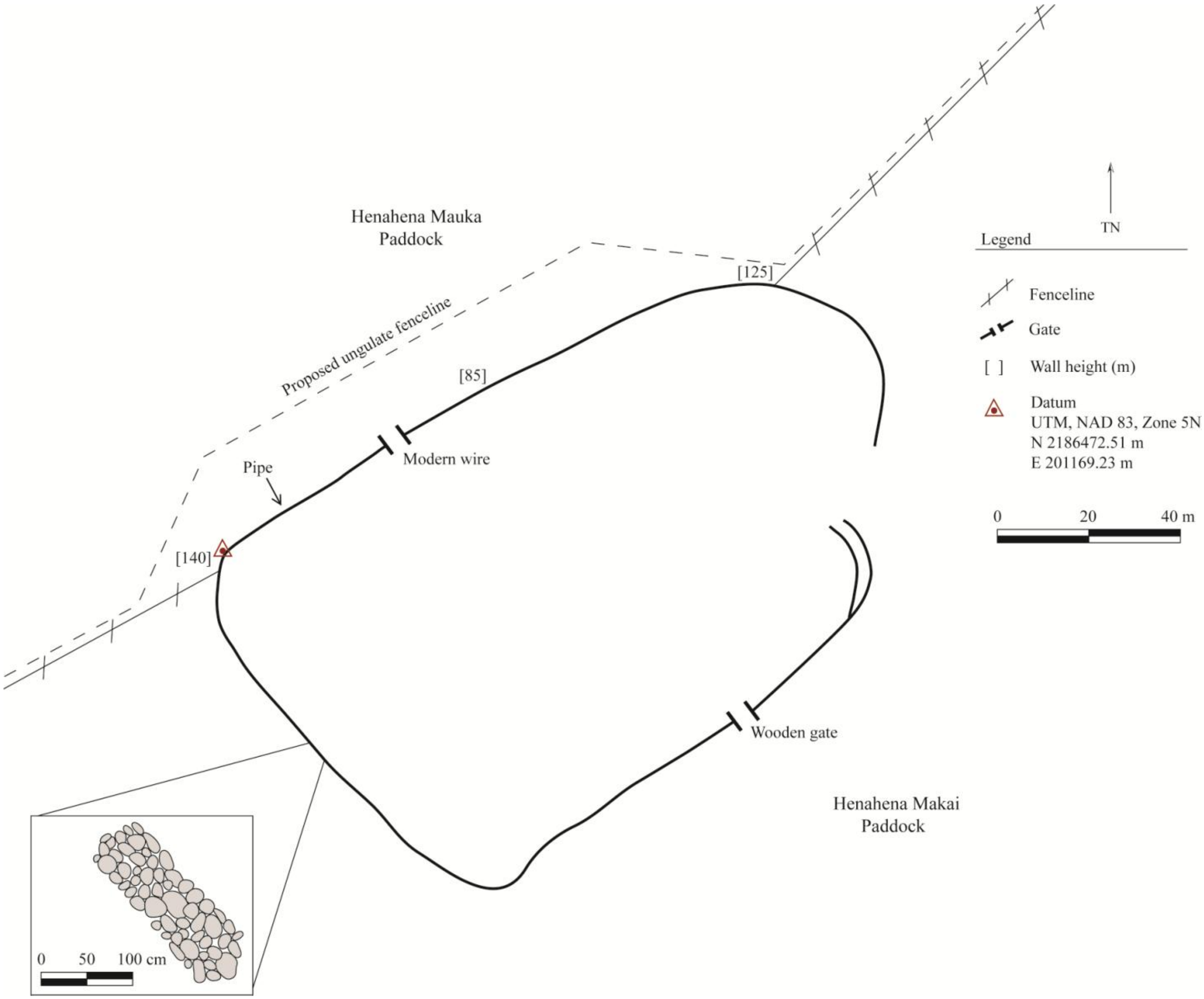


**Figure 45. Site 30311 corral plan map.**

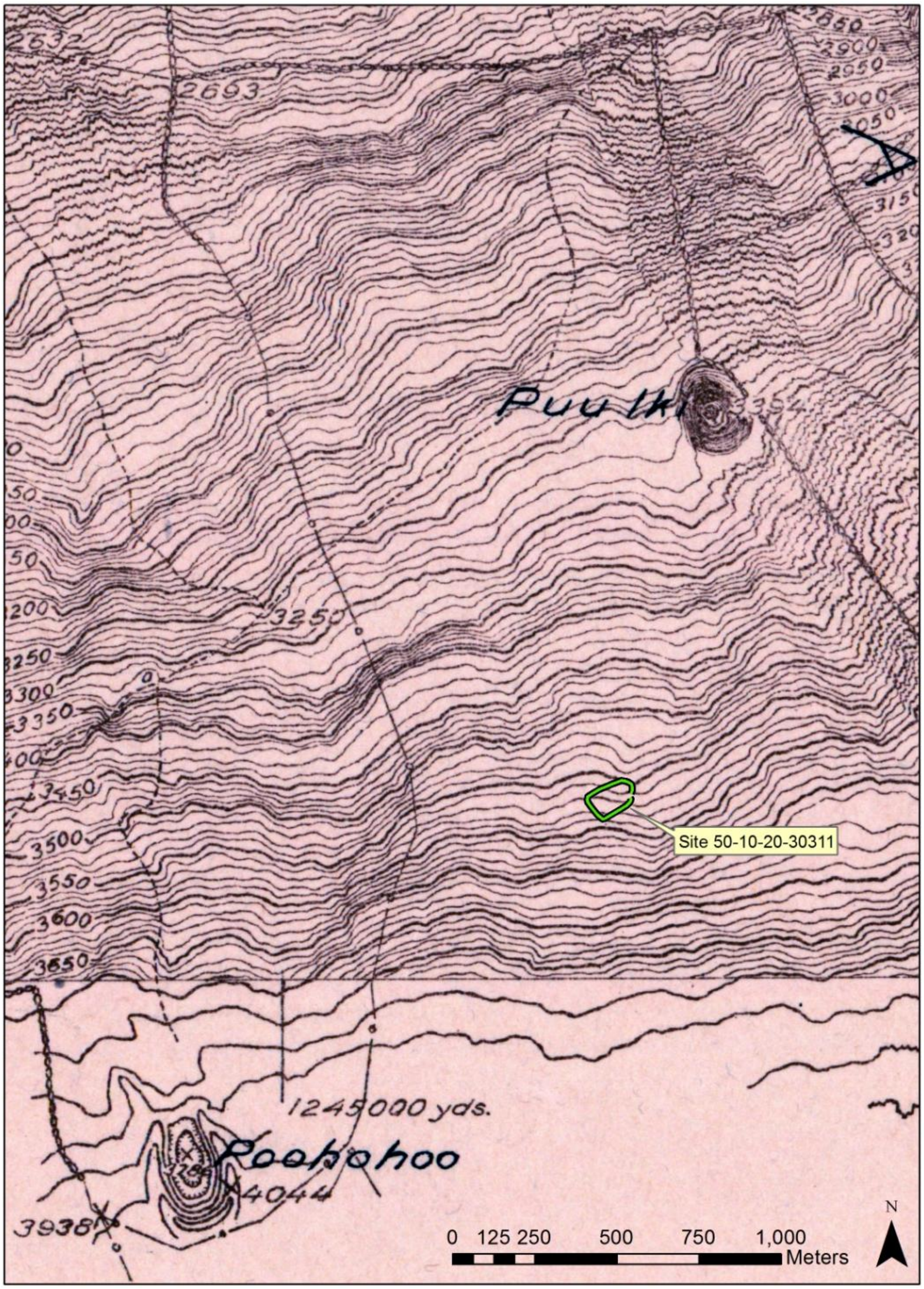


Figure 46. 1923 Puu Anahulu Quadrangle with location of corral.

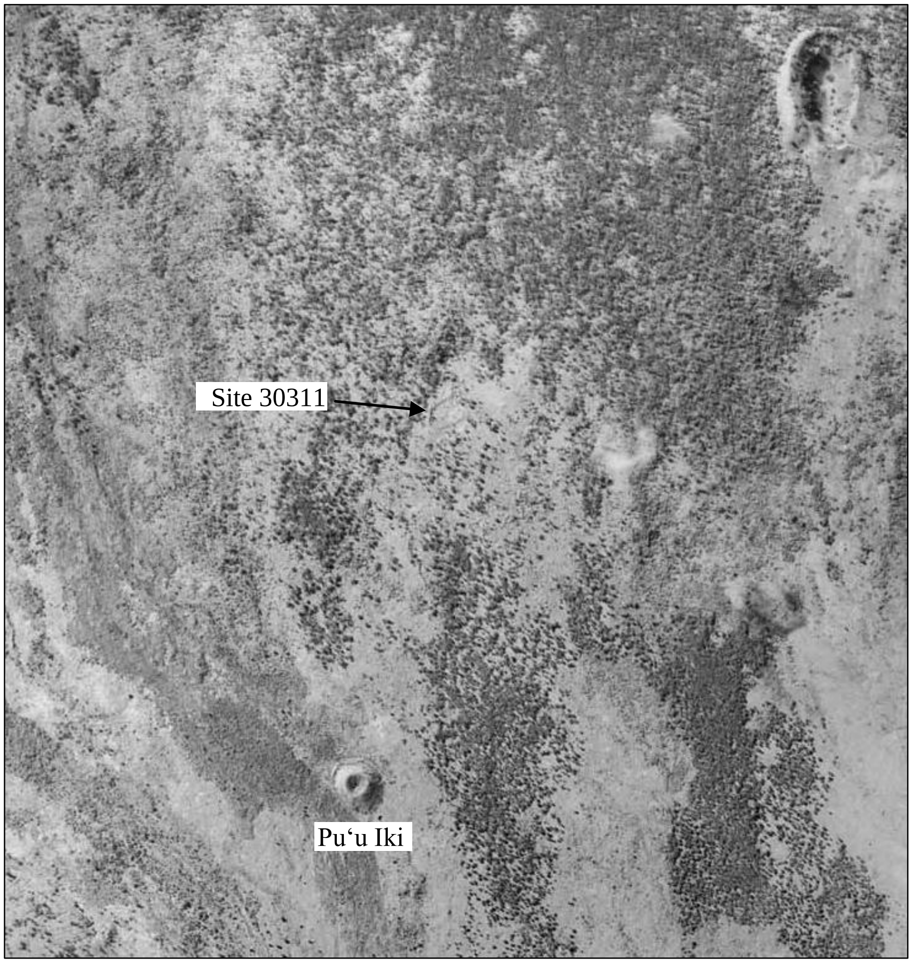


**Figure 47. 1954 USGS aerial photograph showing Site 30311, top of photograph is to the south.**

somewhat offset. Both roads are currently in use and their antiquity is uncertain. It seems likely that they may have been used for fence maintenance historically. The section that runs along Fence 5 is somewhat circuitous due to the many sinkholes along that stretch. These roads do not appear on ranch hand Miki Kato’s annotated ranch map or any of the USGS quadrangles.

## 5.3 Section 3

Section 3 begins at the intersection of the proposed ungulate fenceline with Fence 5. The proposed fence corridor takes a sharp turn to the south at this point and runs for approximately 1750 m at a 180 degree bearing before terminating at an existing DOFAW ungulate exclusion fenceline (Figure 50). This section is currently maintained as a firebreak and runs through the middle of Henahena Mauka Paddock (Figure 51). The corridor does not follow any existing ranch fencelines or ranch roads, nor does it intersect any. Survey of Section 3 produced no evidence of historic properties.

**Figure 48. Site 30311 corral on right and proposed ungulate fence centerline at arrow to left.**

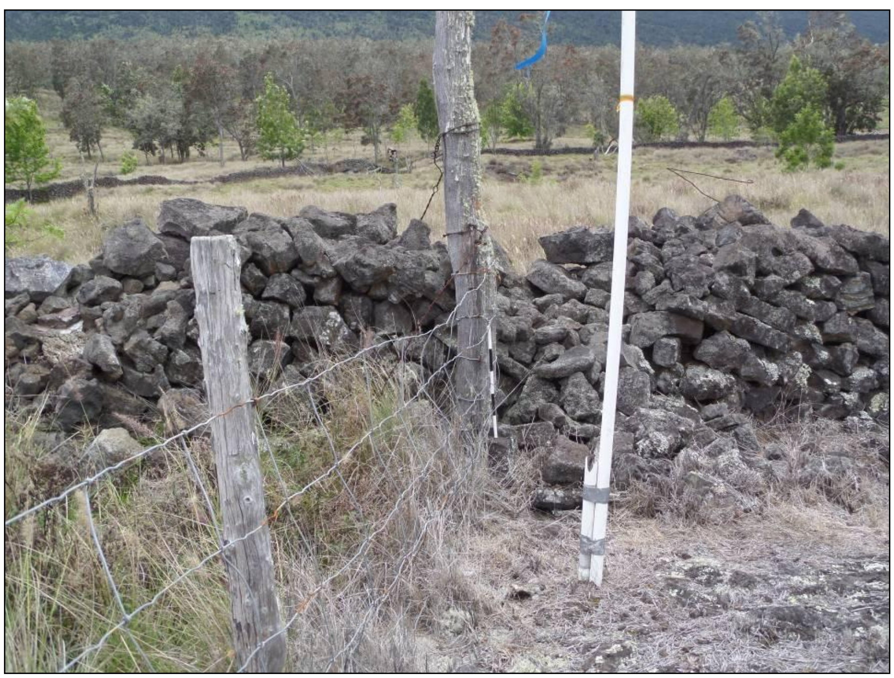

**Figure 49. Proposed ungulate fence (white stake), with Fence 5 to the left and Site 30311 directly behind.**

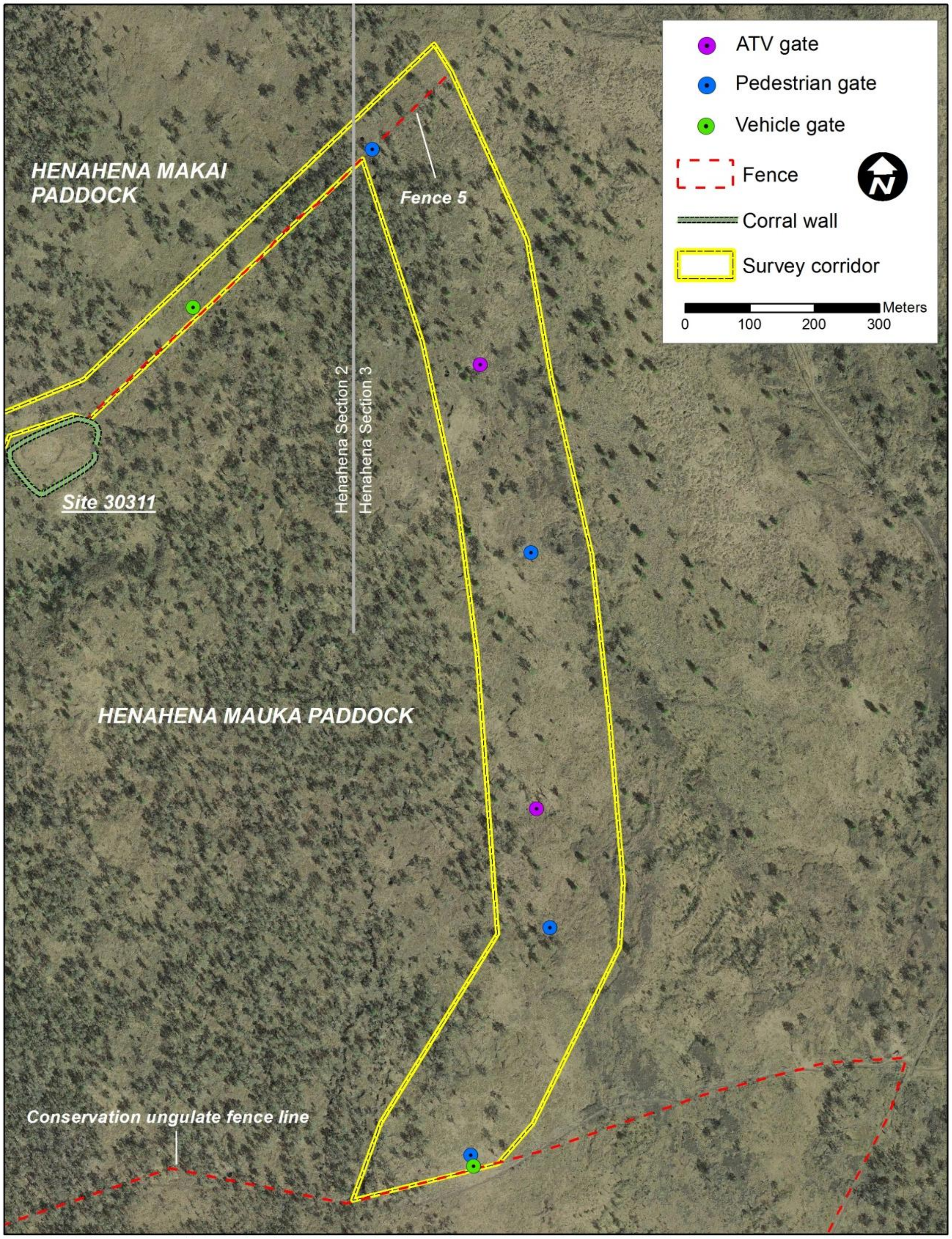


**Figure 50. Aerial image showing Section 3 of Henahena Unit and identified historic resources.**

**Figure 51. Section 3 running north through Henahena Mauka Paddock. Proposed ungulate fence crosses Fence 5 at flagging on far right. View to north.**

## 5.4 Discussion

The Henahena Unit survey corridor produced a variety of features associated with historic Pu‘u Wa‘awa‘a Ranch including three historic fencelines, a water pipeline, ranch roads, and a large corral. The fencelines include one intra-paddock fence (Fence 3) of the same type recorded in Waiho 1 Waimea Paddock in the Aiea Unit. The consistency in design and construction of intra-paddock fencing is noteworthy, and there is little chance of confusing these fences with the older paddock boundary fences. The older style fences are typified by Fence 5, which forms the Henahena Makai-Henahena Mauka Paddock boundary. These older fences date to 1948 or slightly earlier and are shown on Murray’s 1948 map of Pu‘u Wa‘awa‘a (see Section 2.0, Figure 4). Notably, Fence 5 exhibits localized adaptation to its uneven and sinkhole-laden topography in the form of cobble ‘chinking’ along fence bases, around void spaces, and at the base of fence posts.

Finally, a new fence style (Fence 4) was recorded in Section 1 of Henahena Unit. Fence 4 exhibits older-style woven wire topped by three plain wires. This is an unusual configuration and was not seen anywhere else on the ranch during the survey. Significantly, the Fence 4 alignment is clearly identifiable on the 1923 Puu Anahulu Quadrangle (Figure 15). This alignment is therefore among the oldest encountered during the AIS. It is possible that Fence 4’s unusual design is a holdover from an earlier era of fence construction.

The single water pipeline observed along the Section 1 alignment is defunct and has largely been removed. After the initial 200 m, it became discontinuous and only discrete pipe segments were observed. Initial installation dates to the period of rapid water resource development under Robert Hind, Ltd.'s management in the mid-twentieth century. Although the galvanized pipe is no longer used, water is still transported on this alignment via a newer polyethylene pipeline.

Ranch roads run continuously along Sections 1 and 2. The ranch roads are mostly linear and are relatively well developed. All of the ranch roads parallel, and provide access to, water or fence infrastructure. None of the roads appear on older historic USGS quadrangle maps. They all appear to date to the mid-twentieth century.

In addition to the general infrastructure features, one major stone corral was recorded in the center of Fence 5. This feature had been previously recorded by Dougherty and Moniz-Nakamura as Temporary Feature 3 (Dougherty and Moniz-Nakamura 2008:19). It is now assigned Site 50-10-20-30311. Although the stacked stone corral has a distinctly older look, its construction date is most likely the mid-twentieth century. The corral is an integral part of Fence 5, a paddock subdivision fence that is shown on Murray's 1948 'Fencing Projects' map as "Completed New Fence." The corral has several openings that allow circulation between the Henahena Paddocks.

## 5.5 Project Effects

Proposed ungulate fencing within the Henahena Unit will intersect numerous infrastructure features associated with historic Puʻu Waʻawaʻa Ranch (Site 7190) and will come very close to a historic stone-walled corral (Site 50-10-20-30311). Infrastructure features include three historic fencelines, a series of connected ranch roads, and one waterline. No features associated with traditional Hawaiian occupation were found within the Henahena Unit survey corridor.

Impact findings for the Henahena Unit are similar to those for the Aiea Unit to the west. The proposed ungulate fence will intersect, and therefore affect, some elements of the historic ranch infrastructure system. However, impacts will be very minimal and do not rise to the level of 'adverse' effect. Descriptions of specific actions and expected effects are as follows:

1. *Historic Fencelines*: Ungulate fences will intersect existing paddock and intra-paddock fencing (Fences 3, 4, and 5) at approximately right angles. The historic fences will be intersected between fence posts and no wooden posts will be removed. The fence wire will be cut and then retied to the newly installed fence to maintain paddock integrity. Original historic fence tension will be maintained in order to prevent excessive pull and potential adverse impact to posts. Circulation and access to the ungulate exclosures will be facilitated by gates in the ungulate fence. New vehicle, self-closing pedestrian, and ATV gates will be installed along all three sides of the Henahena Unit in the historic fencelines. These will be built away from other historic features.

2. *Ranch Roads*: Existing ranch roads will remain in use and will not be adversely impacted by fencing. Gates will be installed at ranch road crossings, as necessary, to permit access and circulation consistent with

present and historical ranch usage patterns. The current ranch road system will function to provide access to the ungulate exclosure fence for maintenance and repair, similar to its historic function for historic paddock fencing.

3. *Waterlines*: One defunct historic ranch waterline is within the survey corridor. This line is discontinuous, but is generally visible on the ground surface. Every effort will be made to avoid the remaining pipe. In some cases, individual pipe sections may be shifted several feet to facilitate avoidance. Since most sections of the waterline appear to have been moved following its decommissioning, this is not considered to be an adverse effect. The modern polyethylene waterline, currently in use, will be avoided.

4. *Stone Corral (Site 50-10-20-30311)*: The proposed ungulate exclosure fenceline generally maintains a 20 m setback from the Site 50-10-20-30311 stone-walled corral. Effects to the site are very unlikely in these areas. However, the centerline of the fence comes within 5 m of the corral at its northeastern end, where the corral links to the historic Henahena Makai-Henahena Mauka Paddock fenceline. At this location, protective orange safety fence will be installed between the historic corral wall and the ungulate fenceline prior to construction and will be maintained and observed as a barrier during construction. The historic corral wall and the Henahena Paddock fencing will be strictly avoided during construction. A DOFAW staff member will be present at all times to monitor construction activities in this area.

If the above practices are followed, there should be no adverse effect to historic resources in the Henahena Unit. As mentioned in Section 4.0, cutting the fencelines clearly qualifies as an ‘effect.’ However, given the scale and extent of fencing at Pu‘u Wa‘awa‘a Ranch, the effect is considered negligible. The effect is not adverse to the historic ranch as a whole because paddock integrity will be maintained. There may be an issue with cumulative impact if historic fences are intersected by new fencing on a regular and ongoing basis. Potential cumulative impact to the historic ranch and possible mitigation actions need to be weighed by land managers and regulators against DOFAW’s conservation goals and public hunting and recreational uses. Historic ranch infrastructure will be very lightly impacted by currently proposed ungulate fence installation.

# 6.0 PUʻU WAʻAWAʻA UNIT RESULTS

The proposed ungulate exclosure fencing on Puʻu Waʻawaʻa consists of a complex arrangement of concentric and interconnected fence corridors, some of which coincide roughly with existing ranch fences and walls. Fence corridors traversed a large area, encircling and crossing over the *puʻu*. Historical features recorded during the AIS are spaced far-apart and spread throughout the Puʻu Waʻawaʻa Unit fenceline corridor. Some are ranch (Site 7190) related features including interconnected ranch infrastructure (e.g., roads and waterlines). Wire fences also run between some of the ranch features. Two sites unassociated with the historic ranch were also recorded. These include a trachyte quarry and a possible Hawaiian encampment.

Puʻu Waʻawaʻa's historic fencelines are very consistent in terms of fencing material. All are comprised of woven wire with a single top strand of barbed wire. There is, however, an important distinction in post types. The fenceline that runs along the base of the *puʻu* (likely the original paddock boundary, as shown on the 1948 paddock map) was originally constructed using wooden posts. T-posts have been added as replacements over time. Intra-paddock fences, however, are almost exclusively supported by t-posts, and appear to have been originally constructed in that manner. The intra-paddock fences that subdivide the *puʻu* appear to post-date the original boundary fence. They are not, however, as new as the intra-paddock fences observed in Aiea Unit. Rather, they appear to represent an intermediate style comprised of woven wire and t-posts, possibly dating to 1950. Many of these fences are probably associated with development of the trachyte quarry.

Because of the orientation of the corridors and the dispersed location of the features within the corridor, the unit was divided into quadrants to facilitate presentation of AIS results (Figure 52). Each of the four quadrants is discussed below, moving clockwise around Puʻu Waʻawaʻa cinder cone.

## 6.1 Quadrant 1

Quadrant 1 consists of the heavily furrowed northwest quarter of Puʻu Waʻawaʻa. The fence corridor crosses through this quadrant at the base of the northwest face of the *puʻu* and along the 3200 foot elevation contour southeast and above the Puʻu Waʻawaʻa Ranch complex. A short section of corridor running with the slope of the *puʻu* along a ridge connects the two sections that follow the contours of the *puʻu*. Within this quadrant, the corridors run across and down the steep and heavily vegetated northwest face of the *puʻu*. The survey corridor intersects a wire fenceline in the northern portion of the quadrant and a small rock platform (Site 30305) was observed 20 meters from the northern edge of the corridor. The rock platform is outside the undertaking APE. It was mapped and recorded and is described in Appendix A.

### 6.1.1 Fence 6: Hill, Kukui, or Big Hay Field Paddock Fence

Fence 6 intersects the fenceline corridor near the base of the north end of the *puʻu* (Figure 52). The fence is on a north-south orientation and consists of three strands of new barbed wire with four-point barbs on two twisted strands. These strands are suspended by mixed t-posts and wooden posts (Figure 53). The uncorroded and "new" appearance of the wire and the use of mixed

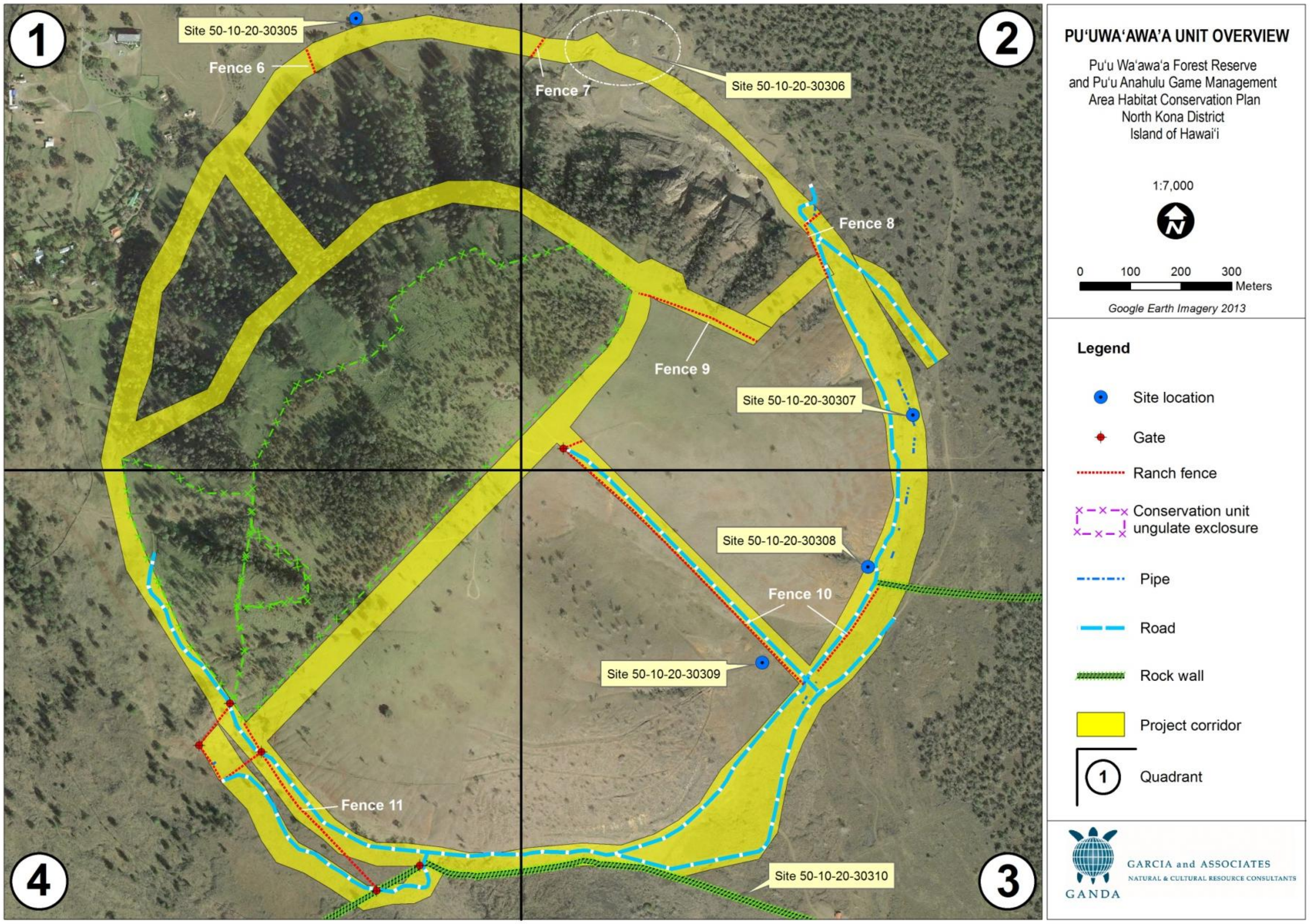


**Figure 52. Map of fenceline corridors, feature locations, and quadrant divisions of the Pu'u Wa'awa'a Unit.**

**Figure 53. Fence 6, facing south.**

wooden and metal t-posts suggest the fence has been recently fixed and is a portion of a paddock used by the current ranch to graze horses. According to the 1948 Puʻu Waʻawaʻa paddock map, Fence 6 may correspond to the location of a partitioning fence between the large Hill Paddock (which encompassed the entire *puʻu*) and the small Kukui Paddock or, alternatively, an enclosure identified as the "Big Hay Field".

## 6.2 Quadrant 2

Quadrant 2 encompasses the northeast face of Puʻu Waʻawaʻa. The north slope of the hill in this quadrant is also heavily furrowed. The fenceline corridor continues along the base of the hill from Quadrant 1. A small section of the corridor branches off to the southeast and terminates at a dirt road. Higher on the slope of the hill, the corridor continues along the 3200 foot contour line to the southeast and branches off with a section running up-slope along an existing conservation area fence to the top of Puʻu Waʻawaʻa. The other branching section runs southeast for about 230 m, then turns northeast and runs down-slope to the base of the *puʻu*. Sections of several fencelines, roads, and waterlines were observed within the survey corridors. At the north end of Quadrant 2, the corridor runs through an abandoned trachyte quarry at the base of the hill. A possible Hawaiian rock feature was recorded in the middle of the corridor at the eastern end of Quadrant 2.

### 6.2.1 Fence 7: Northern Quarry Boundary

Fence 7 is located at the northern boundary of the trachyte quarry at the northwest end of Quadrant 2. The fence crosses the corridor on a roughly northeast-southwest orientation. The fence consists of woven wire with a single top strand of barbed wire hung on mostly metal t-posts (Figure 54). The fence was built on a graded surface. Fence 7 does not appear to be associated with any paddock alignments shown on historic paddock maps and most likely functioned as a boundary fence for the quarry.

### 6.2.2 Fence 8: Southern Quarry Boundary and Hill Paddock Fence

Fence 8 marks the southern boundary of the quarry and is a portion of the Tamaki 1, Tamaki 2, and Hill Paddock fenceline. The section marking the southern boundary of the quarry crosses through the project corridor on a northeast-southwest bearing. Fence 8 then turns ninety degrees to the south and runs along the base of the *pu'u* for approximately 355 m. It then turns west and runs up the *pu'u* to intersect Fence 9 and terminates at Fence 10 near the top of the *pu'u*. Along the quarry boundary are two metal gates attached to metal posts. One is a small gate for pedestrians and the other consists of two welded metal tube panels that span an unpaved road (Figure 55). Fence 8 continues south for approximately 340 m before turning 90 degrees west out of the corridor and up the side of the *pu'u*, connecting to Fence 9. Fence 8 is constructed of woven wire with a single top-strand of barbed wire. The wires are hung on metal t-posts with intermittent wooden posts (Figure 56). The barbed wire is corroded and consists of four barbs on two twisted strands. The portion of Fence 8 running along the base of the hill appears to align with the Tamaki 1 and Hill Paddock boundaries shown on the 1948 paddock map (Figure 4).

### 6.2.3 Fence 9: Tamaki 1 and Hill Intra-Paddock Fence

Fence 9 is attached to the northeast corner of the Pu'u Wa'awa'a Conservation Unit fence. There is a wooden gate at this junction (Figure 57) from which the fence runs down the southeast face of the *pu'u* and connects to the chute and corral complex (Site 30308) (Figure 58). This fence was constructed from woven wire hung on metal t-posts with intermittent wooden posts with a single top-strand of barbed wire. The barbed wire is corroded and consists of four barbs on two twisted strands. The woven wire has been dislodged from the posts. This fence corresponds generally with the Tamaki 1 and Hill Paddock boundaries on the 1948 paddock map (Figure 4). However, the fenceline differs somewhat from the 1948 paddocks and may represent a change in paddock design on the *pu'u* in recent times (i.e., post-1948).

### 6.2.4 Roads and Waterlines

Aside from the minor roads associated with the trachyte quarry, two unpaved ranch roads run through the survey corridor. This includes a portion of grass covered road that runs through the gate at the southeast end of the quarry and continues along Fence 8 and the base of the *pu'u*. The corridor also parallels an unpaved road that branches off the first road just southeast of the gate running through Fence 8 and connects to another unpaved access road about 125 m east of the base of the *pu'u* (Figure 52). The road at the base of the *pu'u* is currently used as a hiking trail and may coincide with the trail shown on the 1923 Puu Anahulu Quadrangle. This trail ran around the base of the *pu'u* and connected to several historic trails that converged on Pu'u Wa'awa'a from different directions. No evidence of trails corresponding to the trails shown on the 1923 Puu Anahulu Quadrangle was observed during the AIS.

**Figure 54. Fence 7 at northern boundary of quarry, facing southwest.**

**Figure 55. Metal gate in Fence 8 along the quarry boundary, facing southeast.**

**Figure 56. Fence 8, facing northwest.**

**Figure 57. Wooden gate at point where Fence 9 attaches to the modern conservation unit enclosure fence on Pu‘u Wa‘awa‘a.**

**Figure 58. Fence 9 near junction with the chute and corral complex (Site 30308).**

Sections of a waterline comprising galvanized pipe were observed crossing the north end of Fence 8 (Figure 59) in the survey corridor and then running through the center of the L-shaped mound (Site 50-10-20-30307) (Figure 60). The sections of pipe follow a northwest-southeast orientation through the middle of the corridor from the quarry to Site 30307. Most of this pipe has been broken, buried, or removed. The existing pipe alignments coincide with waterlines sketched by informant Miki Kato (Appendix B).

### 6.2.5 Puʻu Waʻawaʻa Trachyte Quarry (Site 50-10-20-30306)

Remnants of a historic trachyte quarry are located at the base of the northern face of Puʻu Waʻawaʻa in Quadrant 2 (Figure 52). This quarry was operated by Volcanite Ltd., from the mid 1950s through 1988 under General Lease No. 3528, obtained at auction by Volcanite Ltd., in 1955. Lease No. 3528 included approximately 500 acres of land, upon which Volcanite LTD. mined trachyte for use as construction aggregate. Mining activities presumably commenced soon after issuance of the lease in 1955. Local informant Miki Kato, who worked for Puʻu Waʻawaʻa Ranch at the time, indicated that several areas around the *puʻu* were bulldozed. He stated that portions of the top of the *puʻu* were dozed counter to the lease agreement. A historical USDA aerial photograph of Puʻu Waʻawaʻa indicates that by 1964 the current site of the quarry had been extensively graded and developed and intensive mining operations were underway (Figure 63). This photo also shows three distinctive features including the Quonset hut, a truck wash station, and the operations office. Remnants of these are still present on the site.

**Figure 59. Galvanized pipe waterline running through Fence 8 at southeastern boundary of quarry, facing northeast.**

**Figure 60. Galvanized pipe waterline running through Site 30307, facing north.**

The fenceline corridor passes through the middle of the large abandoned quarry, running south of the buildings along the northeastern edge of the large open barrow pit (Figure 61). The quarry site currently consists of a large open barrow pit, several unpaved and broken asphalt roads, numerous graded surfaces (including remains of a truck washing area), spoil/refuse piles, two buildings, and other quarry related infrastructure features. Detailed descriptions of some of these features are presented in an Environmental Site Assessment conducted by the USDA (USDA Forest Service Enterprise Program, ETS 2009). Updated description of these features and additional data collected on the quarry during the present AIS is provided below.

#### *6.2.5.1 Barrow Pit*

The barrow pit runs along the base of the cinder cone southeast of the quarry buildings. This large pit is approximately 230 m long and 70 m wide and opens to the west. Quarry excavations cut into the base of the hill leaving steep, unstable faces. The edges of the quarry have collapsed in several places and landslides from the exposed portion of the *puʻu* above the quarry have partially filled the large pit (Figure 62). Historic aerial photographs from 1964 (Figure 63) and 1976 (Figure 64) indicate that while quarrying had initially cut into the side of the *puʻu*, excavation of the barrow pit did not begin until after 1976.

#### *6.2.5.2 Roads, Graded Surfaces, and Spoil Piles*

The entire surface of the site was modified as a result of trachyte mining activities. These activities have left roads, graded and leveled areas, and spoil piles composed of mixed soils, concrete, boulders, and scrap metal. These features are interconnected and distributed throughout the site (Figure 67).

Minor unpaved and partially paved roads weave throughout the quarry site and facilitate circulation (Figure 65). Graded and leveled surfaces are also located throughout the quarry and provided platforms for the operation of quarry and mining equipment, material storage, and construction of support facilities (Figure 66). This included a partially paved truck washing area located in the middle of the site. The large rectangular feature measures approximately 36 m long and 8 m wide (see Figure 61 and Figure 67) The large-scale grading and excavation activities also left large spoil piles. These are distributed throughout the site and contain various forms of refuse including metal construction materials, remnants of equipment and vehicles, and broken concrete (Figure 68).

#### *6.2.5.3 Quonset Hut*

Two standing buildings are present at the quarry site. These include a Quonset hut made of corrugated metal sheeting and wood and a cinder block office. The Quonset hut is located 65 m southeast of Fence 7 (Figure 67 and Figure 70) within a fenced area that contained ornamental trees and shrubs, metal storage tanks (Figure 69), and piles of discarded rubbish and construction materials (Figure 71). The structure consists of a steel frame covered by an arched corrugated steel exterior with several wood framed windows and doors (Figure 72 and Figure 73). The ends of the rectangular hut are capped by wooden walls (Figure 74). The structure is 12 m long and 6 m wide and the interior consists of three bedrooms, one bathroom, a common area, and a kitchen area. The structure is supported by wooden beams and posts on concrete footings (Figure 75).

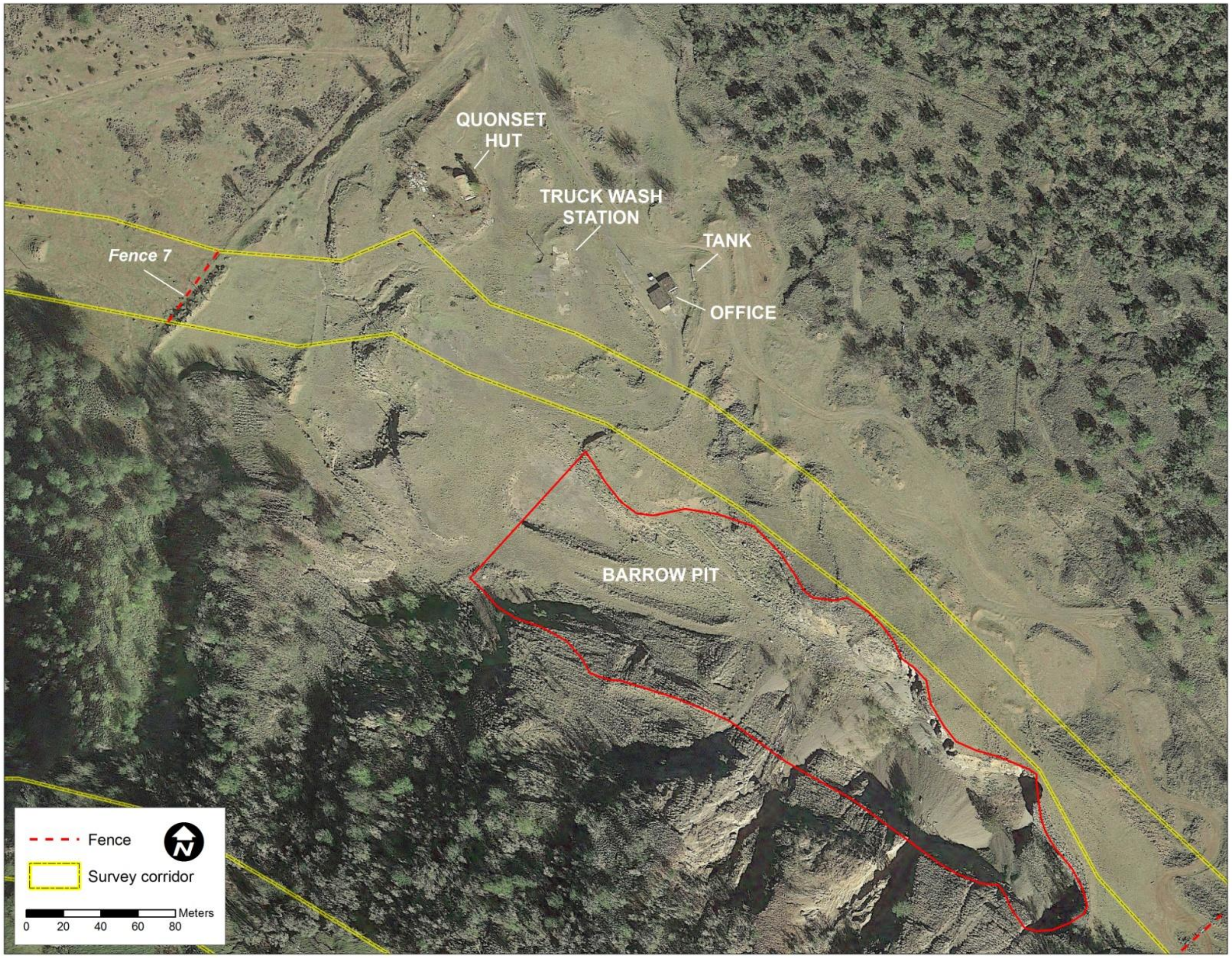


**Figure 61. Quarry site showing location of features and fenceline corridor.**

**Figure 62. Barrow pit at the base of Pu‘u Wa‘awa‘a, facing southeast.**

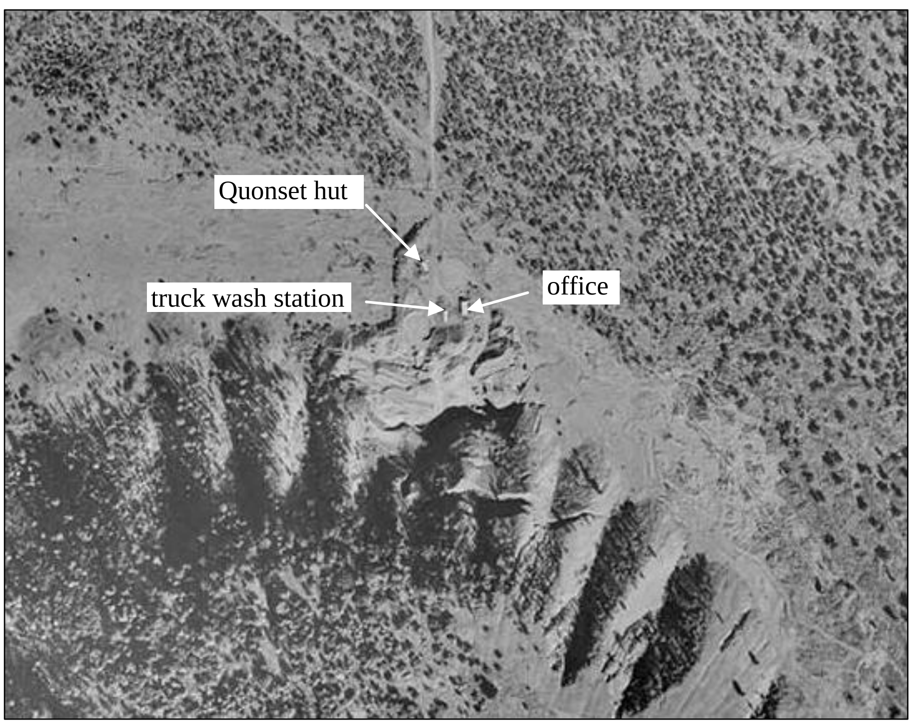


**Figure 63. A 1964 USDA aerial photograph of the northern portion of Pu‘u Wa‘awa‘a.**

**Figure 64. A 1976 USDA aerial photograph of Pu‘u Wa‘awa‘a with quarry shown at top right portion of figure.**

**Figure 65. Minor surface road at the northwestern boundary of the quarry, facing southwest.**

**Figure 66. Large graded area in the northwestern portion of the quarry site, facing northwest.**

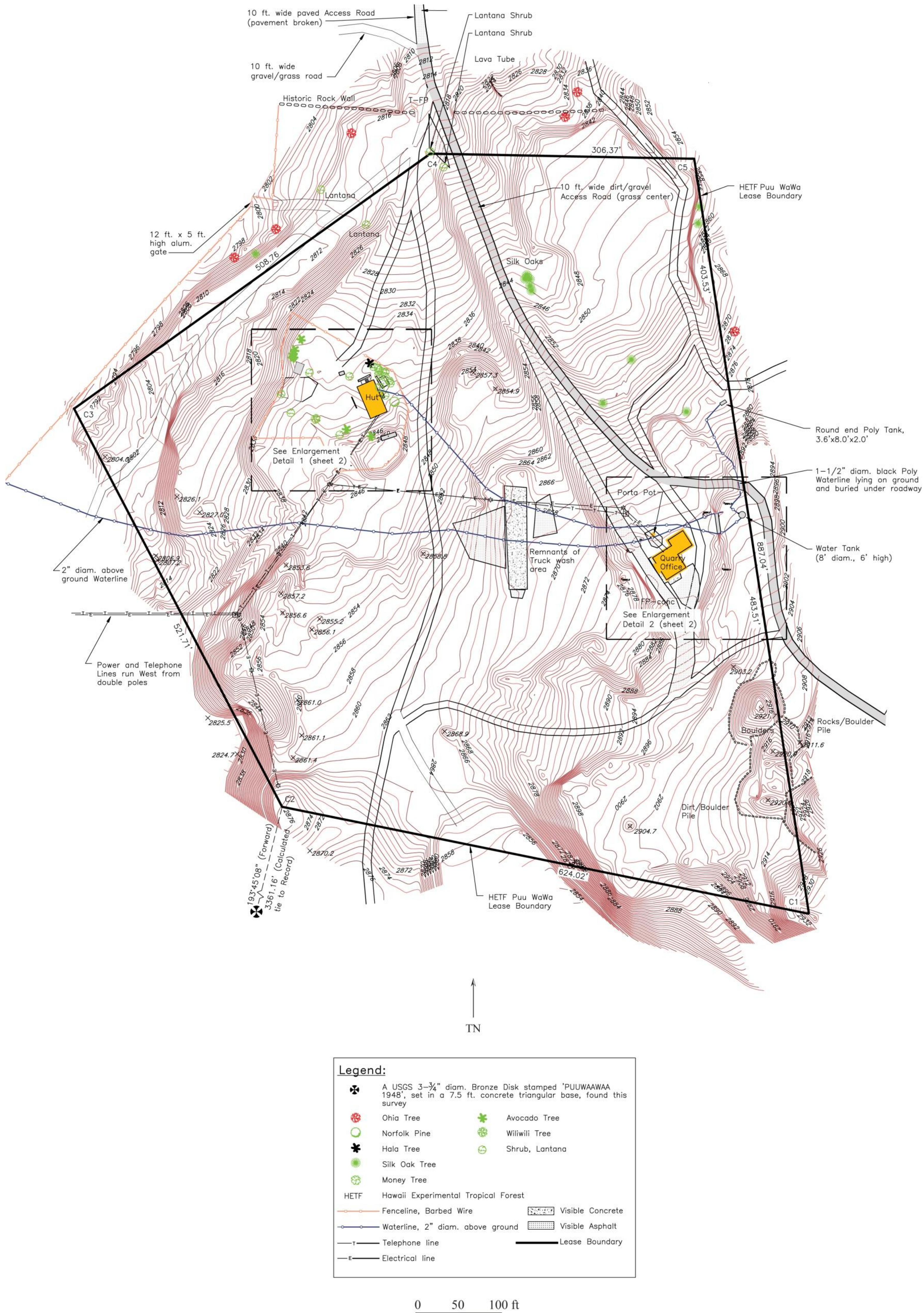


**Figure 67. Detailed map of quarry facilities (taken from USDA Forest Service Enterprise Program 2009:Appendix 16-2).**

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**Figure 68. Pile of broken concrete, rebar, and a large truck tire (left).**

**Figure 69. Large water tank behind Quonset hut, facing southeast.**

Enlargement Detail 1

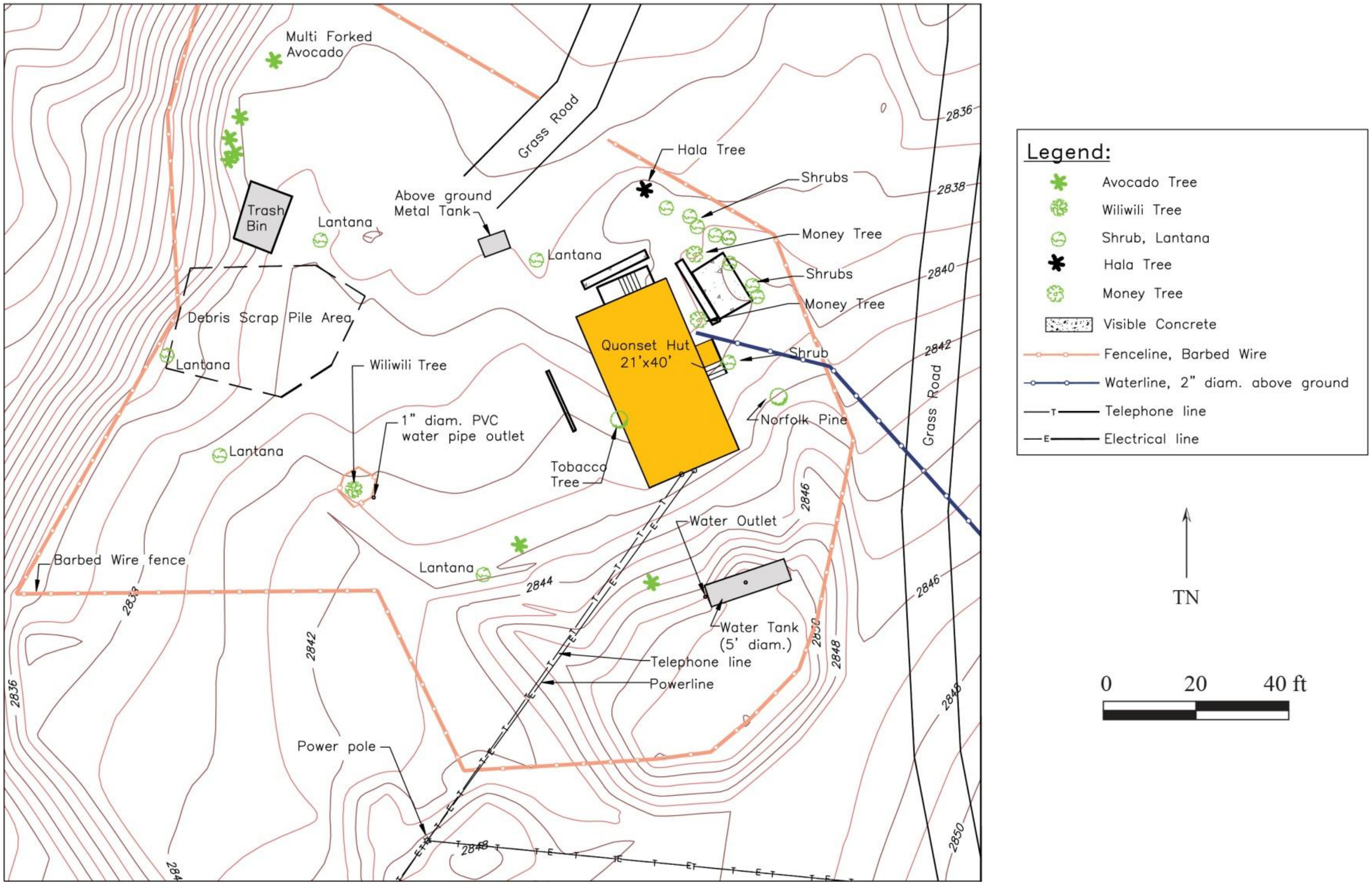



**Figure 70. Plan map of Quonset hut and associated features (taken from USDA Forest Service Enterprise Program 2009:Appendix 16-2).**

**Figure 71. Discarded corrugated sheet metal near hut.**

**Figure 72. Arch-framed Quonset hut with water tank, facing southeast.**

**Figure 73. Close-up of corrugated metal roof and wood-framed windows, facing northeast.**

**Figure 74. Southeast side of hut enclosed with wood framed wall and two windows, facing northwest.**

**Figure 75. Close-up of wooden support post and rock pier, facing southwest.**

According to a recent environmental assessment of the site conducted by the USDA Forest Service Enterprise Program (2009:5–6), the Quonset hut was maintained by the state as a quarters for visiting researchers and site workers and the interior of the structure was in fair condition with broken windows and a leaky roof that caused minor water damage. Currently, the Quonset hut is in poor condition and has deteriorated significantly since 2009. The doors and most of the windows have been broken and the wooden door and window frames are in an advanced state of deterioration (Figure 76). The interior of the hut is also in poor condition with extensive water damage.

#### *6.2.5.4 Quarry Office*

The quarry office is located approximately 50 m from the eastern boundary of the quarry and is accessed by a partially paved asphalt road (Figure 67 and Figure 78). The office is constructed of cinder blocks and mortar on a concrete slab and measures 47 feet long, 38 feet wide, and covers approximately 112 $m^2$. Most of the exterior of the building is covered with green paint and some red wooden letters are attached to the front of the building left of the entryway (Figure 77 and Figure 79). A prefabricated concrete roof covers most of the structure except for the northeast portion. This appears to be a later addition and consists of unpainted cinder block walls and a wood joist ceiling (Figure 80 and Figure 81). The interior of the structure has been gutted and all of the windows, doors, and fixtures have been removed (Figure 82). All of the floor tiles are loose and broken and it appears that cows, sheep, and goats regularly enter the structure.

**Figure 76. Broken door on northeast side of Quonset hut, facing southwest.**

**Figure 77. Quarry office, facing northeast.**

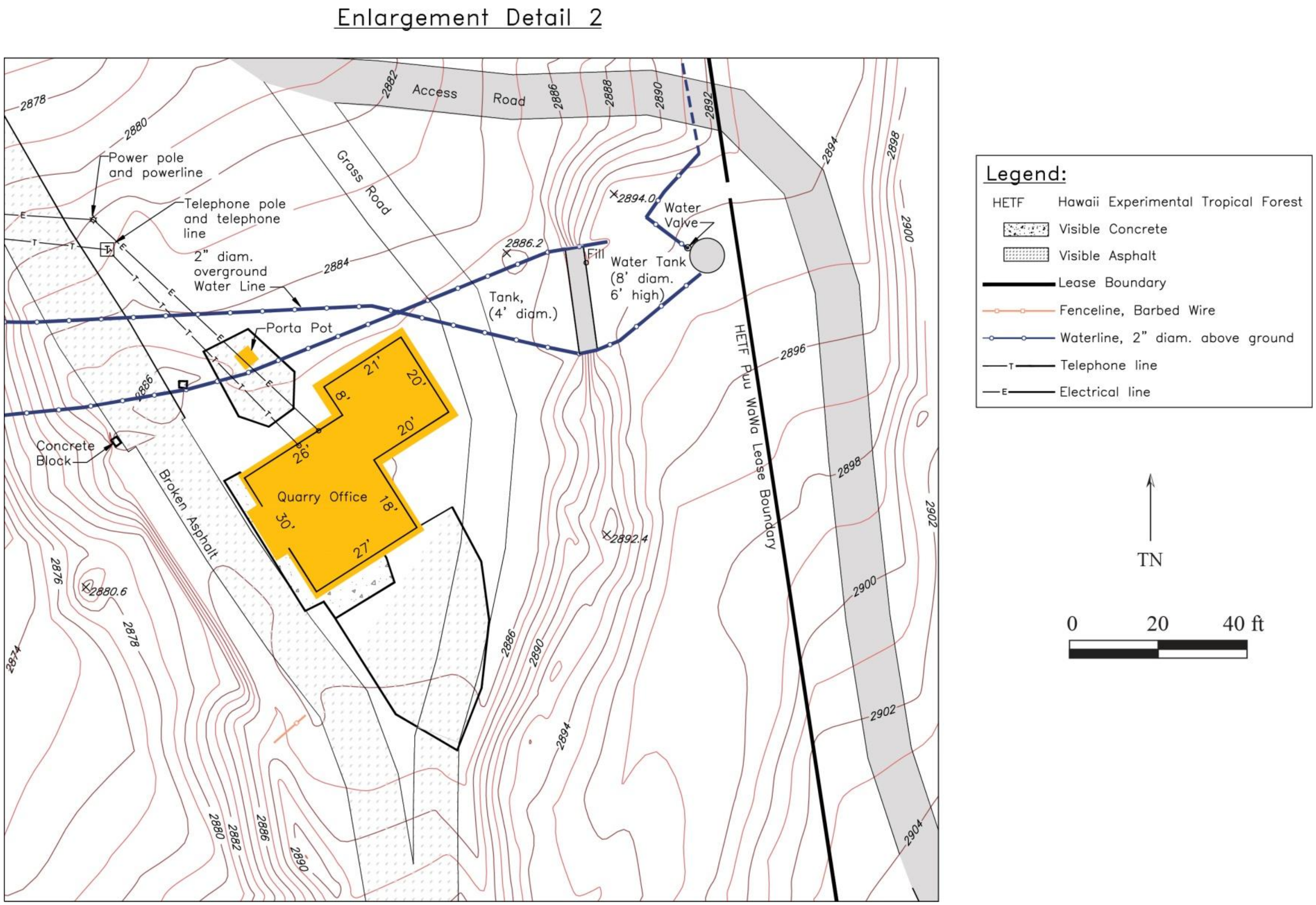



**Figure 78. Plan map of quarry office and surrounding features (taken from USDA Forest Service Enterprise Program 2009:Appendix 16-2).**


**Figure 79. Wooden letters attached to wall of office near entrance, facing northeast.**

**Figure 80. Northeast portion of quarry office with unpainted wall and wood joist ceiling.**


**Figure 81. Close-up of addition walls and eves.**


**Figure 82. Main room of quarry office.**

Other features located near the office include a large partially-buried water storage tank (Figure 83), broken asphalt and gravel roads, concrete slabs, and overhead power and telecommunication lines. A portable toilet has been placed near the building.

#### *6.2.5.5 Conclusion*

Quarry operations began in the mid-1950s and the Quonset hut, office building, and truck washing station were erected sometime before 1964. The quarry pit appears to have steadily expanded in size over time and currently reflects its maximum operational size in the late 1980s.

According to Kuʻulei Keakealani, a local informant interviewed during the AIS, the quarry was a large operation and mainly employed people from Puʻu Anahulu. She said this included some of her uncles and she could also remember the green and orange trucks of Volcanite LTD. constantly coming and going.

Currently, the site and its various features are in poor condition. It appears that when the site was abandoned, quarry related refuse, materials, and equipment were left behind and buried. Erosion and collapse of the steep sides of the quarry pit have expanded the edges of this feature during the decades following abandonment. Although the Quonset hut was briefly maintained by the state, it has since fallen into disrepair. The office structure has also fallen into disrepair and is also in poor condition. Aside from these two structures, the large quarry pit, scattered refuse, and buried materials and equipment, other visible remnants of the quarry include roads, leveled areas, wooden utility poles, and storage tanks. Site abandonment activities (e.g., stripping valuable

**Figure 83. Partially buried tank northeast of quarry office, facing northeast.**

fixtures and materials) from standing structures, grading, burying useless equipment and materials, and the effects of erosion have changed the site's appearance so much that once easily recognizable features associated with quarrying activities are no longer visible.

### 6.2.6 L-Shaped Mound (Site 50-10-20-30307)

An L-shaped mound was recorded on the eastern side of Puʻu Waʻawaʻa, within the southeastern portion of Quadrant 2 (Figure 52). The mound is comprised of a large number of *ʻaʻā* cobbles and pebbles of various sizes arranged along a slope-break (Figure 84 and Figure 85). The feature is approximately 20 m long, 13 m wide, and ranges from 70 to 120 cm high (Figure 86). It has a 1 m break within which a 1.5-inch (3.5 cm) metal pipe runs on a northwest bearing (Figure 87). Although there is no direct evidence, it appears likely that cobbles were removed to allow the pipe to pass through the mound unobstructed.

One interior side of the mound exhibits what appears to be on-end slab facing, possibly associated with traditional Hawaiian encampment. The majority of the mound, however, is simply a concentration of cobbles and pebbles on a slope with no visible facing or intentional modification. Despite the slab facing, a historic origin for the feature was considered a reasonable possibility given the amount of historic landscape modification in the area (e.g., ranching activities, commercial quarrying). Test excavation was therefore conducted to seek empirical evidence for cultural affiliation and function.

#### *6.2.6.1 Test Excavation Results*

A 1 x 1 m test unit was excavated in the interior of the L-shaped mound. The unit was positioned against what appears to be a faced interior wall. This location was selected on the rationale that it would have the highest likelihood of producing archaeological remains, if any were present.

The test unit was excavated in arbitrary 20 cm levels using trowel and shovel. Two levels were excavated and the unit was terminated at the base of Level 2 (40 cm depth). Stratigraphy consisted of one layer of very rocky silt. *ʻAʻā* cobbles and pebbles comprised approximately 80 percent of the unit by volume. The interstitial sediment was a very dark brown (7.5YR 2.5/2) silt. Roots were present in the upper 10 cm. In Level 2, the sediment percentage increased somewhat, but the matrix was still very rocky. A few small pieces of charcoal were found in Level 2. These are most likely naturally occurring eco-facts, possibly from root burn associated with grass fires. No artifacts or cultural features were observed in the test unit. Complete technical description of the excavated sediments is presented in Figure 88. Also included in the figure are a wall profile and plan maps of the ground surface and base of excavation. Note that the rocks shown are only those that broke the surface and were clearly visible. Both sidewalls and excavation base were very rocky with only a very thin layer of overlying silty sediment.

#### *6.2.6.2 Conclusion*

The outward form and shape of Site 30307 appears intentionally designed. However, close inspection of the arrangement and size range of the constituent cobbles indicates that most of this feature is naturally occurring. There is no evidence of large-scale historic land alteration (e.g.,

**Figure 84. East side of Site 30307 *ʻaʻā* mound. View to west.**

**Figure 85. Profile of Site 30307, showing elevation change. View to south-southeast.**

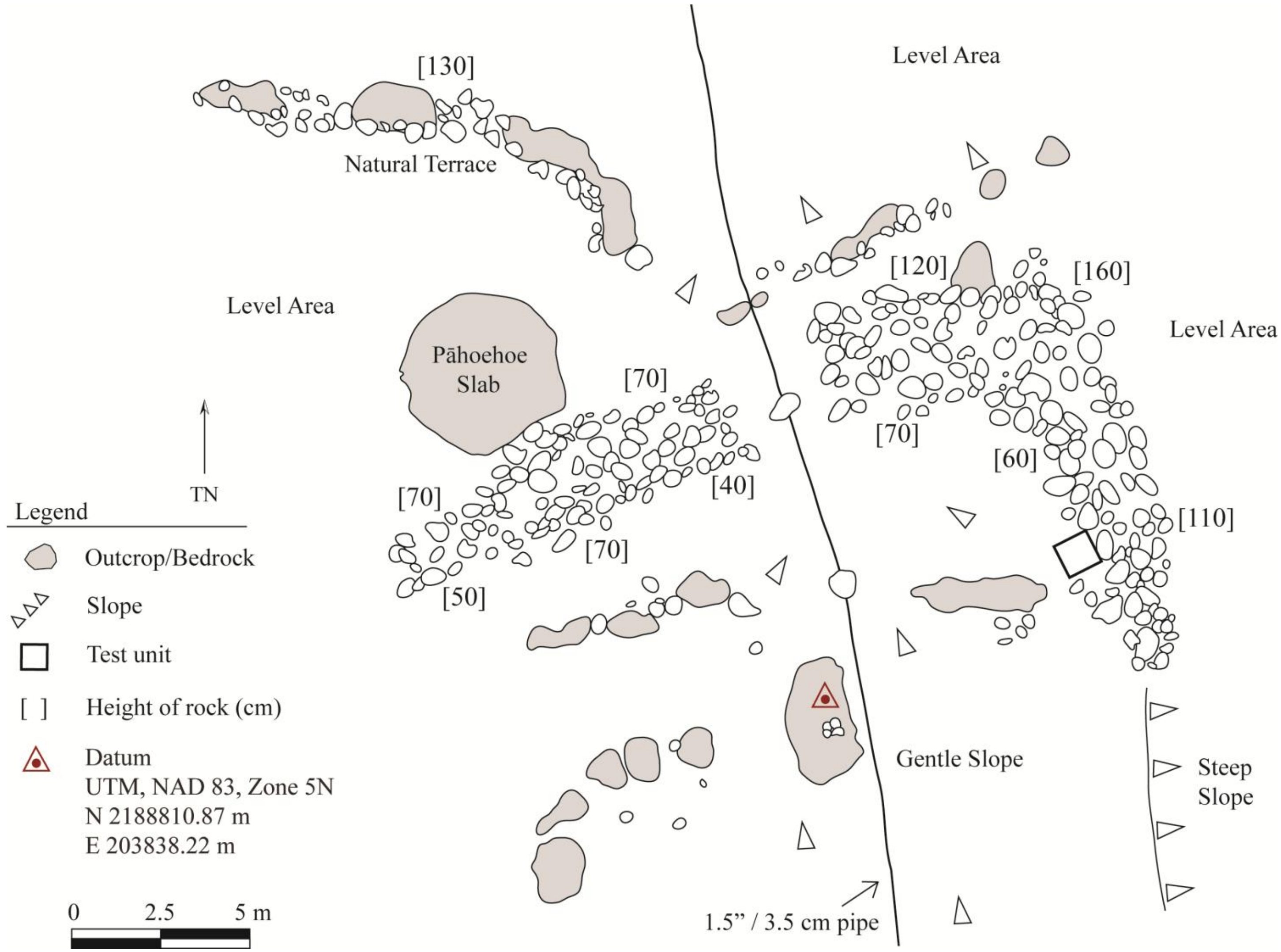



**Figure 86. Site 30307, L-shaped mound, water pipeline, and test unit location.**

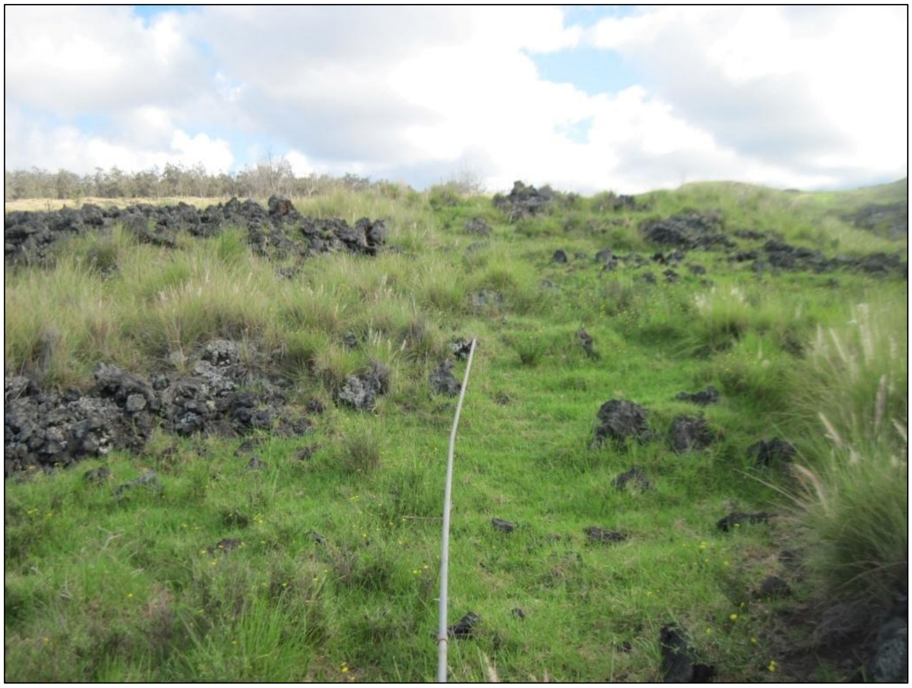
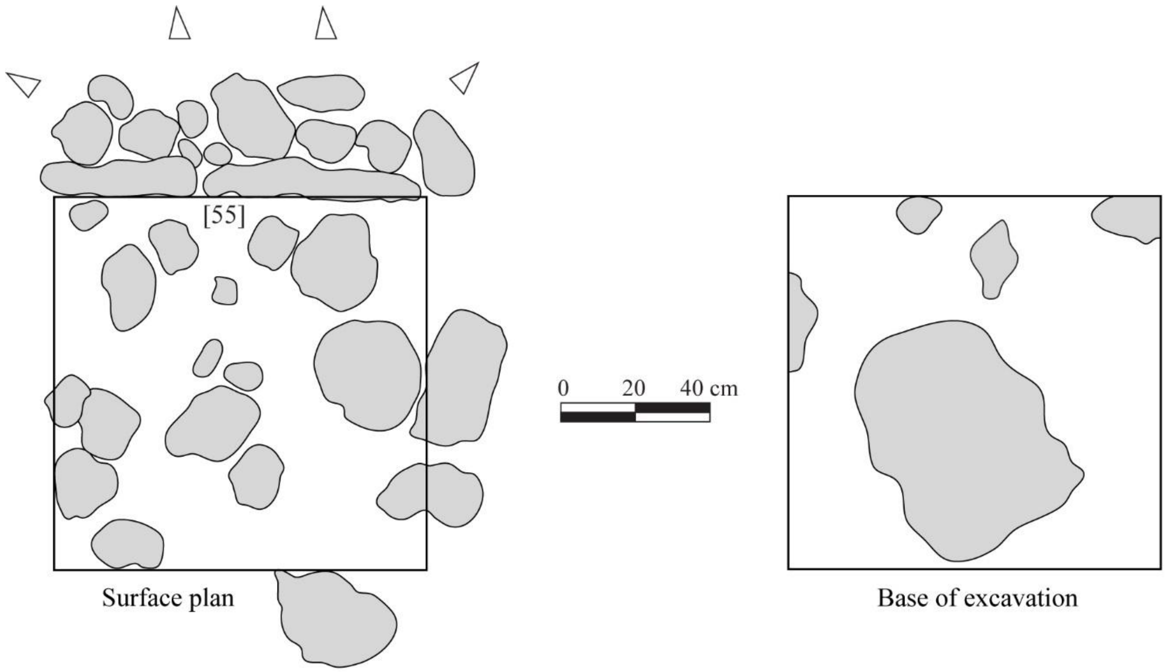


**Figure 87. Galvanized water pipe running through Site 30307. View to south.**




Level 1: 0-20 cm; 7.5YR 2.5/2 (very dark brown); very rocky sediment; aa cobbles and pebbles (3-15 cm in diameter) with 20% interstitial sediment (loose silt, pea-size structure); grass roots in upper 10 cm; no cultural material.

Level 2: 20-40 cm; 7.5YR 2.5/2 (very dark brown); very rocky; same as Level 1 but with more silt up to 50%; small charcoal pieces found in screen (n=6) and appears to be part of natural deposit; no cultural material.

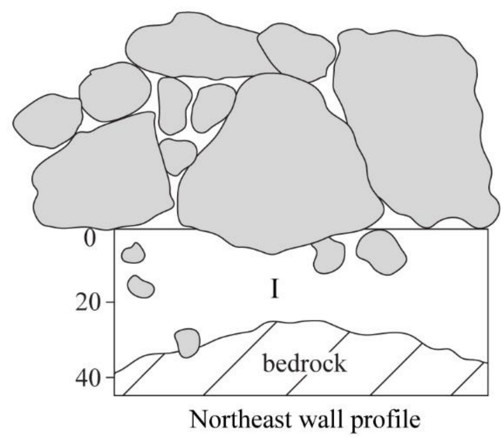



**Figure 88. Excavation data for Site 30307, Test Unit 1.**

bulldozer push piles) in the immediate vicinity. The mound also does not resemble a pile dumped from the bed of a truck. The interior of the L, however, does exhibit a well-formed wall, several cobbles of which may have been intentionally placed on end. This portion of the feature may be associated with traditional Hawaiian temporary encampment at the site, although test excavation produced no supporting evidence for this interpretation. This absence of data, however, does not necessarily mean the feature is not of Hawaiian origin. Temporary encampments would not be expected to produce substantial deposits and often contain no material at all.

Pending further investigation, the L-shaped mound is interpreted as a traditional Hawaiian shelter associated with temporary encampment, possibly in support of volcanic glass or other resource procurement activities.

## 6.3 Quadrant 3

Quadrant 3 encompasses the southeast face of Puʻu Waʻawaʻa. The south and east slopes of the hill are relatively smooth and unfurrowed when compared to the north face. The crater of the cinder cone opens to the southeast and forms a large gully in this quadrant. The survey corridor continues along the base of the hill from Quadrant 2, and branches off to the northeast, running up the *puʻu* along a ranch road to the top of the cinder cone. There it connects to a section of the survey corridor that crosses over the *puʻu* in a southwesterly-northeasterly direction (Figure 52).

Sections of a wire fenceline, roads, and waterlines were observed within the survey corridor of this quadrant. At the east end of Quadrant 3 the corridor runs through a historic chute and corral complex, and at the south end runs along a historic rock wall (Site 30310). A historic cistern (Site 30309) was observed 26 m southwest of the corridor segment that runs up the *puʻu* parallel with Fence 10 and an unpaved ranch road. Although not in the APE, the cistern was recorded during the AIS and is described in Appendix A.

### 6.3.1 Fence 10: Hill Intra-Paddock Fence

Fence 10 runs southwest from the chute and corral complex (Site 30308) along the ranch road than runs around the base of the *puʻu* (Figure 89) to an intersection where the fence runs up the cinder cone in a northwesterly orientation along another ranch road (Figure 90) to the top of the hill. At the top of the hill, Fence 10 ends at a fallen metal gate (Figure 91).

At the base of the *puʻu*, Fence 10 runs along the edge of a ranch road. This road is covered with grass and it appears that it has never been graded. The location of this road appears to coincide with a trail that runs around the base of the *puʻu* shown on the 1923 Puʻu Anahulu Quadrangle (Figure 15). Where Fence 10 runs up the *puʻu*, it runs along the southwest edge of a ranch road that has been cut into the southwestern slope of the interior portion of the cinder cone.

Fence 10 was built from a combination of metal t-posts and wood posts. Wooden posts were not used in the portion of the fence running up the hill. Both sections of fence consisted of woven wire with a single top-strand of barbed wire. The barbed wire is corroded and consists of four barbs on two twisted strands. According to the 1948 paddock map (Figure 4), Fence 10 appears to be an intra-paddock fence within the Hill Paddock.

**Figure 89. Section of Fence 10 running to Site 30308, facing northeast.**

**Figure 90. Fence 10 at base of *pu‘u*, facing northwest.**

**Figure 91. End of Fence 10 at top of *pu'u*, facing west.**

### 6.3.2 Roads and Waterline

Proposed fenceline corridors in Quadrant 3 run along portions of three unpaved ranch roads (Figure 52). These include two interconnected roads that run around the base of the *pu'u* (Figure 92) and a road that runs up to the top of the *pu'u* through the interior portion of the cinder cone (Figure 93).

The location of the road at the toe of the *pu'u* appears to coincide with a trail that ran around the base of the *pu'u* shown on the 1923 Pu'u Anahulu Quadrangle. This trail was connected to several historical trails including the Kiholo, Hualalai, and Old Pu'u Wa'awa'a-Keamuku trail. Sections of this road are covered with grass and are ungraded with branching alternative routes.

Sections of a galvanized waterline were observed along the east and southeast side of the road running along the toe of the *pu'u* within the survey corridor. This line runs from the L-shaped mound (Site 50-10-20-30307) (Figure 60) to Site 30308. A short section was also observed running across the base of the road that runs to the top of the *pu'u*. All of the pipe has been broken, buried, or removed. The existing pipe segments coincide with waterlines sketched by informant Miki Kato (see Appendix B).

**Figure 92. Road around base of Pu‘u Wa‘awa‘a, facing northeast.**

**Figure 93. Road into interior of Pu‘u Wa‘awa‘a running along Fence 10, facing northwest.**

### 6.3.3 Chute and Corral Complex (Site 50-10-20-30308)

This historic chute and corral complex (Site 30308) is located on the southeast side of Puʻu Waʻawaʻa (Figure 52). This ranching complex consists of a cattle chute, corral, two roughly circular arrangements of preformed concrete footings, a road, and associated fences (Figure 94). During the onsite interview with Mr. Kato, he stated that he had built the chute in the late 1960s. A historic USDA aerial photograph from 1954 indicates that a larger facility was present at the site in the mid-1950s (Figure 95). However, this photograph is not detailed enough to determine whether the corral and chute complex was present in its current configuration. A more detailed 1964 photograph also shows the larger complex and a corral with a similar footprint as Site 30308 (Figure 96). The additional features shown on this photograph were located south of the rock wall (Site 30310). No remains of these features were found during the current AIS.

#### *6.3.3.1 Chute and Corral*

The wooden chute and corral, also known as cattle crush or squeeze chute, comprises the northern half of the site complex (Figure 97). The purpose of this feature was to safely hold livestock while being examined, given veterinary treatment, or marked.

The run portion of the chute leading to the narrow stall was built from large wooden posts and thick milled wooden planks and the sheltered stall is covered with a wood frame and corrugated sheet metal roof that is 265 cm high (Figure 98). This feature is integrated into the north and southeast corral fence. The entrance to the chute is located along the northeast fence of the corral and the sheltered stall is located along the southeast corral fence at the edge of the road running through the site. The planks measured 6.5 cm thick, 30 cm wide, and up to 5 m long (Figure 98). Posts for the chute range from 16–30 cm in diameter and average about 170 cm in height. Four planks were hung vertically on the wood posts to an average height of 135 cm in the sheltered portion of the chute (Figure 99). A wooden placard engraved with a “9” and a galvanized waterline are also attached to a post on the northwest side of the chute (Figure 100).

The corral portion of the complex consists of all-wooden fences. The corral is rectangular in shape and is 27 m long from the northwest fence to the sheltered chute and 25 m wide from the northeast fence to the southwest fence. There is also a fallen fence that runs from the northwest corner of the corral towards the northwest corner of the sheltered chute (Figure 94). Similar sized wooden posts were used for construction of the corral as for the chute, however, smaller planks consisting of mixed 12 and 6 foot, 2 x 4 inch or 2 x 6 inch studs were nailed between the posts. These were hung in four levels to a height of 115 cm (Figure 101).

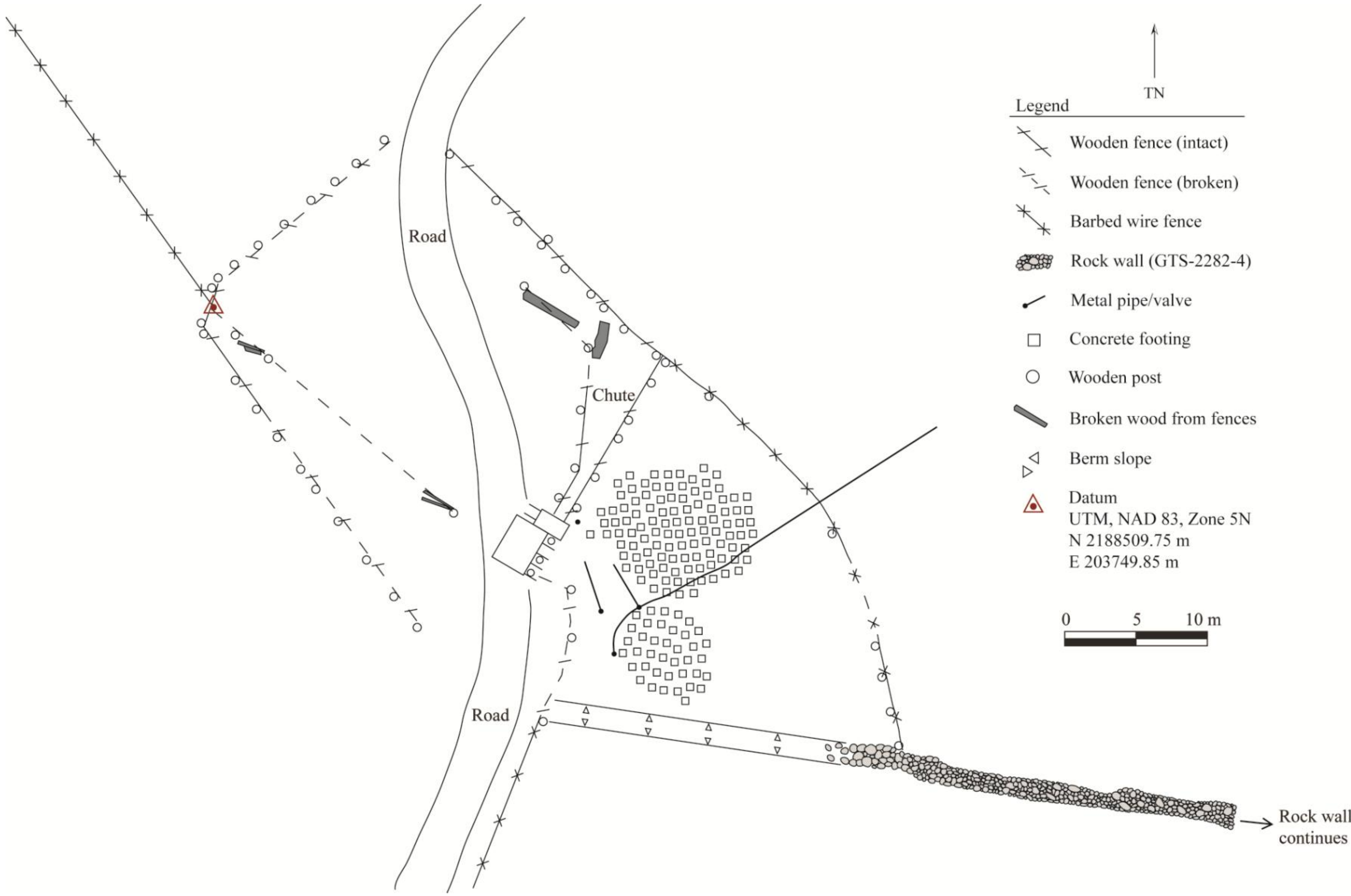



**Figure 94. Plan view map of Site 30308.**

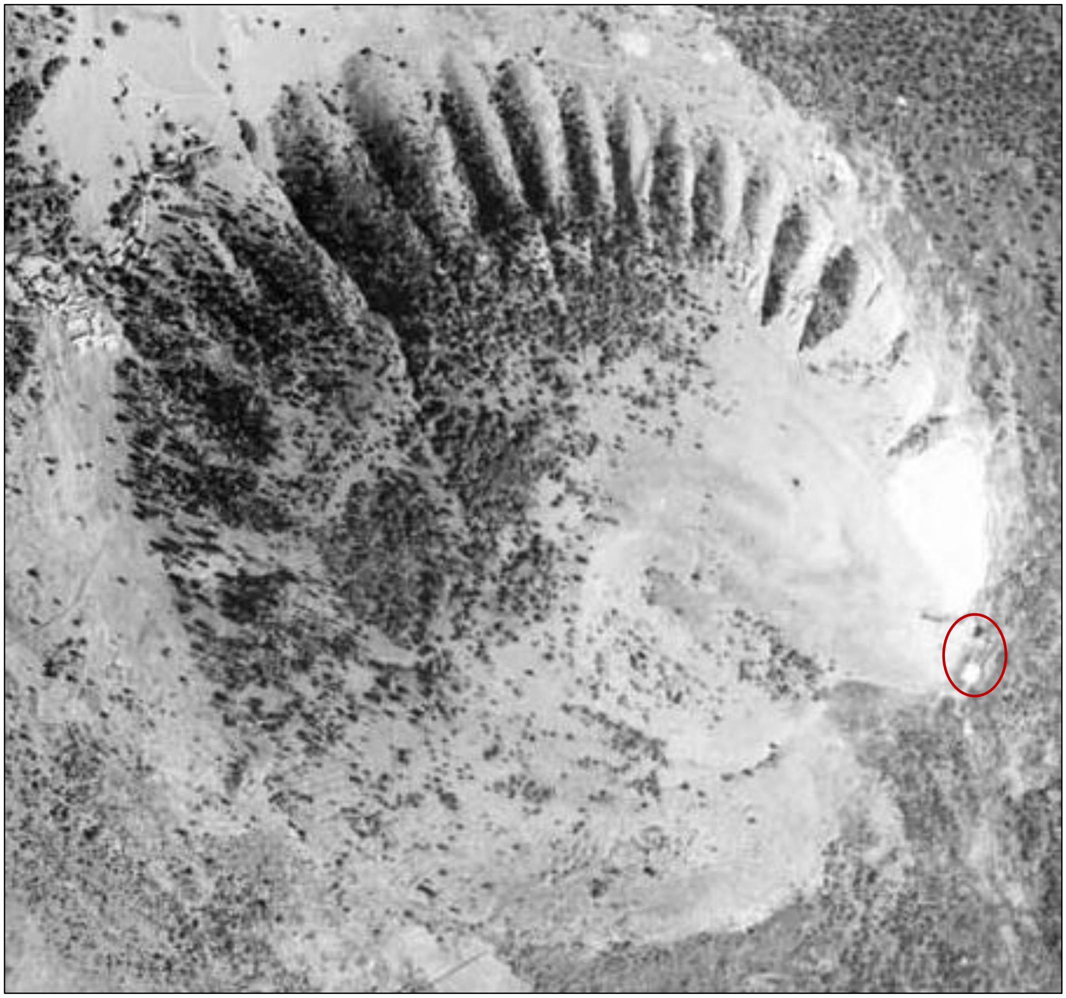


**Figure 95. 1954 USDA aerial photograph of Pu‘u Wa‘awa‘a. Site 30308 in red oval at far right.**

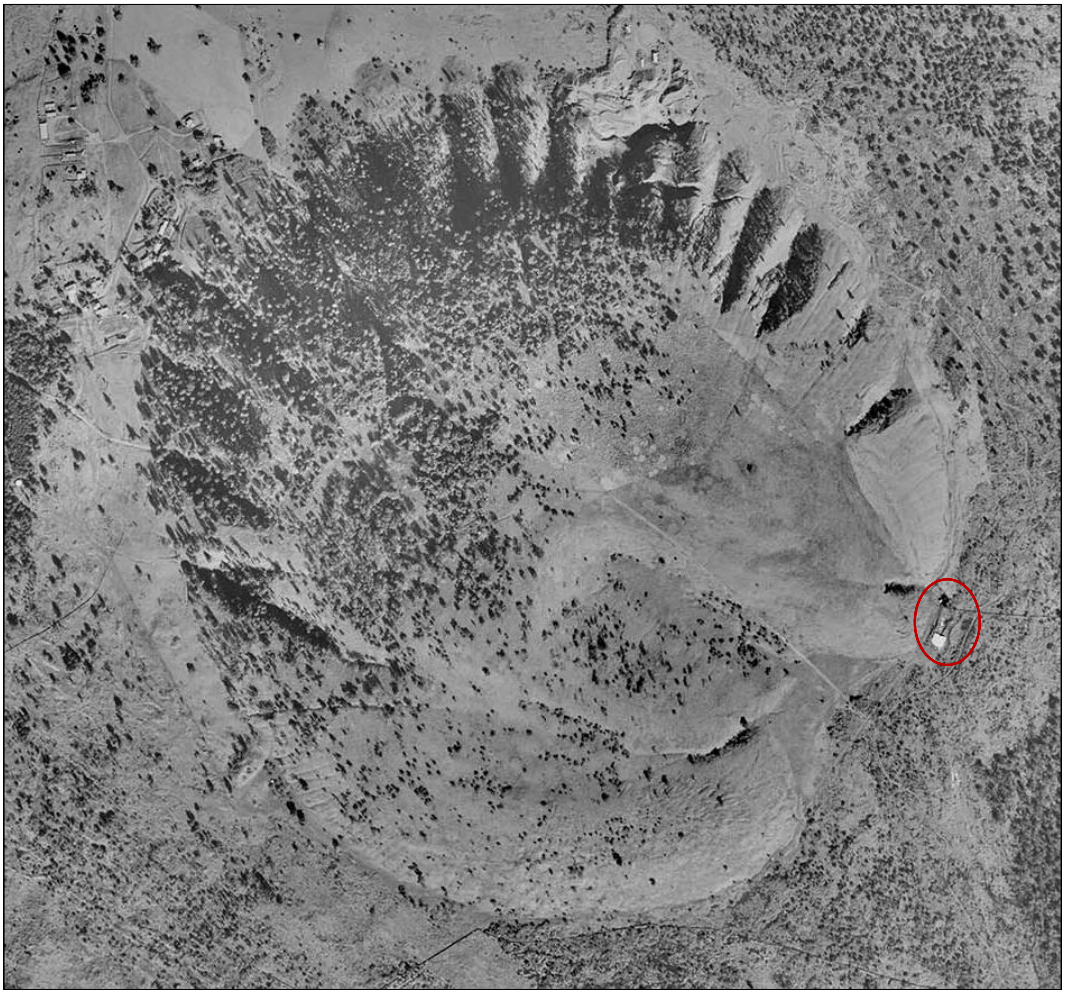


**Figure 96. 1964 USDA aerial photograph of Pu‘u Wa‘awa‘a. Site 30308 in red oval at far right.**

**Figure 97. Site 30308, facing north.**

**Figure 98. Sheltered stall of the chute, facing northeast.**

**Figure 99. sheltered section of the chute, facing southeast.**

**Figure 100. Close-up of engraved wooden marker and galvanized pipe waterline attached to support post of chute.**

**Figure 101. Northwest corner of corral, facing northwest.**

#### *6.3.3.2 Concrete Footings*

Two roughly circular arrangements of pre-formed concrete footings are located on the southeast side of the chute and corral. These are likely portions of post and beam foundations for large water tanks. The larger of the two is approximately 11 m in diameter and the smaller is about 8 m in diameter (Figure 94). In both arrangements, the footings have been laid out in rows and range from 90 cm to 100 cm apart (Figure 102). The concrete footings vary slightly in shape, being either cubical or trapezoidal, but are all similar in size (25 $cm^3$) (Figure 103). Galvanized pipe runs from each foundation to a single pipe that runs to the northeast away from the site (Figure 104). Both foundations are enclosed by the southeast chute fence, two barbed wire fences, and a rock wall (Site 30310). On the east side of the smallest foundation, Fence 8 is attached to the southwest corner of the chute and runs southwest. West of the foundation footings, a wire fence runs from the southeast corner of the chute and corral to a wooden post placed next to the rock wall (Site 30310). Both Fence 8 and the wire fence enclosing the foundations were constructed from woven wire hung on metal t-posts with intermittent wooden posts with a single top-strand of barbed wire. The barbed wire is corroded and consists of four barbs on two twisted strands. In some places, the woven wire has been dislodged from the posts.

#### *6.3.3.3 Connected Features*

Two wire fences and a rock wall (Site 30310) connect or terminate at the chute corral complex. Fence 8 connects to the northwest corner of the corral (Figure 105), Fence 10 connects to the southeast end of the chute (see Figure 97), and a rock wall (Site 30310) extends east from the end of a wire fence south of the concrete footing blocks (Figure 106).

**Figure 102. Concrete footings laid out in rows, facing north.**

**Figure 103. Close-up of one of the concrete footings, waterline, and a valve.**

**Figure 104. Galvanized waterline running from the foundations to the northeast.**

**Figure 105. Barb wire fence northeast of foundation footings, facing northeast.**

**Figure 106. End of wire fence at rock wall (Site 30310), facing southeast.**

#### *6.3.3.4 Conclusion*

This site complex was a focal point for various ranch related activities. First, the chute and corral were built for examining and working with livestock. Second, the clusters of foundation footings and associated waterlines served to distribute water to paddocks surrounding the site.

The sheltered chute is in good condition and would require minor repairs to be functional. Most of the wood fencing for the corral has collapsed, however, and the gates where the road crosses through the corral have been removed.

The water storage tanks supported by the footing are gone. Aside from a piece of sheet metal, all materials from the structures have been completely removed from the site. According to Mr. Kato, he built the chute in the late 1960s. However, aerial photographs indicate that the site may have been in use at least since 1954. These photographs also indicate that more features were present at the site from 1954 until sometime after 1964. While much of the original site has been removed, Mr. Kato's work on the site during the late 1960s suggests that use of the corral and chute continued into the modern period.

## 6.4 Quadrant 4

Quadrant 4 encompasses the southwest face of Pu‘u Wa‘awa‘a and the slopes in this portion of the hill are smooth and unfurrowed. Three fenceline corridors run through Quadrant 4. One continues along the base of the hill from Quadrant 3. The second section branches off the first to the northwest and runs through the rock wall (Site 30310) in two places along a ranch road and extends into the northwest corner of a small paddock on the southwest side of the *pu‘u*. The first corridor also runs into this small paddock (Figure 52). The third section of the corridor branches off the first corridor and runs up the *puʻu* in a northeasterly direction to the top of the cinder cone. This corridor runs along a modern conservation fence for an existing ungulate exclosure. In addition to intra-paddock fences, roads, and Site 30310, a section of galvanized water pipe was also observed within one of the corridors of this quadrant.

### 6.4.1 Fence 11

Fence 11 consists of a series of fences located at the southwest base of Puʻu Waʻawaʻa. The longest section runs from a manufactured metal gate in the rock wall (Site 30310) to the northwest where in connects to the southern corner of a conservation exclosure (Figure 107). Two fences branch southwest from the longer fence to another parallel fence approximately 95 m southwest of the base of the *puʻu*. This forms a relatively small paddock or corral (Figure 52). The northernmost branching fence is likely a paddock boundary fence between the Bull and Orchard (or Stone) Paddocks. The southern branching fence appears to be an intra-paddock fence within the Orchard Paddock. Three gates were present in the Fence 11 system. These include an intact wooden gate passing through the intra-paddock fence (Figure 108), the remnant of a wooden gate passing through the paddock boundary fence (Figure 109), and a metal gate at the northwest corner of the small Fence 11 paddock (Figure 110). The fence running along the base of the *puʻu* is likely a boundary fence between the Hill Paddock and the smaller Bull and Orchard Paddocks.

The fences designated as Fence 11 were built from a combination of metal t-posts and wood posts. All of the different sections of fence consisted of woven wire with a single top-strand of barbed wire. The barbed wire is corroded and consists of four barbs on two twisted strands.

### 6.4.2 Roads and Waterline

Two ranch roads run through the Quadrant 4 survey corridor. The first is the road that runs around the base of the *puʻu* which extends west from Quadrant 3 and runs along Fence 11 (Figure 111). The road then appears to fade out as it continues northwest past the second wooden gate. The second road branches off to the southwest and runs through two gates in the rock wall as it turns to the northeast and parallels the first road. This road turns southwest and runs out of the project corridor at a metal gate at the southwest corner of a small unnamed paddock formed by the Orchard intra-paddock fence (Fence 11) (Figure 110).

Only a piece of galvanized waterline was observed near the southwest edge of the small Fence 11 paddock. Otherwise, no intact waterlines were observed within the project corridors in Quadrant 4.

### 6.4.3 Rock Wall (Site 50-10-20-30310)

Site 30310 is a dry-laid stone wall associated with historic Puʻu Waʻawaʻa Ranch. According to the 1923 USGS Puu Anahulu Quadrangle map and modern aerial imagery, the wall is part of an extensive enclosure system that encircles Puʻu Waʻawaʻa cinder cone. The Site 30310 wall crosses the survey corridor at two locations in Quadrants 3 and 4. A total of 705 linear meters of the wall was recorded during the current AIS, although it is important to note that that it extends much further and is integrated with the woven wire paddock fences.

**Figure 107. Fence 11, facing northwest.**

**Figure 108. Intact wooden gate, facing northwest.**

**Figure 109. Remnant of wooden gate, facing northwest.**

**Figure 110. Road running southwest past gate at southwest corner of Fence 11, facing west.**

**Figure 111. Road running along Fence 11, facing northwest.**

A 65 m portion of the wall oriented in an east-west direction runs through the corridor on the eastern side of Pu‘u Wa‘awa‘a cinder cone in Quadrant 3 (Figure 52). This includes a 25 m section running through the chute and corral complex (Site 30308), as noted in Section 6.3.3.3. This portion of the wall has been knocked down leaving only a linear grass-covered mound (Figure 112). From the eastern edge of Site 30308, a well-preserved portion of the wall extends east for another 40 m until reaching the east edge of the survey corridor (Figure 113).

Along the base of the southern face of Pu‘u Wa‘awa‘a cinder cone the wall runs along the southern border of the survey corridor for 595 m (Figure 52). The wall is well preserved near the south boundary of the survey corridor (Figure 114). In a 135 m long section of wall in the southeast portion of Quadrant 4, two gates have recently been installed (Figure 115 and Figure 116). Aside from the collapsed section of wall running through Site 30308, the portions of the rock wall recorded during the current AIS appear to be in excellent condition and averaged 1.3 m high and 80 cm thick (Figure 117).

#### *6.4.3.1 Conclusion*

The rock wall crosses through the project area in Quadrants 3 and 4. It also extends well beyond project area boundaries and is part of a larger system of walls that possibly encircles Pu‘u Wa‘awa‘a. This wall is likely related to early ranch related activities and was built as a large system of cattle enclosures prior to the use of barbed wire fencing.

**Figure 112. Rock wall termination at Site 30308, facing west.**

**Figure 113. Rock wall (Site 30310) extending east from chute and corral complex (Site 30308), facing east.**

**Figure 114. Site 30310 at south boundary of Pu‘u Wa‘awa‘a survey corridor.**

**Figure 115. Mr. Kato at gate in Site 30310 in southwest extension of the survey corridor.**

**Figure 116. Gate in southwest extension of the survey corridor.**

**Figure 117. Site 30310 rock wall, facing southwest.**

The rock wall is in good condition. Within the project area only a small section has been knock down, or removed in the chute and corral complex and two modern gates appear to have been incorporated into wall on the southwest side of the *pu'u*.

According to a historic USGS Puu Anahulu Quadrangle, the rock wall was built sometime before 1923. This map shows that the wall extended around most of the *pu'u*. The extent of the wall established in 1923 suggests that construction might have begun much earlier. Most of the wall within the project corridor and in adjacent areas is in excellent condition. This feature has not been systematically surveyed and it is currently unknown what percentage of the site has been destroyed or remains intact.

## 6.5 Discussion

Survey of the Puʻu Waʻawaʻa Unit corridor identified numerous historic properties. These included a possible pre-Contact shelter (Site 30307), various infrastructure features and sites associated with historic Puʻu Waʻawaʻa Ranch (Site 7190), and the Puʻu Waʻawaʻa Trachyte Quarry (Site 30306). Ranch infrastructure features include historic fencelines, waterlines, and ranch roads. Sites associated with historic Puʻu Waʻawaʻa Ranch include portions of a stacked rock wall (Site 30310) and a chute and corral complex (Site 30308).

Fencelines in the Puʻu Waʻawaʻa Unit include three quarry boundary fences (Fences 7 and 8), two intra-paddock fences (Fences 9 and 10), and one paddock boundary fence (Fence 11). Fence 11 was of the same type as the Waiho 1 Waimea Paddock Boundary fence (Fence 1) recorded in the Aiea Unit, and dates to around 1948. Fences 9 and 10 were of slightly later, intermediate type consisting of woven wire and metal t-posts.

A water pipeline was observed in Quadrant 2 running from Site 30307 to Site 30308. The line is defunct and has largely been removed with only isolated segments remaining. This waterline likely dates to the period of rapid water resource development under Robert Hind, Ltd.'s management in the mid-twentieth century.

Ranch roads run along the base of the east, south, and west sides of Puʻu Waʻawaʻa, through Quadrants 2, 3, and 4. There is also a road running to the top of the *pu'u* in Quadrant 3. The ranch roads are all relatively well developed. All of the ranch roads parallel, and provide access to, water or fence infrastructure. The road running along the base of the wall is consistent with a trail shown on a historic 1923 USGS quadrangle map. This initial trail was likely expanded during the mid-twentieth century under Robert Hind, Ltd.'s management.

## 6.6 Project Effects

Proposed ungulate fencing within the Puʻu Waʻawaʻa Unit will intersect numerous infrastructure features associated with historic Puʻu Waʻawaʻa Ranch. These features include five historic fencelines, a series of connected ranch roads, and one waterline. The proposed fence will also intersect the Puʻu Waʻawaʻa Trachyte Quarry (Site 30306). Importantly, the fence will not intersect the Chute and Corral Complex (Site 30308) or the L-shaped Mound site (Site 30307).

Impact findings for the Puʻu Waʻawaʻa Unit are similar to those for the Aiea and Henahena Units to the west. The proposed ungulate fence will intersect, and therefore affect, some elements of the historic ranch infrastructure system. However, impacts will be very minimal and do not rise to the level of ‘adverse’ effect. Descriptions of expected effects specific mitigation or avoidance actions are as follows:

1. *Historic Fencelines*: Proposed ungulate fences will intersect existing paddock and intra-paddock fencing (Fences 6–10) at approximately right angles. The historic fences will be intersected between fence posts and no wooden posts will be removed. The fence wire will be cut and then retied to the newly installed fence to maintain paddock integrity. Original historic fence tension will be maintained in order to prevent excessive pull and potential adverse impact to posts. Circulation and access to the ungulate exclosures will be facilitated by gates in the ungulate fence.

2. *Ranch Roads*: Existing ranch roads will remain in use and will not be adversely impacted by fencing. Gates will be installed at ranch road crossings, as necessary, to permit access and circulation consistent with present and historical ranch usage patterns. The current ranch road system will function to provide access to the ungulate exclosure fence for maintenance and repair, similar to its historic function for historic paddock fencing.

3. *Waterlines*: Sections of defunct historic ranch waterline are within the survey corridor. These are discontinuous, but are generally visible on the ground surface. Every effort will be made to avoid the remaining pipe. In some cases, individual pipe sections may be shifted several feet to facilitate avoidance. Since most sections of the waterline appear to have been moved following its decommissioning, this is not considered to be an adverse effect.

4. *L-Shaped Mound (Site 50-10-20-30307)*: The proposed ungulate exclosure fenceline will be placed 20 m or more away from the L-shaped mound and will therefore not impact it. The route of the proposed fence will therefore completely avoid the site and fence construction will pose no adverse impact to the site.

5. *Chute and Corral Complex (Site 50-20-10-30308)*: The proposed ungulate exclosure fenceline will be placed 15 meters upslope from the chute and corral complex and will therefore not impact it. It will, however, run through a fence attached to the western side of the site at an approximate right angle. The historic fence will be intersected between fence posts and no wooden posts will be removed. The fence wire will be cut and then retied to the newly installed fence to maintain paddock integrity. Original historic fence tension will be maintained in order to prevent excessive pull and potential adverse impact to posts.

6. *Rock Wall (Site 50-10-20-30310)*: The proposed ungulate exclosure fenceline will run parallel with the historic rock wall for approximately

445 m and will cross the wall in two places. Generally, the proposed ungulate exclosure fenceline will maintain a 20 m setback from the stone wall and effects to the site are therefore very unlikely. However, the fence comes within 5 m of the wall in certain locations and crosses the wall in two locations at the western extremity of the project area. At locations where the fence runs in close proximity, protective orange safety fence will be installed between the historic wall and the ungulate fenceline prior to construction and will be maintained and observed as a barrier during construction. Locations where the fence crosses the wall will occur where two modern gates have been previously installed. At these locations, the fence will be attached to existing support posts for the gates. Modifications to the historic wall will be strictly avoided during construction and a DOFAW staff member will be present at all times to monitor construction activities in these areas.

If the above practices are followed, there should be no adverse effect to historic resources in the Puʻu Waʻawaʻa Unit. As mentioned in Section 4.0, cutting the fencelines clearly qualifies as an 'effect.' However, given the scale and extent of fencing at Puʻu Waʻawaʻa Ranch, the effect is considered negligible. The effect is not adverse to the historic ranch as a whole because paddock integrity will be maintained. There may be an issue with cumulative impact if historic fences are intersected by new fencing on a regular and ongoing basis. Potential cumulative impact to the historic ranch and possible mitigation actions need to be weighed by land managers and regulators against DOFAW's conservation goals and public hunting and recreational uses. Historic ranch infrastructure will be very lightly impacted by currently proposed ungulate fence installation.

## 7.0 CONCLUSIONS AND SIGNIFICANCE RECOMMENDATIONS

Archaeological inventory survey of 15.4 linear kilometers (103.6 ha) of proposed ungulate fenceline corridor produced one temporary Hawaiian encampment (Site 30307), one historic quarry (Site 30306), and three discrete sites (Sites 30308, 30310, and 30311) which are associated with historic Puʻu Waʻawaʻa Ranch (Site 7190). In addition to the discrete historic ranch sites, a large amount of historic Puʻu Waʻawaʻa Ranch infrastructure was also identified and recorded. These infrastructure features include paddock fences, waterlines, and ranch roads, all of which contribute to the significance of historic Puʻu Waʻawaʻa Ranch. Finally, two additional ranch sites (Sites 30305 and 30309) were documented outside the survey corridor. These sites are not within the APE for the undertaking and are therefore not evaluated for significance. Full documentation for these sites can be found in Appendix A.

Summary information, significance recommendations, and recommended treatments for sites recorded within the APE are presented in Table 2 below. Significance and integrity for each of the sites is discussed in greater detail in the following sections.

### 7.1 Significance Criteria

As stated above, all five of the newly identified sites, plus elements associated with previously identified Site 7190, were evaluated for significance and National Register of Historic Places eligibility. To be eligible for NRHP listing, a site must be 50 years old or older,[1] possess historic significance, and retain integrity when evaluated within its historic context (National Register Bulletin 1997:2). These rules have also been adopted by the State of Hawaiʻi for the evaluation of historic sites in compliance with Chapter 6E of the Hawaiʻi Revised Statutes.

A property may be eligible for the NRHP and/or significant under Hawaiʻi Administrative Rules (HAR) (§13-275-6) if it is significant under one or more of the following criteria:

- Criterion A: It is associated with events that have made a significant contribution to the broad patterns of our history.
- Criterion B: It is associated with the lives of persons who are significant in our past.
- Criterion C: It embodies the distinctive characteristics of a type, period, or method of construction; represents the work of a master; possesses high artistic values; or represents a significant and distinguishable entity whose components may lack individual distinction.
- Criterion D: It has yielded, or may be likely to yield, information important in prehistory or history.

[1] There can be exceptions to this rule, but they do not apply here.

**Table 2. Site Significance and Treatment Recommendation**

| Conservation Unit | Site No. | Site/Feature Type | Cultural Affiliation/ Historic Context | Function | Period | Significance Criteria | Recommended Treatment |
|---|---|---|---|---|---|---|---|
| All | 50-10-19-7190 | Paddock fencelines, waterlines, ranch roads | Historic Ranching | Paddock enclosure, water distribution, and circulation | Early 1900s–present | C, D | Paddock Fence: Preservation; avoid fence posts at fence intersections. Reattach paddock fence to maintain alignment integrity.<br>Ranch Roads: Preservation/avoidance<br>Waterlines: Preservation for functional galvanized lines. No further work for defunct and destroyed galvanized lines. |
| Puʻu Waʻawaʻa | 50-10-20-30306 | Trachyte quarry | Modern Commercial Quarrying | Mineral extraction | 1955–1988 | None | No further work |
| Puʻu Waʻawaʻa | 50-10-20-30307 | Modified outcrop | Traditional Hawaiian | Temporary shelter | Pre-Contact | None | No further work |
| Puʻu Waʻawaʻa | 50-10-20-30308 | Chute and corral complex | Historic Ranching | Cattle management, water storage | Early 1900s–present | C, D | Preservation; Phase II recordation |
| Puʻu Waʻawaʻa | 50-10-20-30310 | Stone wall | Historic Ranching | Paddock enclosure | Early 1900s–present | C, D | Preservation |
| Henahena | 50-10-20-30311 | Stone corral | Historic Ranching | Cattle management | Early 1900s–present | C, D | Preservation |

Additionally, an historic property may be significant under Hawai‘i Administrative Rules §13-275-6 under Criterion E:

- Criterion ‘E’: Have an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events, or oral accounts--these associations being important to the group’s history and cultural identity.”

### 7.1.1 Integrity

In addition to significance, a property must also retain its historic integrity. Historic integrity is “the survival of physical characteristics that existed during the property’s prehistoric or historic period” that authenticates the property’s historic identity (National Register Bulletin 1998:4). In order for an historic property to retain integrity, it must meet a combination of the following seven aspects of integrity:

- Location: the place where the historic property was constructed or the place where the historic event occurred;
- Design: the combination of elements that create the form, plan, space, structure, and style of a property;
- Setting: the physical environment of a historic property;
- Materials: the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property;
- Workmanship: the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory;
- Feeling: a property’s expression of the aesthetic or historic sense of a particular period of time; and
- Association: the direct link between an important historic event or person and a historic property.

These seven aspects of integrity are also used by the State of Hawai‘i (HAR §13-275-6 (b)). All historic properties documented within the project area during the archaeological inventory survey were evaluated according to the above NRHP and State of Hawai‘i significance and integrity criteria.

## 7.2 Site 50-10-19-7190 (Historic Pu‘u Wa‘awa‘a Ranch)

Historic Pu‘u Wa‘awa‘a Ranch has been listed on the Hawaii Register of Historic Places as Site 7190 since 1973. Although listed as a site, the ranch would probably be better classified as an historic rural landscape, a cultural landscape, or an archaeological district. There are many possible classifications for such large-scale ‘sites’ within the National Park Service’s guidance documents. No matter what terminology is used, it is clear that the historic ranch is significant under NRHP Criteria C and D. Under C, the ranch is clearly associated with the historical development of the cattle industry (and to a lesser extent the sheep industry) in Hawai‘i. It embodies the distinctive characteristics of early to mid-twentieth century cattle ranching in Hawaiʻi. Notably, the historic ranch also "represents a significant and distinguishable entity whose components may lack individual distinction." This is in reference to the many barbed wire paddock fences, waterlines, and ranch roads that comprise the infrastructure of the ranch. Individually, they may be of limited historic interest, but taken together, they represent the most salient and important systemic features that comprise a ranch.

Under Criterion D, the ranch landscape has clear information value of historical importance. Although it has been listed on the Hawaiʻi Register for over forty years, very little of the ranch landscape has been systematically documented or analyzed. It has great potential to contribute information on the development and exploitation of water resources, the historical intensification of ranching, and adaptation strategies for ranching on a marginal landscape.

Although the ranch is an NRHP-eligible historic property, its treatment and management must take into account the immensity of the landscape involved and acknowledge that it is only the historical features and characteristics that contribute to the significance of the property that need to be considered during Section 106 consultation. Although it is beyond the scope of this project to document all of the features and characteristics that comprise the ranch landscape, several important large-scale infrastructure features were identified within the undertaking APE. These consist of a variety of paddock boundary fences, water distribution lines, and ranch roads. These features were identified in all of the conservation units. All of these features contribute to the significance of the historic ranch landscape. The integrity of the features is generally very good, with the notable exception of the waterlines. Large sections of the original galvanized water pipeline in the Henahena and Puʻu Waʻawaʻa Conservation Units have been removed and partially destroyed. Galvanized pipeline in the Aiea Conservation Unit, by contrast, appears intact and functional. Preservation is recommended for the fencelines, major ranch roads, and intact, functional portions of the water distribution system.

### 7.2.1 Undertaking Impact

Installation of ungulate exclosure fencing will affect the historic paddock fencelines but will have no effect on ranch roads or water pipelines. These latter features will be avoided during construction. Major ranch roads will continue to be accessible in most locations through gates. Minor fenceline access roads will also be accessible, though possibly in a more restricted manner due to the new exclosure fencing.

Historic paddock fencelines will be directly affected by the undertaking. These fences, including newer intra-paddock fencelines, will be cut to allow the new ungulate fence to pass through. The fences will be restrung, tensioned, and tied off to the ungulate fence to maintain the original paddock alignments. Because the original fencelines will be maintained, this is not considered an 'adverse' impact to the historic integrity of Site 7190. It should be noted that cutting and retying the line is consistent with the kinds of fence maintenance activities and impacts that have occurred historically, and continue to occur, at Puʻu Waʻawaʻa Ranch.[2]

[2] Portions of the ranch remain in cattle production and fence maintenance in those areas is ongoing.

## 7.3 Site 50-10-20-30306 (Trachyte Quarry)

Site 30306 is a commercial trachyte quarry that operated between 1955 and 1988. The 500-acre quarry site is a highly modified landscape including roads, two buildings, refuse, and a quarry pit. The quarry site, although more than 50 years old, does not meet any of the NRHP significance criteria. It is not associated with significant historical events or persons and does not represent the distinctive characteristics of a type, period, or method of construction. Background research indicates that the Puʻu Waʻawaʻa trachyte quarry was and remains Hawaiʻi Island's only trachyte quarry. While this is of some historical interest, the design and operation of the quarry was exactly the same as the many other cinder cone mining operations found on the island. Trachyte quarrying does not appear to have involved any distinctive characteristics not found at other mid-twentieth-century open-pit cinder cone mines.

The Puʻu Waʻawaʻa trachyte quarry has two standing buildings, a Quonset hut and the quarry office. Considered separately from the larger quarry site, these structures also do not meet any of the NRHP significance criteria. They are not architecturally significant or distinctive of a period or style and are not associated with important historical events or persons. Furthermore, the buildings are in very poor condition. Both have been gutted of internal wiring and plumbing and many of the windows and doors are broken or missing. Although the buildings continue to convey their original utilitarian functions, they have clearly decayed beyond repair.

### 7.3.1 Undertaking Impact

The ungulate fenceline will run through the middle of the quarry site and will not affect the two buildings or any other site element. The undertaking will have no adverse effect on Site 30306.

It should be noted that the ungulate fence will intersect existing cattle fence at the northwest and southeast quarry site boundaries. As with other fencelines, these will be cut and retied to maintain their original alignments and functionality.

## 7.4 Site 50-10-20-30307 (L-Shaped Mound)

Site 30307 is an L-shaped mound comprised of a large number of *ʻaʻā* cobbles and pebbles arranged along a slope-break. One interior side of the mound exhibits what appears to be on-end slab facing, possibly associated with traditional Hawaiian encampment. Test excavation near the slab facing produced no evidence of traditional Hawaiian or historical use.

Although its architecture is equivocal and test excavation produced negative results, Site 30307 is provisionally interpreted as a temporary Hawaiian shelter based on its architecture. With respect to significance, the feature is not a good representation of its type (temporary shelter) or a good example of Hawaiian stonework craftsmanship (Criterion C). Furthermore, test excavation demonstrated that the site does not have the potential to produce important information on traditional Hawaiian occupation and activities in the area (Criterion D). Site 30307 therefore does not meet any of the pertinent NRHP significance criteria and is not eligible for NRHP listing.

### 7.4.1 Undertaking Impact

The ungulate fence will pass more than 20 m west of Site 30307. The proposed ungulate fenceline is therefore very unlikely to affect Site 30307. Because the site is recommended as ineligible for NRHP listing, no precautionary avoidance measures are recommended.

## 7.5 Site 50-10-20-30308 (Chute and Corral Complex)

The Site 30308 Chute and Corral Complex is a clustered arrangement of features associated with historic Puʻu Waʻawaʻa Ranch. Features include a cattle chute, corral, two circular arrangements of preformed-concrete-footings, a ranch road, and fences. The presence of the water tank foundation piers, as well as information from informant Miki Kato, indicate that the complex dates to the mid-twentieth century. During the interview and site tour with Mr. Kato, he indicated that elements of the corral and chute complex were built during Hind's tenancy of the ranch prior to 1959. These statements have been confirmed with historic aerial imagery. Mr. Kato also said that he helped build the wooden chute structure in the late 1960s, indicating that this feature was in use until relatively recently.

Site 30308 is significant under Criteria C and D. Under Criterion C, the site's construction style embodies the distinctive characteristics of a type, period, or method of construction. Specifically, it embodies the method of construction used for chutes and fenced (non-stone) corrals built and used during Puʻu Waʻawaʻa Ranch's mid-twentieth century expansion and intensification. Under Criterion D, the site may yield important information on late-period chute construction and on integration of chutes and corrals with major water distribution features. The site is in good condition with only localized damage and natural decay to some of the wooden fence posts. The site retains all seven aspects of integrity. It reflects the materials, workmanship, and design of the original construction and accurately conveys its historic function and period of use.

Present recording efforts, including photo-documentation and accurate GPS coordinates, have not exhausted the information potential of this site. Phase II-level recordation could be conducted, including measured engineering plans of the construction of the corral and chute following the National Park Service's Historical American Engineering Record standards. Preservation is recommended for these features until such intensive recordation is conducted. Although the chute was constructed less than 50 years ago, its preservation and intensive recordation are recommended based on the fact that it will be considered 'historic' within just a few years. Also important is the fact that the original builder, Mr. Kato, is still present to serve as an informant for such work.

### 7.5.1 Undertaking Impact

The proposed ungulate fenceline will have no adverse affect on Site 30308. The ungulate fence passes west of the Chute and Corral Complex. It will intersect Fence 8 (see Section 6.3.3) several meters from the corral fencing and will be some 45 meters away from the chute itself. Fence 8 is a barbed wire fence running along the base of Puʻu Waʻawaʻa cinder cone. As with all other intersected historic fencelines, it will be cut and retied to maintain its original alignment and functionality.

### 7.6 Site 50-10-20-30310 (Rock Wall)

The Site 30310 Rock Wall is associated with historic Puʻu Waʻawaʻa Ranch. The wall is part of the early (pre-1923) Puʻu Waʻawaʻa Ranch cattle management system and likely delineated an early paddock system. Based on informant data, the wall was likely built during the Hind years and appears to roughly correspond with the current Mawae Mauka, Hill, Orchard, Stone, and Bull Paddocks.

As an early cattle management feature, Site 30310 is significant under Criteria C and D. It can also be considered a contributing element to Site 7190, historic Puʻu Waʻawaʻa Ranch. Under Criterion C, the site's construction style embodies the distinctive characteristics of a type, period, or method of construction. Specifically, it embodies the dry-stone method of construction used for cattle walls in the earliest period of Puʻu Waʻawaʻa Ranch's history. It represents an example of the construction style used in the pre-1923 period. Under Criterion D, the site may yield important information on dry-stone construction technique and may provide information on the ranch's earlier paddock system, prior to the mid-twentieth century expansion and intensification of Puʻu Waʻawaʻa Ranch operations. The site is in a relatively good state of preservation and retains integrity of design, workmanship, materials, and setting. Well constructed dry-stone walls are relatively uncommon at Puʻu Waʻawaʻa Ranch, compared with the many miles of barbed-wire fencing, and it is recommended that Site 30310 be preserved.

#### 7.6.1 Undertaking Impact

Proposed ungulate fencing in Puʻu Waʻawaʻa Conservation Unit will avoid Site 30310 and should have no adverse impact to it. It is important to note, however, that the ungulate fence will come in very close proximity to the stone wall in two locales, both on the southwest side of the cinder cone. These are locations where the ungulate fence meets two existing stone wall gates. The new fence will anchor at the ends of the older gates, and a new gate will be installed to facilitate movement through the stone wall, as originally designed. The new ungulate fence gate will be constructed without impact to the existing stone wall. Because of its close proximity to Site 30310, this work should be carefully monitored during construction to avoid impacting the site.

### 7.7 Site 50-10-20-30311 (Stone Corral)

The Site 30311 Stone Corral is associated with historic Puʻu Waʻawaʻa Ranch. It is a cattle aggregation and management feature located at the boundary between Henahena Makai and Henahena Mauka Paddocks and allows passage between them. This site was originally documented by National Park Service archaeologists (Dougherty and Moniz-Nakamura 2008:19). Further documentation is provided in this report, including a plan map and additional photographs.

As a critical cattle management feature, Site 30311 is significant under both Criteria C and D. It can also be considered a contributing element to Site 7190, historic Puʻu Waʻawaʻa Ranch. Under Criterion C, the corral's construction style embodies the distinctive characteristics of a type, period, or method of construction. Specifically, it embodies the dry-stone method of construction used for corrals in early to mid-1900s Hawaiian ranching. Under Criterion D, the site may yield important information on construction technique and inter-paddock cattle management at historic Puʻu Waʻawaʻa Ranch. The site is in good condition with only localized, repairable wall collapse. The site retains all seven aspects of integrity and preservation is recommended.

### 7.7.1 Undertaking Impact

Although the Site 30311 Stone Corral is within the undertaking APE, it will be avoided during ungulate fence installation. The fence centerline is about 20 meters *makai* of the corral along most of its length and there is a very low likelihood of impact in these areas. However, the fence comes within two meters of the corral at its northeastern end. There is a high potential for inadvertent impact at this locale. This potential can be reduced to acceptable levels by either 1) off-setting the ungulate fence further from the corral or 2) installing high visibility orange construction fencing between the ungulate fence and the corral during construction and ensuring that construction is monitored closely. If either of these actions are taken, the undertaking should have no adverse effect on Site 30311.

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# APPENDIX A: SITES RECORDED OUTSIDE PROJECT AREA

**Cistern (Site 50-10-20-30309)**

Site 30309 is a large concrete cistern located on level ground southwest of the dirt road that runs to the top of Puʻu Waʻawaʻa cinder cone. The cistern measures 7.5 x 7.5 m and is 2 m deep. Its side walls are at least 30 cm thick (Figure 118 and Figure 119). The walls are partially buried and an exact thickness could not be determined. "Henry SPT" is inscribed on the north side of the feature. The bottom of the cistern was covered with grass and a little water was visible at the time of recordation. Plastic orange safety fence has recently been erected around the cistern but has now fallen down (Figure 120). Prior to this, the cistern was surrounded by a barbed wire fence supported by wooden posts and metal t-posts.

The cistern is a water retention feature associated with mid-twentieth century ranch operations. The wooden posts and woven wire fence are of the same type as paddock fencing that was originally installed in the late 1940s (See Section 4.1.1). Although its exact construction date is unknown, it is most likely associated with the period of rapid expansion and modernization of the ranch's water delivery system.

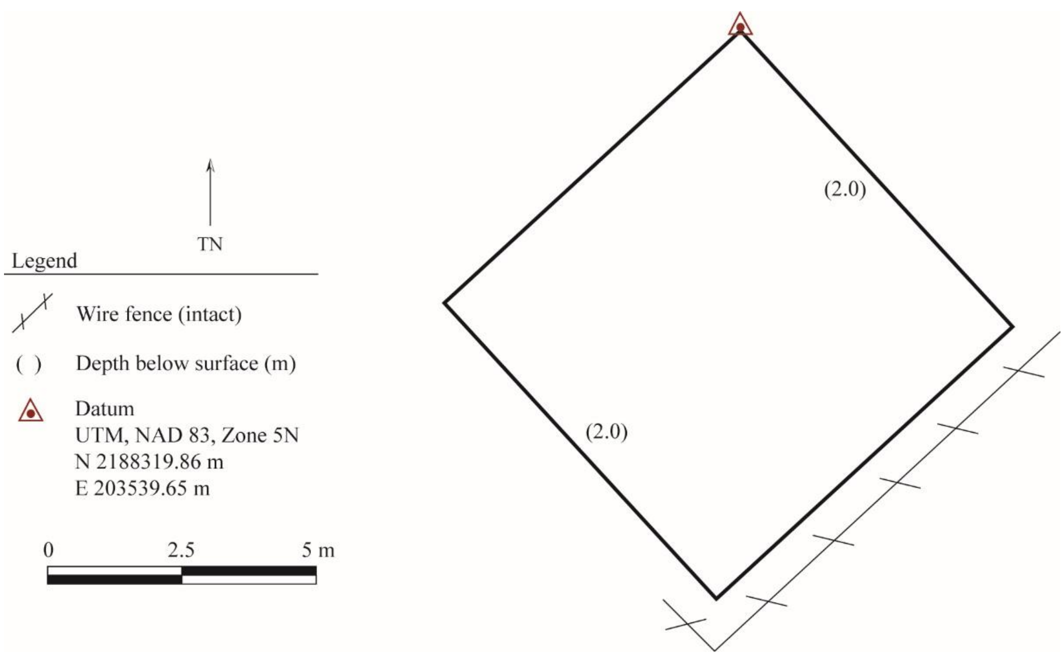


**Figure 118. Plan map of Site 30309, concrete cistern.**

**Figure 119. Site 30309, concrete cistern. View to west.**

**Figure 120. Historic and modern fencing surrounding Site 30309. View to southwest.**

### Small Platform (Site 50-10-20-30305)

Site 30305 is a small basalt cobble platform recorded just outside of the project area on the north side of Puʻu Waʻawaʻa. The platform is roughly 2 m square and consists of one layer of large cobbles with metal t-posts placed at each corner and an additional small t-post on the northeast side (Figure 121 and Figure 122). The platform is located under a large tree. Two concrete blocks are also present next to the platform. The function of the platform is unclear and the presence of concrete block and metal posts suggest the feature is modern. Given its similarity to traditional Hawaiian platforms, Site 30305 should be considered a possible traditional Hawaiian site pending test excavation.

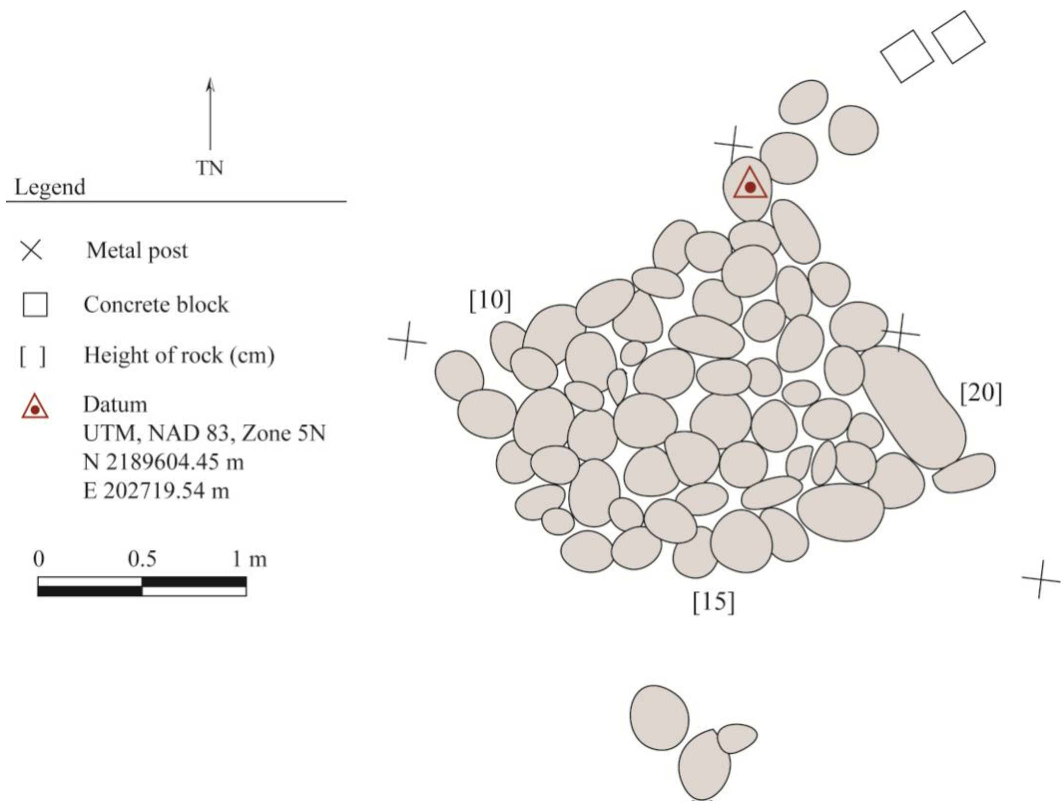


**Figure 121. Plan map of Site 30305, platform.**

**Figure 122. Site 30305, small basalt cobble platform. Note concrete block on far right.**

### Water Tank Base (Site 50-10-20-30397)

Site 30397 is a water tank base consisting of a wooden beam support structure with associated galvanized piping and a wooden trough. The wooden base supported a water tank and is located 13 m west of the corner of the modern conservation fence at the western terminus of the Aiea Unit corridor. The floor plan of the base is octagonal and the east side has fallen over (Figure 123). The water tank has long-since been removed and it appears that some of the base has been dismantled. Several loose planks and metal t-posts have been laid across the north end of the structure (Figure 124). The water tank base measures 3.8 x 3.1 m and is 0.6 m tall. This structure was built from wooden beams and planks and is supported by 14 wooden piers set on stones (Figure 125). The beams are 15 cm high and 10 cm thick and the planks are 10 cm high and 5 cm thick. A 1-inch galvanized pipe with a 90° bend is still attached to the north end of the base (Figure 126).

The wooden trough is located 8 m southwest of the wooden tank base and is 55 cm deep. The top is 55 cm wide and the base is 35 cm wide. Planks used in the construction of the trough are 4 cm thick and have been fastened with galvanized nails. The planks are weathered and most of the trough is covered by thick grass. The boards have become separated and splayed at one end (Figure 127).

The water tank base and wooden trough are water storage and livestock watering/feeding features associated with mid-twentieth century ranch operations. The wooden post construction and galvanized pipe are of the same type used in other portions of the project area and were originally installed in the late 1940s (see Section 4.1.1). Although the exact construction date of these features is unknown, they are most likely associated with the period of rapid expansion and modernization of the ranch's water delivery system.

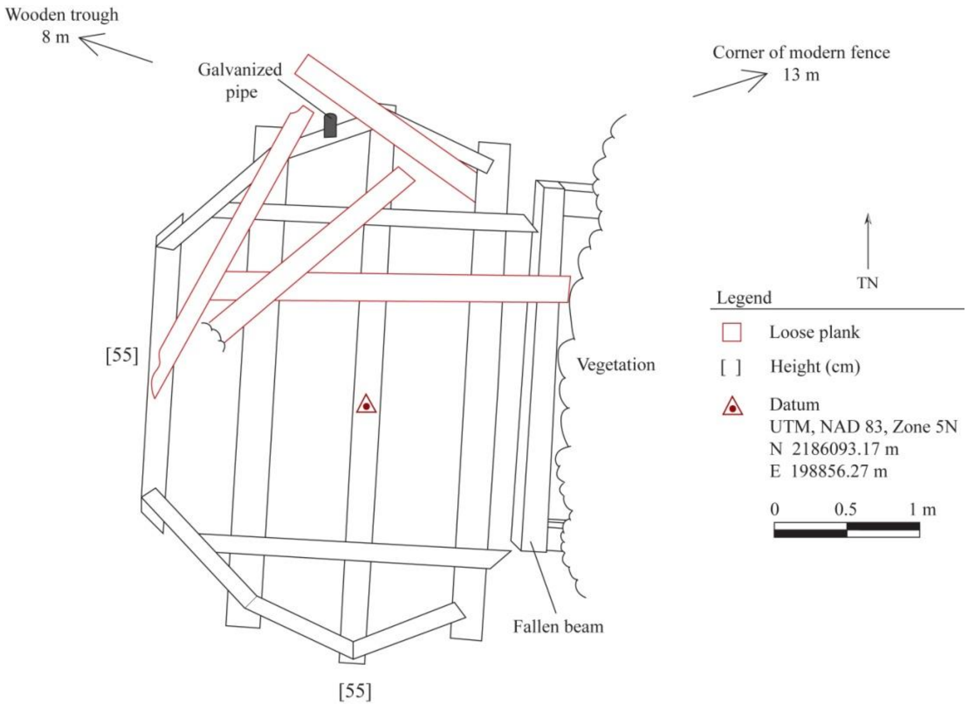


**Figure 123. Plan map of Site 30397, wooden base feature.**

**Figure 124. Site 30397, wooden beam support structure, facing northwest.**

**Figure 125. Close-up view of support pier with showing beam resting on rock.**

**Figure 126. Close-up of galvanized pipe associated with support structure.**

**Figure 127. Trough, facing northwest.**

# APPENDIX B: MR. MIKI KATO CONSULTATION

An interview and tour of the project area was conducted with Mr. Kato on September 22, 2014. Mr. Kato is a long-time resident of the area who started working at Puʻu Waʻawaʻa Ranch in 1956, just prior to the beginning of Lowell Dillingham's tenancy in 1959. He is still a resident of the area and still works in the Puʻu Waʻawaʻa Forest Reserve for the Hawaiʻi Division of Forestry and Wildlife. Mr. Kato's knowledge of the area is extensive. Due to the limited scope of the present project, the interview with Mr. Kato focused on questions about the features observed in project area during the archaeological survey. These included inquiries regarding ranch paddocks and fences, buildings and bulldozing activities related to the quarry, and the rock terrace and platform features.

According to Mr. Kato, the ranching paddocks and corresponding rock walls and wire fences were established by Hind. Mr. Kato said that Dillingham also built all of the roads for fire breaks to fix and build wire fences. He also stated that he had been personally involved in this work during Dillingham's lease between the late 1950s up until around 1973. He provided a hand drawn map that includes locations of paddock fences, names of the paddocks, and acreage of each paddock (Figure 128). He indicated that the use of rock in building and maintaining wire fences was common throughout his time on the ranch. Rock was used to anchor wire fences and stacked in collapsed lava tubes or depressions under a fence to keep pigs from getting through. Mr. Kato also said that Dillingham was keenly interested in preserving and restoring native dry-land forests on Puʻu Waʻawaʻa Ranch and that building roads and maintaining fences was done primarily to prevent fires.

The rock platform, "L" shaped mound, the wooden chute and corral complex, and cistern were visited during the site tour with Mr. Kato. He had not seen the small platform or terrace feature before and could not say what function they served or who had built them. He did indicate that the spoil piles located near the platform were likely related to the quarry. He said the concrete cistern was built during Hind's tenancy as were portions of the chute and corral complex. He indicated that he had helped build the wooden chute in the late 1960s.

When asked about the quarry located on the northeast side of Puʻu Waʻawaʻa, Mr. Kato indicated that mining activities started in the late 1950s when they began to dig at various locations around the cinder cone and that the quarry was in operation until the late 1980s. During the site tour, Mr. Kato pointed out various locations on the north side of the *puʻu* near the platform and along the west side of the *puʻu* that had been bulldozed during initial mining activities associated with the quarry. He also indicated that they had also bulldozed on top of the *puʻu* until Dillingham put a stop to it.

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**Figure 128. Map of Pu‘u Wa‘awa‘a Ranch paddocks provided by Miki Kato.**

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## APPENDIX C: MS. KU'ULEI KEAKEALANI CONSULTATION

A phone interview was conducted with Ms. Kuʻulei Keakealani on July 21, 2015. Before the interview, Ms. Keakealani was emailed a map of the proposed fenceline corridors to familiarize her with the project. During the interview, the archaeologist and Ms. Keakealani discussed three major topics. These included Traditional Hawaiian cultural resources and archaeological sites, historic Puʻu Waʻawaʻa Ranch, and the trachyte quarry. Ms. Keakealani grew up in the Puʻu Anahulu/Puʻu Waʻawaʻa area and spent a lot of time on Puʻu Waʻawaʻa Ranch with her father, noted *paniolo* Robert Kamuela "Sonny" Keakealani Jr. Mr. Keakealani worked for Puʻu Waʻawaʻa Ranch for 12 years until 1975, when he moved to Parker Ranch where he worked for another 27 years. Ms. Keakealani is a past member of the Puʻu Waʻawaʻa Advisory Council.

First, Ms. Keakealani was asked if she knew of the locations of any Hawaiian archaeological sites in or near the project corridors specifically and about the L-shaped mound (Site 30307) identified during the survey. She was not aware of this or any other traditional Hawaiian sites within the project area corridors. Additionally, she was asked if she knew of any *moʻolelo* associated with the landscape crossed by the project area corridors. Ms. Keakealani is very familiar with the primary published legends associated with the broader region. This specifically included the myth associated with the naming of Puʻu Anahulu and Puʻu Waʻawaʻa, but she was not aware of any *moʻolelo* concerning specific portions of the project area (i.e., Henahena, Aiea, or Puʻu Waʻawaʻa).

Second, Ms. Keakealani was asked about historic Puʻu Waʻawaʻa Ranch. She is very knowledgeable regarding this subject and was able to provide important insight based on her father's knowledge and her own experiences participating in ranch work with her father and extended family. She pointed out that all "Native Ranch Hands," or *paniolo*, that worked at Puʻu Waʻawaʻa, as well as other ranches on Hawaiʻi Island, were intimately tied to the ranch lands. Aside from being cowboys that managed livestock, a complex task in and of itself, *paniolo* also managed range lands, forest resources, and game. They built dry-stacked stone walls in the same manner as their ancient predecessors, planted and maintained orchards, were first responders during forest and brush fires, and possessed a wealth of knowledge concerning the local environment and weather patterns upon which they relied to keep cattle alive during severe drought conditions. These included tricks such as controlled burns of cactus to remove needles so that it could be consumed by cattle and using *hala pepe* as cattle fodder during droughts. She also indicated that paddocks were traditionally named after people or families.

Third, Ms. Keakealani was asked about her memories of the quarry. She said it was a large operation and she remembers the green and orange trucks of Volcanite LTD constantly coming and going. She also said that the quarry was generally viewed as a good thing because it employed people from Puʻu Anahulu. She said several of her uncles worked for the quarry, one of whom is Levi Mitchell, the only one still living. She also indicated that the white pillars at the entrance of the ranch at the main highway were actually associated with the quarry and were once decorated with eagles.

Overall, Ms. Keakealani views construction of the fences for the conservation units positively. She indicated that her biggest concern was with preserving dry stacked rock walls because they represent ancient Hawaiian construction styles and are the handicraft of the native tenants of the ranch lands, including *paniolo* like her father.

# APPENDIX C: INTERNAL SECTION 7 EFFECT DETERMINATION

# INTERNAL SECTION 7 EFFECTS DETERMINATION

| | |
|---|---|
| Originating Person: | Donna Ball |
| Originating Program: | Pacific Islands FWO |
| Telephone Number: | 808-933-6963 |
| Date: | March 19, 2014 |
| Section 7 Tracking Number: | F13AP01028; 2014-I-0228 |

**I.** **Project Name**: Puuwaawaa Forest Reserve Protection and Restoration (Henahena unit)

**II.** **Location and Geographic Specifics:** (Figures 1-4)

a) Location: Island of Hawaii, Hawaii County, State of Hawaii (North Kona District, Puuwaawaa Ahupuaa).
b) Distance (miles) and direction to nearest town: 11 miles northeast of Kailua-Kona, Hawaii.
c) Section, township, and range: TMK: (3) 7-1-001:006
d) Listed species, proposed species, and designated and proposed critical habitat (if appropriate): see Figure 4.

**III.** **Listed Species**

Table 1. Endangered Species (E) and Critical Habitat within the action area.

| | **Common Name** | **Scientific Name** | **Federal Status** | **Observed in area since 1980?** | **Critical Habitat in area?** |
|---|---|---|---|---|---|
| Animals | Opea pea (Hawaiian hoary bat) | *Lasiurus cinereus* | E | Yes | N/A |
| | Io (Hawaiian hawk) | *Buteo solitarius* | E | Yes | N/A |
| | Blackburn's sphinx month | *Manduca blackburnii* | E | Yes | Yes |
| Plants | Aiea | *Nothocestrum breviflorum* | E | Yes | Yes |
| | Ae | *Zanthoxylum dipetalum ssp. tomentosum* | E | Yes | Yes |
| | No Common Name | *Delissea undulata* | E | Yes | Yes |
| | Hau kuahiwi | *Hibiscadelphus hualalaiensis* | E | Yes | Yes |

**VI.** **Description of the Proposed Action**

Objectives for this project include construction of 1.5 miles of fencing to complete a 950 acre ungulate management unit (Figure 1). This area is part of the larger Puuwaawaa management area managed by the State of Hawaii, Division of Forestry and Wildlife (DOFAW) (Puuwaawaa Management Plan, DOFAW 2003). Upon completion of fencing, DOFAW will remove feral ungulates and undertake habitat restoration activities including invasive fountaingrass control along fence lines. Endangered species known from the area include: Aiea (*Nothocestrum breviflorum*), Blackburn's sphinx moth

*(Manduca blackburnii),* the Hawaiian hoary bat (*Lasiurus cinereus*), and Hawaiian hawk (*Buteo solitarius*). 1.5 miles of 72" high fence will be constructed using hog wire fence mesh supported by galvanized pipes and fence posts. The outside of the fence will be skirted along the base with a hog wire apron. To construct the fencing, a four-foot wide corridor will be manually cleared of vegetation, avoiding any native trees larger than 15 feet. Installation of 72" inch woven wire fencing will follow and will be tacked flush to the ground, with additional wire "skirts" placed in areas with uneven terrain to restrict pig ingress by digging.

After fence construction is completed, the project will involve the removal of feral ungulates and invasive weeds from the fenced area. Invasive weeds will be controlled by DOFAW staff using manual control and herbicide methods proven successful elsewhere in the state.

Photo points will be established for natural resource monitoring to document habitat response inside the project area.

## V. Avoidance and Minimization Measures

The following project actions will be implemented to minimize or avoid project impacts to listed species.

1. <u>Clearing the fence corridor and installation of the fence:</u> Clearing the fence corridor and installation of the fence could result in some short term disturbance to soil and native vegetation, as well as create noise that could disturb Hawaiian hawks and Hawaiian hoary bats.

   <u>Actions to reduce impacts of corridor clearing and installation of the fence</u>: Surveys for rare and listed plants, Blackburn's sphinx moth, as well as for Hawaiian hawks and Hawaiian hoary bats will be completed. To avoid negative impacts to listed taxa along the proposed fence line the following monitoring measures will be implemented:

   - Walk the fence line two to three times a year in order to observe and address any changes in erosion; presence of invasive weeds; non-native vertebrates and invertebrates; and repair any damaged fence line (e.g., fallen trees, deterioration from elements, vandalism).

   - Undertake surveys to determine if Hawaiian hoary bats use the area in the exclosure in the future.

- Trees over 15 feet tall will not be removed during the bat-pupping and rearing season.

- Blackburn's sphinx moth host plants (Aiea) will be surveyed and protected from disturbance

- Soil disturbance is expected to be short-term and no changes in the normal runoff or percolation are expected. Common species of native plants will be removed only when necessary and removal of native plants greater than six inches in diameter will be avoided as much as possible. Cut vegetation will be left to decompose. Areas with sensitive biological resources will be avoided. It is anticipated that the natural recovery of plants protected by the fencing will compensate for any damage to common species incurred during construction.

2. Fence crew will be trained to identify endangered species and sensitive habitats.

3. Contamination by workers: Workers could be agents for the unintentional introduction and/or spread of weedy or invasive plants along the corridor potentially harming listed species, or their habitat.

   Actions to reduce the effects of workers: Gear cleaning procedures to reduce the introduction of noxious plant seeds and propagules, as well as arthropods such as exotic ants will be strongly enforced. Boots, field gear (packs, rain gear, etc.) fencing equipment, and materials will be inspected for seeds, eggs, larvae, etc., prior to delivery and/or entry into the project area, and cleaned outside the area. All food, refuse, tools, gear, and construction scrap will be removed by the fence crew upon completion of work. DOFAW staff will ensure that gear cleaning procedures are followed. The project area will be monitored regarding this concern following fence construction.

4. Feral ungulate removal: Initially after completion, any ungulates residing within the fenced area would be penned, egress from the area being closed. This could result in a period of amplified ungulate damage potentially harming listed species or their habitat.

   Actions to reduce the impacts of feral ungulate removal: Following the completion of the fence, control efforts will immediately be implemented to eliminate ungulates remaining in the enclosed area. Ungulate activity monitoring will be performed to ensure all ungulates are removed.

5. Fence and Hawaiian hoary bats: The completed fence could serve as a hazard for Hawaiian hoary bats flying in the area.

Actions to reduce the impacts of the fence: No barbed wire will be used in fence construction.

## VI. Determination

Overall the project will benefit listed species and their habitats by protecting the area from the negative environmental impacts of ungulates and invasive plant species. Pigs are known to kill plants by digging and rooting and introduced sheep and mouflon girdle and browse native plants. Invasive weeds crowd-out listed species due to their vigorous and rapid growth. Listed species may proliferate in an undisturbed habitat without competition from invasive plant and animal species.

Listed Species

With the implementation of the aforementioned avoidance and minimization measures, it is our determination the Puuwaawaa Forest Reserve Protection and Restoration (Henahena unit) Fencing project will not adversely affect the threatened and endangered species listed in Table 1. We have determined the Puuwaawaa Forest Reserve Protection and Restoration Fencing project may create minor disturbance to listed and proposed species; however, any adverse effects are considered to be insignificant and/or discountable.

Critical Habitat

***Plants***

Critical habitat is designated for four plant species within the proposed Henahena unit: *Nothocestrum breviflorum, Zanthoxylum dipetalum* var. *tomentosum*, *Delissea undulata* and *Hibiscadelphus hualalaiensis*. Fencing the Henahena unit will have a beneficial effect on critical habitat for the four plant species through creation of a protected conservation area, promulgation of rules regarding use of the conservation area, enforcement, and habitat restoration.

***Blackburn's sphinx moth***

Critical habitat is designated for Blackburn's sphinx moth (*Manduca blackburnii*) within the proposed Henahena unit. Aiea, the native host plant for Manduca blackburnii, is also present inside the unit and protection of these endangered host plants is one of the primary goals in protecting the area with conservation fencing. The project area matches the climatic criteria for one the primary constituent elements of Blackburn's sphinx moth critical habitat: dry and mesic habitat between sea level and 5,000 feet receiving between 10 and 100 inches of annual precipitation. The non-native host plant, tree tobacco, is not established and the project area has been highly modified by fountaingrass. With measures taken to protect the few existing Aiea trees, it is discountable that the proposed project would adversely affect Blackburn's sphinx moth critical habitat.

In summary, the Puuwaawaa Forest Reserve Protection and Restoration (Henahena unit) Fencing project will enhance the natural regeneration of a native, healthy ecosystem thereby providing long-term benefits for listed species within the 950-acre conservation unit.

## VII. Island Team Leader

| Determination | Response requested |
| --- | --- |
| Not anticipated to adversely affect listed species or critical habitat. | __X_ Concurrence |

Determination by: ____________________ 3-20-14
Hawaii-Maui Nui Team Leader Date

## VIII. Reviewing Ecological Services Office Evaluation

____________________ 3-24-14
Geographic Supervisor Date

[X] Concur (Mark one) [ ] Do not concur

Internal Section 7 Informal Consultation – Puuwaawaa Forest Reserve Protection and Restoration (Henahena unit)

**Figure 1. Location of the Puuwaawaa Forest Reserve Protection and Restoration Project –Henahena Unit**

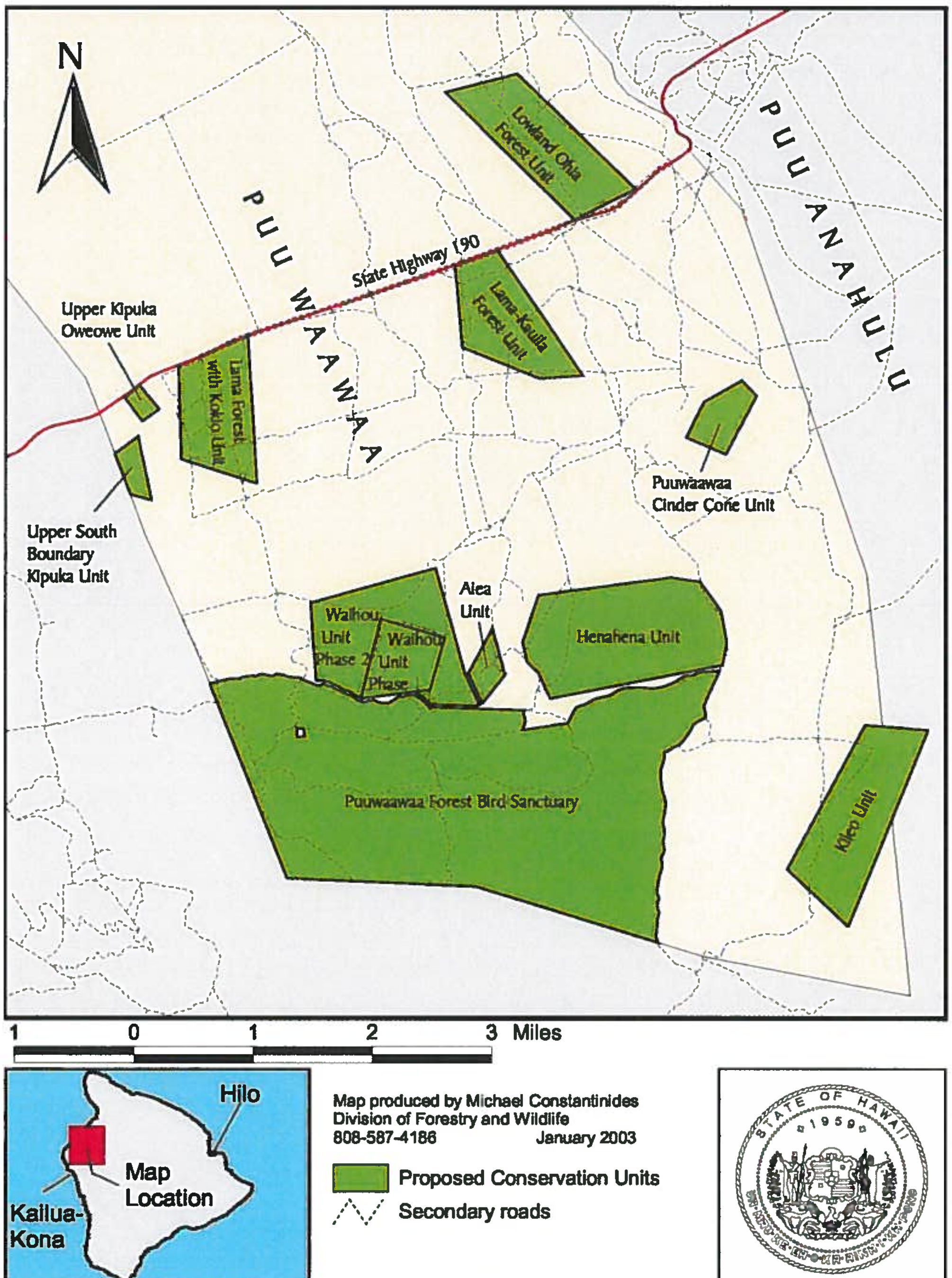
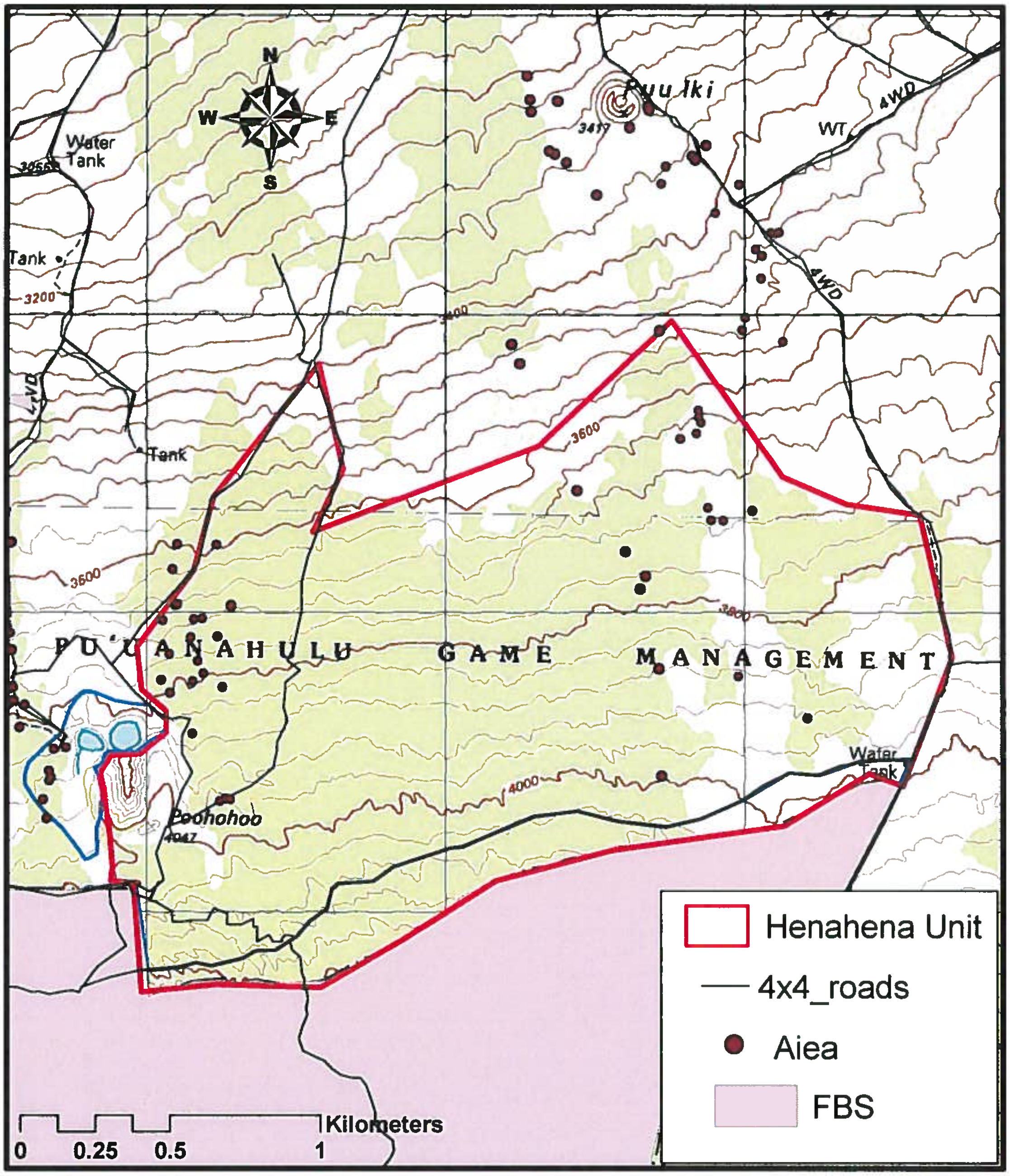
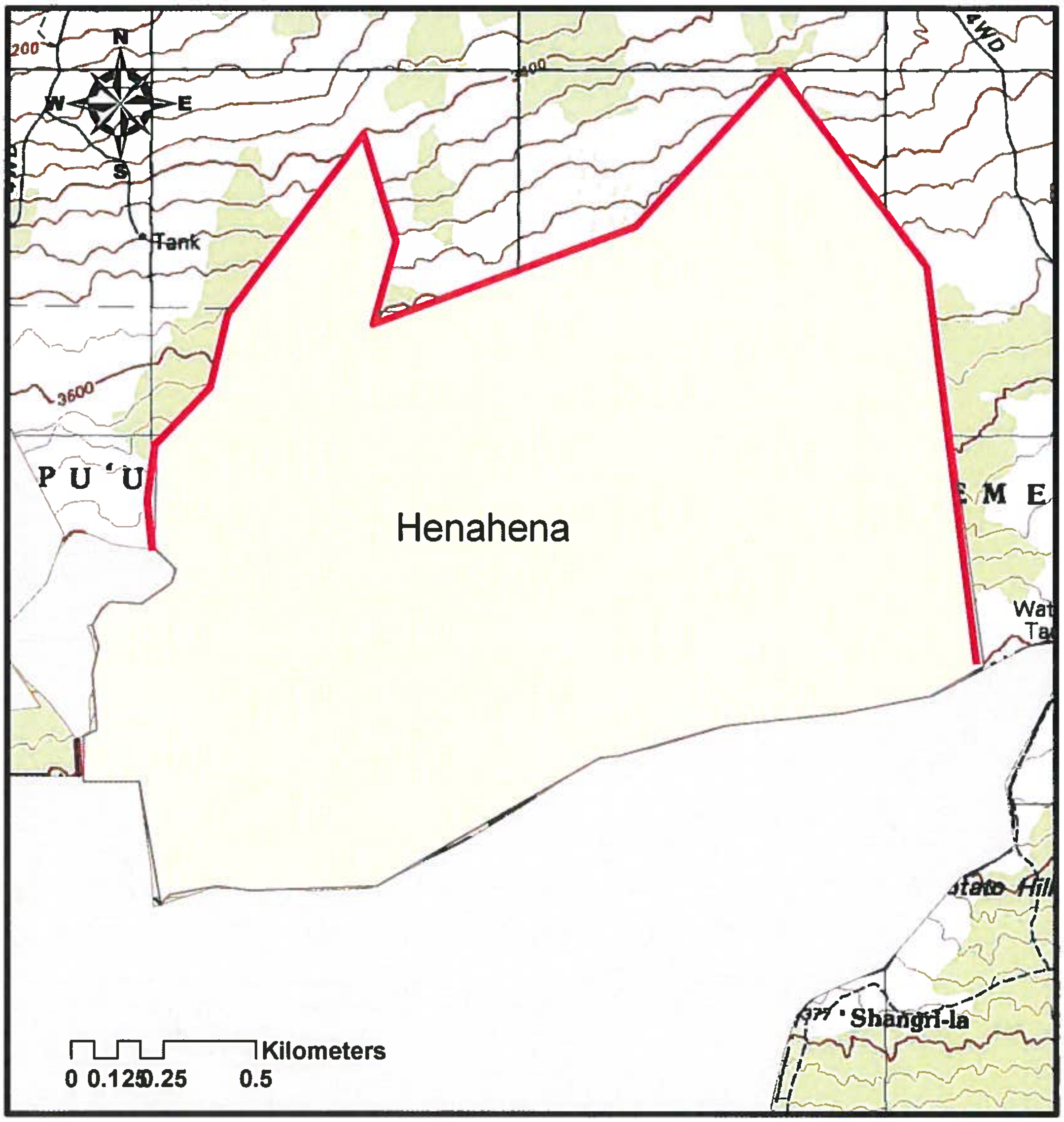


**Figure 2. T&E Species in the Puuwaawaa Henahena Management Unit**



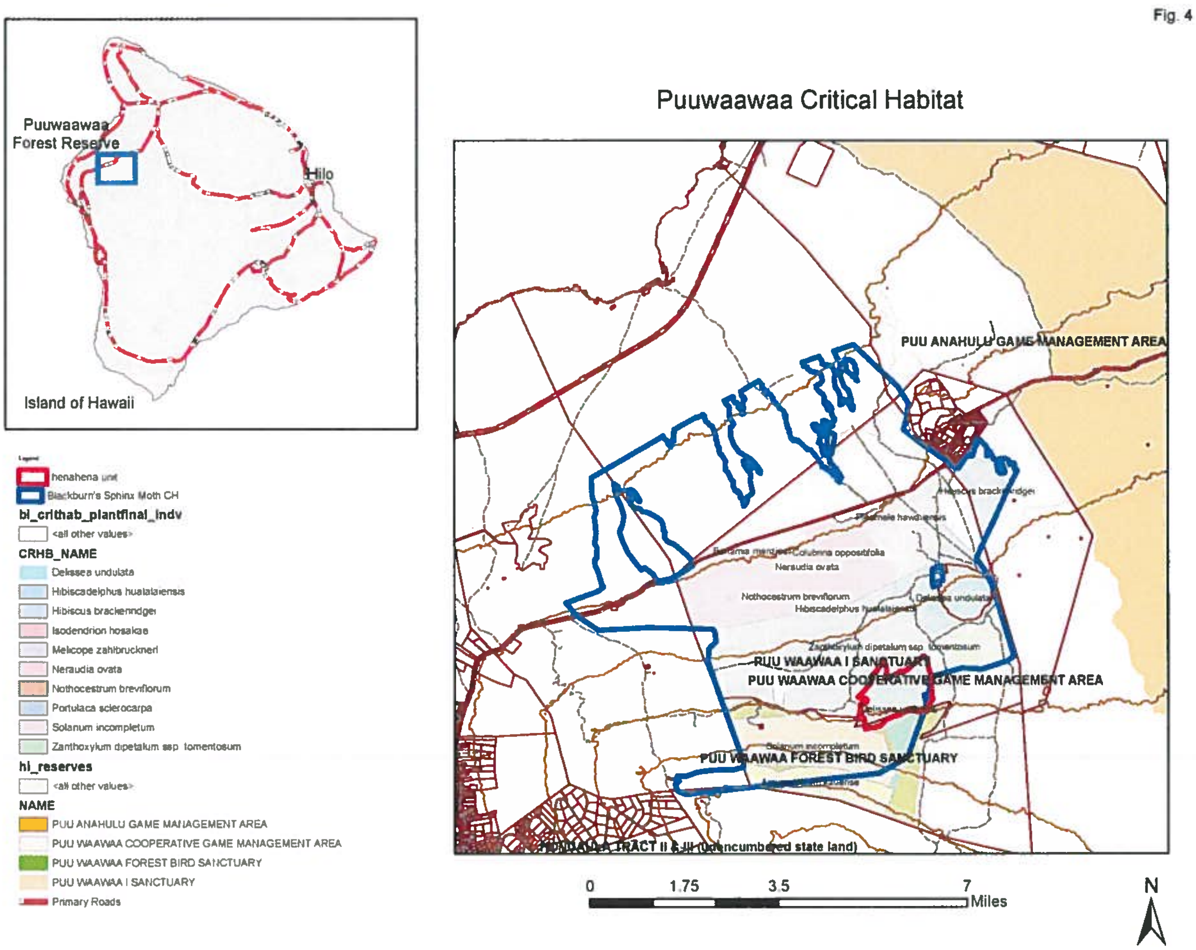

Henahena Conservation Unit

**Figure 3. Henahena Fence Alignment**




Red outline is where fence is needed
= 5065m or 16617 ft
= ~51 rolls of fence.

**Figure 4. Rare Species and Critical Habitat**



# APPENDIX D: BIOLOGICAL OPINION

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

TAKE PRIDE IN AMERICA

OCT 0 6 2015

In Reply Refer To:
01EPIF00-2014-F-0276-R001

To: Ruth Utzurrum, Wildlife and Sport Fish Restoration Program, Honolulu

From: David Tessler, Pacific Islands Fish and Wildlife Office, Honolulu

Subject: Reinitiation of Biological Opinion for Clearing of Fire Roads and Fuel Breaks at Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area, Hawai'i

## INTRODUCTION

The U.S. Fish and Wildlife Service (Service) Wildlife and Sport Fish Restoration Program (WSFRP) has provided WSFRP funds to the State of Hawai'i Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW), for the maintenance of fuel breaks and four wheel drive access roads within the Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area in North Kona, Hawai'i (Project Area). This Biological Opinion addresses the potential impacts of the proposed project on the endangered Blackburn's sphinx moth (*Manduca blackburni*; BSM) and designated BSM critical habitat in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C 1531 et seq.). This Biological Opinion covers a five year period beginning in October, 2015, and continuing to October 2020.

## CONSULTATION HISTORY

April 16, 2014 – DOFAW requested of the Service a Biological Opinion for maintenance of four wheel drive roads and fuel breaks in the Project Area. The Service's WSFRP requested the Service's Pacific Island Fish and Wildlife Office (PIFWO) to evaluate the effects of this action. PIFWO notified WSFRP and DOFAW that they would write a Biological Opinion covering these actions.

May 1, 2014 – PIFWO and DOFAW biologists discussed the proposed action, avoidance and minimization measures, and mitigation projects.

June 12, 2014 – PIFWO and DOFAW biologists conducted a site visit of the Project Area.

July 3, 2014 – DOFAW provided PIFWO with additional information regarding the proposed action.

September 4, 2014 – PIFWO issued "Biological Opinion for Clearing of Fire Roads and Fuel Breaks at Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area, Hawai'i" (Service File No. 2014-F-0276).

February 4, 2015 – DOFAW and PIFWO biologists met to discuss challenges with keeping tree tobacco cleared from roads and fuel breaks and potential solutions, including reinitiation of the section 7 consultation.

March 31, 2015 – The proposed action was discussed at the Endangered Species Recovery Committee meeting and anticipated take levels of BSM were presented.

May 6, 2015 – DOFAW, PIFWO, and WSFR staff met and discussed reinitiation of the Biological Opinion and take levels.

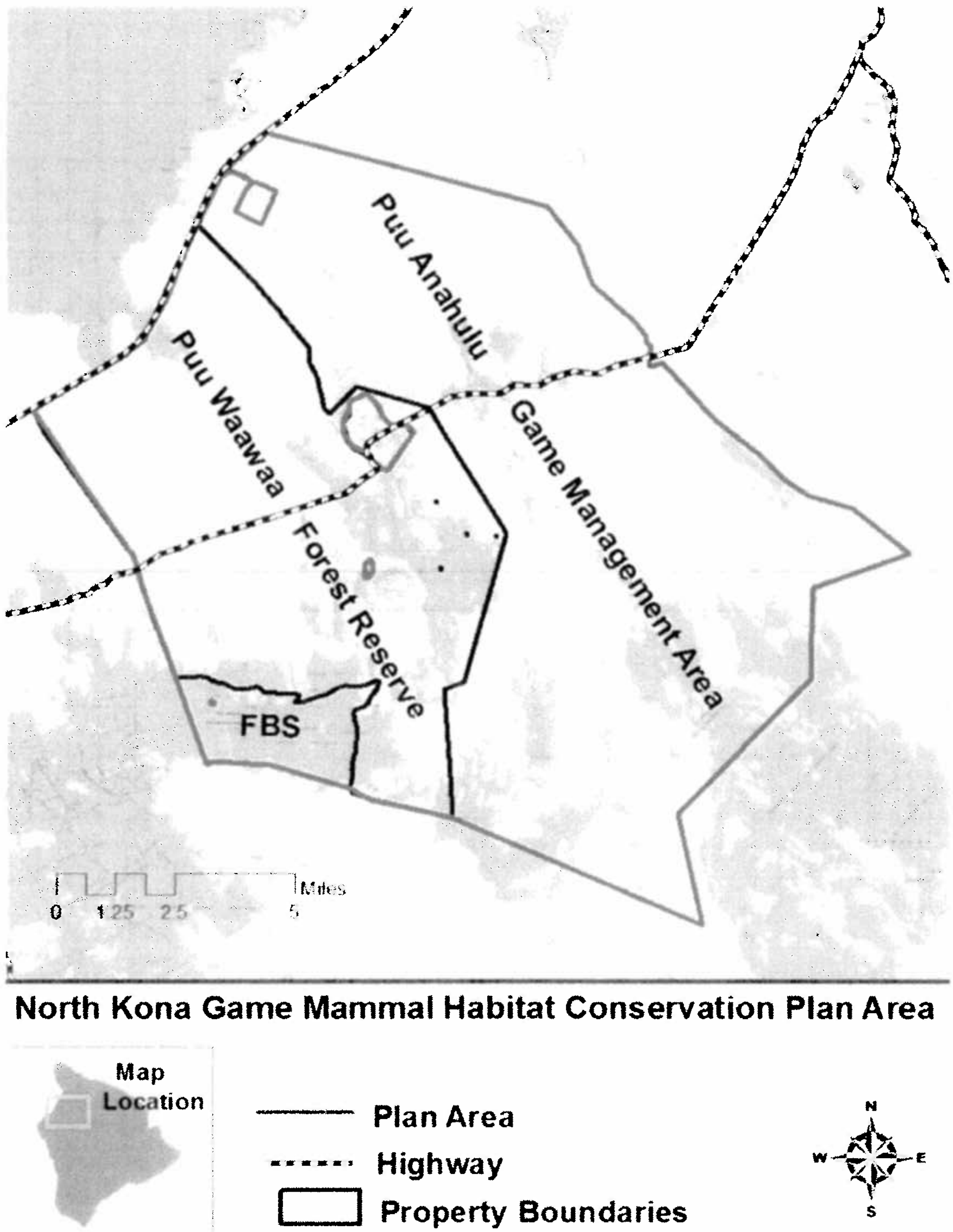
August 12, 2015 – DOFAW, PIFWO, and WSFR staff had a conference call to discuss timeline for draft of reinitiated Biological Opinion.

September 8-11, 2015 – DOFAW and PIFWO staff met in Honolulu, and exchanged emails and data clarifying take estimates and methods of vegetation clearing.

## ACTION AREA

The action area for this consultation includes all four wheel drive access roads and fuel breaks within the Pu'u Wa'awa'a and Pu'u Anahulu Game Management Areas in North Kona, Hawai'i (Figure 1). Roads and fuel breaks in the Program Area are 370 km (230 miles) long and approximately seven m (23 ft) wide, resulting in an action area of 259 ha (640 ac) (DOFAW 2015, pg. 37).

**Figure 1**. Project Area: 42,082 ha (103,988 ac), including Pu'u Wa'awa'a Forest Reserve, Pu'u Anahulu Game Management Area, and the Pu'u Wa'awa'a Forest Bird Sanctuary (FBS). Internal red outlines signify private inholdings and are excluded from the Project Area (DOFAW 2015).



## DESCRIPTION OF THE PROPOSED ACTION

Roadside and fuel break maintenance within the Project Area is necessary to reduce the quantity of fine fuels that can lead to fires, to prevent the spread of fire into native habitats, and to clear roads to provide continued access for fire control vehicles. The roads are maintained for fuel breaks and access for fire control.

Roads and fuel breaks need to be maintained free of vegetation year-round to reduce the potential for fires and ensure accessibility to respond to fires on the ground. Vegetation is cleared mechanically and with herbicides. Equipment used for clearing includes:

- Skid sprayers with a boom and wand
- All-terrain vehicle (ATV) and Utility vehicle battery pump sprayers
- Backpack sprayers
- Weed whacker
- ATV tow-behind brush/grass mowers
- Tractor
- Pruners, clippers, loppers, handsaws, chainsaws
- Small plastic containers for treating stumps
- Bulldozer

Roads and fuel breaks are sprayed with herbicide after precipitation events that lead to vegetation regrowth. Most rainfall occurs between December and May. The number of spraying events per year varies based on vegetative growth, and can range from zero (in drought years like 2010) to bimonthly (every-other month). If vegetation has already grown back up in the road or fuel break then the vegetation is initially cleared with an ATV tow-behind brush/grass mower, weed whackers, or a tractor. Once this vegetation has been cleared, and a new flush of green growth has appeared, herbicides are used.

A pesticide product with the active ingredient glyphosate (such as Roundup Pro Max, RangerPro, and generic brands) is typically used for road and fuel break clearing. Application quantities are based on the label instructions. A concentration of 1.5 percent to three percent is usually used depending on the time of year, amount of vegetation, and type of vegetation. Lower concentrations can easily kill grasses but higher concentrations may be necessary to kill small trees or shrubs. A blue dye is used at approximately one ounce per gallon to mark areas where the herbicide has been sprayed. Broadcast spray is not effective on larger woody shrubs, and these plants are treated using a cut and treat method. Loppers, clippers, handsaws, and chainsaws are typically used to cut the shrub down, and then the stump is treated with a product with an active ingredient of Triclopyr (usually Element 4 or Garlon 4). The Triclopyr product is mixed with 70 percent crop oil (a surfactant) and blue dye. The types and quantities of pesticides used for road and fire fuel break maintenance may vary depending on factors such as cost, availability, evolved plant resistance, and density. All label specifications and all regulations are followed for use of herbicides in forested and natural areas.

The primary shrub being cleared in the roads and fuel breaks is the non-native tree tobacco (*Nicotiana glauca*), which is a host plant for the BSM.

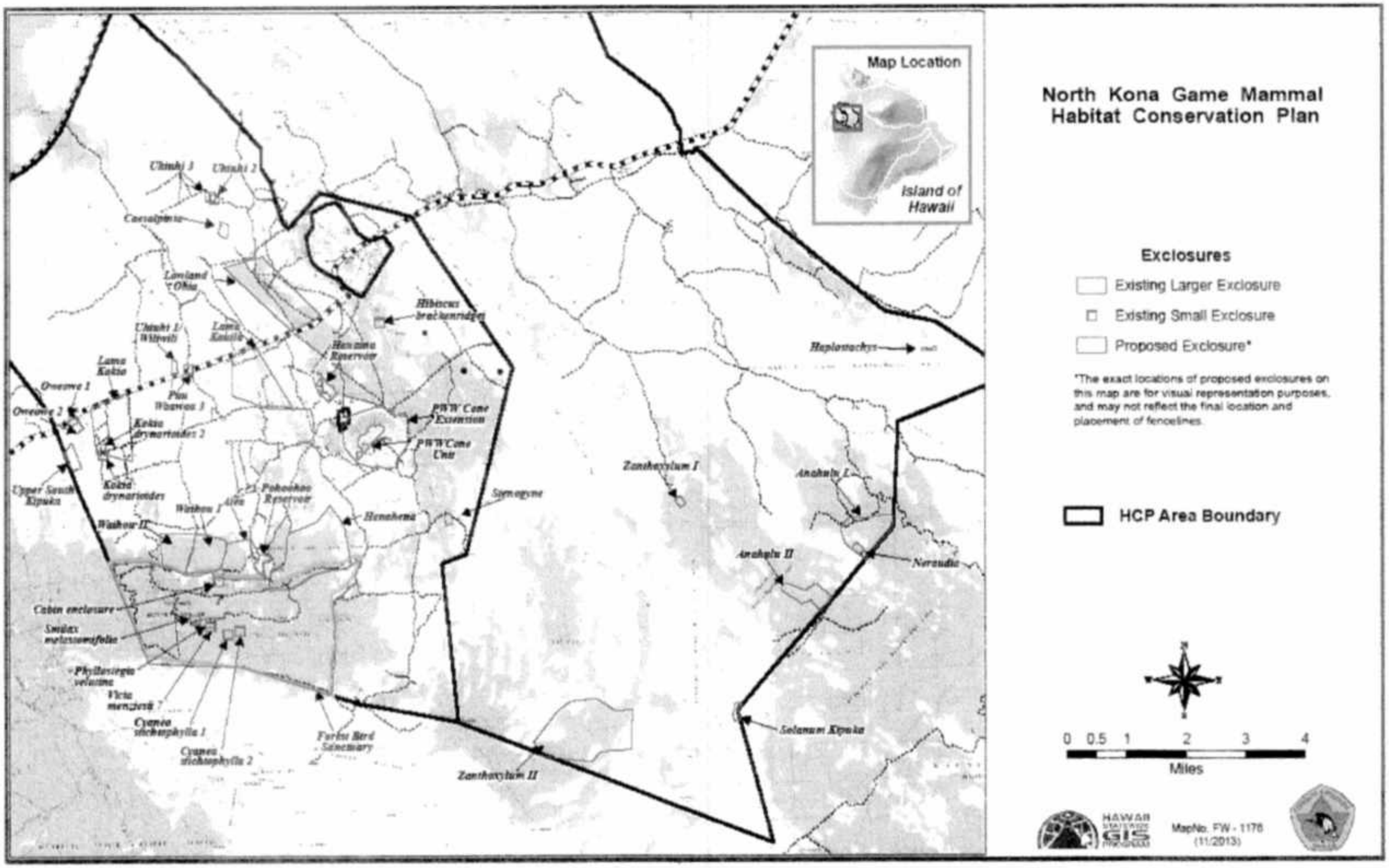
Conservation Measures

- The spread of invasive, non-native plant species will be minimized through cleaning and inspecting equipment and material coming to the site. Trash, especially food stuffs, will be removed from work areas on a weekly basis to avoid attraction of ants and other animals such as mongooses, cats, and rats that may negatively affect listed species.
- Control and removal of tree tobacco along roads and fuel breaks may occur year round, but whenever possible control and removal will be timed to reduce adverse effects to BSM eggs and larvae. The presence of BSM eggs and larvae on tree tobacco is strongly influenced by moisture and tree tobacco height, with increased presence during wet months and on plants taller than 1 meter (DOFAW 2015). Therefore;
    1. Whenever possible, tree tobacco, especially over 1 meter tall, will be controlled during dry periods
    2. Tree tobacco clearing will occur year-round at intervals designed to prevent new growth from exceeding 1 meter. These conservation measures will reduce the number of eggs and larvae on roads and fuel breaks and minimize the amount of take anticipated to occur as a result of the proposed action.

Measures to Offset Impacts to BSM

DOFAW is currently writing a Habitat Conservation Plan for the State of Hawai'i for game management actions within the Project Area. Mitigation of covered plant species will include the creation of large conservation units and exclosures for the protection and out-planting of BSM's native host tree, 'aiea (*Nothocestrum breviflorum*), and other endangered plant species, as well as potential and known native BSM nectar plant species. The exclosures will be built with six foot hog wire fencing, and will be skirted with additional hog wire or deer fence to prohibit burrowing under fences. As much as is feasible, all known 'aiea plants in the Project Area will be permanently fenced to protect them from ungulates. All of the proposed or current exclosures (totaling approximately 3,600 ha (9,000 ac)) within the Project Area that will be used for mitigation purposes fall within the range of 'aiea and BSM (Figure 4; DOFAW 2015). The construction of the Henahena fenced unit (288 ha (711 ac)) is slated to begin in late 2015/early 2016, and is designed to mitigate loss of 'aiea.

**Figure 2**. Map of Existing and Proposed Conservation Areas (from DOFAW 2014)



## NOT LIKELY TO ADVERSELY AFFECT DETERMINATION

***Blackburn's Sphinx Moth Critical Habitat***

In 2003 critical habitat was designated for BSM on the islands of Hawai'i (9,954 ha (24,597 ac)), Kaho'olawe (1,721 ha (4,252 ac)), Maui (six units, 9,509 ha (23,496 ac)), and Moloka'i (1,256 ha (3,105 ac)) (USFWS 2003, pp. 34710-34766). These designations include habitat on State and private lands totaling 22,440 ha (55,451 ac) (USFWS 2003, pp. 34710-34766). Approximately 10,100 ha (25,000 ac) of designated critical habitat occur within the Project Area, specifically within the Pu'u Wa'awa'a Forest Reserve.

Four wheel drive roads and fuel breaks are not included in the critical habitat designation because they were existing man-made features when critical habitat was designated (USFWS 2003, pp. 34721). The action area for the proposed project only includes four wheel drive roads and fuel breaks; no work will occur outside these areas. In addition, tree tobacco is not a primary constituent element for BSM critical habitat (USFWS 2003, pp. 34742). Therefore, it is discountable that the proposed project would adversely affect BSM critical habitat. The maintenance of access roads and fuel breaks in the project area will have a beneficial effect on BSM critical habitat by reducing the chance a fire will spread and degrade native habitat in the area.

## STATUS AND ENVIRONMENTAL BASELINE OF THE SPECIES

The Blackburn's sphinx moth was listed as endangered on February 1, 2000 (USFWS 2000, pp. 4770-4779).

**Status of the Species**

Historic and Current Distribution

Reports by early naturalists indicate that BSM was once widespread and abundant, at least during European settlement, on nearly all the main Hawaiian Islands (Riotte 1986, p. 88). Very few specimens of the moth had been seen since 1940, and after a concerted effort by staff at the Bishop Museum to relocate this species in the late 1970s, it was considered to be extinct (Gagné and Howarth 1985, p. 5). In 1984, a single population was rediscovered on Maui (Riotte 1986, p. 80), and subsequent populations on Hawai'i, Kaho'olawe, and Lana'i were rediscovered (USFWS 2005, pp. 9-10; Duvall, pers. comm., 2011). Moth population numbers were believed to be small based upon past sampling results, however, no reasonably accurate estimate exists due to the adult moths' wide-ranging behavior and its overall rarity (A. Medeiros, USGS-BRD, pers. comm., 2014; Van Gelder and Conant 1998, pp. 7-16). However, the continuing expansion of the non-native tree tobacco (*Nicotiana glauca*) on Hawai'i may support more BSM than previously recorded. Recent surveys at Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area on Hawai'i indicate that the number of BSM eggs and larvae in winter months may exceed 150,000 (DOFAW 2015); it is unknown how many of these eggs and larvae survive to adulthood. Before humans arrived, dry and mesic shrubland and forest covered about 823,283 ha (2,034,369 ac) on all the main islands and it is likely the moth inhabited much of that area (USFWS 2005, p. 16).

The BSM has been recorded from the islands of Kauai, Kahoolawe, Oahu, Lanai, Molokai, Maui, and Hawaii, and has been observed from sea level to 1,525 m (5,000 ft) elevation (USFWS 2005, p. 10; Duvall, pers. comm., 2011). Most historical records were from coastal or lowland dry forest habitats in areas receiving less than 127 cm (50 in) annual rainfall. On the island of Kaua'i, the moth was recorded only from the coastal area of Nawiliwili. Populations were known from Honolulu, Honouliuli, and Makua on leeward Oahu, and Kamalo, Mapulehu, and Keopu on Molokai. On Hawai'i, it was known from Hilo, Pahala, Kalaoa, Kona, and Hamakua. It appears this moth was historically most common on Maui, where it was recorded from Kahului, Spreckelsville, Makena, Wailuku, Kula, Lahaina, and West Maui. Historical records are lacking for the islands of Kaho'olawe and Lana'i: the moth has been observed there only in very recent years during biological surveys conducted for various restoration activities.

Life History
Sphingid moths develop from egg to adult in 56 days (Williams 1947, p. 10), but pupae may remain in a state of torpor (inactivity) in the soil for up to a year (B. Gagné, pers. comm., 2010; Williams 1931, p. 373). BSM larvae have been seen in all months but July, and it is likely that with good rainfall they could be found year-round (Rounds pers. comm. 2014). Adult sphingid moths have been found throughout the year (Riotte 1986, p. 88; DOFAW 2014;) and are known to live longer than most moths because of their ability to feed and take in water from a variety of plants, rather than relying only upon stored fat reserves. A longer adult period allows more time to locate host plants for egg laying (Kitching and Cadiou 2000). During 14 surveys conducted between August 15, 1996 and May 29, 1997, Van Gelder and Conant (1998, p.14) noted the presence of eggs on host plants and substantial variation in larval length throughout the BSM breeding season. Van Gelder and Conant (1998, p. 15) hypothesized that BSM either produce eggs during more than one generation each "season," or produce eggs during a single generation with an extended adult emergence time and/or laying period of several weeks.

Sphingid moths exploit nutritious but low-density host plants such as vines and sapling trees (Kitching and Cadiou 2000), many of which possess secondary compounds the larvae can metabolize and/or sequester for their own defense (Nishida 2002). Native host plants include trees within the 'aiea genus *Nothocestrum* (Riotte 1986, p. 89), on which the larvae consume leaves, stems, flowers, and buds (B. Gagne, pers. comm., 2010). *Nothocestrum* is a genus of four species endemic to the Hawaiian Islands (Symon 1999, pp. 1251-1278) that currently occur on Kaua'i, Oahu, Moloka'i, Lana'i, Hawai'i, and Maui. Three of the 'aiea species are federally listed as endangered: *N. latifolium*, located on Maui, Moloka'i, Lana'i, Oahu and Kaua'i; *N. breviflorum*, located on the island of Hawai'i; and *N. peltatum*, located only on the island of Kaua'i. One species, *N. longifolium*, primarily occurs in wet forests, but can occur in mesic forests as well. Three species, *N. latifolium*, *N. breviflorum*, and *N. peltatum*, occur in dry to mesic forests, the habitat in which the moth has been most frequently recorded. Moth larvae have been documented feeding on *N. latifolium* and *N. breviflorum* and it is likely that *N. peltatum* and *N. longifolium* are suitable host plants as well.

The largest populations of BSM, on Maui and Hawai'i, have been associated with remnant populations of *Nothocestrum* (Van Gelder and Conant 1998, pp.14-15), though the spread of tree tobacco may have changed this. The large stand of *Nothocestrum* trees within Kanaio Natural Area Reserve, Maui, is likely the largest in the State (Medeiros *et al*. 1993, p. 19), and may explain why BSM was able to persist in the Kanaio area (A. Medeiros, USGS-BRD, pers. comm., 1994).

There are also four native species in the popolo genus *Solanum* (*Solanum americanum*, *S. incompletum*, *S. nelsonii*, and *S. sandwicense*) that may also be host plants, though there is only evidence of moth larvae utilizing *S. sandwicense* (Rubinoff and San Jose 2010, p. 55) and *S. americanum* (E. Parsons, pers. comm., 2014). BSM have also been observed feeding on non-native *Solanum* species including the common tomato plant (*Solanum lycopersicum*) (E. Parsons, pers. comm., 2015). Plant species composition in the moth's habitat varies considerably depending on location and elevation, but some of the most common native plants in areas where the moth occur are lama (*Diospyros sandwicensis*), hao (*Rauvolfia sandwicensis*), ohe (*Polyscias sandwicensis*), ala'a (*Planchonella sandwicensis*), aalii (*Dodonaea viscosa*), wiliwili (*Erythrina sandwicensis*), and naio (*Myoporum sandwicense*) (USFWS 2005, p. 13).

In their 1998 study, Van Gelder and Conant never observed BSM adults feeding or attempting to feed on native morning glory (*Ipomea* spp.) flowers provided within their enclosures, and captive-reared adult moths lived no longer than 12 days. However, three field observations of feeding BSM adults have been made. One observation occurred within the Kanaio Beach area of southeast Maui, where BSM adults were seen feeding upon the nectar of the native Hawaiian morning glory species (*Ipomea indica*) (D. Hopper, USFWS, pers. comm. 1997). The second observation was made in the upper Kanaio Natural Area Reserve where a single BSM adult was also seen feeding upon the nectar of koali awa (D. Hopper, *in litt.*, 2002). The third observation occurred within a 4 ha (10 ac) exclosure located in the Auwahi dry forest area within the Ahihi-Kinau Natural Area Reserve – Ulupalakua-Auwahi-Kanaio Unit (Leeward Maui) (F. Duvall, DOFAW, pers. comm. 2005). This observation involved an adult moth feeding upon the nectar of a native halepepe (*Pleomele auwahiensis*) flower. It is expected the native Hawaiian species of caper, maiapilo (*Capparis sandwichiana*), and ilie'e (*Plumbago zeylanica*) are also likely native adult BSM food sources. All three species, *C. sandwichiana*, *P. zeylanica*, and *I. indica,* bear flowers with characteristics suggestive of moth pollination, including nocturnal anthesis (opening at night), light coloration, or the emittance of strong fragrances upon opening. Notable differences in BSM proboscis length between the sexes ranging from 14 to 38 millimeters (6 to 15 inches) have been documented (Van Gelder and Conant 1998, p. 28). If further research demonstrates the validity of this potential characteristic of BSM sexual dimorphism, the difference may indicate a division of adult foraging resources in the wild.

Many of the other host plants recorded for this species are not native to the Hawaiian Islands, and include commercial tobacco (*Nicotiana tabacu)*, tree tobacco (*Nicotiana glauca*), common tomato (*Solanum lycopersicum*) and possibly Jimson weed (*Datura stramonium*) (Riotte 1986, p. 89). The non-native tree tobacco has spread extensively throughout Maui and Hawai'i Island and has extended the current range of BSM well beyond the current range of *Nothocestrum* species, although BSM is still well below its historic range.

<u>Threats, Recovery Strategy, and Ongoing Conservation Measures</u>

The primary threats to the BSM include: habitat loss and degradation from urban and agricultural development and wildfires, predation by non-native birds, lizards, and ants, and parasitism by non-native parasitoid wasps and flies.

Dry to mesic forest habitats in Hawai'i have been greatly altered due to land management practices including ranching, the impacts of introduced plants and animals, wildfire, and agricultural development (Cuddihy and Stone 1990, pp. 17-107). Currently, there are approximately 148,588 ha (367,169 ac) of dry to mesic shrub and forest habitats that are, or could be made, suitable for BSM statewide. It is apparent that the moth's range has declined on the order of 82 percent since humans arrived in Hawai'i 1,600 years ago (HBMP 2000; Kirch 1982) and habitat continues to be threatened by development and degradation by fire and ungulates (USFWS 2005, p. 16).

The primary predatory threats to BSM are introduced ants, introduced birds (e.g., Japanese white-eye (*Zosterops japonicus*); Van Gelder and Conant 1998, p. 17), and introduced reptiles (Van Gelder and Conant 1998, p. 18). All ant species in Hawai'i have been introduced from the mainland and several foreign locations, and BSM has evolved in the absence of predation pressure from ants. Ants can be particularly destructive predators because of their high densities, aggressiveness, and broad range of diet (Reimer 1993, p. 19-20). Seven ant species are significant threats to BSM: the big headed ant (*Pheidole megacephala*), the Argentine ant (*Iridomyrmex humilis*), the long-legged ant (*Anoplolepis longipes*), *Ochetellus glaber* (no common name), the red imported fire ant (*Solenopsis invicta*), the tropical fire ant (*Solenopsis geminata*), and the Papuan thief ant (*Solenopsis papuana*) (USFWS 2005, pp. 28-30). The big headed ant is found on all of the islands where BSM occur and it is known to be a predator of eggs and caterpillars of native Lepidoptera, and can exterminate entire populations (Zimmerman 1948, pp. 173-174). The Argentine ant is found on seven of the main Hawaiian Island and has been found to impact native insects (Cole *et al.* 1992, pp. 1113-1322; Krushelnycky *et al.* 2005, pp. 5-9). The long-legged ant occurs on Kaua'i, Oahu, Maui, and Hawai'i (Reimer *et al.* 1990, p. 44; Holway *et al.* 2002). *Ochetellus glaber* is found on Kaho'olawe, Kaua'i, Oahu, Maui, and Hawai'i (Nishida 2002, p. 169; Starr *et al.* 2004, p. 52) and was reported to have preyed upon or scavenged a BSM larvae (A. Medeiros, pers. comm., 1998). The tropical fire ant and Papuan thief ant are found on seven of the main Hawaiian Island (Reimer et al. 1990, p. 44). Ants, including the tropical fire ant are known to be the most significant and consistent mortality factor on eggs, and probably larvae, of the common eggfly (*Hypolimnas bolina*), a butterfly on Guam (Nafus 1993a, p. 19; 1993b, pp. 143-144).

The primary threat of parasitism to BSM is from non-native braconid, ichneumonid, and trichogrammatid wasps and tachinid flies. Most species of non-native braconid and ichneumonid wasps that parasitize Lepidoptera in Hawai'i are not host-specific, but attack caterpillars or pupae of a variety of species (Zimmerman 1948, pp. 174-175, 1978, pp. 94-98; Funasaki *et al.* 1988, pp. 111) and have become the dominant larval parasitoids even in intact, high-elevation, native forest areas of the Hawaiian Islands (Zimmerman 1948, pp. 174-175; Howarth *et al.*, *in litt.* 1994). These wasps lay their eggs within the eggs or caterpillars of Lepidoptera. Upon hatching, the wasp larvae consume internal tissues, eventually killing the host. At least one species established in Hawai'i, *Hyposoter exiguae* (no common name), is known to attack the tobacco hornworm and the related tomato hornworm in North America (Carlson 1979, pp. 676-677). This wasp is recorded on Kaua'i, Oahu, Moloka'i, Maui, and Hawai'i Island (Nishida 2002, pp. 171) and is a recorded parasitoid of the lawn army worm (*Spodoptera maurita*) on tree tobacco on Maui (Swezey 1927, pp. 404-405). Because of the rarity of BSM, no documentation exists of non-native braconid and ichneumonid wasps parasitizing the species. However, given the abundance and the breadth of available hosts of these wasps; they are considered significant threats to the moth (Howarth 1983, pp. 239-244; Howarth *et al.*, *in litt.* 1994; F.G. Howarth, pers. comm. 1994; Gagne and Howarth 1985, p. 77).

Small wasps in the family Trichogrammatidae parasitize insect eggs, with numerous individuals sometimes developing within a single host egg. Several non-native species are established in Hawai'i (Nishida 2002, pp. 180), including *Trichogramma minutum* (no common name), which is known to attack the sweet potato hornworm in Hawai'i (Fullaway and Krauss 1945, pp. 99). In 1929, the wasp *Trichogramma chilonis* (no common name) was purposefully introduced into Hawai'i as a biological control agent for the Asiatic rice borer moth (*Chilo suppressalis*) (Funasaki *et al.* 1988, pp. 136). The wasp parasitizes the eggs of a variety of Lepidoptera in Hawai'i, including sphinx moths (Funasaki *et al.* 1988, pp. 136). Parasitism of BSM eggs by unknown *Trichogramma* species was observed during 2012 BSM surveys in Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area. While no Trichogrammatid wasps successfully emerged from BSM eggs, dissections confirmed the presence of the developing wasps (DOFAW 2014).

Two species of tachinid flies, *Lespesia archippivora* and *Chaetogaedia monticola*, were purposefully introduced to Hawai'i for control of army worm moths (Funasaki *et al.* 1988, pp. 140-141; Nishida 2002, pp. 116). These flies lay their eggs externally on caterpillars, and upon hatching, the larvae burrow into the host, attach to the inside surface of the cuticle, and consume soft tissues (Etchegaray and Nishida 1975a, pp. 42-43). In North America, *Chaetogaedia monticola* is known to attack at least 36 species of Lepidoptera in eight families, including sphinx moths; *Lespesia archippivora* is known to attack over 60 species of Lepidotera in 13 families, including sphinx moths (Arnaud 1978, pp.136). These species are on record as parasites of a variety of Lepidoptera in Hawai'i and are believed to depress populations of at least two species of native moth (Lai 1988, pp. 188-187). Over 40 percent of the caterpillars of the monarch butterfly (*Danaus plexippus*) on Oahu are parasitized by *Lespesia archippivora* (Etchegaray and Nishida 1975b, pp. 35-37).

*Conservation Needs of the Species*

The 2005 Recovery Plan (USFWS 2005, p. 46) identified 3 recovery units comprised of 13 management units on seven of the main Hawaiian Islands: the Kaua'i-Oahu Recovery Unit; the Maui Nui Recovery Unit; and the Big Island (Hawai'i Island) Recovery Unit. The primary criterion used to identify the three recovery units includes the priority need to encompass an extended portion of the moth's former range. Establishing and restoring the moth to three widely-spaced recovery units distant from each other within the main island chain will offer the best protection to the species from the possibility of severe habitat loss and effects from invasive predators.

Actions needed to recover the BSM are detailed below. For additional information on these recovery actions see the recovery plan (USFWS 2005).

- Site/area/habitat protection – Protection, management, and restoration of BSM and wild *Nothocestrum* spp. host plant populations.
- Monitoring protocol development – Development and implementation of a detailed long-term monitoring program.

- Reintroduction/ translocation implementation – Re-establish and augment wild moth populations within the species' historic range.
- Captive propagation protocol development – Continue efforts to develop and refine captive propagation techniques for the species; assess oviposition preference by female BSM on native vs. native host plants; and determine if larval development on native vs. non-native host plants confers egg or larval resistance to predation and parasitism.
- Threats research – Identify primary predators, competitors, and parasites of BSM and develop and implement appropriate control measures.
- Ungulate control – Remove ungulates and restore habitat in management units.

*Ongoing Conservation Actions*

Conservation efforts that have been implemented to help support the recovery of the BSM or its host plant are detailed below.

- Ungulate exclosures – Exclosures of various sizes have been constructed in management units on Kaua'i to protect potential BSM host plants (M. Clark, USFWS, pers. comm. 2008). In addition, ungulate exclosures and, in some cases, ungulate control has been undertaken in various locations on Kaua'i Lana'i, Moloka'i, Maui, and Hawai'i (Medeiros 2006, pp. 1-4; DLNR 2007, pp.1-9; J. Higashino, USFWS, pers. comm. 2008). Additional exclosures are needed to support BSM recovery.
- Habitat and natural process management and restoration – Forest restoration, including outplanting of 'aiea (*Nothocestrum* spp.), has been undertaken in management units on Kaua'i (M. Clark, USFWS, pers. comm. 2008). Efforts to outplant *Nothocestrum* species have been undertaken in various locations on Maui and Hawai'i including fenced exclosures in the Kipuka Oweowe, Uhiuhi, Cone, and Hauaina units around Pu'u Wa'awa'a (Allen 2000, pp.1037-1041; Medeiros 2006, pp.1-4; E. Parsons, pers. comm., 2015). However, additional management is needed in these management units to help achieve the recovery of the BSM.
- Threats research – Efforts to develop control measures for some potential predators, like the big-headed ant (*Pheidole megacephala*) and Argentine ant (*Linepithema humile*), have met with some success (Peck *et al.* 2007, p. 91; Snook *et al.* 2008, p. 56). Additional research and application is needed.
- Reintroduction / translocation protocol development – Rubinoff and San Jose (2010, pp. 53-59) undertook efforts to develop captive propagation techniques for the BSM in 2005 and 2009 which could support a reintroduction program on Kaua'i. Additional work is needed.

**Environmental Baseline**

The action area is within the Hawai'i Island Recovery Unit, Management Unit 11- Pu'u Wa'awa'a – Hūalalai Unit. This management unit consists of approximately 12,197 ha (42,495 ac) encompassing portions of the flows and northwest slopes of the Hūalalai volcano. Frequent and persistent observations by numerous biologists of both moth larvae and adults throughout this unit indicate that this area contains the largest known population of BSM on the island of Hawai'i (USFWS 2005, p. 64). The unit is important because it provides refugia for adults that are migrating to other areas of existing suitable plant habitat.

Surveys for eggs, larvae, and adult moths and host plants were conducted in the Project Area from 2010-2012. Additionally, there were observations made regarding BSM and host plants made in 2014 and 2015. The purpose of these surveys was to quantify BSM density and distribution on tree tobacco, and to attempt to identify significant factors affecting density and distribution, such as plant density, leaf density, plant height, and elevation. Survey methods focused on quantification of eggs and larvae, and adults separately, because of potential differences in distribution, timing, and effective survey strategies for these different life stages. Surveys for tree tobacco were conducted on roadsides and fuel breaks across the Project Area in advance of the BSM surveys. Complete survey methodology can be found Appendix D of the draft HCP (DOFAW 2015).

The tree tobacco surveys found that tree tobacco covered approximately 15.6 ha (38.6 ac) of roads and fuel breaks within the Project Area (DOFAW 2015). BSM surveys found a total of 120 larvae, 91 hatched eggs, and 101 un-hatched eggs on tree tobacco (DOFAW 2015). The highest density of BSM eggs and larvae per acre was recorded in February, 2011, with 50 eggs/acre and 48 larvae/acre (DOFAW 2015). The surveys found that BSM preferentially select plants with relatively large leaves and in the two to five meter size class. Only two percent of tobacco trees less than one meter tall had eggs or larvae (DOFAW 2015). There was no difference in BSM use of tree tobacco on versus off of the roads (DOFAW 2015). Larvae have been documented on tree tobacco between the months of August and May, with highest numbers found to date from December to March (DOFAW 2015).

Seventeen ‘aiea trees were surveyed and BSM feeding damage was documented on all the trees (DOFAW 2015). Larvae and eggs were documented on two individuals, one located in the Uhiuhi/Wiliwili exclosure and the other in the proposed Henahena exclosure. There have been observations from DOFAW staff of larvae on ‘aiea on two other instances in recent years, one on a wild individual and the other on an outplant on the Pu‘u Wa‘awa‘a cinder cone (DOFAW 2015).

Light trapping was conducted in the Project Area on four occasions in 2009-2010 (DOFAW 2015). In September, 2009, two light traps were deployed in a mixed silk oak (*Grevillea robusta*) and ‘ōhi‘a forest along the road for four hours. One adult moth was documented visiting a trap. From January 11 -15, 2010, three light traps were deployed for five hours each and no adult moths were observed. These light traps were located in three habitat types: 1) mixed native/alien forest with tree tobacco and ‘aiea; 2) predominantly native forest with ‘aiea present; and 3) highly disturbed area dominated by tree tobacco. Light trapping was conducted on the Pu‘u Wa‘awa‘a cinder cone, in native outplanted habitat with ‘aiea present, in February, 2011. Light traps were deployed on two nights for five hours each and no adult moths were observed. It is important to note that the absence of adult BSM at light traps does not indicate absence of the species in the area.

Distribution of BSM in the project area most likely coincides with its primary host plants, tree tobacco and ‘aiea. Current distribution of tree tobacco and ‘aiea can be seen in Figures 3 and 4. Based on this data and the surveys described above, it can be assumed that BSM has a moderate to wide distribution within the Project Area (DOFAW 2015). Estimating the population of BSM in the project area at any given point in time is very challenging given the short generational time (~56 days) and the degree to which BSM density is dependent on weather, season, and host plants. However, using the BSM density data collected in the winter of 2012 and the results of a January 2015 helicopter survey of tree tobacco area, DOFAW estimated that in the winter of 2012 the number of larvae and eggs in the Project Area on tree tobacco was 156,965 (DOFAW 2015). This number does not include adults or pupae.

**Figure 3**. Distribution of tree tobacco within the Project Area in 2015. Areas where *N. glauca* was observed are highlighted in purple (from DOFAW 2015).

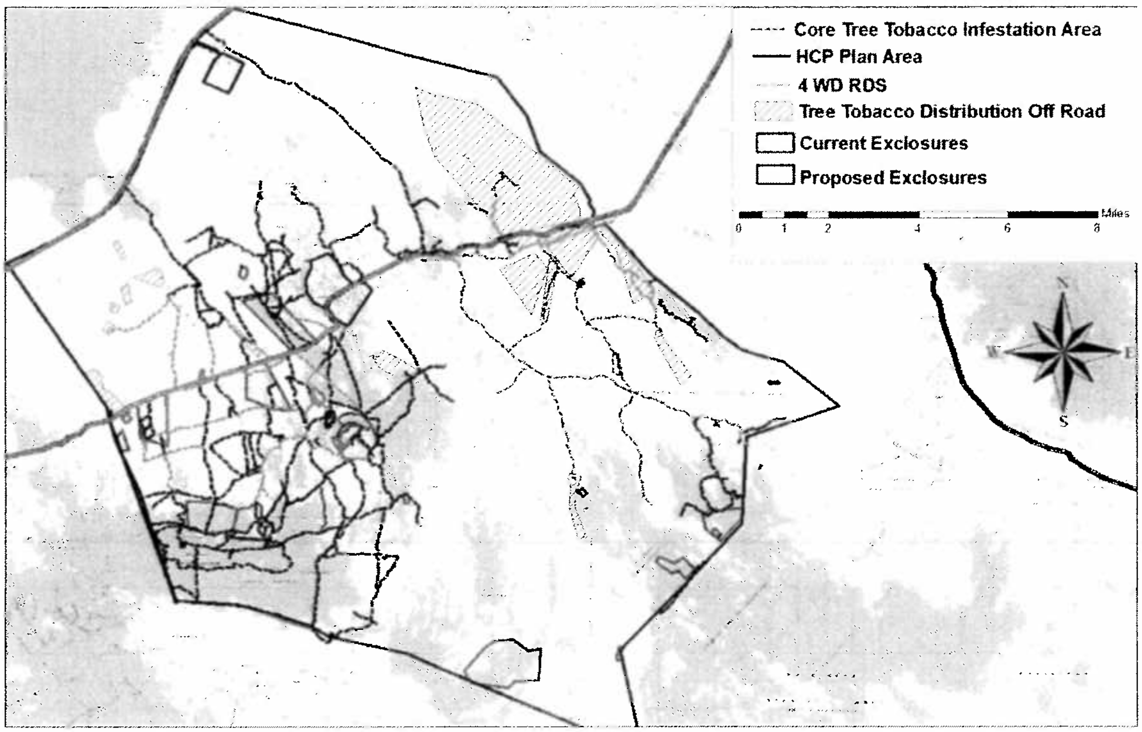
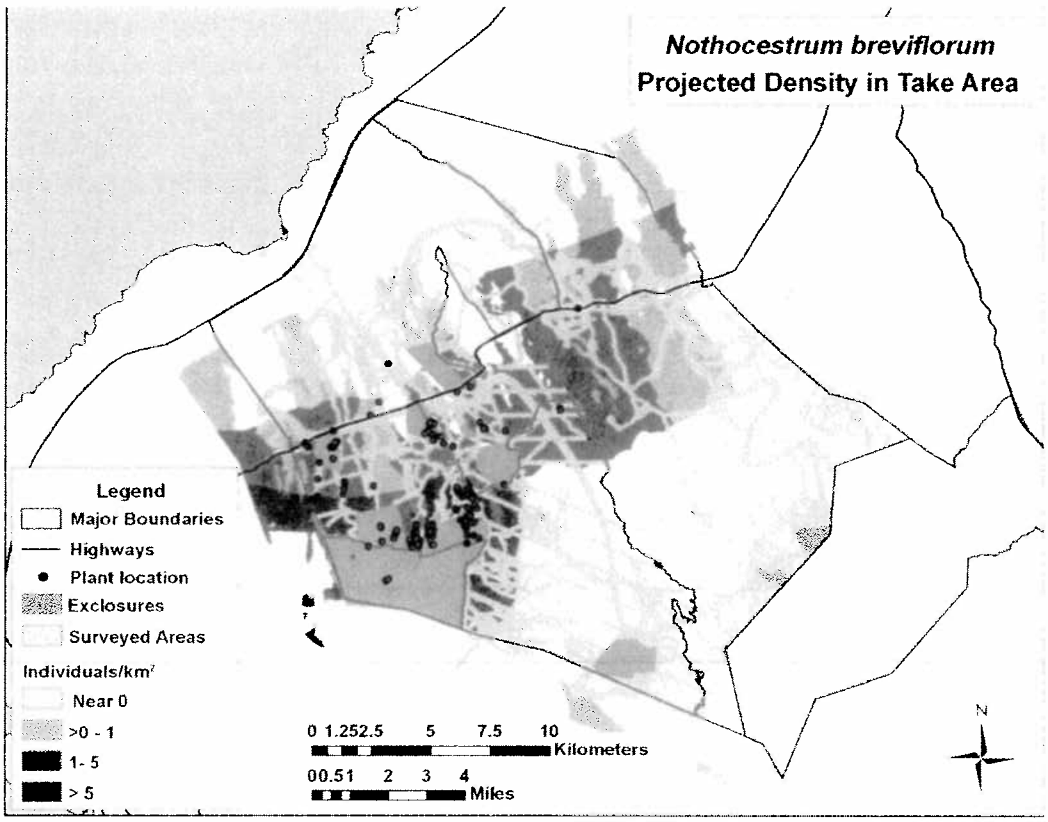


**Figure 4**. Map of the Project Area showing known *Nothocestrum breviflorum* locations, areas surveyed, the species range, and projections of *N. breviflorum* density into unsurveyed areas. Species range is depicted by all colors except tan; shades of green indicate areas the species is most likely to be found (from DOFAW 2015).




## EFFECTS OF THE ACTION

Adverse effects to BSM from the proposed project will occur from habitat loss and from mortality of eggs and larvae. Because adult moths are mobile and there will not be night work, no adverse effects to adult BSM are expected.

Clearing tree tobacco from roads and fuel breaks will result in habitat loss for BSM. There are approximately 15.6 ha (38.6 ac) of tree tobacco on four-wheel drive roads and fuel breaks proposed for clearing (DOFAW 2015). Tree tobacco has been steadily spreading throughout the action area, and is likely to spread further during the term of this Biological Opinion. However, given timely and consistent clearing year-round, tree tobacco should not expand significantly on roads and fuel breaks, and the action area should remain approximately the same size throughout the course of this Biological Opinion. Some amount of habitat loss will be reoccurring; some regrowth will occur between maintenance periods and serve as habitat for BSM again, which will then be re-cleared.

The loss of tree tobacco within roads and fuel breaks will not substantially reduce the amount of BSM habitat in the north Kona region. There are an estimated 2,630 ha (6,500 ac) of terrain with tree tobacco in the Project Area both on and off roads/fuel breaks (DOFAW 2015). However, the density of tree tobacco differs between on and off roads/fuel breaks (Table 1), with more tree tobacco plants per meter on roads/fuel breaks. As calculated in Table 1, the loss of 15.6 ha (38.6 ac) of tree tobacco within the roads and fuel breaks constitutes 0.9 percent of the total number of tree tobacco plants that serve as BSM habitat in the Project Area. This analysis does not include 'aiea within, nor thousands of acres of tree tobacco outside the Project Area. Given the rate at which tree tobacco is spreading in the action area, it is likely that these 15.6 ha (38.6 ac) lost will quickly be replaced by new growth of tree tobacco elsewhere.

The loss of tree tobacco habitat will be more than off-set by proposed fencing and outplanting of native BSM habitat. The Service currently recommends a one to five offset ratio (1/5 of an acre of native habitat conserved per acre of non-native habitat removed) for loss of non-native BSM habitat, including tree tobacco. Applying the 1/5 mitigation ratio used by the Service, approximately 3.1 ha (7.7 ac) of native habitat needs to be conserved in order to off-set the loss of 15.6 ha (38.6 ac) of tree tobacco. The construction of the 287 ha (711 ac) Henahena fenced unit is slated to begin in late 2015 or early 2016, is primarily intended for protection and outplanting of native habitat including 'aiea, and more than compensates for the loss of 15.6 ha (38.6 ac) of tree tobacco (DOFAW 2015; E. Adkins pers. comm.).

Clearing tree tobacco from roads and fuel breaks will likely result in direct mortality of BSM eggs and larvae as tree tobacco is cut down. The Service anticipates incidental take of BSM will be difficult to detect and impossible to accurately quantify for the following reasons.

First, take of BSM will be difficult to detect because of the small size and cryptic nature of its eggs and newborn larvae, as well as the density at which BSM occurs on the landscape. BSM eggs and larvae are hard to find. Eggs are approximately 1.5 mm in diameter, newly hatched larvae are approximately one cm long and ~one mm wide, both are similar colors to the leaves of tree tobacco, and often loiter in cryptic areas on the undersides and folds of leaves. Furthermore, BSM eggs and larvae can be present in very low densities. For instance, during the winter of 2012, which was during the wet part of the year when *more* BSM were present, there were still only 0.03 larvae/eggs per plant, or roughly 1 larvae/egg per 33 stems (DOFAW 2015). Because some surveyed plants had multiple eggs and/or larvae, less than 3 percent of tree tobacco surveyed had eggs or larvae on them.

Secondly, quantifying the anticipated amount of take is nearly impossible given the seasonal and annual variability of the species. The density of BSM in the Project Area fluctuates annually and seasonally by at least an order of magnitude, e.g. 20 egg/19.5 larvae per hectare in the winter of 2011 to 1.6 eggs/0.4 larvae per hectare in the summer of 2012 (DOFAW 2015). In addition, 2011 and 2012 were years of low rainfall in the Project Area compared to 2014 and thus do not necessarily represent BSM densities and distribution in wetter years. However, 2011 and 2012 are considered wet years relative to 2009 and 2010.

However, the level of take of BSM can be anticipated by the proportional loss of tree tobacco in the action area. Surveys show that there is no significant difference between the density of BSM eggs and larvae on tree tobacco *on* roads/fuel breaks (0.0312 larvae/eggs per tree tobacco ) versus *off* roads/fuel breaks (0.0305 larvae/eggs per tree tobacco) (E. Adkins 2015, pers comm).

Therefore, whatever proportion of tree tobacco is cut down in the Project Area, the same proportion of BSM eggs and larvae will experience take. One important note however, is that there is a difference in the density of tree tobacco plants on and off roads/fuel breaks, with higher densities being on roads/fuel breaks (Table 1). Taking those two factors into account, clearing roads/fuel breaks will account for 0.9 percent of the tree tobacco in the Project Area. Therefore, given that 0.9 percent of the available tree tobacco will be cleared in the Project Area, we estimate that 0.9 percent of BSM larvae and eggs will be taken in the process. In reality the percentage of BSM taken in the Project Area is almost certain to be less on an annual basis. Use of tree tobacco by BSM correlates strongly with plant height; surveys found that only 1.9 percent of tree tobacco < one meter tall have BSM eggs and/or larvae whereas 23.1 percent of plants 1-2 m and 67.3 percent of plants 2-5 m tall have eggs and/or larvae (DOFAW 2015). Given that DOFAW will clear roads and fuel breaks regularly year-round, the majority of tree tobacco regrowth will be less than one meter when cleared, which will minimize the number of eggs and larvae on roads and fuel breaks during subsequent maintenance, thereby reducing direct mortality of BSM.

**Table 1.** Densities of tree tobacco on and off roads/fuel breaks, and proposed proportional clearing of tree tobacco.

| Road/Fuel break | Tree tobacco area (hectare) | Tree tobacco per hectare | Est. number of tree tobacco | Percent of tree tobacco |
|---|---|---|---|---|
| On | 15.6 | 2,940 | 45,925.4 | **0.9%** |
| Off | 2,615.0 | 1,950 | 5,099,407.8 | **99.1%** |
| Total | 2,630.7 | NA | 5,145,333.2 | **100.0%** |

Improved access through routinely cleared four wheel drive roads, as well as vegetation free fuel breaks, will have a beneficial effect to the BSM by reducing the chances that a fire destroys BSM native or non-native habitats. Given the spread of readily ignitable fuels such as fountain grass (*Pennisetum setaceum*) throughout the Project Area, projections of decreasing rain due to El Nino and climate change, and past fire history in and around the Project Area, fire control is of utmost importance.

## CUMULATIVE EFFECTS

Cumulative effects include the effects of future non-Federal actions that are reasonably certain to occur within the area of action subject to consultation. Future federal actions will be subject to the consultation requirements established in section 7 of the Act and, therefore, are not considered cumulative for the proposed action. The State of Hawai‘i manages Pu‘u Anahulu as a Game Management Area and Pu‘u Wa‘awa‘a as a Forest Reserve. Non-federal actions that occur within the action area include on-going DOFAW administered hunting for game birds and ungulates, recreation (hiking and bird-watching), and conservation actions to benefit native lowland dry and mixed-mesic forest species. The primary threat to BSM from these actions is potential for an accidental or intentional fire to start and spread across the action area. Maintenance of fuel breaks and four wheel drive roads will improve response to any fires. Conservation actions, including forest restoration, invasive species control, and fencing will benefit the BSM and BSM critical habitat.

## CONCLUSION

The Service anticipates that the direct and indirect effects of the proposed action will result in the loss of 15.6 ha (38.6 ac) of occupied non-native BSM habitat and mortality of up to 0.9 percent of larvae and eggs within the Project Area per year. Adverse effects of the proposed actions on Blackburn's sphinx moth will be minimized by avoidance and minimization measures, and off-set by fenced conservation units and outplanting of native ‘aiea as well as native nectar plants for adults.

Beneficial effects from the proposed project include improved fire prevention and control. Overall, the adverse effects from this proposed project are smaller than the beneficial effects of protecting native and non-native habitat from fire. While the proposed project may cause loss of degraded BSM habitat and a number of BSM eggs and larvae, when balanced with the beneficial effects of the proposed project, it is expected that the proposed action will help with recovery of BSM.

After reviewing the current status, the environmental baseline, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that implementation of the proposed action discussed herein is not likely to jeopardize the continued existence of the Blackburn's sphinx moth.

## INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulations promulgated pursuant to section 4(d) of the Act prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the Act, taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

**Amount or Extent of Take**

Based on the proposed project description and the analysis of the effects of the proposed action provided above, the Service anticipates that as a result of the proposed project, non-native BSM habitat will be lost and BSM larvae and eggs may be killed. The breakdown of potential take for each activity is as follows:

1. Loss of up to 15.6 ha (38.6 acres) of non-native BSM habitat on roads and fuel breaks from clearing, per year.
2. Mortality of 0.9 percent of BSM eggs and larvae due to clearing tree tobacco on roads and fuel breaks within the Project Area, per year.

**Effect of the Take**

The Service has determined that this level of anticipated take is not likely to jeopardize the continued existence of the Blackburn's sphinx moth based on the information provided in this document.

**Reasonable and Prudent Measures**

The reasonable and prudent measures given below, with their implementing terms and conditions, are designed to minimize the impacts of incidental take that might otherwise result from the proposed actions. If, during the course of the action, the level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. In addition, the action that caused the taking must cease; the action agency must immediately provide an explanation of the causes of the taking; and must review with the Service the need for possible modification of the reasonable and prudent measures. The following reasonable and prudent measures are necessary and appropriate to minimize the effect of take on Blackburn's sphinx moth.

1. The Service, along with DOFAW, shall minimize harassment, harm, or mortality of Blackburn's sphinx moth within the action area.

**Terms and Conditions**

In order to be exempt from the prohibitions of section 9 of the Act, the Service and any subsequent project applicant, must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are nondiscretionary.

The following terms and conditions implement reasonable and prudent measure number one.

1(a) DOFAW will annually provide the Service with an estimate of the amount of tree tobacco over one meter tall that is cleared, an estimate of the spread of tree tobacco throughout the Project Area on roadside and fuel breaks, any new observations or research on BSM in the Project Area, and report on implementation of the above conservation measures.

## CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authority to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The term "conservation recommendations" has been defined as suggestions from the Service regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information. The recommendations provided here relate only to the proposed action and do not necessarily represent complete fulfillment of the agency's 7(a)(1) responsibilities for these species.

1. The Service's WSFRP, along with DOFAW, should fund additional restoration actions, beyond those planned for in the draft HCP, to promote recovery of BSM and ‘aiea within the Project Area.

## REINITIATION-CLOSING STATEMENT

This concludes formal consultation on this action. As required in 50 CFR § 402.16, reinitiation of consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operation causing such take must cease pending reinitiation.

As stated in the Conclusion (above), the Service's finding of non-jeopardy is based in large part on the conservation measures. Should there be a failure to carry out any or all of the described measures, or if the measures are not effective, or if these measures are modified in any way without Service coordination, reinitiation of consultation will be required. If you have any questions regarding this Biological Opinion, please contact Jon Sprague at (808) 792-9400.

Sincerely,

David Tessler
Deputy Field Supervisor

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# APPENDIX E: WRITTEN COMMENTS RECEIVED DURING EARLY CONSULTATION

**William P. Kenoi**
*Mayor*

**Harry S. Kubojiri**
*Police Chief*

**Paul K. Ferreira**
*Deputy Police Chief*

# County of Hawai'i

**POLICE DEPARTMENT**
349 Kapi'olani Street • Hilo, Hawai'i 96720-3998
(808) 935-3311 • Fax (808) 961-2389

September 18, 2013

Mr. Huang-Chi Kuo, PhD
Garcia and Associates-Pacific Region
146 Hekili Street Suite101
Kailua, HI 96734

Dear Mr. Kuo:

RE: EARLY CONSULTATION ON ENVIRONMENTAL ASSESSMENT FOR PU'U WA'AWA'A FOREST RESERVE AND PU'U ANAHULU GAME MANAGEMENT AREA HABITAT CONSERVATION PLAN
NORTH KONA DISTRICT, ISLAND OF HAWAI'I

This responds to your letter dated September 9, 2013, regarding the environmental assessment for above-referenced project.

We have no comments or objections to offer at this time.

If you have any questions, please feel free to contact Captain Randal M. Ishii, Commander of the Kona District, at 326-4646, extension 299.

Sincerely,

HARRY S. KUBOJIRI
POLICE CHIEF

PAUL H. KEALOHA JR.
ASSISTANT CHIEF
AREA II OPERATIONS

RMI:dmv
RS130622

"Hawai'i County is an Equal Opportunity Provider and Employer"

William P. Kenoi
*Mayor*

Darren J. Rosario
*Fire Chief*

Renwick J. Victorino
*Deputy Fire Chief*

# County of Hawai'i
## HAWAI'I FIRE DEPARTMENT
25 Aupuni Street • Room 2501 • Hilo, Hawai'i 96720
(808) 932-2900 • Fax (808) 932-2928

September 16, 2013

Huang-Chi Kuo, PhD
Garcia and Associates – Pacific Region
146 Hekili Street, Suite 101
Kailua, Hawai'i 96734

SUBJECT: EARLY CONSULTATION ON ENVIRONMENTAL ASSESSMENT PU'U WA'AWA'A FOREST RESERVE AND PU'U ANAHULU GAME MANAGEMENT AREA HABITAT CONSERVATION PLAN NORTH KONA DISTRICT, ISLAND OF HAWAI'I

We have no comments to offer at this time in reference to the above-mentioned Early Consultation on Environmental Assessment.

DARREN J. ROSARIO
Fire Chief

KT:lpc

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ESTHER KIA'AINA
FIRST DEPUTY

WILLIAM M. TAM
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

**STATE OF HAWAII**
**DEPARTMENT OF LAND AND NATURAL RESOURCES**

OFFICE OF CONSERVATION AND COASTAL LANDS
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

REF: OCCL: AJR

COR: HA-14-39

Huang-Chi Kuo
c/o Garcia and Associates
146 Hekili St., Ste. 101
Kailua, HI 96734

SEP 19 2013

**SUBJECT: EARLY CONSULTATION ON AN ENVIRONMENTAL ASSESSMENT (EA) FOR THE PROPOSED PU'U WA'AWA'A FOREST RESERVE AND PU'U ANAHULU GAME MANAGEMENT AREA HABITAT CONSERVATION PROJECT**
North Kona District, Island of Hawai'i
*TMKs: (3) 7-1-002:001; (3) 7-1-001:004; (3) 7-1-004:001 & 018*

The Office of Conservation and Coastal Lands (OCCL) is in receipt of your letter regarding the preparation of an Environmental Assessment (EA) to be submitted on behalf of the Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) for the proposed Pu'u Wa'awa'a Forest Reserve (FR) and Pu'u Anahulu Game Management Area (GMA) Habitat Conservation project; portions of which are located within the State Land Use (SLU) Conservation District Resource Subzone.

Based on our maps, and the information provided to this office, the following project areas appear to be situated within the Conservation District Resource Subzone:

*ZAN HAW; HAP HAP; PAH A; PAH B; SOLANUM* – [TMK: (3) 7-1-004:001]
*STE ANG* – [TMK: (3) 7-1-004:018]
*PWW CONE EXT* – [TMK: (3) 7-1-001:004]

According to the project description the purpose of the proposed Habitat Conservation Plan is to support the preservation and restoration of habitat for covered plant and wildlife species during the implementation of DOFAWs ongoing game management activities throughout the FR and GMA. The project will be conducted in phases; Phase I will include the construction of exclosure fencing and invasive species control/removal while Phase II will focus on planting of native or endemic species for increased habitat restoration. The project proposes to construct twenty (20) ungulate-proof fenced-in areas covering approximately 8500 acres. Fence exclosures will be 6-foot high hog wire fences with similar size posts. Fence sections will be skirted with additional hog wire to prevent access to these areas by burrowing animals.

According to DLNR policy (c. 1992), divisions within DLNR that are proposing to conduct land uses on their own managed lands inside the Conservation District are not required to apply for a Conservation District Use Permit (CDUP) when, 1) a management plan is already in place for the specified land use, and 2) the proposed land use is consistent with that specific divisions management objectives for the project area. However, those divisions must adhere to the criteria and guidelines of §183C Hawaii Revised Statutes (HRS) and §13-5 Hawaii Administrative Rules (HAR). Similarly, those divisions proposing land use actions in the conservation district shall ensure compliance with §343 HRS in regards to specific environmental review requirements.

At this time the Office of Conservation and Coastal Lands has no comments for the pre-consultation. We look forward to reviewing the Draft Environmental Assessment (DEA) when it is completed and reserve the right to comment on any proposals located within the Conservation District.

Should you have any questions concerning this correspondence, please feel free to contact Alex J. Roy, M.Sc. of our Office of Conservation and Coastal Lands staff at 808-587-0316 or via email at alex.j.roy@hawaii.gov

Sincerely,

Samuel J. Lemmo, Administrator
*Office of Conservation and Coastal Lands*

*CC: HDLO*
*County of Hawaii Department of Planning*
*DOFAW*

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

LORETTA J. FUDDY, A.C.S.W., M.P.H.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
EMD/CWB

09047PST.13

September 18, 2013

Mr. Huang-Chi Kuo, Ph.D.
Garcia and Associates – Pacific Region
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Dear Dr. Kuo:

**SUBJECT: Comments on the Environmental Assessment Early Consultation for Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area Habitat Conservation Plan North Kona District, Island of Hawaii, Hawaii**

The Department of Health (DOH), Clean Water Branch (CWB), acknowledges receipt of your letter, dated September 9, 2013, requesting comments on your project. The DOH-CWB has reviewed the subject document and offers these comments. Please note that our review is based solely on the information provided in the subject document and its compliance with the Hawaii Administrative Rules (HAR), Chapters 11-54 and 11-55. You may be responsible for fulfilling additional requirements related to our program. We recommend that you also read our standard comments on our website at: http://health.hawaii.gov/epo/files/2013/05/CWB-standardcomment.pdf.

1. Any project and its potential impacts to State waters must meet the following criteria:

   a. Antidegradation policy (HAR, Section 11-54-1.1), which requires that the existing uses and the level of water quality necessary to protect the existing uses of the receiving State water be maintained and protected.

   b. Designated uses (HAR, Section 11-54-3), as determined by the classification of the receiving State waters.

   c. Water quality criteria (HAR, Sections 11-54-4 through 11-54-8).

2. You may be required to obtain a National Pollutant Discharge Elimination System (NPDES) permit for discharges of wastewater, including storm water runoff, into State surface waters (HAR, Chapter 11-55). An application for an NPDES individual permit must be submitted at least 180 calendar days before the commencement of the discharge. To request NPDES permit coverage, you must submit the CWB Individual NPDES Form through the e-Permitting Portal and the hard copy certification statement with $1,000 filing fee. Please open the e-Permitting Portal

website at: https://eha-cloud.doh.hawaii.gov/epermit/View/home.aspx. You will be asked to do a one-time registration to obtain your login and password. After you register, click on the Application Finder tool and locate the "CWB Individual NPDES Form." Follow the instructions to complete and submit this form.

3. If your project involves work in, over, or under waters of the United States, it is highly recommend that you contact the Army Corp of Engineers, Regulatory Branch (Tel: 438-9258) regarding their permitting requirements.

   Pursuant to Federal Water Pollution Control Act [commonly known as the "Clean Water Act" (CWA)], Paragraph 401(a)(1), a Section 401 Water Quality Certification (WQC) is required for "[a]ny applicant for Federal license or permit to conduct any activity including, but not limited to, the construction or operation of facilities, which may **result** in any discharge into the navigable waters..." (emphasis added). The term "discharge" is defined in CWA, Subsections 502(16), 502(12), and 502(6); Title 40 of the Code of Federal Regulations, Section 122.2; and Hawaii Administrative Rules (HAR), Chapter 11-54.

4. Please note that all discharges related to the project construction or operation activities, whether or not NPDES permit coverage and/or Section 401 WQC are required, must comply with the State's Water Quality Standards. Noncompliance with water quality requirements contained in HAR, Chapter 11-54, and/or permitting requirements, specified in HAR, Chapter 11-55, may be subject to penalties of $25,000 per day per violation.

If you have any questions, please visit our website at: http://health.hawaii.gov/cwb, or contact the Engineering Section, CWB, at (808) 586-4309.

Sincerely,

Alec Wong

ALEC WONG, P.E., CHIEF
Clean Water Branch

ST:rh

c: DOH-EPO [via email only]

NEIL ABERCROMBIE
GOVERNOR

GLENN M. OKIMOTO
DIRECTOR

Deputy Directors
JADE T. BUTAY
FORD N. FUCHIGAMI
RANDY GRUNE
JADINE URASAKI

**STATE OF HAWAII**
**DEPARTMENT OF TRANSPORTATION**
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:
STP 8.1323

September 17, 2013

Mr. Huang-Chi Kuo, Ph.D.
Garcia and Associates – Pacific Region
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Dear Mr. Kuo:

Subject: Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area
Habitat Conservation Plan
Early Consultation for Environmental

Thank you for requesting the State Department of Transportation's (DOT) review of the subject project. DOT understands the State Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife is proposing to do a Habitat Conservation Plan for the Pu'u Wa'awa'a Forest Reserve (FR) and Pu'u Anahulu Game Management Area (GMA).

Given the location and the nature of the project, DOT does not anticipate any significant adverse impacts to the State transportation facilities. However, it appears that several existing and proposed exclosure areas are located along the State highway. Plans for any improvements along the State highway right-of-way need to be coordinated with the DOT Highways Division for review and approval.

DOT appreciates the opportunity to provide comments. If there are any other questions, please contact Mr. Norren Kato of the DOT Statewide Transportation Planning Office at telephone number (808) 831-7977.

Very truly yours,

GLENN M. OKIMOTO, Ph.D.
Director of Transportation

William P. Kenoi
*Mayor*

West Hawai'i Office
74-5044 Ane Keohokalole Hwy
Kailua-Kona, Hawai'i 96740
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Fax (808) 327-3563

# County of Hawai'i
**PLANNING DEPARTMENT**

Duane Kanuha
*Director*

Bobby Command
*Deputy Director*

East Hawai'i Office
101 Pauahi Street, Suite 3
Hilo, Hawai'i 96720
Phone (808) 961-8288
Fax (808) 961-8742

September 25, 2013

Dr. Huang-Chi Kuo, Ph.D.
Garcia and Associates
146 Hekili Street, Suite 101
Kailua, HI 96734

Dear Dr. Kuo:

**Subject: Pre-Consultation for Draft Environmental Assessment**
**Project: Pu'u Wa'awa'a Forest Reserve**
**Pu'u Anahulu Game Management Area Habitat Conservation Plan**
**TMKs: Various; North Kona, Hawai'i**

Thank you for your letter dated September 09, 2013, requesting comments from this office regarding the preparation of a Draft Environmental Assessment (DEA) for the subject project. The majority of the project boundary, as depicted on the supplied map, is comprised of eight State of Hawai'i owned parcels totaling approximately 99,185 acres, more or less. The State Land Use (SLU) designation for the combined properties is roughly 57% Conservation (C) and 43% Agricultural (A). The County of Hawai'i General Plan Land Use Pattern Allocation Guide (LUPAG) map similarly partitions the project properties between Conservation and Extensive Agriculture. County zoning for the SLU Agricultural lands is Agricultural (A-5a and A-20a). No portion of the project is within the Special Management Area (SMA). Based on the map supplied with the subject inquiry, the land parcels involved appear to be those listed below. Please indicate the actual parcels involved in the DEA.

| TMK Number | Owner(s) | SLU Designation(s) and Acreage |
|---|---|---|
| (3) 7-1-004:001 | State | 43,680.115 acres C |
| (3) 7-1-001:001 | State | 2,038.088 acres C / 106.7 acres A |
| (3) 7-1-001:007 | State DLNR | 2,001.775 acres C / 1,805 acres A |
| (3) 7-1-001:004 | State | 441 acres C / 65.046 acres A |
| (3) 7-1-001:006 | State | 213.9 acres C / 12,832.2 acres A |
| (3) 7-1-002:013 | State | 2,589.5 acres A |
| (3) 7-1-002:001 | State | 8,529.294 acres C / 4743.834 acres A |
| (3) 7-1-003:001 | State / AT&T Wireless | 20,138.175 acres A |

We understand that the Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife's Pu'u Wa'awa'a Forest Reserve (FR) and Pu'u Anahulu Game Management Area (GMA) is seeking an Incidental Take License in accordance with Chapter 195-D, Hawai'i Revised Statutes (HRS). DLNR is developing a Habitat Conservation Plan in support of the license to address the potential impacts to federal and state-listed endangered species known to occur in the subject properties. Specifically, DLNR's land management activities in the area are in support of non-native game mammal management, protection and restoration of native ecosystems, support of commercial cattle grazing to reduce fire fuel loads, public recreational trail use, and research and educational activities. The goal of the management activities are to "*provide local communities and the general public with sustainable hunting opportunities while at the same time preserving rare and sensitive Hawaiian natural resources*".

The Habitat Conservation Plan proposes the installation and maintenance of exclosure fence units established for ungulate removal and exclusion. Approximately 20 hog wire fence exclosure units enclosing approximately 8,500 acres will be established within the subject parcels. After the units have been established, ungulates will be removed and the exclosure units monitored for reoccurrence of ungulates or other alien plant and animal species. Later, the units will be planted with fourteen species of federal and state-listed plants. The Habitat Conservation Plan will be implemented in three phases over 25 years and will include provisions for continuous long-term monitoring and adaptive management based upon knowledge gained during the plan's implementation.

The County of Hawai'i General Plan 2005 (amended December 2006) is the policy document for the long range comprehensive development of the island of Hawai'i and identifies the visions, values, and priorities important to the people of this County. It can be found electronically at http://www.cohplanningdept.com/community-planning/general-plan/. Some of the General Plan goals and policies related to Hawai'i Island's natural resources, and relevant to this EA, include:

Natural Resources and Shoreline

| | |
|---|---|
| *8.3(a)* | "Require users of natural resources to conduct their activities in a manner that avoids or minimizes adverse effects on the environment" |
| *8.3(o)* | "Encourage the continued identification and inclusion of unique wildlife habitat areas of unique native Hawaiian flora and fauna within the Natural Area Reserve System." |
| *8.3(q)* | "Develop policies by which native Hawaiian gathering rights will be protected as identified under judicial decisions." |
| *8.3(r)* | "Ensure public access is provided to the shoreline, public trails and hunting areas, including free public parking where appropriate." |
| *8.3(s)* | "Establish a system of pedestrian access trails to places of scenic, historic, cultural, natural, or recreational resources." |

We recommend that the draft Environmental Assessment include a discussion of the proposed project's alignment with the Kona Community Development Plan (KCDP), which can be found electronically at http://www.hawaiicountycdp.info/north-and-south-kona-cdp. Additionally, the draft Environmental Assessment should include any plans that DLNR may have for providing public access to the scenic, historic, cultural, natural and recreational resources within the subject area. The access plans should be inclusive of any regulations that would promote the Habitat Conservation Plan's and the County of Hawai'i General Plan's conservation and protection goals, while at the same time allowing for appropriate use of the area's resources.

We have no further comments to offer, at this time. However, please keep us informed and provide our department with a copy of the draft Environmental Assessment for our review and comment. If you have any questions or if you need further assistance, please feel free to contact Lucas Mead of this office at (808) 961-8140.

Sincerely,

DUANE KANUHA
Planning Director

LM:cs
P:\wpwin60\Luke\dEA, EA, & EIS Comments\preconsultdraftea Pu'u Wa'awa'a FR & GMA.doc

# OFFICE OF PLANNING
# STATE OF HAWAII

NEIL ABERCROMBIE
GOVERNOR

JESSE K. SOUKI
DIRECTOR
OFFICE OF PLANNING

235 South Beretania Street, 6th Floor, Honolulu, Hawaii 96813
Mailing Address: P.O. Box 2359, Honolulu, Hawaii 96804

Telephone: (808) 587-2846
Fax: (808) 587-2824
Web: http:/planning.hawaii.gov/


Ref. No. P-14133

October 8, 2013

Huang-Chi Kuo, Ph.D.
Garcia and Associates – Pacific Region
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Dear Dr. Kuo:

Subject: Early Consultation on Environmental Assessment for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan, North Kona District, Island of Hawaii

Thank you for the opportunity to provide comments on the Early Consultation on Environmental Assessment for the Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan.

We have reviewed the documents you submitted to us via letter dated September 11, 2013, and have the following comments to offer:

1. The entire state is defined to be within the Coastal Zone Management Area, pursuant to Hawaii Revised Statutes (HRS) §205A-1 (definition of "coastal zone management area"). The Draft Environmental Assessment (Draft EA) should include a discussion of the proposed project's ability to meet the objectives and policies set forth in HRS §205A-2.

2. The land management activities may have nonpoint pollution impacts on coastal waters. The applicant should review the *Hawaii Watershed Guidance*, which provides a summary and links to management measures that may be implemented to minimize coastal nonpoint pollution impact.

   To limit land disturbance activities from fence construction, please see Section 5.3 – Site Development Measures (pg. 122), and for vegetation of disturbed areas, see Section 5.2 – Forestry. The *Hawaii Watershed Guidance* is available for viewing online or download at http://files.hawaii.gov/dbedt/op/czm/initiative/nonpoint/HI Watershed Guidance Final.pdf.

If you have any questions regarding this comment letter, please contact Josh Hekekia of our Hawaii CZM Program at 587-2845.

Sincerely,

Jesse K. Souki
Director

NEIL ABERCROMBIE
GOVERNOR
STATE OF HAWAII

JOBIE M. K. MASAGATANI
CHAIRMAN
HAWAIIAN HOMES COMMISSION

DARRELL T. YOUNG
DEPUTY TO THE CHAIRMAN

**STATE OF HAWAII**
**DEPARTMENT OF HAWAIIAN HOME LANDS**
P. O. BOX 1879
HONOLULU, HAWAII 96805

October 9, 2013

Huang-Chi Kuo, PhD
Garcia and Associates
Pacific Region
146 Hekili Street, Suite 101
Kailua, HI 96734

Dear Huang-Chi Kuo,

Subject: Early Consultation on Draft Environmental Assessment (DEA) for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan
North Kona District, Island of Hawaii

Mahalo for consulting with the Department of Hawaiian Home Lands (DHHL) and soliciting our input in the development of a DEA for the Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan in North Kona, Hawaii. DHHL has the following comments at this time:

1. DHHL owns approximately 1,500 acres of land in the North Kona District and approximately 40,000 acres of land in Kawaihae and Waimea in the South Kohala District.

2. DHHL has existing residential, agricultural, and pastoral homestead communities in Kealakehe, Kawaihae, and Waimea.

3. Please consult with the following homestead associations and beneficiary organizations in West Hawaii as they may have cultural knowledge of the history, traditions, and practices of the Puu Waawaa and Puu Anahulu area:
   a. The Villages of Lai Opua Association

b. Laiopua 2020
c. Kailapa Community Association
d. Kawaihae Puakailima Community Association
e. Lalamilo Residence Lots Association
f. Waimea Hawaiian Homesteaders Association Inc.

4. DHHL has commented and participated in the most recent federal rule making process that proposed listing of 15 species on Hawaii Island as endangered and the designation of approximately 18,766 acres of critical habitat in North Kona for 3 species that include: uhiuhi (*Mezoneuron kavaiensis)*, kookoolau (*Bidens micrantha* ssp. *ctenophylla)*, and aupaka or wahine noho kula (*Isodendron pyrifolium)*. DHHL strongly suggests that the Habitat Conservation Plan include the assessment and inclusion of these species.

5. Please send a copy of the Draft EA.

Mahalo for the opportunity to provide early consultation comments. If you have any questions or require additional information, please contact Kaleo Manuel in our Planning Office at 620-9485.

Aloha,

Jobie M.K. Masagatani
Chairman
Hawaiian Homes Commission

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

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'13 SEP 13 AM 11:06 ENGINEERING

**STATE OF HAWAII**
**DEPARTMENT OF LAND AND NATURAL RESOURCES**
**LAND DIVISION**

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

September 12, 2013

## MEMORANDUM

FR:
~~TO~~: **DLNR Agencies:**
_X_ Div. of Aquatic Resources
___ Div. of Boating & Ocean Recreation
_X_ Engineering Division
___ Div. of Forestry & Wildlife
_X_ Div. of State Parks
_X_ Commission on Water Resource Management
_X_ Office of Conservation & Coastal Lands
_X_ Land Division – Hawaii District
_X_ Historic Preservation

TO:
~~FROM~~: Russell Y. Tsuji, Land Administrator
SUBJECT: Early Consultation on Environmental Assessment for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan
LOCATION: North Kona, Hawaii
APPLICANT: Garcia and Associates for Division of Forestry and Wildlife

Transmitted for your review and comment is information on the above referenced project. We would appreciate your comments on this document. Please submit any comments by October 11, 2013. If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

( ) We have no objections.
(✓) We have no comments.
( ) Comments are attached.

Signed: [signature]

Print name: for Carty S. Chang, Chief Engineer
Date: 9/30/13

cc: Central Files

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

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September 12, 2013

# MEMORANDUM

TO: **DLNR Agencies:**
X Div. of Aquatic Resources
__ Div. of Boating & Ocean Recreation
X Engineering Division
__ Div. of Forestry & Wildlife
X Div. of State Parks
X Commission on Water Resource Management
X Office of Conservation & Coastal Lands
X Land Division – Hawaii District
X Historic Preservation

FROM: Russell Y. Tsuji, Land Administrator
SUBJECT: Early Consultation on Environmental Assessment for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan
LOCATION: North Kona, Hawaii
APPLICANT: Garcia and Associates for Division of Forestry and Wildlife

Transmitted for your review and comment is information on the above referenced project. We would appreciate your comments on this document. Please submit any comments by October 11, 2013. If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

( ✓ ) We have no objections.
( ) We have no comments.
( ) Comments are attached.

Signed: ____________

Print name: GORDON C. HEIT
Date: 9/23/13

cc: Central Files

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

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September 12, 2013

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STATE OF HAWAII

## MEMORANDUM

~~TO:~~ FROM:

**DLNR Agencies:**
X Div. of Aquatic Resources
__ Div. of Boating & Ocean Recreation
X Engineering Division
__ Div. of Forestry & Wildlife
X Div. of State Parks
X Commission on Water Resource Management
X Office of Conservation & Coastal Lands
X Land Division – Hawaii District
X Historic Preservation

TO:
~~FROM:~~ ~~Russell Y. Tsuji, Land Administrator~~
SUBJECT: Early Consultation on Environmental Assessment for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan
LOCATION: North Kona, Hawaii
APPLICANT: Garcia and Associates for Division of Forestry and Wildlife

Transmitted for your review and comment is information on the above referenced project. We would appreciate your comments on this document. Please submit any comments by October 11, 2013. If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

( ) We have no objections.
( ) We have no comments.
(X) Comments are attached.

Signed: [signature]

Print name: ALEX ROY/OCCL
Date: 9/19/2013

cc: Central Files

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

ESTHER KIA'AINA
FIRST DEPUTY

WILLIAM M. TAM
DEPUTY DIRECTOR - WATER

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
BUREAU OF CONVEYANCES
COMMISSION ON WATER RESOURCE MANAGEMENT
CONSERVATION AND COASTAL LANDS
CONSERVATION AND RESOURCES ENFORCEMENT
ENGINEERING
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
KAHOOLAWE ISLAND RESERVE COMMISSION
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STATE PARKS

**STATE OF HAWAII**
**DEPARTMENT OF LAND AND NATURAL RESOURCES**

OFFICE OF CONSERVATION AND COASTAL LANDS
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

REF: OCCL: AJR

COR: HA-14-39

Huang-Chi Kuo
c/o Garcia and Associates
146 Hekili St., Ste. 101
Kailua, HI 96734

SEP 19 2013

**SUBJECT: EARLY CONSULTATION ON AN ENVIRONMENTAL ASSESSMENT (EA) FOR THE PROPOSED PU'U WA'AWA'A FOREST RESERVE AND PU'U ANAHULU GAME MANAGEMENT AREA HABITAT CONSERVATION PROJECT**
North Kona District, Island of Hawai'i
*TMKs: (3) 7-1-002:001; (3) 7-1-001:004; (3) 7-1-004:001 & 018*

The Office of Conservation and Coastal Lands (OCCL) is in receipt of your letter regarding the preparation of an Environmental Assessment (EA) to be submitted on behalf of the Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW) for the proposed Pu'u Wa'awa'a Forest Reserve (FR) and Pu'u Anahulu Game Management Area (GMA) Habitat Conservation project; portions of which are located within the State Land Use (SLU) Conservation District Resource Subzone.

Based on our maps, and the information provided to this office, the following project areas appear to be situated within the Conservation District Resource Subzone:

*ZAN HAW; HAP HAP; PAH A; PAH B; SOLANUM* – [TMK: (3) 7-1-004:001]
*STE ANG* – [TMK: (3) 7-1-004:018]
*PWW CONE EXT* – [TMK: (3) 7-1-001:004]

According to the project description the purpose of the proposed Habitat Conservation Plan is to support the preservation and restoration of habitat for covered plant and wildlife species during the implementation of DOFAWs ongoing game management activities throughout the FR and GMA. The project will be conducted in phases; Phase I will include the construction of exclosure fencing and invasive species control/removal while Phase II will focus on planting of native or endemic species for increased habitat restoration. The project proposes to construct twenty (20) ungulate-proof fenced-in areas covering approximately 8500 acres. Fence exclosures will be 6-foot high hog wire fences with similar size posts. Fence sections will be skirted with additional hog wire to prevent access to these areas by burrowing animals.

According to DLNR policy (c. 1992), divisions within DLNR that are proposing to conduct land uses on their own managed lands inside the Conservation District are not required to apply for a Conservation District Use Permit (CDUP) when, 1) a management plan is already in place for the specified land use, and 2) the proposed land use is consistent with that specific divisions management objectives for the project area. However, those divisions must adhere to the criteria and guidelines of §183C Hawaii Revised Statutes (HRS) and §13-5 Hawaii Administrative Rules (HAR). Similarly, those divisions proposing land use actions in the conservation district shall ensure compliance with §343 HRS in regards to specific environmental review requirements.

At this time the Office of Conservation and Coastal Lands has no comments for the pre-consultation. We look forward to reviewing the Draft Environmental Assessment (DEA) when it is completed and reserve the right to comment on any proposals located within the Conservation District.

Should you have any questions concerning this correspondence, please feel free to contact Alex J. Roy, M.Sc. of our Office of Conservation and Coastal Lands staff at 808-587-0316 or via email at alex.j.roy@hawaii.gov

Sincerely,

Samuel J. Lemmo, Administrator
*Office of Conservation and Coastal Lands*

*CC: HDLO*
*County of Hawaii Department of Planning*
*DOFAW*

NEIL ABERCROMBIE
GOVERNOR OF HAWAII





WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

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KAHOOLAWE ISLAND RESERVE COMMISSION
LAND
STATE PARKS

**STATE OF HAWAII**
**DEPARTMENT OF LAND AND NATURAL RESOURCES**

DIVISION OF STATE PARKS
POST OFFICE BOX 621
HONOLULU, HAWAII 96809

September 30, 2013

MEMORANDUM

To: Russell Y. Tsuji, Land Administrator
Land Division

From: Daniel S. Quinn, State Parks Administrator
Division of State Parks

Subject: Early Consultation on an EA for Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area Habitat Conservation Plan

On September 11, 2013, we received a letter from Huang-Chi Kuo of Garcia and Associates and responded by email to his request for early consultation.

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**EA for Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area Habitat Conservation Plan, North Kona, Hawai'i**

Lauren A Tanaka to: kuo 09/30/2013 05:26 PM

Cc: Dan S Quinn

| | |
|---|---|
| Lauren A Tanaka | EA for Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Are |

We received your letter dated Sept. 9, 2013 re early consultation on the EA. The Division of State Parks manages Kiholo State Park Reserve and works together with the Division of Forestry and Wildlife in overseeing the ahupuaa of Pu'u Wa'awa'a and Pu'u Anahulu. You may find it useful to review the draft Master Plan and draft EA for the reserve that is available on the OEQC website.

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AQUATIC RESOURCES

September 12, 2013

**MEMORANDUM**

TO: **DLNR Agencies:**
X Div. of Aquatic Resources
__Div. of Boating & Ocean Recreation
X Engineering Division
__Div. of Forestry & Wildlife
X Div. of State Parks
X Commission on Water Resource Management
X Office of Conservation & Coastal Lands
X Land Division – Hawaii District
X Historic Preservation

JKV
WW

FROM: Russell Y. Tsuji, Land Administrator
SUBJECT: Early Consultation on Environmental Assessment for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan
LOCATION: North Kona, Hawaii
APPLICANT: Garcia and Associates for Division of Forestry and Wildlife

Transmitted for your review and comment is information on the above referenced project. We would appreciate your comments on this document. Please submit any comments by October 11, 2013. If no response is received by this date, we will assume your agency has no comments. If you have any questions about this request, please contact Kevin Moore at 587-0426. Thank you.

Attachments

(X) We have no objections. WJW
( ) We have no comments.
( ) Comments are attached.

Signed: ________________

Print name: MCGILVRAY

Date: 10-7-13

cc: Central Files

NEIL ABERCROMBIE
GOVERNOR

GLENN M. OKIMOTO
DIRECTOR

Deputy Directors
JADE T. BUTAY
FORD N. FUCHIGAMI
RANDY GRUNE
JADINE URASAKI

**STATE OF HAWAII**
**DEPARTMENT OF TRANSPORTATION**
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

DIR 1328
HWY-PS 2.5851

October 17, 2013

Mr. Huang-Chi Kuo, Ph.D.
Garcia and Associates - Pacific Region
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Dear Mr. Kuo:

Subject: Early Consultation on Environmental Assessment for Pu'u Wa'awa Forest Reserve and Pu'u Anahulu Game Management Area Habitat Conservation Plan, North Kona District, Island of Hawaii

Thank you for consulting with us regarding the subject project. It is our understanding that the Department of Land and Natural Resources is proposing the subject Pu'u Wa'awa Forest Reserve and Pu'u Anahulu Game Management Area Habitat Conservation Plan. The Mamalahoa Highway (State Route 190) traverses across the project site, generally in the east-west direction, with two (2) existing exclosures and three (3) proposed exclosures located adjacent to Mamalahoa Highway.

We have the following comments in addition to those comments in the attached Department of Transportation letter STP 8.1323, dated September 17, 2013:

1. The Environmental Assessment (EA) should discuss and specify a) the roadway access to the project site, b) vehicle types (motorized and non-motorized), c) project related vehicle trip generation and distribution, d) impacts to Mamalahoa Highway and, e) transportation mitigations, as required.

2. Please provide us with a copy of the EA for our review.

If you have any questions, please contact Gary Ashikawa, Systems Planning Engineer, Highways Division, Planning Branch at 587-6336.

Very truly yours,

GLENN M. OKIMOTO, Ph.D.
Director of Transportation

Attachment: Letter STP 8.1323, dated September 17, 2013

NEIL ABERCROMBIE
GOVERNOR

GLENN M. OKIMOTO
DIRECTOR

Deputy Directors
JADE T. BUTAY
FORD N. FUCHIGAMI
RANDY GRUNE
JADINE URASAKI

**STATE OF HAWAII**
**DEPARTMENT OF TRANSPORTATION**
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

IN REPLY REFER TO:
DIR 1328
STP 8.1323

September 17, 2013

Mr. Huang-Chi Kuo, Ph.D.
Garcia and Associates – Pacific Region
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Dear Mr. Kuo:

Subject: Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area
Habitat Conservation Plan
Early Consultation for Environmental

Thank you for requesting the State Department of Transportation's (DOT) review of the subject project. DOT understands the State Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife is proposing to do a Habitat Conservation Plan for the Pu'u Wa'awa'a Forest Reserve (FR) and Pu'u Anahulu Game Management Area (GMA).

Given the location and the nature of the project, DOT does not anticipate any significant adverse impacts to the State transportation facilities. However, it appears that several existing and proposed exclosure areas are located along the State highway. Plans for any improvements along the State highway right-of-way need to be coordinated with the DOT Highways Division for review and approval.

DOT appreciates the opportunity to provide comments. If there are any other questions, please contact Mr. Norren Kato of the DOT Statewide Transportation Planning Office at telephone number (808) 831-7977.

Very truly yours,

GLENN M. OKIMOTO, Ph.D.
Director of Transportation

EKT:cc

## Huang-Chi Kuo

**From:** paul bueltmann <paul.bueltmann@gmail.com>
**Sent:** Thursday, September 26, 2013 3:01 PM
**To:** kuo@garciaandassociates.com
**Subject:** EA for Pu'u Wa'a Wa'a

Aloha

My name is Paul Bueltmann and I am part of the Game Management Advisory Council for the Big Island. Would it be possible to get the GPS information for all of the proposed fenced in areas that were shown on the EA. In selecting the areas to fence off was consideration given to put the majority of the ex closures in areas that in the SZ of that area? Also what happens in those ex closures if an sheep or other animal gets in will they only be removed by contract/DLNR workers? I read in the report that animals will be driven out of the ex closures but if that takes too long or is ineffectual they will be eradicated what time table are you folks working with to make an assessment like that.

Mahalo for your time and I look forward to hear from you.

Mahalo
pb

## Huang-Chi Kuo

**From:** Dean, Melissa K -FS <mkdean@fs.fed.us>
**Sent:** Thursday, September 26, 2013 3:29 PM
**To:** kuo@garciaandassociates.com
**Subject:** Puu Waawaa and Puu Anahulu GMA HCP information
**Attachments:** PWW cultural assess sm.pdf; Cooperative Agreement (fully signed).pdf

Aloha,

You likely already have the attached cultural assessment but just in case you don't.

Puu Waawaa is also part of the Hawaii Experimental Tropical Forest (HETF), a USDA Forest Service federal land designation. I've attached the cooperative agreement that established the HETF. I'm happy to answer any questions you have about this. I would like to take part in any draft review and receive a copy of the draft EA.

There are some maps available at the bottom of this site: http://www.hetf.us/page/puu_waa_waa/

Thanks - Mel

Mel Dean
HETF Coordinator
Pacific Southwest Research Station in Hilo
Institute of Pacific Islands Forestry
60 Nowelo Street, Hilo HI 96720
Phone: 808.854.2651
Fax: 808.933.8120
Email: mkdean@fs.fed.us

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## Huang-Chi Kuo

**From:** paul bueltmann <paul.bueltmann@gmail.com>
**Sent:** Friday, September 27, 2013 8:16 AM
**To:** kuo@garciaandassociates.com
**Subject:** Re: EA for Pu'u Wa'a Wa'a

Aloha e Dr. Kuo

Thank your for your quick response to my email. I appreciate that my comments will be included but I guess my questions is, if I ask questions to you would they be addressed and answered by either yourself or DOFAW? I have a few more questions I would like to ask and get answers.

Mahalo
pb

On Thu, Sep 26, 2013 at 5:51 PM, Huang-Chi Kuo <kuo@garciaandassociates.com> wrote:
> Aloha Mr. Bueltmann,
>
> Thank you for your comments submitted during the Early Consultation
> Process for the Draft Environmental Assessment for Pu'u Wa'awa'a
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> Conservation Plan. All comments and questions submitted are very
> important to the Division of Forestry and Wildlife's planning process for this project.
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> All comments and questions submitted will be forwarded to the Division
> of Forestry and Wildlife at the end of the early consultation comment period.
> We will work to ensure that your comments and concerns are addressed
> and incorporated in the Draft Environmental Assessment.
>
> Mahalo,
> Huang-Chi
>
>
> Huang-Chi Kuo PhD
> Botanist/Project Director
> Garcia and Associates (GANDA)
> Pacific Regional Office
> 146 Hekili St., Suite 101
> Kailua HI, 96734
> office: 808.262.1387
> fax: 808.262.1384
> cell: 808.292.8734
>
> -----Original Message-----
> From: paul bueltmann [mailto:paul.bueltmann@gmail.com]
> Sent: Thursday, September 26, 2013 3:01 PM
> To: kuo@garciaandassociates.com
> Subject: EA for Pu'u Wa'a Wa'a
>
> Aloha
>

> My name is Paul Bueltmann and I am part of the Game Management
> Advisory Council for the Big Island.  Would it be possible to get the
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>
> Mahalo for your time and I look forward to hear from you.
>
> Mahalo
> pb
>
>

## Huang-Chi Kuo

**From:** Hawaii Hunting Association <hawaiihuntingassociation@hawaiiantel.net>
**Sent:** Saturday, September 28, 2013 7:38 PM
**To:** kuo@garciaandassociates.com
**Subject:** Draft EA for Puu Waawaa and Puuanahulu Habitat Conservation Plan

Dear Kuo,

Please if you would, send us a copy of the Draft EA for Puuanahulu and Puu Waawaa Habitat Conservation Plans. The draft notice that we got via email is an unusable document and possibly you could send it to us via PDF.

Much Aloha,

Tom Lodge
Hawaii Hunting Association
16-1596 Pahoa Hwy
Keaau, HI 96749
808-982-4747
hawaiihuntingassociation@hawaiiantel.net

## Huang-Chi Kuo

| | |
|---|---|
| **From:** | Lauren.A.Tanaka@hawaii.gov |
| **Sent:** | Monday, September 30, 2013 5:26 PM |
| **To:** | kuo@garciaandassociates.com |
| **Cc:** | Dan.Quinn@hawaii.gov |
| **Subject:** | EA for Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area Habitat Conservation Plan, North Kona, Hawai'i |

We received your letter dated Sept. 9, 2013 re early consultation on the EA. The Division of State Parks manages Kiholo State Park Reserve and works together with the Division of Forestry and Wildlife in overseeing the ahupuaa of Pu'u Wa'awa'a and Pu'u Anahulu. You may find it useful to review the draft Master Plan and draft EA for the reserve that is available on the OEQC website.

## Huang-Chi Kuo

**From:** paul bueltmann <paul.bueltmann@gmail.com>
**Sent:** Tuesday, October 01, 2013 9:15 PM
**To:** kuo@garciaandassociates.com
**Subject:** Re: EA for Pu'u Wa'a Wa'a
**Attachments:** Concerns on Pu'u Wa'a Wa'a proposed fencing EA 2013.docx

Aloha e Dr. Kuo

So I have talked to a few hunters that have participated in this past weekend's hunt and I have also attached concerns from one hunter.

Here are some of the concerns from the other Hunters I did my best to compile what was given to me.

1. What is the carrying capacity of the GMA for game animals and what method was used to derive that information.
2. What method was used to determine how much habitat was needed for the endangered species.
3. What improvements are planned for the game mammals in the GMA.
4. Fencing is bad for wildlife and the fence proposed for the area has been known to trap game mammals who die a slow and agonizing death.
What control measures are in place to see that this does not happen.
5. Why was wildlife friendly or electric fencing not considered 6. What is going to be done about all of the cattle in the area and the damage that they can cause 7. What will be the on going costs to maintain the fencing and how will that be funded 8. Were there controlled hunts/eradication prior to the area being opened up because there were unusually low number of animals in the GMA especially since there have been no hunts in a very long time.
9. What control measure will be used to control invasive plants.
10. What kind of predator control is going to be implemented to protect the birds listed on the EA.
11. Will a full report be available to the public 12. With such low number of game mammals in the area why was it necessary to have a controlled hunt..

Comment from one hunter that people making these decisions should go hunting with a hunter to see what it actually takes to do what they do.

I look forward to hearing from you and hopefully get all of these concerns addressed.

Mahalo
pb

On Fri, Sep 27, 2013 at 10:11 AM, Huang-Chi Kuo <kuo@garciaandassociates.com> wrote:
> Aloha Paul,
>
> I apologize that I didn't explain to you more clearly how your
> comments and questions will be addressed. The process of early
> consultation is to identify groups or individuals with interest,
> knowledge or expertise and note the comments. As a consultant I was
> instructed by DOFAW to collect questions and comments for now, and
> DOFAW will designate a point of contact to respond to you after the early consultation period concluded (Oct.14).
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> When I pass the questions to DOFAW yesterday they do acknowledge that
> you raised very important questions that need to be carefully examined
> by the project team. I believe DOFAW take your questions and inputs
> very seriously since hunting is a major component of the project and

> only the hunters can provide insights from the people who are
> constantly on the ground and know the area and animals the best.
>
> Please let me know your other questions and comments and I will pass
> it to DOFAW. I really appreciate your time and participation in the
> project and looking forward to learning from you. Mahalo!
>
> Sincerely,
> Huang-Chi
>
> -----Original Message-----
> From: paul bueltmann [mailto:paul.bueltmann@gmail.com]
> Sent: Friday, September 27, 2013 8:16 AM
> To: kuo@garciaandassociates.com
> Subject: Re: EA for Pu'u Wa'a Wa'a
>
> Aloha e Dr. Kuo
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> Thank your for your quick response to my email.  I appreciate that my
> comments will be included but I guess my questions is, if I ask
> questions to you would they be addressed and answered by either
> yourself or DOFAW?  I have a few more questions I would like to ask and get answers.
>
> Mahalo
> pb
>
> On Thu, Sep 26, 2013 at 5:51 PM, Huang-Chi Kuo
> <kuo@garciaandassociates.com>
> wrote:
>> Aloha Mr. Bueltmann,
>>
>> Thank you for your comments submitted during the Early Consultation
>> Process for the Draft Environmental Assessment for Pu'u Wa'awa'a
>> Forest Reserve  and Pu'u Anahulu Game Management Area Habitat
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>> Division of Forestry and Wildlife at the end of the early
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>> We will work to ensure that your comments and concerns are addressed
>> and incorporated in the Draft Environmental Assessment.
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>> Huang-Chi
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>> Huang-Chi Kuo PhD
>> Botanist/Project Director

>> Garcia and Associates (GANDA)
>> Pacific Regional Office
>> 146 Hekili St., Suite 101
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>> office: 808.262.1387
>> fax: 808.262.1384
>> cell: 808.292.8734
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>> that in the SZ of that area?  Also what happens in those ex closures
>> if an sheep or other animal gets in will they only be removed by
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>> ineffectual they will be eradicated what time table are you folks
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> with to make an assessment like that.
>>
>> Mahalo for your time and I look forward to hear from you.
>>
>> Mahalo
>> pb
>>
>>
>
>

## Huang-Chi Kuo

**From:** Kathleen Johnson <konahikingclub@gmail.com>
**Sent:** Thursday, October 03, 2013 2:29 PM
**To:** kuo@garciaandassociates.com
**Subject:** Early Consultation for the North Kona Game Management Habitat Conservation Plan EA

To: Huang-Chi Kuo
After reviewing the documents you sent out, below are my thoughts and the thoughts of my fellow hikers.

I've volunteered many times at Pu`u Wa`awa`a and look forward to seeing continued preservation and re-establishment of the dryland forest. I fully understand the need to fence off areas in order to make this happen. However, as a hiker I am very concerned that access for recreation will be denied, especially as one of the targeted areas is the cinder cone itself. The following statement from one of my fellow hikers clearly addresses these concerns and offers solutions.

Kathleen Johnson
Kona Hiking Club
PH#808-557-9246

---

I am fundamentally in favor of the proposed enclosures to protect threatened flora and fauna. However, for a large area such as the Pu'uwa'awa'a cinder cone (that also offers stunning views following vigorous sustained cardio exercise) – where I and other hikers sometimes like to go independently purely for recreational purposes, aside from being part of large groups formally organized for work projects – I think provision needs to be made for continuing access: keep the ungulates out, but still allow human access, probably with a stile. Unrestricted access is preferable, and I believe virtually all hikers will be responsible observers of conservation best practices. Perhaps there could be instructional signage at the access point(s) to explain the purpose of the enclosure and also serve as a fresh reminder to clean footwear before entering, and so on. A much less desirable alternative would be supervised access in the company of a ranger on a limited number of specified days; but is such extreme limitation of access really necessary?

Kaleopono Norris

---

## Huang-Chi Kuo

**From:** paul bueltmann <paul.bueltmann@gmail.com>
**Sent:** Saturday, October 05, 2013 6:53 AM
**To:** kuo@garciaandassociates.com
**Subject:** Re: EA for Pu'u Wa'a Wa'a

Aloha e Dr. Kuo

Thank you for your quick response. I was told that carrying capacity is an old concept and that there are now qualitative measures used now. Would it be possible to have that concept explained.

I look forward from hearing from DOFAW.

Mahalo
pb

On Thu, Oct 3, 2013 at 9:09 AM, Huang-Chi Kuo <kuo@garciaandassociates.com> wrote:
> Aloha e Mr. Bueltmann,
>
> Thank you again for your scrutiny for the proposed project. I really
> appreciate your diligence to collect and synthesize concerns for the
> hunting community. I have forwarded your questions and comments to
> DOFAW and I believe they will contact you shortly after 10/14. I will
> also work with DOFAW to address these concerns in the draft EA.
>
> Mahalo,
> Huang-Chi
>
> -----Original Message-----
> From: paul bueltmann [mailto:paul.bueltmann@gmail.com]
> Sent: Tuesday, October 01, 2013 9:15 PM
> To: kuo@garciaandassociates.com
> Subject: Re: EA for Pu'u Wa'a Wa'a
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> Aloha e Dr. Kuo
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> maintain the fencing and how will that be funded 8. Were there
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>> Huang-Chi
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>> Sent: Friday, September 27, 2013 8:16 AM
>> To: kuo@garciaandassociates.com

>> Subject: Re: EA for Pu'u Wa'a Wa'a
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>> <kuo@garciaandassociates.com>
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>>> Huang-Chi Kuo PhD
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>>> Kailua HI, 96734
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>>> To: kuo@garciaandassociates.com

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>>> Mahalo for your time and I look forward to hear from you.
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>>> pb
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>
>

**Huang-Chi Kuo**

---

**From:** Kathleen Johnson <konahikingclub@gmail.com>
**Sent:** Tuesday, October 08, 2013 10:23 AM
**To:** kuo@garciaandassociates.com
**Subject:** Fwd: input re Puu Waawaa Habitat Conservation Plan
**Attachments:** Puuwaawaa input 10-7-13 (email).doc

Attached is input from another of member of our hiking group.

Thank you,
Kathleen Johnson
Kona Hiking Club

---------- Forwarded message ----------
From: NolanChock@gmail.com
Date: Mon, Oct 7, 2013 at 6:27 PM
Subject: input re Puu Waawaa Habitat Conservation Plan
To: konahikingclub@gmail.com

Hi Kathleen,

Attached is my personal input.
This is the first time I have provided input re an environmental issue.
Feel free to use it in any way you feel would be appropriate.

Send any responses, questions, or concerns to my personal email:
NolanChock@gmail.com

*Confidentiality Notice: This e-mail message, including any attachments, is for the sole use of the intended recipient(s) and may contain confidential and/or privileged information. Any review, use, disclosure, or distribution by unintended recipients is prohibited. If you are not the intended recipient, please contact the sender by reply e-mail and destroy all copies of the original message.*

PERSONAL MEMO

TO: Garcia and Associates
FROM: Nolan Chock
DATE: October 7, 2013
RE: Input for Environmental Assessment for Pu'u Wa'awa'a Forest Reserve and Game Management Area

Many hikers, including myself, have been appalled by the condition of the Pu'u Wa'awa'a ahupua'a. The ungulates, which have been allowed to run wild through the area, have decimated the trees and plants (except the areas already fenced by DLNR). Many of the existing fences are in disrepair. Everywhere you go you smell the feces of goats, sheep, and other ungulates.

I was very pleased to learn of the Habitat Conservation Plan. However, the project goal of fencing only 8.2% of the project area seems quite inadequate. Given the years of neglect, there is a need to fence a much larger percentage of the ahupua'a.

Fencing is even more important given the continuing years of less-than-average rainfall in this dryland forest area. In the drought years, the ungulates present an even greater menace to the native ecosystem due to their desperate need for food.

I understand that, unlike the Volcano National Park, the Pu'u Wa'awa'a ahupua'a has a dual purpose. But the balance seems to be unfairly tipped toward the hunters. Currently, there many more ungulates than the area can sustain. They can easily be observed in packs along the roads and hiking trails. Without more protection, the Pu'u cone and its surrounding area, which has become nearly naked grassland, could turn into a dust bowl. It's important to keep in mind that ungulates can easily come back, but the endangered plants and birds can't.

Once the areas are fenced, access for hiking, bird watching, and environmental education needs to be permitted. These minimal impact activities have been successfully permitted in many sensitive areas on the Big Island (e.g. Hakalau National Wildlife Refuge) without adversely affecting the endangered plants and birds.

## Huang-Chi Kuo

| | |
|---|---|
| **From:** | Kaleo.L.Manuel@hawaii.gov |
| **Sent:** | Wednesday, October 09, 2013 4:06 PM |
| **To:** | kuo@garciaandassociates.com |
| **Cc:** | Norgaard.U.Lota@hawaii.gov; Darrell.C.Yagodich@hawaii.gov |
| **Subject:** | Pre-Consultation DEA Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan |

Aloha Huang-Chi Kuo,

I am writing to ask for an extension to get pre-consultation comments to you. We are in the process of drafting a letter and it will need to be signed by our Chair.

Please advise if this is possible.

Mahalo nui,

M. Kaleo Manuel
Planner
Department of Hawaiian Home Lands
P.O. Box 1879, Honolulu, Hawaii 96805
fax: (808) 620-9559
direct: (808) 620-9485

## Huang-Chi Kuo

**From:** Ryan Kohatsu <kohatsu_ryan@hotmail.com>
**Sent:** Thursday, October 10, 2013 5:01 PM
**To:** kuo@garciaandassociates.com
**Subject:** Puu Waawaa and Puu Anahulu Game Management and Habitat Conservation Plan

I would like to receive a copy of the draft EA.

My comments/questions:

Dr Kuo,

I would like to give input into the recent Puu Waawaa and Puu Anahulu Game Management Habitat Conservation Plan as stated and requested in your letter dated, 9 September 2013. My name is Ryan Kohatsu and I am a mechanical engineer and life-life long hunter of the Puu Waawaa and Puu Anahulu area.

## Huang-Chi Kuo

**From:** Kevin.E.Moore@hawaii.gov
**Sent:** Monday, October 14, 2013 8:46 AM
**To:** kuo@garciaandassociates.com
**Subject:** Early Consultation on EA for Puu Waawaa Forest Reserve and Puu Anahulu
**Attachments:** g_a_dofaw.pdf

Dear Huang-Chi- Kuo,

Attached please find a pdf of Land Division Administrator Russell Tsuji's letter dated October 14, 2013 on the above-referenced matter. A hard copy will not be sent.

Kevin E. Moore
State Lands Assistant Administrator
Department of Land and Natural Resources, Land Division
1151 Punchbowl Street, #220
Honolulu, HI 96813
Tel. (808) 587-0426

NEIL ABERCROMBIE
GOVERNOR OF HAWAII

WILLIAM J. AILA, JR.
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES
COMMISSION ON WATER RESOURCE MANAGEMENT

**STATE OF HAWAII**
**DEPARTMENT OF LAND AND NATURAL RESOURCES**
**LAND DIVISION**

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

October 14, 2013

Garcia and Associates – Pacific Region
Attention: Huang-Chi Kuo via email: kuo@garciaandassociates.com
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Dear Huang-Chi Kuo:

SUBJECT: Early Consultation on Environmental Assessment for Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan, Garcia and Associates for Division of Forestry and Wildlife, Applicant, Puu Waawaa, North Kona, Hawaii

Thank you for the opportunity to review and comment on the subject matter. The Department of Land and Natural Resources' (DLNR) Land Division distributed or made available a copy of your report pertaining to the subject matter to DLNR Divisions for their review and comments.

At this time, enclosed are comments from the (i) Engineering Division, (ii) Hawaii District Land Office, (iii) Office of Conservation and Coastal Lands, (iv) Division of State Parks, and (v) Division of Aquatic Resources on the subject matter. Should you have any questions, please feel free to call Kevin Moore at (808) 587-0426. Thank you.

Sincerely,

Russell Y. Tsuji
Land Administrator

Enclosure(s)

**Huang-Chi Kuo**

---

**From:** Mike Donoho <kukuiplanning@gmail.com>
**Sent:** Tuesday, October 15, 2013 2:27 PM
**To:** kuo@garciaandassociates.com
**Subject:** PWW/PA HCP EA

Aloha,

I would like to receive a copy of the Draft EA for this project. I was formerly employed by DOFAW and stationed at Pu'u Wa'awa'a, so I am familiar with the issues and resources that pertain to this area. Please let me know if there is anything that I can do to assist you in this EA.

Mahalo, Mike

--
Mike Donoho, AICP
Kukui Planning Company, LLC
**P.O. Box 437141**
**Kamuela, HI 96743**
**(808) 936-7526**
**(808) 885-7526 Fax**

## Huang-Chi Kuo

**From:** Rachel Rounds <Rachel_Rounds@fws.gov>
**Sent:** Friday, October 18, 2013 2:12 PM
**To:** kuo@garciaandassociates.com
**Subject:** EA for Puu Waawaa and Puu Anahulu

Dear Mr. Kuo,

The U.S. Fish and Wildlife Service received a request on September 12, 2013 for comments on preparation of an EA for activities at the Puu Waawaa FR and Puu Anahulu GMA. We had begun working on our comments when the Federal government shutdown began, and so were unable to meet the deadline for submission of comments.

We would like to receive a copy of the draft EA when it is available. In addition, we plan to still submit comments and hope that they can be accepted late.

Thank you for your consideration,

Rachel Rounds
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Honolulu, HI
808-792-9454

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawaii 96850

In Reply Refer To:
2013-TA-0450

NOV 1 5 2013

Huang-Chi Kuo
Garcia and Associates
146 Hekili Street, Suite 101
Kailua, Hawaii 96734

Subject: Early Consultation Request on an Environmental Assessment for the Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan, North Kona, Hawaii

Dear Mr. Kuo:

We received your letter requesting comments on preparation of an Environmental Assessment (EA) for the Puu Waawaa Forest Reserve and Puu Anahulu Game Management Area Habitat Conservation Plan (HCP) on September 12, 2013. Due to a lack of appropriations within the Federal government, we were unable to respond to your request in a timely manner, and we apologize for the delay in our response. We reviewed the proposed project pursuant to the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

The dry forest of Hawaii is a unique and biologically diverse ecosystem that has been severely impacted by land development, fire, non-native ungulate grazing and invasive species. Over 90 percent of dry forests in Hawaii have been destroyed (Bruegmann 1996). The North Kona region of Hawaii Island, including Puu Waawaa and Puu Anahulu, contains one of the largest remaining dry forests left in Hawaii. As noted in your letter and in the draft HCP (DOFAW 2013), the project area supports dozens of native plants, vertebrates, and invertebrates, including the fourteen plants and one invertebrate covered by the HCP.

Currently, the project area is being managed for grazing of non-native ungulates, fire control, natural resources, and public hunting (DOFAW 2013). The proposed project would fence approximately nine percent of the project area for conservation of natural resources, and maintain and enhance habitat for game mammals in the remaining areas. Our recommendations for preparation of an EA are provided below.

- The State of Hawaii Department of Lands and Natural Resources (DLNR) is applying for an Incidental Take License in accordance with Chapter 195-D, Hawaii Revised Statues for its management actions at Puu Waawaa and Puu Anahulu. The DLNR is preparing an

HCP to support the application that addresses take of listed plants and the Blackburn's sphinx moth (*Manduca blackburni*) from the management actions. The State of Hawaii also needs an incidental take permit from the U.S. Fish and Wildlife Service (Service) under either section 7 or section 10 of the ESA for adverse impacts to Federally-listed species. The Service's Wildlife and Sport Fish Restoration Program (WSFRP) has written an informal consultation under section 7 to cover actions funded by the WSFRP. However, this informal consultation does not cover all actions proposed in the draft HCP, and does not provide incidental take coverage for the proposed action. Consequently, the State of Hawaii will also need an incidental take permit from the Service under the ESA.

- The EA should analyze whether the proposed fenced exclosures are large enough to support viable populations of the listed plants included in the draft HCP.

- The draft HCP uses baseline populations for listed plants primarily from data collected since 2003 (DOFAW 2013). However, loss of dry forest habitat in the project area has been on-going for over a hundred years. Loss of listed species and their habitats began well before the initiation of the HCP process, and the proposed HCP will only fence nine percent of the Puu Waawaa and Puu Anahulu project area. In addition, it is our understanding that not all remnant dry forest is being fenced. We recommend that an alternative be analyzed in the EA that provides additional fencing and conservation measures for current and historically listed species in the area and native habitat beyond that presently in the draft HCP.

- The draft HCP uses stabilization criteria (as defined by the Hawaii and Pacific Plants Recovery Coordinating Committee) to determine the plant populations necessary to off-set take from the proposed actions. As stated in the draft HCP "It is important to note that the requirements for stabilization are far below those required for delisting or downlisting, and that stabilization is *not* synonymous with recovery" (DOFAW 2013).

  Some of the plants covered by the draft HCP have an extremely limited distribution, and are only found in remnant dry forests of Hawaii Island. For example, *Zanthoxylum dipetalum* var. *tomentosum* is endemic to Puu Waawaa and has never been found elsewhere. *Neraudia ovata*, *Nothocestrum breviflorum*, *Solanum incompletum*, and *Kokia drynarioides* all have a limited distribution outside Puu Waawaa and Puu Anahulu. For these plants, use of stabilization criteria to determine mitigation numbers has the potential to preclude eventual recovery of the species. Plant population targets in the HCP should provide for the recovery of listed species. The EA should analyze how the proposed project will impact the long-term recovery of these species, and analyze whether alternatives with larger fenced areas would allow for recovery of species with limited distribution.

- There may be a time-lag between clearing of *Nicotiana glauca* for road maintenance and fire breaks and the restoration of *Nothocestrum breviflorum* habitat, to benefit the Blackburn's sphinx moth, in fenced exclosures. Please analyze the potential effects of this time-lag and discuss ways these effects can be minimized.

- Critical habitat is designated within the project area for Blackburn's sphinx moth and eight plant species. The EA should analyze the impacts, both adverse and beneficial, of the proposed project on designated critical habitat.

- As defined by the State of Hawaii, a cumulative impact "is the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (OEQC 2012).

  The EA should thoroughly analyze the cumulative impacts of historic and current land development, fire, non-native ungulate grazing, and invasive species on dry forest habitat and species. The analysis should look at effects at the ecosystem and individual species level within the dry forest regions of Puu Waawaa, Puu Anahulu, and elsewhere in the North Kona region. While nine percent of remnant dry forest habitat at Puu Waawaa and Puu Anahulu will be fenced as part of the proposed project and have a beneficial effect to native ecosystems, the large historic loss of dry forests in North Kona combined with on-going current threats from development, fire, and ungulate grazing, have had an adverse cumulative impact effect on native dry forests.

If you have questions regarding these comments, please contact Rachel Rounds, Fish and Wildlife Biologist, (phone: 808-792-9400, email: Rachel_Rounds@fws.gov).

Sincerely,

for Jess Newton
Island Team Manager
(Maui, Molokai, Lanai, and Hawaii)

cc: Ruth Utzurram, U.S. Fish and Wildlife Service
cc: Lasha-Lynn Salbosa, Hawaii Division of Forestry and Wildlife
cc: Edith Adkins, Hawaii Division of Forestry and Wildlife
cc: Lisa Hadway, Hawaii Division of Forestry and Wildlife

Literature Cited

Bruegmann M.M. 1996. Hawaii's dry forests. Endangered Species Bulletin 11:26-27.

Office of Environmental Quality Control (OEQC). 2012 . Guidebook for the Hawaii State Environmental Review Process. Honolulu, Hawaii. 96 pp.

State of Hawaii Department of Lands and Natural Resources, Division of Forestry and Wildlife (DOFAW). 2013. Draft Habitat Conservation Plan for Pu'u Wa'awa'a Forest Reserve and Pu'u Anahulu Game Management Area, Island of Hawaii (dated August 2013). 193 pp.

# APPENDIX F: MODIFIED FUNDING MATRIX

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | **Item description** | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 1** | **YR 2** | **YR 3** | **YR 4** | **YR 5** | **YR 6** | **YR 7** |
| 2 | | *Ungulate Exclosures (contracting and materials)* | | | | | | | | | | | |
| 3 | | Henahena | 3.3 | miles | 168,480.00 | 555,984.00 | 555,984.00 | | | | | | |
| 4 | | Hala pepe | 1.8 | miles | 168,480.00 | 304,748.57 | 304,748.57 | | | | | | |
| 5 | | Aiea | 3.0 | miles | 168,480.00 | 503,656.94 | | 503,656.94 | | | | | |
| 6 | | Honohono | 0.6 | miles | 168,480.00 | 97,360.42 | | 97,360.42 | | | | | |
| 7 | | Solanum | 0.8 | miles | 168,480.00 | 139,602.27 | | 139,602.27 | | | | | |
| 8 | | Zanthoxylum II | 4.6 | miles | 168,480.00 | 773,544.20 | | | 773,544.20 | | | | |
| 9 | | Kauila Halapepe | 3.4 | miles | 168,480.00 | 576,415.53 | | | 576,415.53 | | | | |
| 10 | | Uhiuhi 4 | 0.8 | miles | 168,480.00 | 130,965.46 | | | 130,965.46 | | | | |
| 11 | | Anahulu I | 2.6 | miles | 168,480.00 | 441,471.90 | | | | 441,471.90 | | | |
| 12 | | Anahulu II | 2.2 | miles | 168,480.00 | 372,272.73 | | | | 372,272.73 | | | |
| 13 | | Puu Loa | 4.2 | miles | 168,480.00 | 710,731.03 | | | | | 710,731.03 | | |
| 14 | | Stenogyne | 0.6 | miles | 168,480.00 | 93,801.00 | | | | | 93,801.00 | | |
| 15 | | PWW CCA buffer | 1.4 | miles | 168,480.00 | 230,210.27 | | | | | | 230,210.27 | |
| 16 | | Manele | 1.8 | miles | 168,480.00 | 302,759.48 | | | | | | | 302,759.48 |
| 17 | | Kohala | 1.6 | miles | 168,480.00 | 262,140.30 | | | | | | | |
| 18 | | Waihou II | 2.3 | miles | 168,480.00 | 395,827.67 | | | | | | | |
| 19 | | Boundary Kipuka | 1.2 | miles | 168,480.00 | 196,605.23 | | | | | | | |
| 20 | | Kileo | 4.2 | miles | 168,480.00 | 709,300.80 | | | | | | | |
| 21 | | Lama Kokio | 3.2 | miles | 168,480.00 | 544,171.44 | | | | | | | |
| 22 | | Fence checks and repairs for large exclosures | 837.38 | miles | 558.00 | 507,814.30 | 2,850.72 | 5,303.62 | 10,208.40 | 12,903.49 | 15,568.07 | 16,330.52 | 17,333.25 |
| 23 | | Supplies for small spot fences | 240 | each | 500.00 | 120,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | |
| 24 | | Labor | | see crew | | | | | | | | | |
| 25 | | | | | | | | | | | | | |
| 26 | | **Subtotal** | | | | **7,969,383.55** | | | | | | | |
| 27 | | *Fire pre-suppression for ungulate exclosures and fuel breaks* | | | | | | | | | | | |
| 28 | | ATV with spray rig | 4 | each | 10,000.00 | 30,000.00 | 15,000.00 | | | | | | |
| 29 | | Annual Maintenance | 50 | each | 500.00 | 25,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 |
| 30 | | Truck spray rig | 6 | each | 7,500.00 | 45,000.00 | 7,500.00 | 7,500.00 | | | | | |
| 31 | | Annual Maintenance | 25 | each | 400.00 | 10,000.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 |
| 32 | | Backpack sprayers | 50 | each | 150.00 | 7,500.00 | 1,500.00 | | | | 1,500.00 | | |
| 33 | | Weed Whacker + PPE and supplies | 42 | each | 1,000.00 | 31,500.00 | 10,500.00 | | | | | | |
| 34 | | Herbicide + surfectant and dye | 500 | each | 1,000.00 | 500,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 |
| 35 | | Bulldozer | 1 | each | 1,500,000.00 | 1,500,000.00 | 1,500,000.00 | | | | | | |
| 36 | | 200 Gallon Tender Truck | 1 | each | 200,000.00 | 200,000.00 | | | 200,000.00 | | | | |
| 37 | | Brush Truck | 1 | each | 150,000.00 | 150,000.00 | | | 150,000.00 | | | | |
| 38 | | Dip Tanks | 2 | each | 60,000.00 | 120,000.00 | 60,000.00 | | | | 60,000.00 | | |
| 39 | | | | | | | | | | | | | |
| 40 | | **Subtotal** | | | | **2,619,000.00** | | | | | | | |
| 41 | | *Predator control* | | | | | | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | **Item description** | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 1** | **YR 2** | **YR 3** | **YR 4** | **YR 5** | **YR 6** | **YR 7** |
| 42 | | Good nature A24 Rat Trap | 250 | 5 Pack | 595.00 | 148,750.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 |
| 43 | | $CO_2$ cartridge refills | 250 | 10 pack | 45.00 | 11,250.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 |
| 44 | | Rat lure replacement | 250 | 10 pack | 70.00 | 17,500.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 |
| 45 | | Rodenticide (for large conservation units) | ? | ? | ? | ? | | | | | | | |
| 46 | | | | | | | | | | | | | |
| 47 | | **Subtotal** | | | | **177,500.00** | | | | | | | |
| 48 | | *Ungulate control in ungulate exclosures* | | | | | | | | | | | |
| 49 | | Game drives (helicopter) | 110 | hours | 800.00 | 88,000.00 | 8000.00 | 8,000.00 | 16,000.00 | 16,000.00 | 8,000.00 | | |
| 50 | | Game traps | 138 | each | 180.00 | 24,840.00 | 16,200.00 | 4,320.00 | | | | | |
| 51 | | Ungulate monitoring | | see crew | | | | | | | | | |
| 52 | | GPS tracking collars | 5 | set | 2,000.00 | 10,000.00 | 2,000.00 | | | | 2,000.00 | | |
| 53 | | Quarterly fence checks | | see crew | | | | | | | | | |
| 54 | | Firearms | 12 | each | 800.00 | 9,600.00 | 4,800.00 | | | | | | |
| 55 | | Ammunition | 25 | annual | 500.00 | 12,500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 |
| 56 | | Boar buster trapping system | 2 | each | 6,000.00 | 12,000.00 | 6,000.00 | | | | | | |
| 57 | | Cell service to support trapping system | 300 | monthly | 70.00 | 21,000.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 |
| 58 | | | | | | | | | | | | | |
| 59 | | **Subtotal** | | | | **177,940.00** | | | | | | | |
| 60 | | *Mitigation and Net benefit* | | | | | | | | | | | |
| 61 | | Nursery Propagation (Volcano Rare Plant Facility) of covered species | 10,250 | each | 8.00 | 82,000.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 |
| 62 | | On-site Green House | 4 | each | 10,000.00 | 40,000.00 | 10,000.00 | | | | 10,000.00 | | |
| 63 | | Green house maintenance and supplies | 25 | annual | 8,000.00 | 200,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 |
| 64 | | Green House labor | | see crew | | | | | | | | | |
| 65 | | Common species propagation | 150,000 | each | 6.00 | 900,000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 |
| 66 | | Labor (seed collection and outplanting) | | see crew | | | | | | | | | |
| 67 | | outplanting | | see crew | | | | | | | | | |
| 68 | | pest control (ant/slug/aphid/etc) | 4000 | acre | 50.00 | 200,000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 |
| 69 | | | | | | | | | | | | | |
| 70 | | **Subtotal** | | | | **1,422,000.00** | | | | | | | |
| 71 | | *Permanent Field Crew* | | | | | | | | | | | |
| 72 | | Project leader | 1 | each | 65,000.00 | 1,625,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 |
| 73 | | Crew Leader (including fringe) | 1 | each | 59,000.00 | 1,475,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 |
| 74 | | Field Assistants (including fringe) | 6 | each | 45,000.00 | 4,500,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 |
| 75 | | Data management/nursery tech (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| 76 | | Volunteer Coordinator (including fringe) | 1 | each | 45,000.00 | 1,125,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| 77 | | Vehicles for Crew | 8 | each | 40,000.00 | 320,000.00 | 80,000.00 | | | | | | |
| 78 | | Flat bed for trucks | 8 | each | 7,000.00 | 56,000.00 | 14,000.00 | | | | | | |
| 79 | | Large trailer | 4 | each | 10,000.00 | 40,000.00 | 10,000.00 | | | | | | |
| 80 | | Small trailer | 4 | each | 5,000.00 | 20,000.00 | 5,000.00 | | | | | | |

|  | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 |  | **Item description** | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 1** | **YR 2** | **YR 3** | **YR 4** | **YR 5** | **YR 6** | **YR 7** |
| 81 |  | Annual truck maintenance | 1 | each | 5,000.00 | 125,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 |
| 82 |  | ATV | 8 | each | 8,000.00 | 64,000.00 | 16,000.00 |  |  |  |  |  |  |
| 83 |  | 2 Seater ATV | 2 | each | 18,000.00 | 36,000.00 | 18,000.00 |  |  |  |  |  |  |
| 84 |  | Training | 25 | annual | 10,000.00 | 250,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 |
| 85 |  | Flight suits | 10 | each | 200.00 | 2,000.00 | 1,000.00 |  |  |  |  |  |  |
| 86 |  | Flight helmets | 10 | each | 1,000.00 | 10,000.00 | 5,000.00 |  |  |  |  |  |  |
| 87 |  | Radios | 8 | each | 2,000.00 | 16,000.00 | 8000.00 |  |  |  |  |  |  |
| 88 |  | Cargo nets and sling load supplies | 6 | each | 5,000.00 | 30,000.00 | 15,000.00 |  |  |  |  |  |  |
| 89 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 90 |  | **Subtotal** |  |  |  | **10,819,000.00** |  |  |  |  |  |  |  |
| 91 |  | *Puu Waawaa Baseyard Facilities* |  |  |  |  |  |  |  |  |  |  |  |
| 92 |  | Modular Office | 2 | each | 90,000.00 | 1,800,000.00 | 90,000.00 |  |  |  |  |  |  |
| 93 |  | Office furniture | 5 | each | 1,500.00 | 7,500.00 | 1,500.00 |  |  |  |  | 1,500.00 |  |
| 94 |  | Shipping container | 4 | each | 8,000.00 | 32,000.00 | 16,000.00 |  |  |  |  |  |  |
| 95 |  | Lumber | 1 | each | 40,000.00 | 40,000.00 | 40,000.00 |  |  |  |  |  |  |
| 96 |  | Diesel air compressor | 5 | each | 8,000.00 | 40,000.00 | 8,000.00 |  |  |  | 8,000.00 |  |  |
| 97 |  | Jack hammer | 5 | each | 2,000.00 | 10,000.00 | 2,000.00 |  |  |  | 2,000.00 |  |  |
| 98 |  | Pneumatic rock drill | 5 | each | 2,000.00 | 10,000.00 | 2,000.00 |  |  |  | 2,000.00 |  |  |
| 99 |  | Electric band saw | 5 | each | 300.00 | 1,500.00 | 300.00 |  |  |  | 300.00 |  |  |
| 100 |  | Welder | 2 | each | 5,000.00 | 10,000.00 | 5,000.00 |  |  |  |  |  |  |
| 101 |  | Portable generators | 10 | each | 1,000.00 | 10,000.00 | 2,000.00 |  |  |  | 2,000.00 |  |  |
| 102 |  | Backhoe | 1 | each | 80,000.00 | 80,000.00 | 80,000.00 |  |  |  |  |  |  |
| 103 |  | Concrete Mixer | 5 | each | 3,500.00 | 17,500.00 | 3,500.00 |  |  |  |  | 3,500.00 |  |
| 104 |  | Gas generator with Electric Starter | 5 | each | 10,000.00 | 50,000.00 | 10,000.00 |  |  |  | 10,000.00 |  |  |
| 105 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 106 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 107 |  | **Subtotal** |  |  |  | **2,108,500.00** |  |  |  |  |  |  |  |

| | A | B | C | D | E | F | G | H | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | **Item description** | **Quantity** | **Units** | **Unit Cost** | **Total Cost** | **YR 1** | **YR 2** | **YR 3** | **YR 4** | **YR 5** | **YR 6** | **YR 7** |
| 108 | | ***Monitoring*** | | | | | | | | | | | |
| 109 | | GPS units | 20 | each | 350.00 | 7,000.00 | 1,400.00 | | | | 1,400.00 | | |
| 110 | | field supplies | 25 | annual | 15,000.00 | 375,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 |
| 111 | | data entry tablets | 28 | each | 200.00 | 5,600.00 | 800.00 | | | | 800.00 | | |
| 112 | | database hosting and tech support | 25 | annual | 1,500.00 | 37,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 |
| 113 | | plant label printer | 5 | each | 1,000.00 | 5,000.00 | 1,000.00 | | | | 1,000.00 | | |
| 114 | | plant labels | 25 | annual | 500.00 | 12,500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 |
| 115 | | | | | | | | | | | | | |
| 116 | | **Subtotal** | | | | **442,600.00** | | | | | | | |
| 117 | | *Blackburn's sphinx moth research* | | | | | | | | | | | |
| 118 | | Post-doc position plus supplies | 3 | annual | 100,000.00 | 300,000.00 | | 100,000.00 | 100,000.00 | 100,000.00 | | | |
| 119 | | | | | | | | | | | | | |
| 120 | | **Subtotal** | | | | 300,000.00 | | | | | | | |
| 121 | | | | | | | | | | | | | |
| 122 | | *Subtotal* | | | | 26,035,923.55 | 3,471,703.29 | 1,396,863.25 | 2,488,253.59 | 1,473,768.12 | 1,460,220.11 | 782,660.79 | 831,212.74 |
| 123 | | **TOTAL (including 3% annual inflation starting in YR2):** | | | | **30,501,833.38** | 3,471,703.29 | 1,438,769.15 | 2,637,548.81 | 1,606,407.25 | 1,635,446.52 | 900,059.91 | 980,831.03 |

|  | B | N | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 8** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** | **YR 16** | **YR 17** | **YR 18** | **YR 19** |
| 2 | *Ungulate Exclosures (contracting and materials)* | | | | | | | | | | | | |
| 3 | Henahena | | | | | | | | | | | | |
| 4 | Hala pepe | | | | | | | | | | | | |
| 5 | Aiea | | | | | | | | | | | | |
| 6 | Honohono | | | | | | | | | | | | |
| 7 | Solanum | | | | | | | | | | | | |
| 8 | Zanthoxylum II | | | | | | | | | | | | |
| 9 | Kauila Halapepe | | | | | | | | | | | | |
| 10 | Uhiuhi 4 | | | | | | | | | | | | |
| 11 | Anahulu I | | | | | | | | | | | | |
| 12 | Anahulu II | | | | | | | | | | | | |
| 13 | Puu Loa | | | | | | | | | | | | |
| 14 | Stenogyne | | | | | | | | | | | | |
| 15 | PWW CCA buffer | | | | | | | | | | | | |
| 16 | Manele | | | | | | | | | | | | |
| 17 | Kohala | 262,140.30 | | | | | | | | | | | |
| 18 | Waihou II | | 395,827.67 | | | | | | | | | | |
| 19 | Boundary Kipuka | | 196,605.23 | | | | | | | | | | |
| 20 | Kileo | | | 709,300.80 | | | | | | | | | |
| 21 | Lama Kokio | | | 544,171.44 | | | | | | | | | |
| 22 | Fence checks and repairs for large exclosures | 18,201.45 | 20,163.57 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 |
| 23 | Supplies for small spot fences | | | | | | | | | | | | |
| 24 | Labor | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | |
| 26 | **Subtotal** | | | | | | | | | | | | |
| 27 | *Fire pre-suppression for ungulate exclosures and fuel breaks* | | | | | | | | | | | | |
| 28 | ATV with spray rig | | | | | 15,000.00 | | | | | | | |
| 29 | Annual Maintenance | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 |
| 30 | Truck spray rig | 7,500.00 | 7,500.00 | | | | | | | | | 7,500.00 | 7,500.00 |
| 31 | Annual Maintenance | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 |
| 32 | Backpack sprayers | | | 1,500.00 | | | | | 1,500.00 | | | | |
| 33 | Weed Whacker + PPE and supplies | 10,500.00 | | | | | | | | 10,500.00 | | | |
| 34 | Herbicide + surfectant and dye | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 |
| 35 | Bulldozer | | | | | | | | | | | | |
| 36 | 200 Gallon Tender Truck | | | | | | | | | | | | |
| 37 | Brush Truck | | | | | | | | | | | | |
| 38 | Dip Tanks | | | | | | | | | | | | |
| 39 | | | | | | | | | | | | | |
| 40 | **Subtotal** | | | | | | | | | | | | |
| 41 | *Predator control* | | | | | | | | | | | | |

| | B | N | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 8** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** | **YR 16** | **YR 17** | **YR 18** | **YR 19** |
| 42 | Good nature A24 Rat Trap | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 |
| 43 | $CO_2$ cartridge refills | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 |
| 44 | Rat lure replacement | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 |
| 45 | Rodenticide (for large conservation units) | | | | | | | | | | | | |
| 46 | | | | | | | | | | | | | |
| 47 | **Subtotal** | | | | | | | | | | | | |
| 48 | *Ungulate control in ungulate exclosures* | | | | | | | | | | | | |
| 49 | Game drives (helicopter) | 8,000.00 | 16,000.00 | 8,000.00 | | | | | | | | | |
| 50 | Game traps | | 4,320.00 | | | | | | | | | | |
| 51 | Ungulate monitoring | | | | | | | | | | | | |
| 52 | GPS tracking collars | | | 2,000.00 | | | | | 2,000.00 | | | | |
| 53 | Quarterly fence checks | | | | | | | | | | | | |
| 54 | Firearms | | | | | 4,800.00 | | | | | | | |
| 55 | Ammunition | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 |
| 56 | Boar buster trapping system | | | | | 6,000.00 | | | | | | | |
| 57 | Cell service to support trapping system | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 |
| 58 | | | | | | | | | | | | | |
| 59 | **Subtotal** | | | | | | | | | | | | |
| 60 | *Mitigation and Net benefit* | | | | | | | | | | | | |
| 61 | Nursery Propagation (Volcano Rare Plant Facility) of covered species | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 |
| 62 | On-site Green House | | | 10,000.00 | | | | 10,000.00 | | | | | |
| 63 | Green house maintenance and supplies | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 |
| 64 | Green House labor | | | | | | | | | | | | |
| 65 | Common species propagation | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 |
| 66 | Labor (seed collection and outplanting) | | | | | | | | | | | | |
| 67 | outplanting | | | | | | | | | | | | |
| 68 | pest control (ant/slug/aphid/etc) | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 |
| 69 | | | | | | | | | | | | | |
| 70 | **Subtotal** | | | | | | | | | | | | |
| 71 | *Permanent Field Crew* | | | | | | | | | | | | |
| 72 | Project leader | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 |
| 73 | Crew Leader (including fringe) | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 |
| 74 | Field Assistants (including fringe) | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 |
| 75 | Data management/nursery tech (including fringe) | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| 76 | Volunteer Coordinator (including fringe) | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 |
| 77 | Vehicles for Crew | 80,000.00 | | | | | | | 80,000.00 | | | | |
| 78 | Flat bed for trucks | 14,000.00 | | | | | | | 14,000.00 | | | | |
| 79 | Large trailer | 10,000.00 | | | | | | | 10,000.00 | | | | |
| 80 | Small trailer | 5,000.00 | | | | | | | 5,000.00 | | | | |

| | B | N | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 8** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** | **YR 16** | **YR 17** | **YR 18** | **YR 19** |
| 81 | Annual truck maintenance | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 |
| 82 | ATV | 16,000.00 | | | | | | | | 16,000.00 | | | |
| 83 | 2 Seater ATV | | | | | 18,000.00 | | | | | | | |
| 84 | Training | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 |
| 85 | Flight suits | | | | | 1,000.00 | | | | | | | |
| 86 | Flight helmets | | | | | 5,000.00 | | | | | | | |
| 87 | Radios | | | | | 8,000.00 | | | | | | | |
| 88 | Cargo nets and sling load supplies | | | | | 15,000.00 | | | | | | | |
| 89 | | | | | | | | | | | | | |
| 90 | **Subtotal** | | | | | | | | | | | | |
| 91 | *Puu Waawaa Baseyard Facilities* | | | | | | | | | | | | |
| 92 | Modular Office | | | | | 90,000.00 | | | | | | | |
| 93 | Office furniture | | | | 1,500.00 | | | | | 1,500.00 | | | |
| 94 | Shipping container | | | | | 16,000.00 | | | | | | | |
| 95 | Lumber | | | | | | | | | | | | |
| 96 | Diesel air compressor | | | 8,000.00 | | | | | 8,000.00 | | | | |
| 97 | Jack hammer | | | 2,000.00 | | | | | 2,000.00 | | | | |
| 98 | Pneumatic rock drill | | | 2,000.00 | | | | | 2,000.00 | | | | |
| 99 | Electric band saw | | | 300.00 | | | | | 300.00 | | | | |
| 100 | Welder | | | | | 5,000.00 | | | | | | | |
| 101 | Portable generators | | | 2,000.00 | | | | | 2,000.00 | | | | |
| 102 | Backhoe | | | | | | | | | | | | |
| 103 | Concrete Mixer | | | | | 3,500.00 | | | | | | 3,500.00 | |
| 104 | Gas generator with Electric Starter | | | 10,000.00 | | | | | 10,000.00 | | | | |
| 105 | | | | | | | | | | | | | |
| 106 | | | | | | | | | | | | | |
| 107 | **Subtotal** | | | | | | | | | | | | |

| | B | N | O | P | Q | R | S | T | U | V | W | X | Y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 8** | **YR 9** | **YR 10** | **YR 11** | **YR 12** | **YR 13** | **YR 14** | **YR 15** | **YR 16** | **YR 17** | **YR 18** | **YR 19** |
| 108 | ***Monitoring*** | | | | | | | | | | | | |
| 109 | GPS units | | | 1,400.00 | | | | | 1,400.00 | | | | |
| 110 | field supplies | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 |
| 111 | data entry tablets | | 800.00 | | | | 800.00 | | | | 800.00 | | |
| 112 | database hosting and tech support | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 |
| 113 | plant label printer | | | 1,000.00 | | | | | 1,000.00 | | | | |
| 114 | plant labels | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 |
| 115 | | | | | | | | | | | | | |
| 116 | **Subtotal** | | | | | | | | | | | | |
| 117 | *Blackburn's sphinx moth research* | | | | | | | | | | | | |
| 118 | Post-doc position plus supplies | | | | | | | | | | | | |
| 119 | | | | | | | | | | | | | |
| 120 | **Subtotal** | | | | | | | | | | | | |
| 121 | | | | | | | | | | | | | |
| 122 | *Subtotal* | 942,461.75 | 1,152,336.46 | 1,837,101.69 | 536,929.45 | 722,729.45 | 536,229.45 | 545,429.45 | 674,629.45 | 563,429.45 | 536,229.45 | 546,429.45 | 542,929.45 |
| 123 | **TOTAL (including 3% annual inflation starting in YR2):** | 1,140,378.72 | 1,428,897.21 | 2,333,119.14 | 698,008.29 | 961,230.17 | 729,272.05 | 758,146.94 | 957,973.82 | 816,972.70 | 793,619.59 | 825,108.47 | 841,540.65 |

| | B | Z | AA | AB | AC | AD | AE | AF |
|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** | |
| 2 | *Ungulate Exclosures (contracting and materials)* | | | | | | | |
| 3 | Henahena | | | | | | | |
| 4 | Hala pepe | | | | | | | |
| 5 | Aiea | | | | | | | |
| 6 | Honohono | | | | | | | |
| 7 | Solanum | | | | | | | |
| 8 | Zanthoxylum II | | | | | | | |
| 9 | Kauila Halapepe | | | | | | | |
| 10 | Uhiuhi 4 | | | | | | | |
| 11 | Anahulu I | | | | | | | |
| 12 | Anahulu II | | | | | | | |
| 13 | Puu Loa | | | | | | | |
| 14 | Stenogyne | | | | | | | |
| 15 | PWW CCA buffer | | | | | | | |
| 16 | Manele | | | | | | | |
| 17 | Kohala | | | | | | | |
| 18 | Waihou II | | | | | | | |
| 19 | Boundary Kipuka | | | | | | | |
| 20 | Kileo | | | | | | | |
| 21 | Lama Kokio | | | | | | | |
| 22 | Fence checks and repairs for large exclosures | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | 24,309.45 | |
| 23 | Supplies for small spot fences | | | | | | | |
| 24 | Labor | | | | | | | |
| 25 | | | | | | | | |
| 26 | **Subtotal** | | | | | | | |
| 27 | *Fire pre-suppression for ungulate exclosures and fuel breaks* | | | | | | | |
| 28 | ATV with spray rig | | | | | | | |
| 29 | Annual Maintenance | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | 1,000.00 | |
| 30 | Truck spray rig | | | | | | | |
| 31 | Annual Maintenance | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | 400.00 | |
| 32 | Backpack sprayers | 1,500.00 | | | | | | |
| 33 | Weed Whacker + PPE and supplies | | | | | | | |
| 34 | Herbicide + surfectant and dye | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | 20,000.00 | |
| 35 | Bulldozer | | | | | | | |
| 36 | 200 Gallon Tender Truck | | | | | | | |
| 37 | Brush Truck | | | | | | | |
| 38 | Dip Tanks | | | | | | | |
| 39 | | | | | | | | |
| 40 | **Subtotal** | | | | | | | |
| 41 | *Predator control* | | | | | | | |

| | B | Z | AA | AB | AC | AD | AE | AF |
|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** | |
| 42 | Good nature A24 Rat Trap | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | 5950.00 | |
| 43 | $CO_2$ cartridge refills | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | 450.00 | |
| 44 | Rat lure replacement | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | 700.00 | |
| 45 | Rodenticide (for large conservation units) | | | | | | | |
| 46 | | | | | | | | |
| 47 | **Subtotal** | | | | | | | |
| 48 | *Ungulate control in ungulate exclosures* | | | | | | | |
| 49 | Game drives (helicopter) | | | | | | | |
| 50 | Game traps | | | | | | | |
| 51 | Ungulate monitoring | | | | | | | |
| 52 | GPS tracking collars | 2,000.00 | | | | | | |
| 53 | Quarterly fence checks | | | | | | | |
| 54 | Firearms | | | | | | | |
| 55 | Ammunition | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | |
| 56 | Boar buster trapping system | | | | | | | |
| 57 | Cell service to support trapping system | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | 840.00 | |
| 58 | | | | | | | | |
| 59 | **Subtotal** | | | | | | | |
| 60 | *Mitigation and Net benefit* | | | | | | | |
| 61 | Nursery Propagation (Volcano Rare Plant Facility) of covered species | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | 3280.00 | |
| 62 | On-site Green House | | | | | | | |
| 63 | Green house maintenance and supplies | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | 8,000.00 | |
| 64 | Green House labor | | | | | | | |
| 65 | Common species propagation | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | 36000.00 | |
| 66 | Labor (seed collection and outplanting) | | | | | | | |
| 67 | outplanting | | | | | | | |
| 68 | pest control (ant/slug/aphid/etc) | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | 8000.00 | |
| 69 | | | | | | | | |
| 70 | **Subtotal** | | | | | | | |
| 71 | *Permanent Field Crew* | | | | | | | |
| 72 | Project leader | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | 65,000.00 | |
| 73 | Crew Leader (including fringe) | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | 59,000.00 | |
| 74 | Field Assistants (including fringe) | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | 180,000.00 | |
| 75 | Data management/nursery tech (including fringe) | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | |
| 76 | Volunteer Coordinator (including fringe) | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | 45,000.00 | |
| 77 | Vehicles for Crew | | | 80,000.00 | | | | |
| 78 | Flat bed for trucks | | | 14,000.00 | | | | |
| 79 | Large trailer | | | 10,000.00 | | | | |
| 80 | Small trailer | | | 5,000.00 | | | | |

| | B | Z | AA | AB | AC | AD | AE | AF |
|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** | |
| 81 | Annual truck maintenance | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | 5,000.00 | |
| 82 | ATV | | | 16,000.00 | | | | |
| 83 | 2 Seater ATV | | | | | | | |
| 84 | Training | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | 10,000.00 | |
| 85 | Flight suits | | | | | | | |
| 86 | Flight helmets | | | | | | | |
| 87 | Radios | | | | | | | |
| 88 | Cargo nets and sling load supplies | | | | | | | |
| 89 | | | | | | | | |
| 90 | **Subtotal** | | | | | | | |
| 91 | *Puu Waawaa Baseyard Facilities* | | | | | | | |
| 92 | Modular Office | | | | | | | |
| 93 | Office furniture | | 1,500.00 | | | | | |
| 94 | Shipping container | | | | | | | |
| 95 | Lumber | | | | | | | |
| 96 | Diesel air compressor | 8,000.00 | | | | | | |
| 97 | Jack hammer | 2,000.00 | | | | | | |
| 98 | Pneumatic rock drill | 2,000.00 | | | | | | |
| 99 | Electric band saw | 300.00 | | | | | | |
| 100 | Welder | | | | | | | |
| 101 | Portable generators | 2,000.00 | | | | | | |
| 102 | Backhoe | | | | | | | |
| 103 | Concrete Mixer | | | | | 3,500.00 | | |
| 104 | Gas generator with Electric Starter | 10,000.00 | | | | | | |
| 105 | | | | | | | | |
| 106 | | | | | | | | |
| 107 | **Subtotal** | | | | | | | |

| | B | Z | AA | AB | AC | AD | AE | AF |
|---|---|---|---|---|---|---|---|---|
| 1 | **Item description** | **YR 20** | **YR 21** | **YR 22** | **YR 23** | **YR 24** | **YR 25** | |
| 108 | ***Monitoring*** | | | | | | | |
| 109 | GPS units | 1,400.00 | | | | | | |
| 110 | field supplies | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | 15,000.00 | |
| 111 | data entry tablets | | 800.00 | | | 800.00 | | |
| 112 | database hosting and tech support | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | 1,500.00 | |
| 113 | plant label printer | 1,000.00 | | | | | | |
| 114 | plant labels | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | 500.00 | |
| 115 | | | | | | | | |
| 116 | **Subtotal** | | | | | | | |
| 117 | *Blackburn's sphinx moth research* | | | | | | | |
| 118 | Post-doc position plus supplies | | | | | | | |
| 119 | | | | | | | | |
| 120 | **Subtotal** | | | | | | | |
| 121 | | | | | | | | |
| 122 | *Subtotal* | 565,629.45 | 537,729.45 | 660,429.45 | 535,429.45 | 539,729.45 | 535,429.45 | |
| 123 | **TOTAL (including 3% annual inflation starting in YR2):** | 888,038.24 | 860,367.12 | 1,076,500.00 | 888,812.89 | 912,142.77 | 920,938.65 | |