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

8/14/2017

EXECUTIVE SUMMARY

The Hawai‘i Department of Land and Natural Resources (DNLR), through the Division of Forestry and Wildlife (DOFAW), manages lands in the Pu‘u Wa‘awa‘a Forest Reserve (PWWFR) and the Pu‘u Anahulu Game Management Area (PAHGMA), in North Kona, on the Island of Hawai‘i. Nāpu‘u (The-hills) is the historical name used for the ahupua‘a of Pu‘u Wa‘awa‘a and Pu‘u 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 Pu‘u Anahulu Game Management Area is primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat. Pu‘u Wa‘awa‘a 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 Pu‘u Wa‘awa‘a and Pu‘u 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*), Ma‘o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Koki‘o (*Kokia drynarioides*), *Neraudia ovata*, ‘Aiea (*Nothocestrum breviflorum*), Uhiuhi (*Mezoneuron kavaiense*), Po‘e (*Portulaca sclerocarpa*), Hawaiian Catchfly (*Silene lanceolata*), Pōpolo kū mai (*Solanum incompletum*), Creeping Mint (*Stenogyne angustifolia*), A‘e (*Zanthoxylum dipetalum* var. *tomentosum*), and A‘e (*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

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.

[1] Plan Area acreage is based on TMK acreage.
[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 5.6.2 for specific fencing goals*).
    a. Remove ungulates from within exclosures within first two year of fencing (this may be dependent upon unit size).
    b. Invasive species control:
        i. Remove invasice species cover by 100% within 1 meter of Covered Species within two years of exclosure completion.
        ii. Conduct rodent and slug control or other threats as needed.
        iii. Establish and maintain fuelbreaks around fencelines semi-annually.
        iv. Conduct quarterly fence line and ungulate ingress checks.
    c. Survey conservation units for Covered Species within a unit within two years of exclosure completion.
    d. Develop a monitoring plan for *in situ* populations for each Covered Species 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 6.7*).
3. Propagation of propagules for all Covered Species at Volcano Rare Plant Facility, DOFAW Waimea Tree Nursery, PWW on-site nursery, or other suitable nursery.
4. 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 subsets of individuals) will be monitored annually.
5. 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:

i. Maintain 100% of fountain grass and kikuyu grass free area within 3 meters of an individual (or cluster of) outplants.
ii. Weeding is scheduled as needed.

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ACRONYMS

AS	Apparently Secure
ATV	All-terrain Vehicle
BIWCG	Big Island Wildfire Coordinating Group
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
FMU	Fire Management Units
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	Hawai‘i Environmental Policy Act
HETF	Hawai‘i Experimental Tropical Forest
HPPRCC	Hawai‘i and Pacific Plants Recovery Coordinating Committee
HRPRG	Hawai‘i Rare Plant Restoration Group
HRS	Hawai‘i Revised Statutes
HVNP	Hawai‘i Volcanoes National Park
ICUN	International Union for Conservation of Nature
ITL	Incidental Take License
ITP	Incidental Take Permit
KS	Kamehameha Schools
NAR	Natural Area Reserve
NEPA	National Environmental Policy Act
PAHGMA	Pu‘u 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	Pu‘u Wa‘awa‘a
PWWFR	Pu‘u Wa‘awa‘a Forest Reserve
PWWMP	Pu‘u Wa‘awa‘a Management Plan
ROI	Rare on Island (PEPP designation)
SOC	Species of Concern
TMK	Tax Map Key
UH	University of Hawai‘i
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
UTM	Universal Transverse Mercator
WUI	Wildland Urban Interface

1.0 INTRODUCTION AND PLAN OVERVIEW

The Hawai‘i Department of Land and Natural Resources (DNLR), through the Division of Forestry and Wildlife (DOFAW), manages lands in the Pu‘u Wa‘awa‘a Forest Reserve (PWWFR) and the Pu‘u Anahulu Game Management Area (PAHGMA), in North Kona, on the Island of Hawai‘i. Pu‘u Wa‘awa‘a is often coupled with its neighbor to the north, the ahupua‘a of Pu‘u 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 “Nāpu‘u”[3], and share common threads of environment, traditions, land tenure, and familial and cultural attachments. The Nāpu‘u 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 Pu‘u Wa‘awa‘a Forest Reserve (TMKs 3-7-1-003-001, 3-7-1-004-001 and 3-7-1-004-018) and Pu‘u 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 Pu‘u Anahulu Game Management Area is primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat. Pu‘u Wa‘awa‘a 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*), Ma‘o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Koki‘o (*Kokia drynarioides*), *Neraudia ovata*, ‘Aiea (*Nothocestrum breviflorum*), Uhiuhi (*Mezoneuron kavaiense*), Po‘e (*Portulaca sclerocarpa*), Hawaiian Catchfly (*Silene lanceolata*), Pōpolo kū mai (*Solanum incompletum*), Creeping Mint (*Stenogyne angustifolia*), A‘e (*Zanthoxylum dipetalum* var. *tomentosum*), and A‘e (*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, Hawai‘i 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] Nāpu‘u (The-hills) is a general name for the hilly region of Pu‘u Wa‘awa‘a and Pu‘u Anahulu. The name also includes variations, such as Nā-pu‘u-pū‘alu (The-loose, crumpled, or folded-hills) or Nā-pu‘u-pū‘alu-kinikini (The-many-folded-hills), which describe the topography - the rolling folds of the hills (Maly and Maly 2006).

[4] Calculated based on TMK tax acreage.

within the PWWFR and PAHGMA. The HCP integrates components of the current Pu‘u Wa‘awa‘a 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.

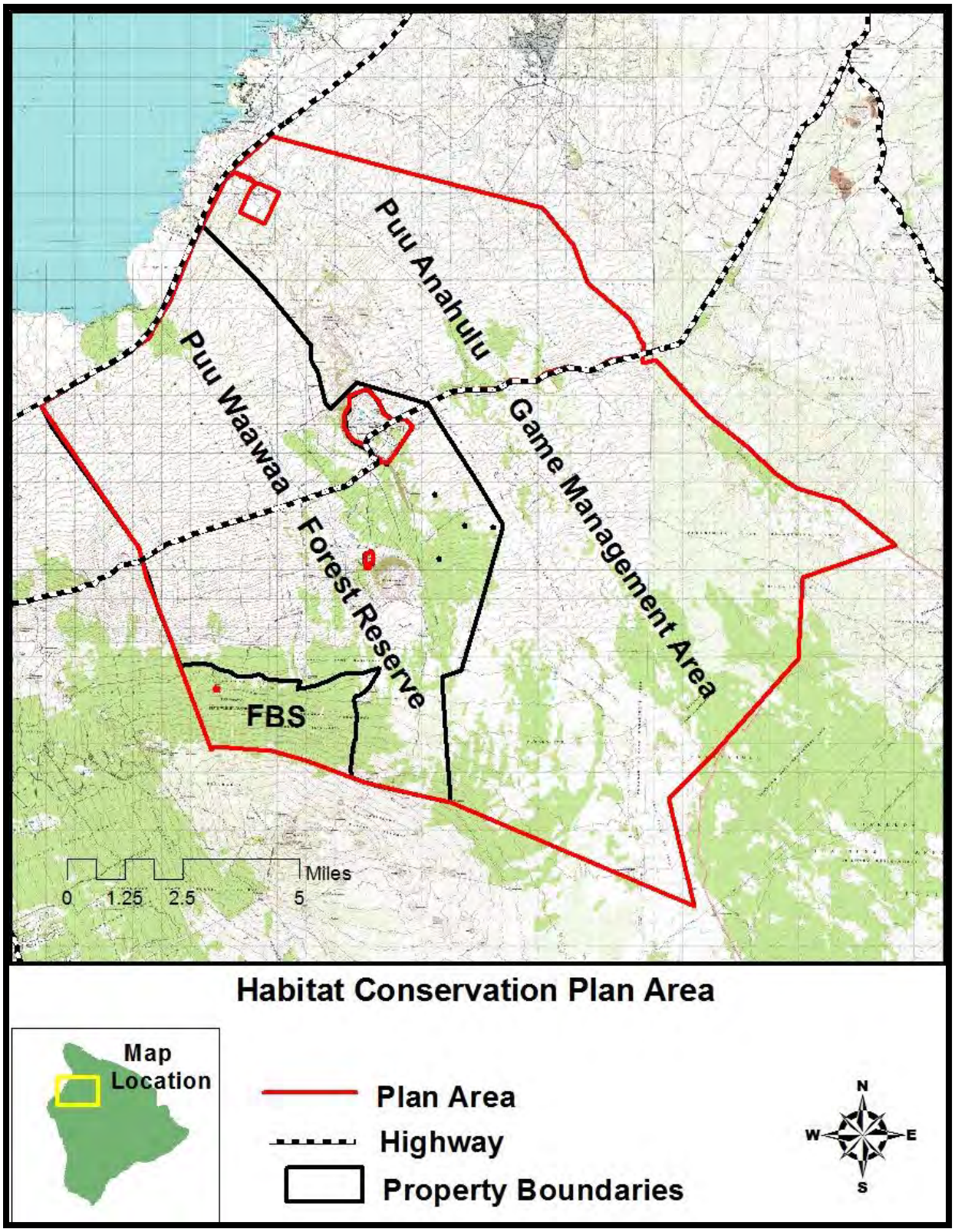

Figure 1.1 Plan Area (103,988 acres), including Pu‘u Wa‘awa‘a Forest Reserve, Pu‘u Anahulu Game Management Area, and the Pu‘u Wa‘awa‘a forest bird sanctuary, North Kona, island of Hawai‘i. Internal red outlines signify private inholdings and are excluded from the Plan Area.

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 Hawai‘i 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, Hawai‘i Revised Statutes

The purpose of Chapter §195D of Hawai‘i 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 Ahupua'a of Pu'u Wa'awa'a and the Makai Lands of Pu'u Anahulu* (PWWMP). Currently, the lands within the Plan Area are being managed for grazing of non-native mammals, fire management, natural resource management, recreation, 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 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. 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 Pu'u 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.

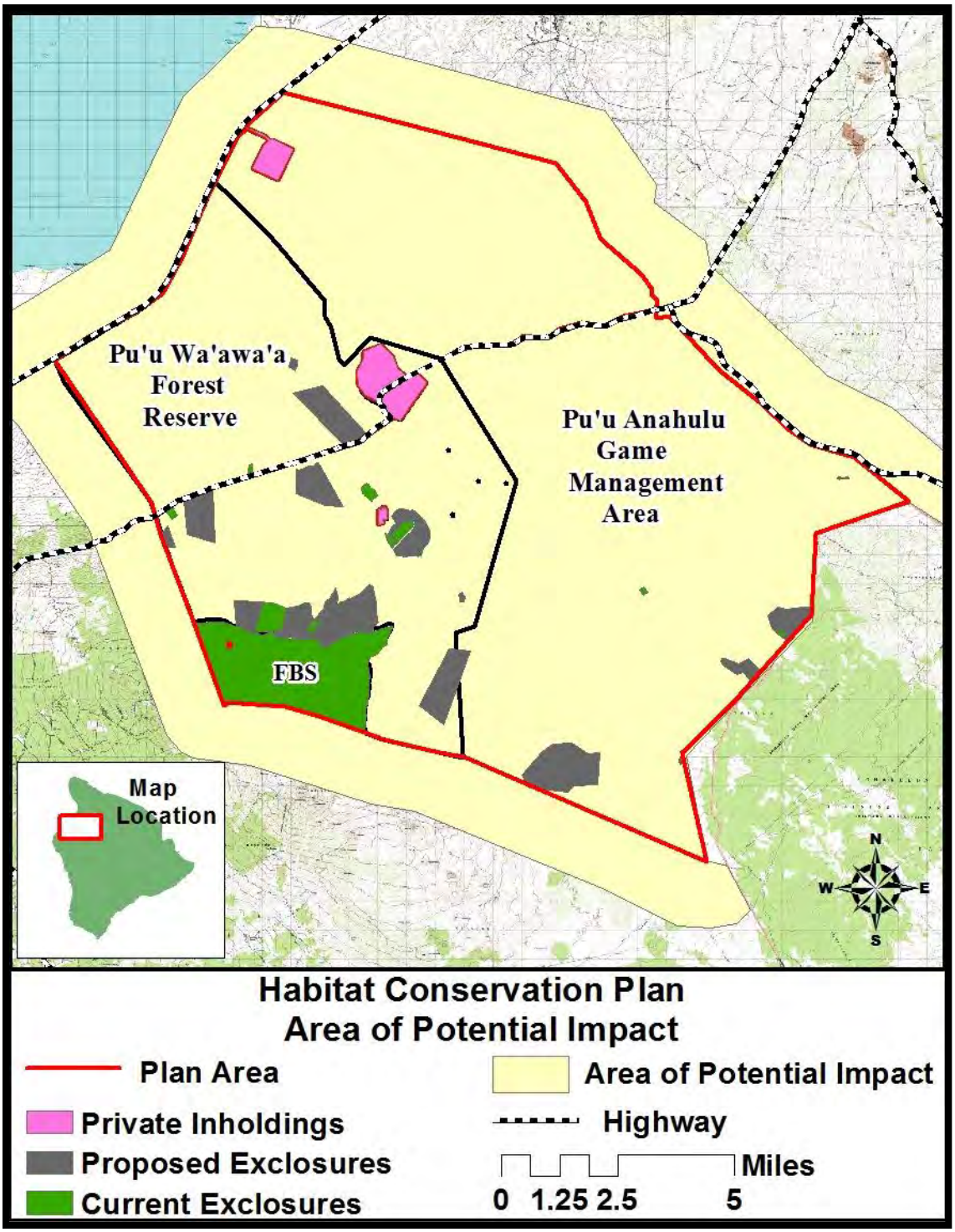

Figure 1.2 Area of Potential Impact (149,228 acres).

1.2.2 Purpose and Need for the Plan

Hawai‘i’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 Pu‘u Wa‘awa‘a and Pu‘u 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.

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: the 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.

1.2.3 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.

1.2.4 List of Preparers

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

1.2.5 Schedule

Implementation of this HCP will be done in three phases. Phase 1: Avoidance and Minimization Phase, years 0-10, Phase 2: Mitigation Phase, years 8-15, 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 Pu‘u Wa‘awa‘a 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.

<u>Phase 1: 0-10 years: Avoidance and Minimization:</u>

- 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.[6]

[6] Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawai‘i Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawai‘i* (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.

- Reduce overall alien plant cover: remove 90% of fountain grass and kikuyu grass[7] 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.
- 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: 8-15 years: Mitigation:

- Install remaining Mitigation fence exclosures.
- Initiate exclosure management:
- Remove ungulates.[8]
- 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.

[7] 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.

[8] Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawai‘i Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawai‘i* (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.

1.3 COVERED ACTIVITES

This HCP, and associated federal and state incidental take authorizations to be issued by the USFWS and DLNR, will cover and provide authorization for incidental take of fifteen covered species that may result from the project actions. These are subject to all requirements or restrictions described in this HCP or the incidental take authorization documents:

- Installation and construction of infrastructure including conservation fences, hunter check stations, and trails
- Construction and maintenance of wildlife guzzlers and troughs
- Game mammal population enhancement activities in the Plan Area resulting in trampling, browsing, and grazing (*see Appendix G for more detailed description on game enhancement activities*)
- Driving, hiking, and biking on the property by employees, contractors, and public on established
  roadways, and paths
- Clearing and maintenance of established roads and fuel breaks
- Clearing and maintenance of newly established fuel breaks around conservation units and in areas of high fire concern
- Implementation of the conservation measures outlined in this HCP

2.0 ENVIRONMENTAL SETTING

2.1 GEOLOGY

The Island of Hawai‘i 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 Pu‘u Wa‘awa‘a, 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 Pu‘u Wa‘awa‘a 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 Pu‘u Wa‘awa‘a. 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 Pu‘u Wa‘awa‘a region. They are the 1859 flow from Mauna Loa and the 1800-1801 Ka‘ūpūlehu 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).

2.1.1 Cinder Cones

An extinct volcanic vent known as Pu‘u Wa‘awa‘a cone and its associated 900-ft-thick lava flow (Pu‘u 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 Hawai‘i. Due to its older age, high degree of soil development, and complex topography, Pu‘u Wa‘awa‘a 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).

2.2 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.

2.3 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 becomes 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.

2.4 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 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 2003, Giambelluca et al. 2013). Differences in precipitation occur with increasing elevation (Figure 2.1). 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 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 (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.

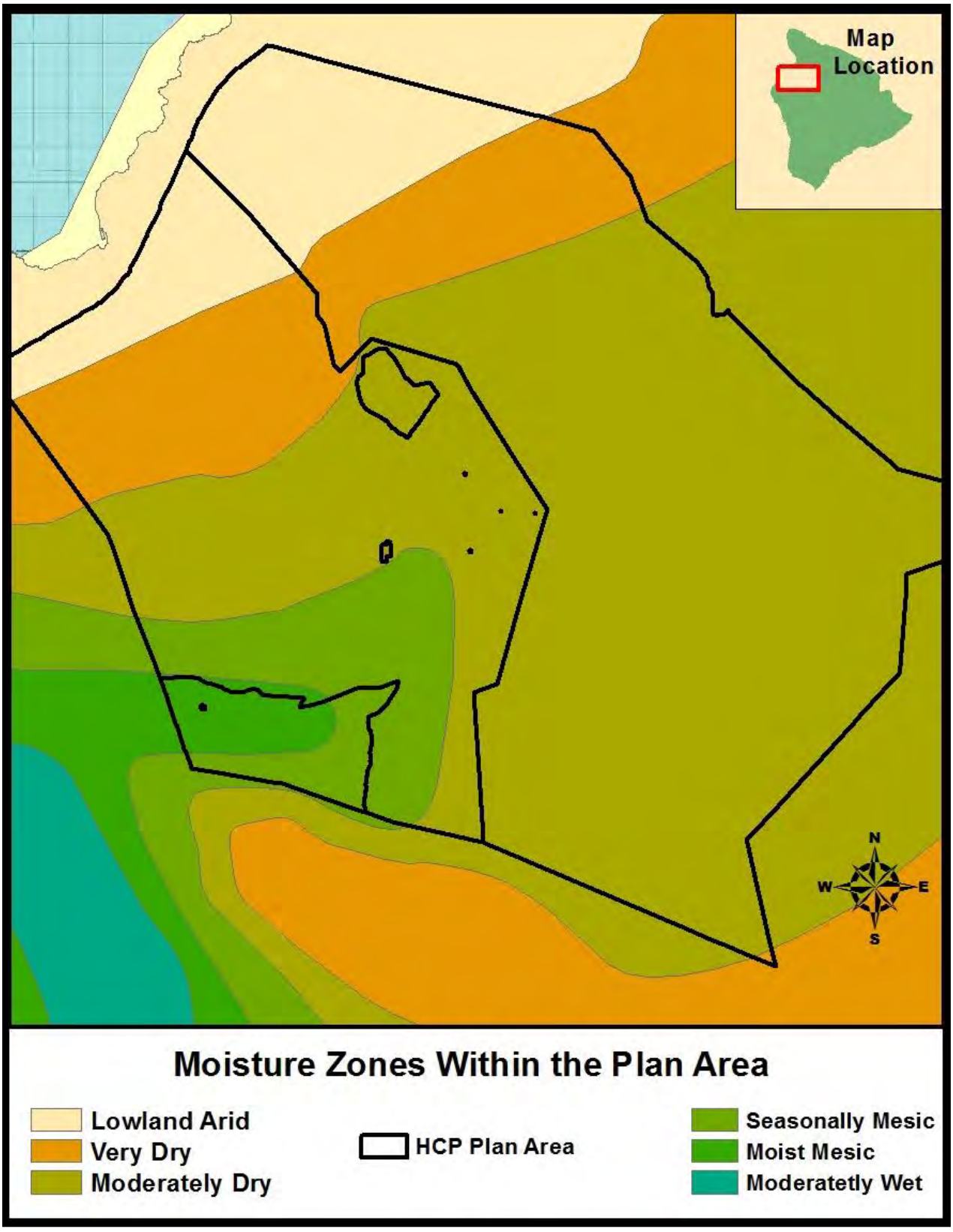

Figure 2.1 Moisture zones within the Plan Area.

2.5 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 Hawai‘i 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 Hawai‘i, 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 Hawai‘i contains some of the largest remaining dry forest remnants in Hawai‘i (Giffin 2003).

2.5.1 Vegetation Zones

Several different ecological regions are present at Pu‘u Wa‘awa‘a and Pu‘u 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 Pu‘u Wa‘awa‘a while moister montane mesic forests lie to the west.

Rare plants are found in all vegetation zones at Pu‘u Wa‘awa‘a and Pu‘u Anahulu. At least 46 rare plant taxa are historically known from the area. 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 Pu‘u Wa‘awa‘a 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 Ka‘ūpūlehu. 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 Hawai‘i. Plants growing here are adapted to relatively dry conditions and dramatic temperature fluctuations.

Days are typically hot and nights cold. These forests at Puʻu Waʻawaʻa are characterized by open, low stature ʻŌhiʻa trees (*Metrosideros polymorpha*) and scattered stands of native shrubs and grasses. Dominant understory species are Pūkiawe (*Leptecophylla tameiameiae*), ʻŌhelo (*Vaccinium spp.*), ʻAʻaliʻi (*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 Puʻu Waʻawaʻa. 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 ʻŌhiʻa, Naio, and ʻAʻaliʻi. Scattered stands of Māmane, ʻIliahi (*Santalum paniculatum*), and ʻAkoko (*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 Aʻe (*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 ʻŌhiʻa 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 Hōʻiʻo (*Athyrium sandwichianum*), ʻAkolea (*Athyrium microphyllum*), and Palapalai (*Microlepia strigosa*) are common in wetter, shaded areas. No tree fern stratum exists although Hāpuʻu (*Cibotium glaucum*) is scattered throughout the forest.

Two species covered under this HCP, ʻAiea (*Nothocestrum breviflorum*) and Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*), occur in the lower mesic zone. ʻAiea is a stout tree in the nightshade family (Solanaceae). The montane mesic forest at Puʻu Waʻawaʻa changes from a Koa/ʻŌhiʻa community to an open-canopied ʻŌhiʻa/ 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 ʻŌhiʻa/ Māmane woodland supports many rare and endemic plants and is still one of the most botanically diverse sections at Puʻu Waʻawaʻa. Trees that characterize this zone include Koa, ʻAkoko, ʻIliahi, Kōpiko (*Psychotria hawaiiensis*), Pāpala (*Charpentiera obovata*), Pāpala kēpau (*Pisonia brunoniana*), Poʻola (*Claoxylon sandwicense*), Aʻiaʻi (*Streblus pendulinus*), Olopua (*Nestegis sandwicensis*), and Hōʻawa (*Pittosporum hosmeri*). The understory is composed primarily of non-native pasture grasses, but scattered stands of Kuluʻi (*Nototrichium sandwicense*), Māʻohiʻohi (*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 kavaiense*), Kokiʻo (*Kokia drynariodes*), Kauila, and Hala pepe (*Chrysodracon hawaiiensis*). Koaiʻa (*Acacia koaia*) is a species of concern.

2.5.2 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 1980's. 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, 12 individuals of *Melicope hawaiiensis* were mapped in 1997 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.

2.5.3 Plan Specific Botanical Surveys

2.5.3.1 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 Hawai‘i DOFAW), Lyman Perry (DOFAW), Mick Castillo (Hawai‘i 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 Pu‘u Anahulu and Pu‘u Wa‘awa‘a (particularly makai of Highway 190) have suffered repeated wildfires in the past two decades and prior (Figure 2.2). 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 Pu‘u Anahulu and Pu‘u Wa‘awa‘a. In most cases, the surveyed areas have been spared from fires because the substrate is rough ‘a‘ā 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 2.3). 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 2.3). 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 2.3). 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 2.3). 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 2.1).

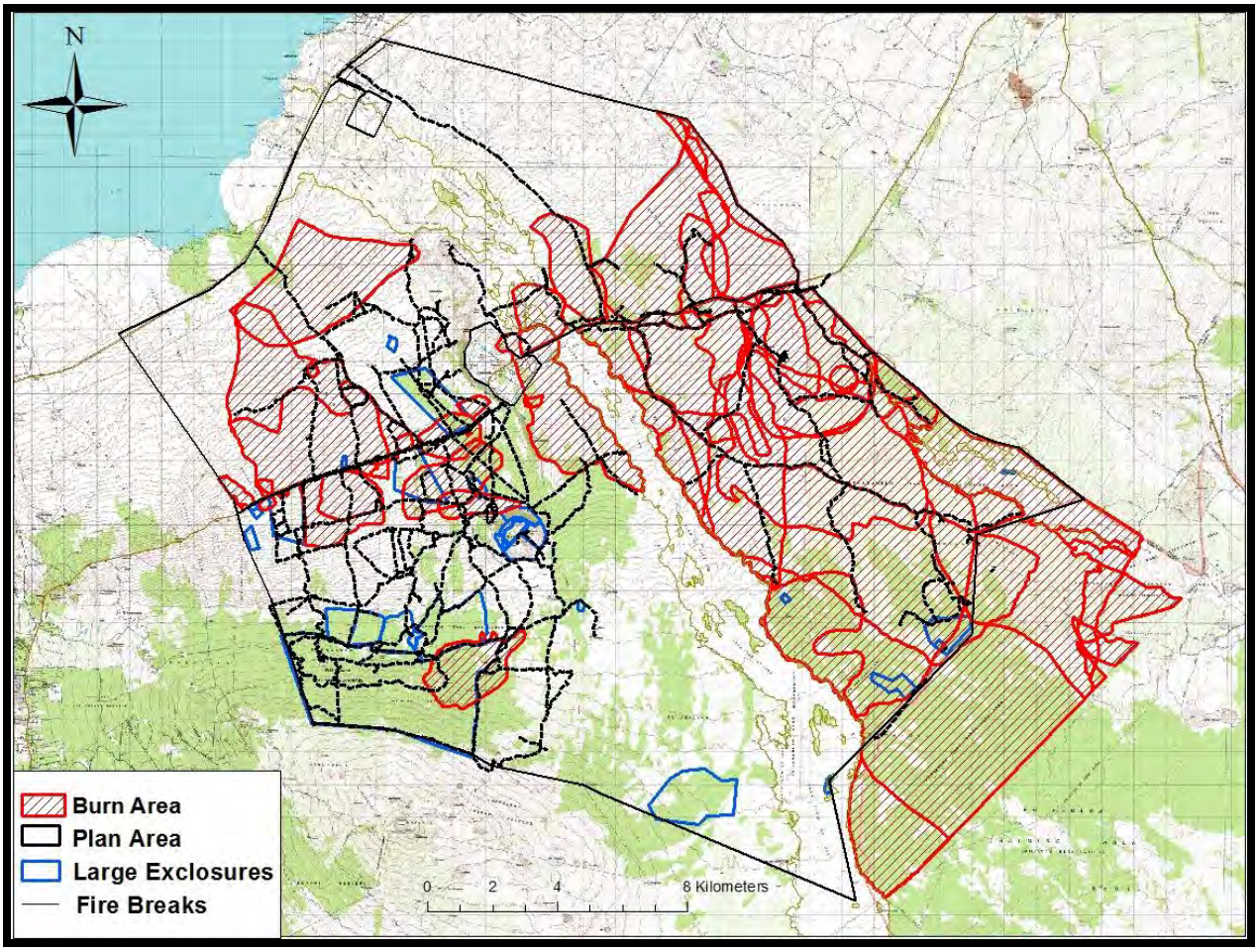

Figure 2.2 Locations of recorded fires that occurred within the Plan Area from 1975 to 2011.

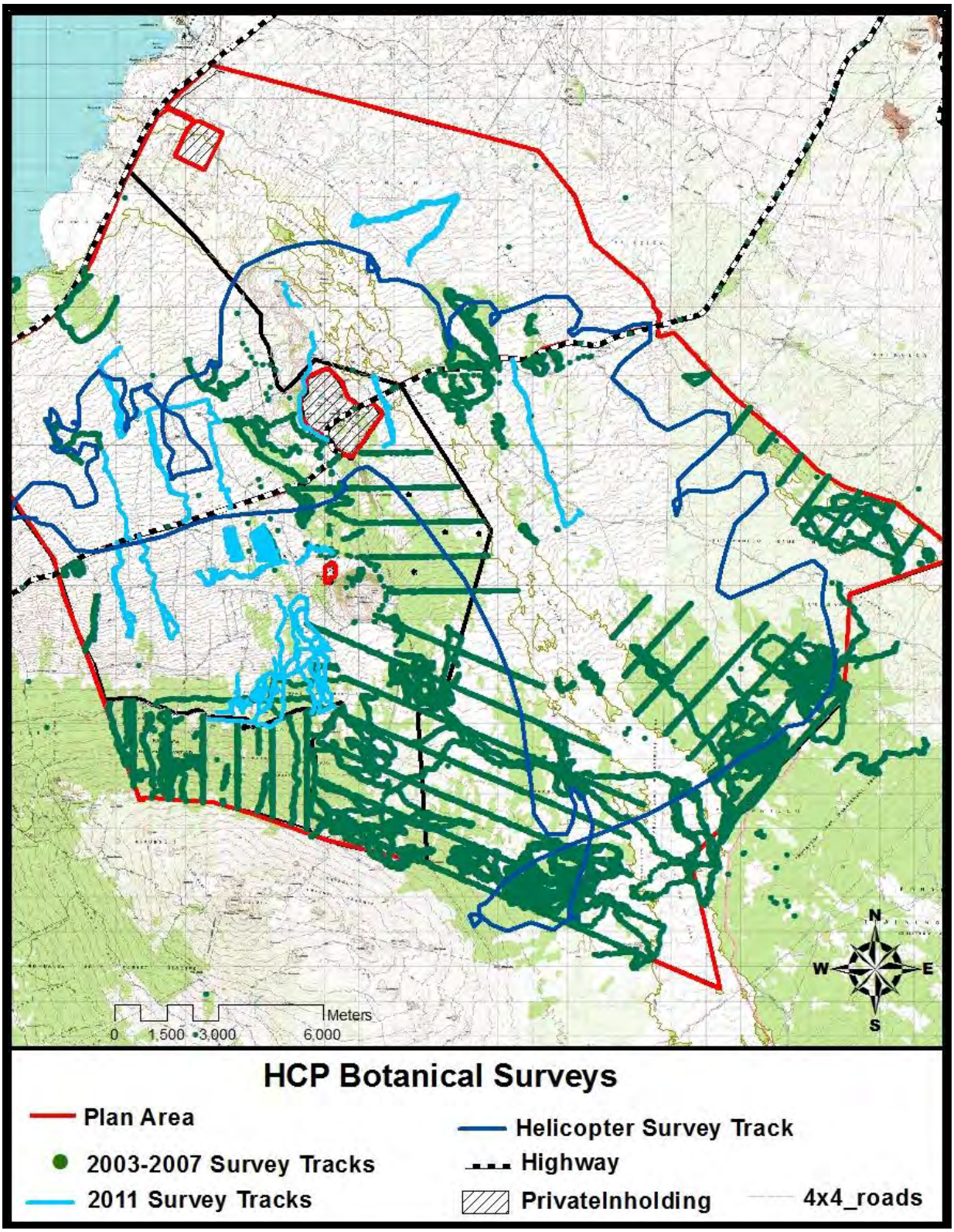

Figure 2.3 Ground (transects and guided searches) and aerial (helicopter) botanical survey tracks completed during the 2003-2007 and 2011 survey periods totaling 144 km of transects surveyed.

Table 2.1 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[9]
Nothocestrum breviflorum	ʻAiea	151
Phyllostegia velutina[10]		35
Silene lanceolata	Hawaiian Catchfly	333[11]
Solanum incompletum	Pōpolo kū mai	14
Stenogyne angustifolia		98
Vicia menziesii		4
Zanthoxylum dipetalum var. *tomentosum*	Aʻe	13
Zanthoxylum hawaiiense	Aʻe	239[12]
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

[9] Three of these individuals occur on PTA lands.
[10] *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.
[11] 98 of these individuals occur on PTA lands.
[12] 18 of these individuals occur on PTA lands and are not included in take estimates.

2.5.3.2 2011 Surveys

The data collected during the 2003-2007 botanical surveys (Table 2.1) 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 2.3). In addition, the proposed Kauila conservation unit was completely censused during these surveys (Table 2.3). 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 2.2 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	ʻAiea	118

Table 2.3 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	ʻAiea	5

2.5.4 Covered Species in the HCP

Plant Extinction Prevention Program

The Plant Extinction Prevention Program's mission is to protect Hawai'i's rarest native plants from extinction focusing on those species with fewer than 50 individuals remaining. Currently on Hawai'i 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 2.4).

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 Hawai'i. 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.

2.5.4.1 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 2.5 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 Hawai‘i in ‘Ōhi‘a dry montane forest, ‘A‘ali‘i dry montane shrubland, Naio/ Māmane dry montane forest, ‘Ōhi‘a /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 ‘Ōhi‘a 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).

2.5.4.2 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 2.5 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 2.4)(USFWS 2003c).

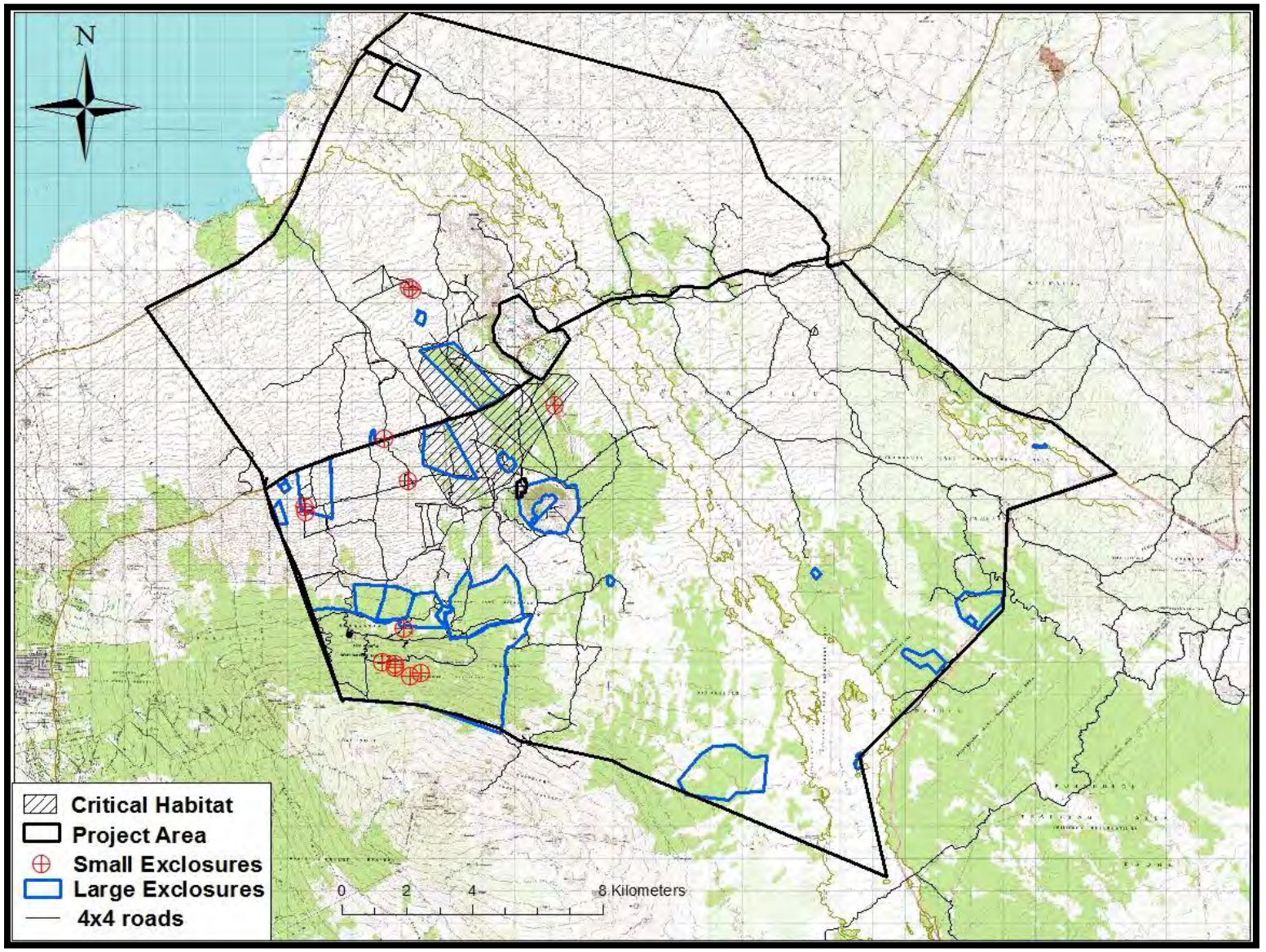

Figure 2.4 Critical habitat for Hala pepe within the Plan Area.

2.5.4.3 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 Hawai‘i 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 O‘ahu, Maui and Hawai‘i Island. Historic populations are known from the central and southern Waianae Mountains on O‘ahu, and from the Kohala mountains; western, southwestern, and southern slopes of Mauna Loa; and northern slopes of Hualālai on the island of Hawai‘i 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 O‘ahu. There are approximately two to five populations containing 1,190 to 1,209 wild individuals on the island of Hawai‘i (USFWS 2015f). See Table 2.5 for a summary table of species distribution state-wide.

This species was found primarily at 488-853 m elevation in Pu‘u Wa‘awa‘a, with some individuals at higher elevation on the Pu‘u Wa‘awa‘a cinder cone, and three individuals found in Pu‘u Anahulu at 732 m. Previously there were thought to be 200-300 individuals at Pu‘u Wa‘awa‘a, however, recent HCP surveys indicate the population at Pu‘u Wa‘awa‘a 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 ‘a‘ā lava flows and

associated with Alahe‘e and ‘Ohe makai. Critical habitat was designated for this species in 2003 (Figure 2.5)(USFWS 2003c).

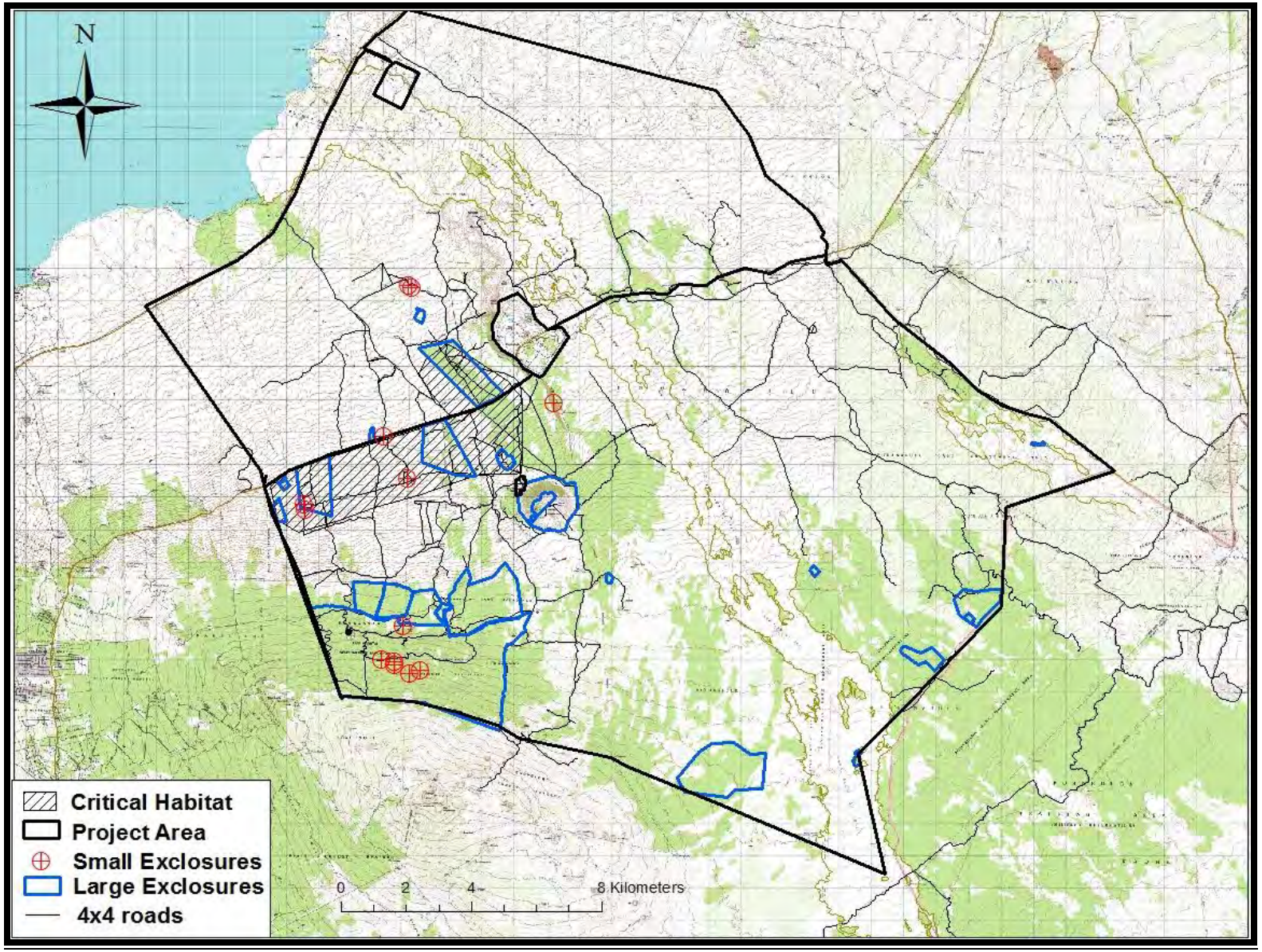

Figure 2.5 Critical habitat for Kauila within the Plan Area.

2.5.4.4 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 Kauaʻi, 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 2.5 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 a 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.

2.5.4.5 Ma‘o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*)


Description: Ma‘o 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: Ma‘o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*) is the subspecies on the islands of Lāna‘i, Maui, and Hawai‘i. On Lāna‘i 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 Hawai‘i has two wild populations of Ma‘o 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 Pu‘u Anahulu bluff across from the hunter check station at Pu‘u Wa‘awa‘a at 731 m elevation. During HCP surveys 65 Ma‘o hau hele individuals were found within the Plan Area. See Table 2.5 for a summary table of species distribution state-wide.

Habitat: Ma‘o hau hele occurs in lowland dry to mesic forest and shrubland from 130-800 m in elevation. Associated plant species include ‘A‘ali‘i, Alahe‘e, Wiliwili, ‘Ohe makai, and ‘Ilima. Critical habitat was designated for this species in 2003 (Figure 2.6) (USFWS 2003c).

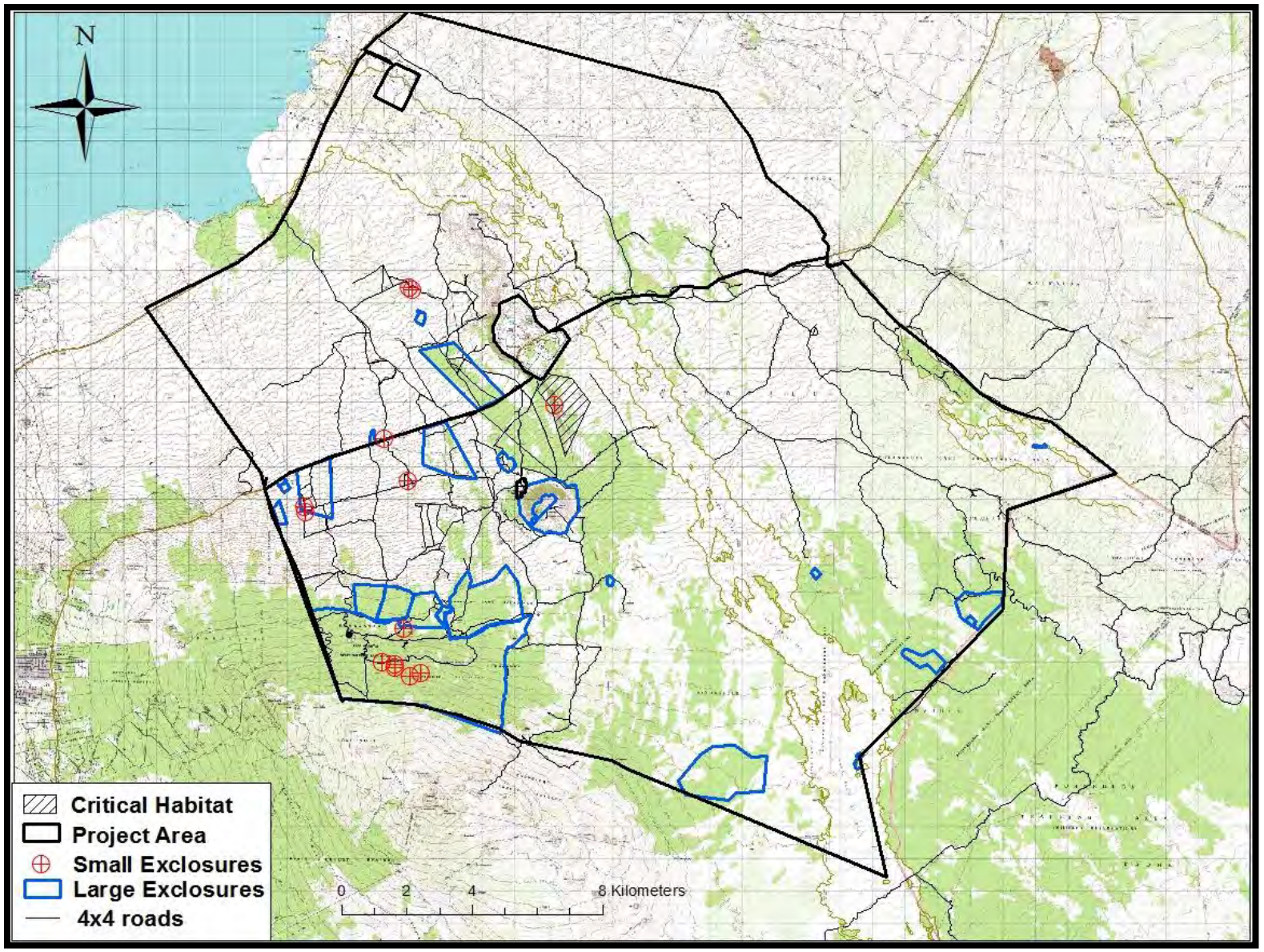

Figure 2.6 Critical habitat for Ma‘o hau hele within the Plan Area.

2.5.4.6 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 2.4). See Table 2.5 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 2.7) (USFWS 1984).

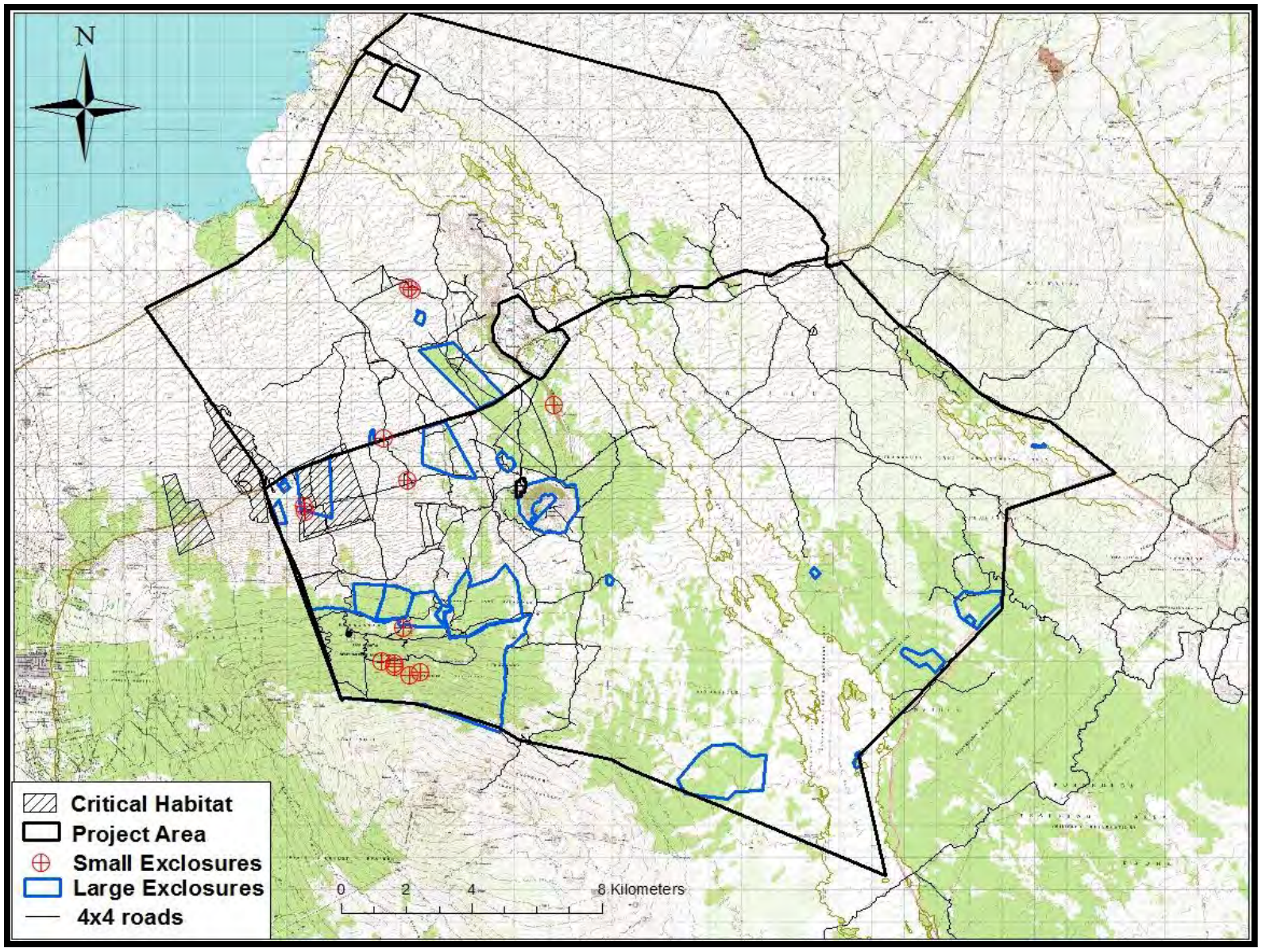

Figure 2.7 Critical habitat for Koki‘o within the Plan Area.

2.5.4.7 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 Kauaʻi (Waimea Canyon), Oʻahu (Waiʻanae Mountains), west Maui, North Kona District, Hawaiʻi, and Lānaʻi. Today, Uhiuhi is extinct on Lānaʻi and is now found only on Oʻahu (Central Waiʻanae Mountains), and Hawaiʻi island (Hualālai). On Kauaʻi, the species was rediscovered as one wild plant was recently found in Waimea Canyon (Letman 2012). On Oʻahu, there are two populations containing five wild mature individuals and two seedlings. On Hawaiʻi Island, Uhiuhi is found on state lands at Puʻu Waʻawaʻa, 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 Kauaʻi, Oʻahu, and Hawaiʻi Island (USFWS 2015a). During HCP surveys, 48 Uhiuhi were within the Plan Area. See Table 2.5 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 ʻAʻaliʻi, Lama, ʻŌhiʻa, Alaheʻe, Wiliwili, ʻĀweoweo, and Kauila. Critical habitat has been proposed but not yet designated for this species (Figure 2.8).

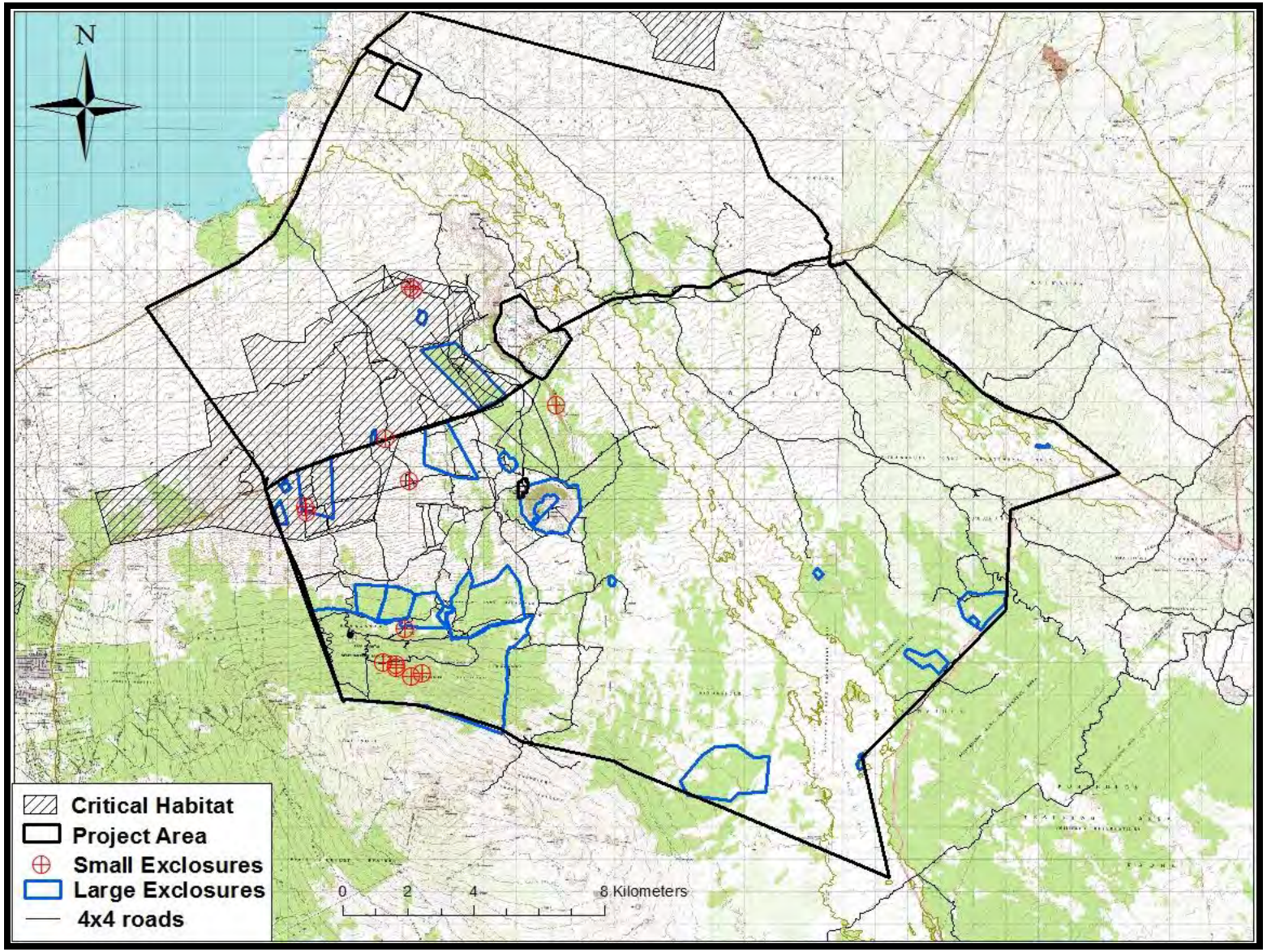

Figure 2.8 Proposed critical habitat for Uhiuhi within the Plan Area.

2.5.4.8 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 Kaʻū. 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 Puʻu 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 Manukā Natural Area Reserve (DOFAW Staff), and a final population has been located in windward Kohala. This species is considered a PEP species (Table 2.4). The number of wild individuals has decreased from 150 individuals reported in 2008 to 90 individuals in 2015 (USFWS 2015b). See Table 2.5 for a summary table of species distribution state-wide.

Habitat: *Neraudia ovata* grows in open ʻŌhiʻa 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 ʻOhe makai, Naio, Huehue, Kōlea species, and christmas berry (*Shinus terebinthefolius*), as well as the federally endangered ʻAiea and Hala pepe, and other species of concern, including Pua pilo, *Fimbristylis hawaiiensis*, and Koʻokoʻolau (*Bidens micrantha* ssp. *Ctenophylla*). Critical habitat was designated for this species in 2003 (Figure 2.9) (USFWS 2003c).

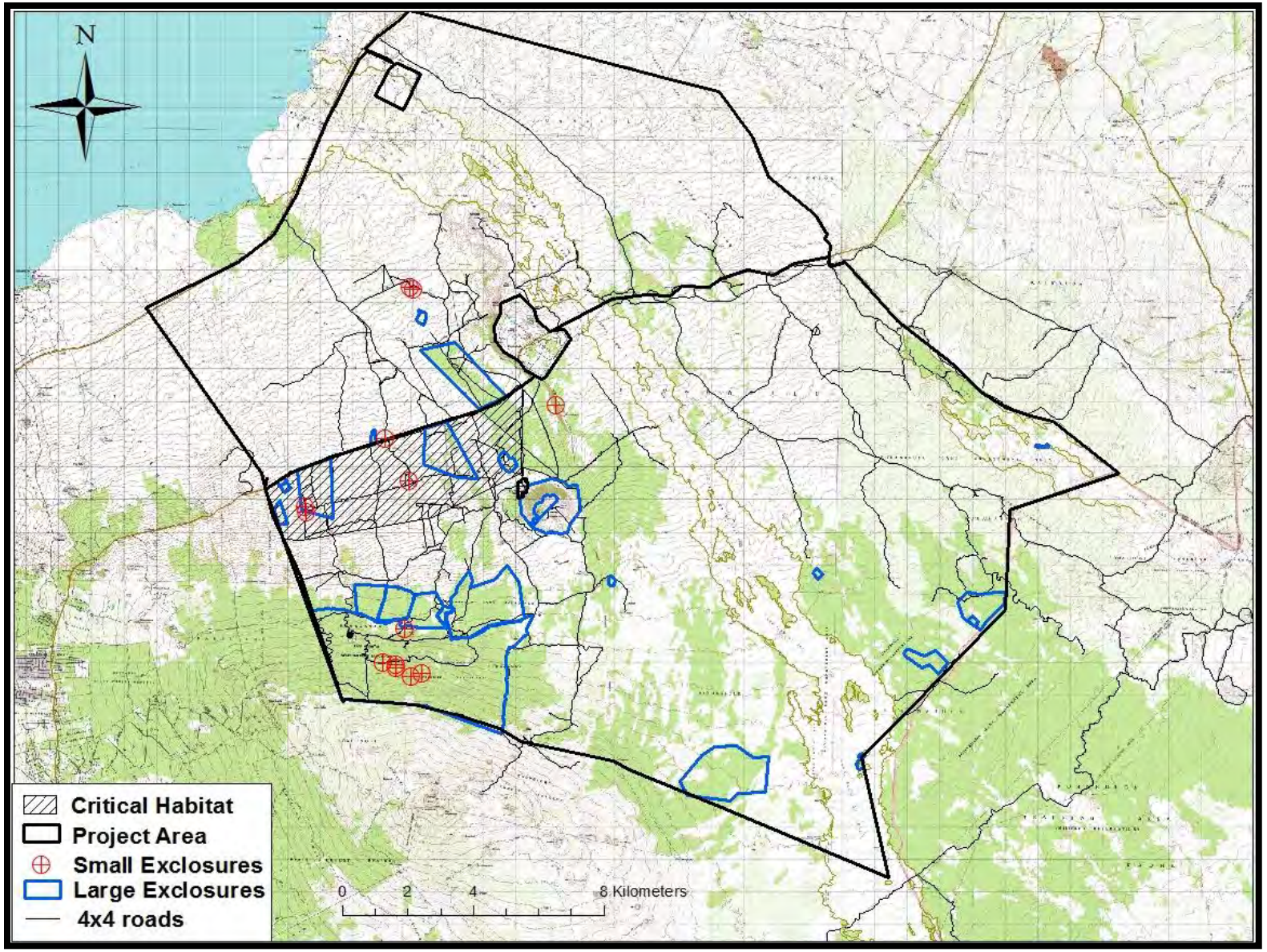

Figure 2.9 Critical habitat for *Neraudia ovata* within the Plan Area**.**

2.5.4.9 ‘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 2.5 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 2.10) (USFWS 2003c).

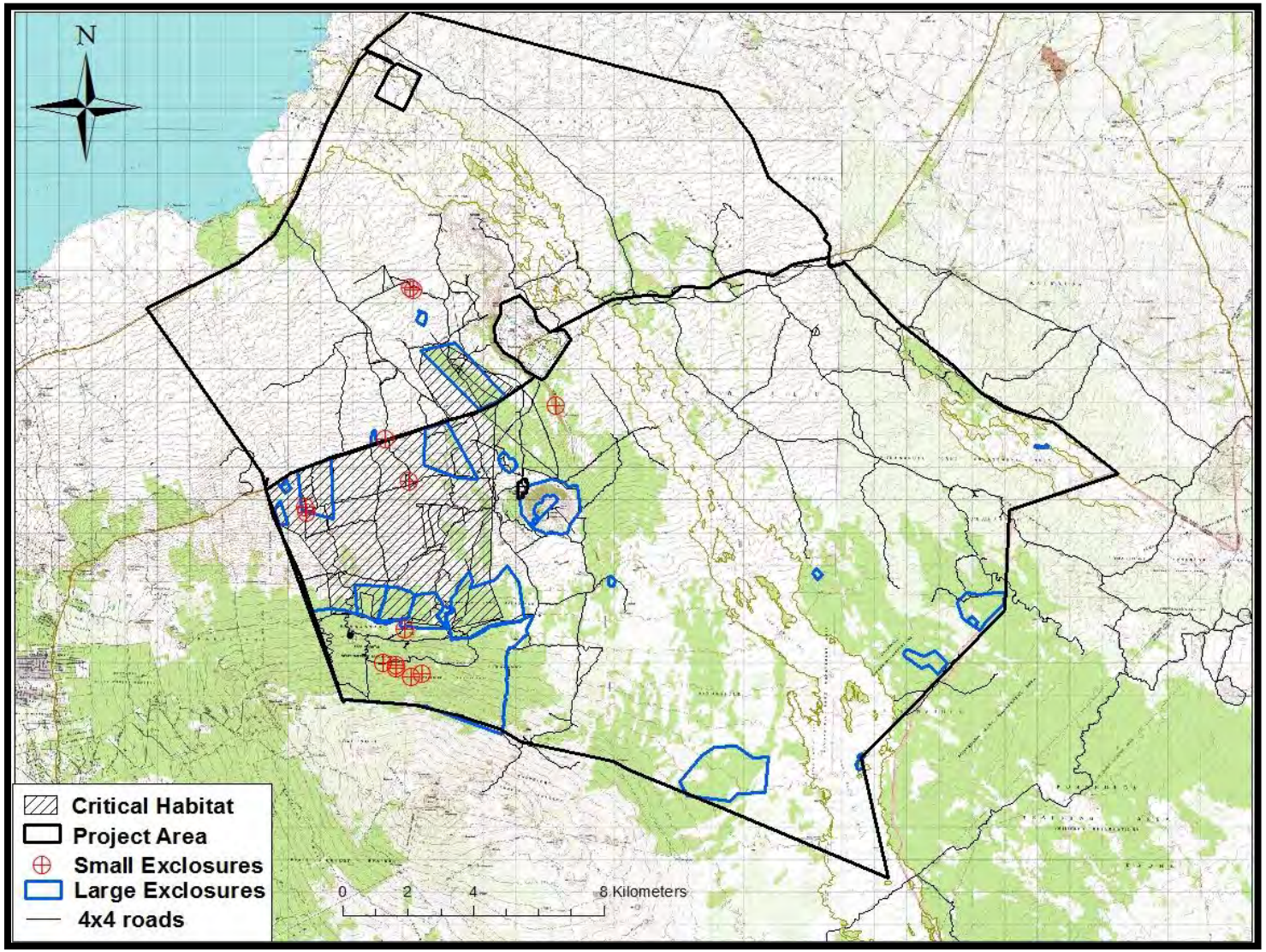

Figure 2.10 Critical habitat for ʻAiea within the Plan Area.

2.5.4.10 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 2.5 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.

2.5.4.11 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 Molokaʻi, Oʻahu, and Hawaiʻi; historically also known from Kauaʻi and Lānaʻi. On island Hawaiʻi, 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 Oʻahu, there were four known populations in 2003, with 62 individuals in Koiʻahi Gulch and Waianae Kai on Federal and State lands. On Molokaʻi, 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 2.5 for a summary table of species distribution state-wide.

Habitat: Occurs from 330-1,900 m in dry to mesic shrubland on Molokaʻi, Kauaʻi, Lānaʻi, and Hawaiʻi (Wagner et al. 1999). The populations on the island of Hawaiʻi grow in two dry habitat types: shrubland dominated by dense Naio, Māmane, Pūkiawe with ʻAʻaliʻi, Pilo, and fountain grass; and on ʻaʻā lava in a former ʻAkoko forest now converted to fountain grass grassland with ʻAʻaliʻi, Māmane, Naio, and ʻĀweoweo. Critical habitat was designated for this species in 2012; however CH does not occur within the Plan Area.

2.5.4.12 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 2.4). See Table 2.5 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 2.11)(USFWS 2003c).

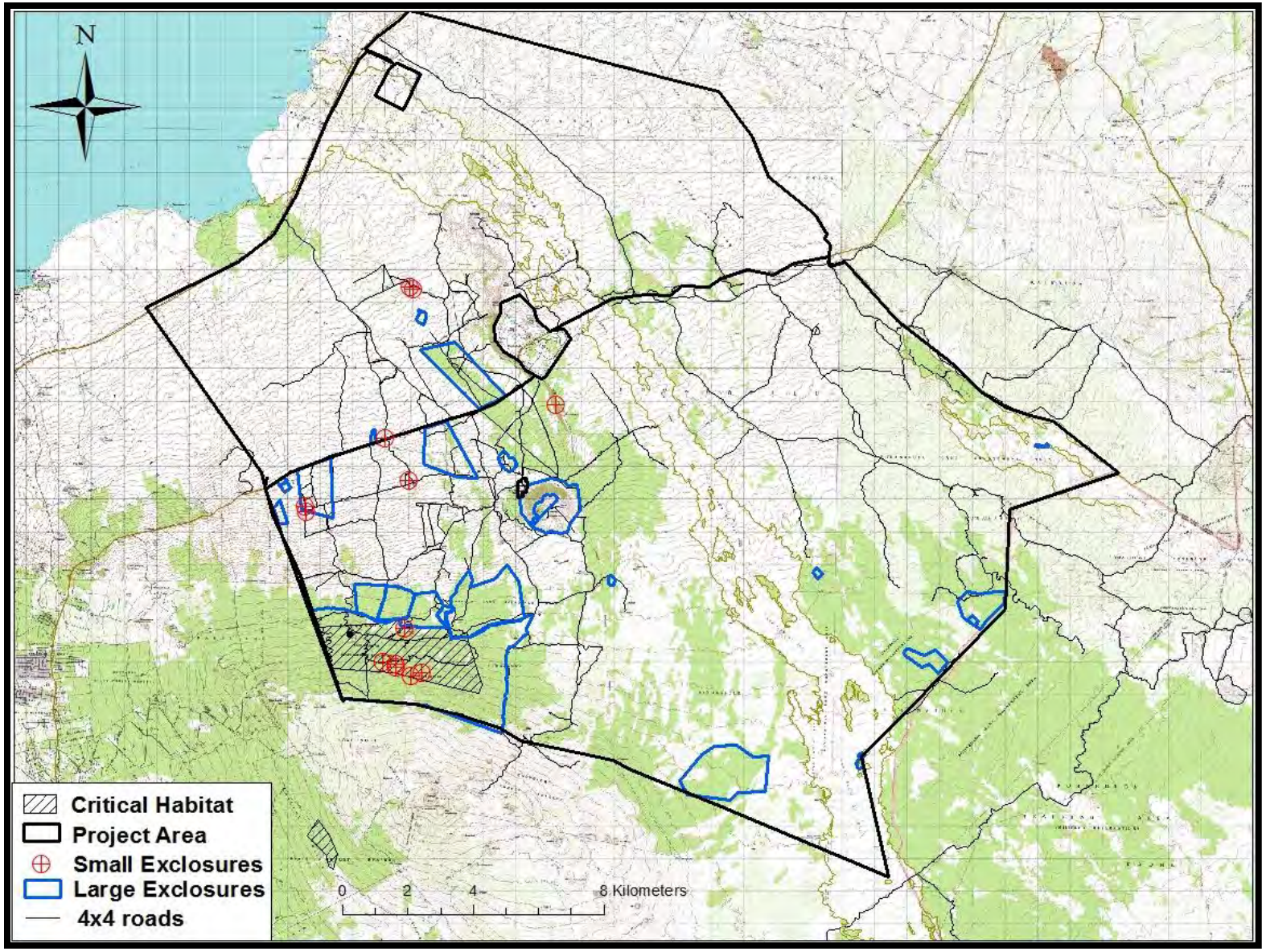

Figure 2.11 Critical habitat for Pōpolo kū mai within the Plan Area.

2.5.4.13 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 2.5 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.

2.5.4.14 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 2.5 for a summary table of species distribution state-wide. This species is considered a PEPP species (Table 2.4).

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 2.12) (USFWS 2003c).

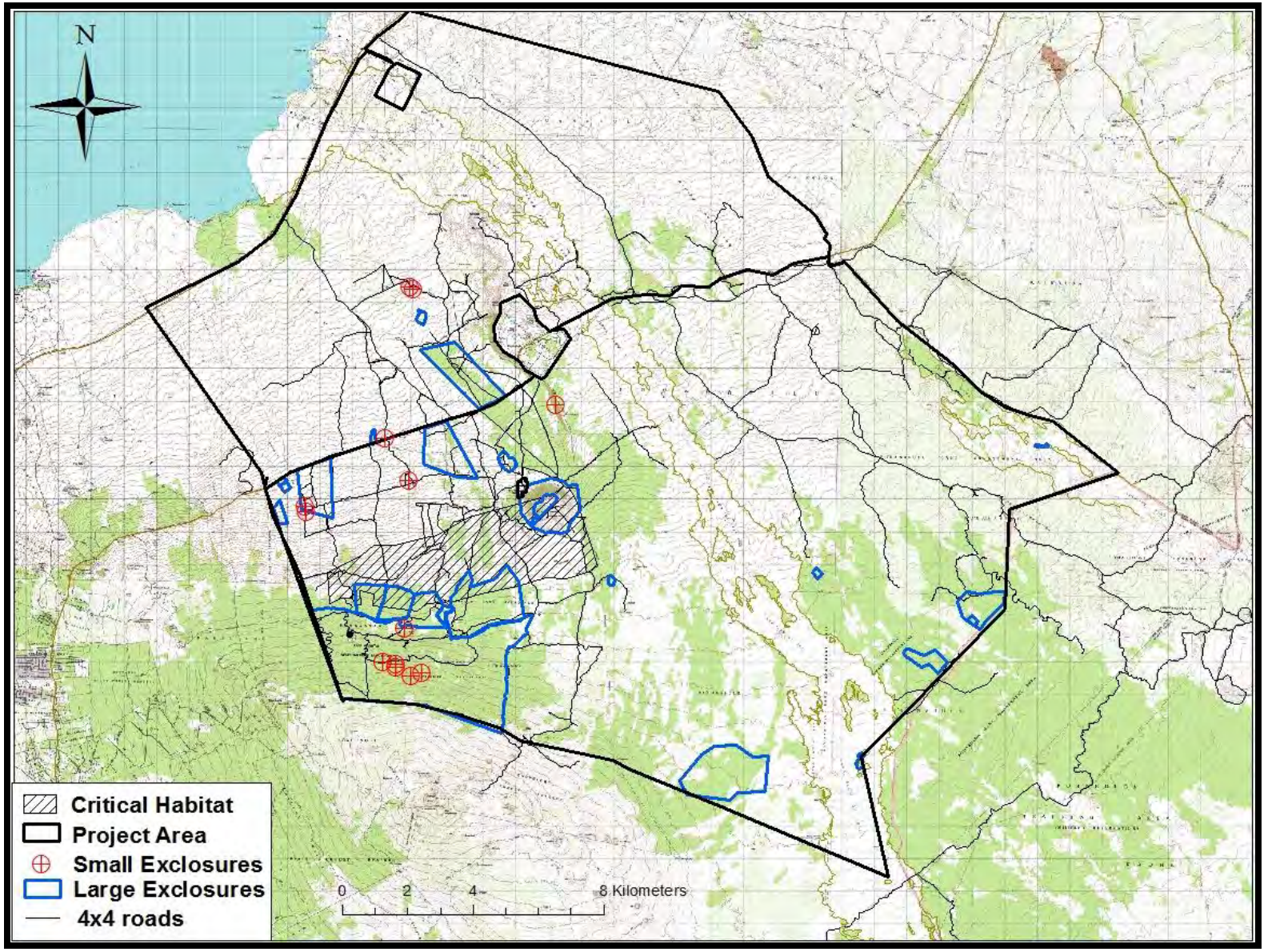

Figure 2.12 Critical habitat for A‘e (Zanthoxylum dipetalum var. tomentosum) within the Plan Area.

2.5.4.15 A‘e (*Zanthoxylum hawaiiense*)


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 2.5 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 ʻŌhiʻa, Lama, and Hala pepe. Other associated species include Hame (Kauaʻi), Aʻiaʻi, 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 2.4 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	ʻAkoko	Euphorbiaceae	Hawaiʻi and Maui	None	SOC
Exocarpus gaudichaudii	Hulumoa	Santalaceae	All the main Hawaiian islands except Kauaʻi	None	SOC
Fragaria chiloensis	ʻŌhelo papa	Rosaceae	Hawaiʻi and Maui	None	SOC
Melicope hawaiensis	Manena	Rutaceae	Hawaiʻi, Maui, Lānaʻi, and Molokaʻi,	None	SOC
Polyscias sandwicensis	ʻOhe makai	Araliaceae	Niʻihau, Hawaiʻi, Lānaʻi, Molokaʻi, Oʻahu, Kauaʻi	None	SOC
Sisyrinchium acre	Mauʻu lāʻili	Iradaceae	Hawaiʻi and Maui	None	SOC
Stenogyne macrantha		Lamiaceae	Hawaiʻi	None	SOC
Tetramolopium consanguineum		Asteraceae	Hawaiʻi and Kauaʻi	None	SOC
Tetramolopium humile		Asteraceae	Hawaiʻi and Maui	None	SOC

Table 2.5 Number of individuals of Covered Species in the Plan Area and across the state. A population is defined as a group of individuals within 1,000m 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	1,265	54	1,209	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	5,000		5,000	X			X
Zanthoxylum dipetalum var. *tomentosum*	13	2	13		13				
Zanthoxylum hawaiiense	219	2	916		860	51	2	X	3

2.5.5 Plant Species of Concern

Plant SOC were also documented during HCP surveys (Table 2.6). 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 2.6 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	ʻAkoko
Eragrostis deflexa	Love Grass
Erythrina sandwicensis	Wiliwili
Exocarpus gaudichaudii	Hulumoa
Fragaria chiloensis	ʻŌhelo papa
Melicope hawaiensis	Manena
Polyscias sandwicensis	ʻOhe Makai
Sisyrinchium acre	Mauʻu lāʻili
Stenogyne macrantha	
Tetramolopium consanguineum	
Tetramolopium humile	

2.6 WILDLIFE

2.6.1 Covered Species

2.6.1.1 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 Hawai'i's largest native insects, with a wingspan of up to 12 centimeters and is one of four federally listed insects in the State of Hawai'i (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 Kaua'i, Kaho'olawe, O'ahu, Moloka'i, Maui, and Hawai'i, extant populations are now limited to Maui, Kaho'olawe, and Hawai'i. On Hawai'i, 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* ('Aiea), 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 2.13). 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).

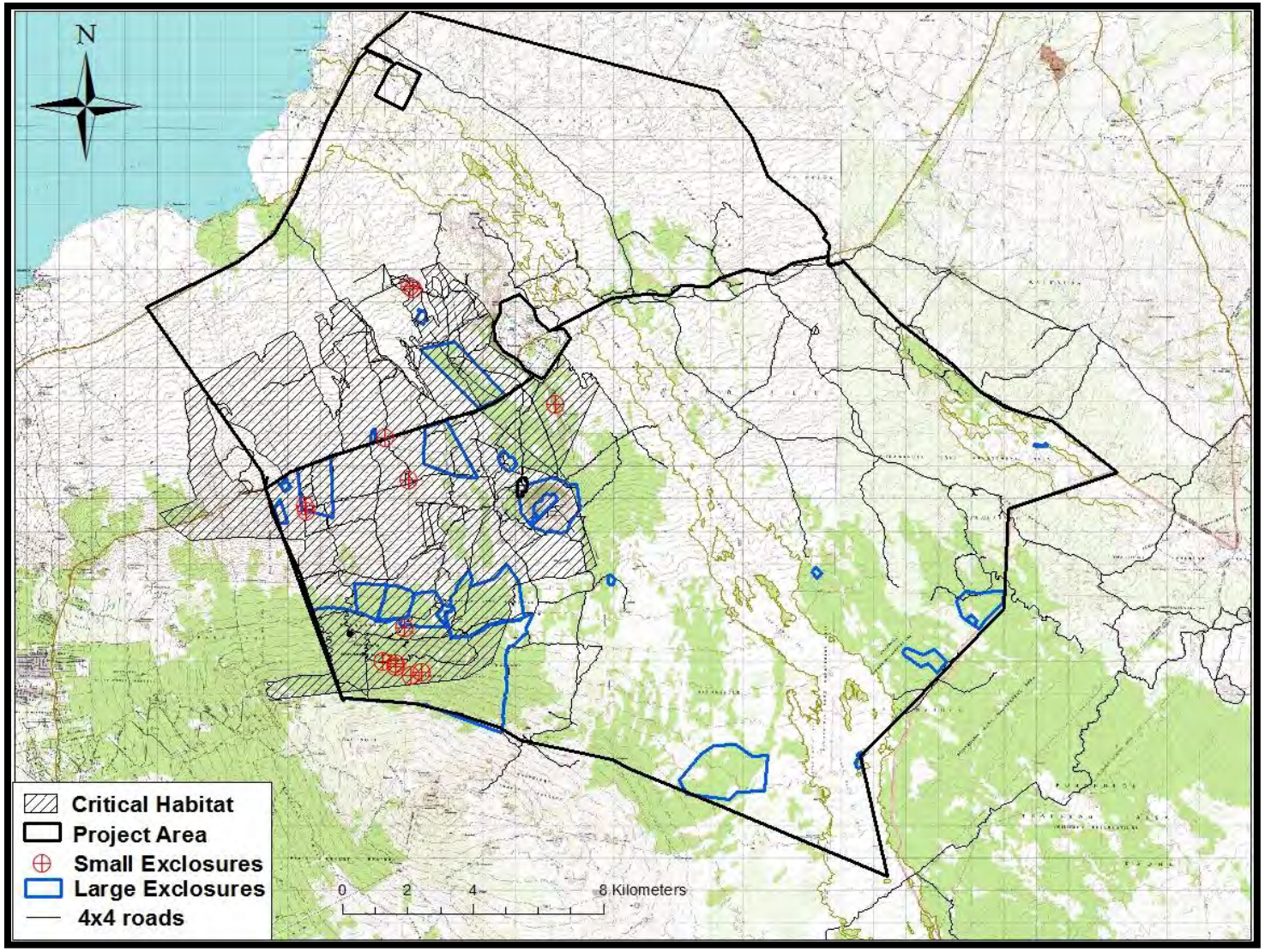

Figure 2.13 Blackburn's sphinx moth critical habitat within the Plan Area.

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 ('Aiea), and non-native plants (tree tobacco). The HCP botanical surveys documented the location and distribution of 'Aiea 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 'Aiea 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*).

2.6.2 Non-Covered Species

2.6.2.1 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.

3.0 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 5.0 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 further in this chapter. 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.

3.1 IMPACTS TO PLANTS

3.1.1 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. As a part of the initial planning for this HCP, study sites were established within the Plan Area to monitor the impacts of ungulates on four endangered plant species (Honohono, Hawaian catchfly, *Stenogyne angustifolia,* and *Phyllostegia velutina*). This study provides evidence that exclosures effectively minimize browsing, resulting in increased plant growth and reproduction inside the fences compared with outside. Exclosure plants exhibited positive growth while the unfenced individuals showed no growth over the same time period. Exclosure plants also exhibited significantly greater reproductive rates compared to their non-protected counterparts. Results of this study suggest that exclosures are highly effective means of minimizing negative impacts from ungulates on native plants at Pu‘u Wa‘awa‘a and Pu‘u Anahulu. Appendix C discusses in detail the methods and results for one of the four species from this study (*S. angustifolia*).

In addition, as a part of the HCP botanical surveys (conducted from 2003 to 2011) incidences of ungulate impacts to individual HCP plants were recorded when encountered. Trained field biologists noted signs of ungulate browsing (including topping where the entire top of the plant is consumed), bark stripping and girdling, and damage to leaves. The surveys showed extensive damage by ungulates to HCP plants with over 120 individuals across 9 Covered Species affected. Bark stripping was the most common

ungulate sign (87% of the plants), followed by browsing (40%). The six Covered Species for which no ungulate impacts were noted exist in either fenced exclosures or lava tubes which provide protection from ungulates. However, biologists have observed feral sheep browsing on two of those species (Koki‘o & Ma‘o hau hele) when fenced units were breached due to tree falls. The Division is continuing to document incidents of ungulate damage, and therefore take, by feral ungulates on the Covered Species in the Plan Area and maintains a photo-library of these and other ungulate impacts on native plants in the Plan Area. Copies of the photo library are available upon request.

Impacts of feral ungulates on Hawaiian native plants and ecosystems are well documented in the scientific literature. To date, there are a minimum of 58 research studies demonstrating the negative impacts of non-native ungulates on native ecosystems, plants, and ecosystem properties in Hawai‘i (Leopold and Hess 2016). Moreover, extensive research conducted in neighboring Ka‘ūpūlehu further validates the negative impacts of ungulates on native dry forest systems in N. Kona (Cabin *et al* 2000, Thaxton *et al* 2010)).

3.2 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.

3.2.1 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.

3.2.2 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 5.2*) 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.

3.2.3 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.

3.3 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.

3.3.1 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 Pu‘u Wa‘awa‘a and Pu‘u Anahulu, we generated a 2.25 km buffer to reflect the entire action area. 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*) (Figure 3.1). 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 Pu‘u Wa‘awa‘a and Pu‘u 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 2.3). 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 (See Figure 3.2 and 3.3).

The Plan Area is characterized by a large elevational gradient, a moderate range of moisture (relative to other areas in Hawai‘i - see Figure 3.4), 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 3.5).

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.

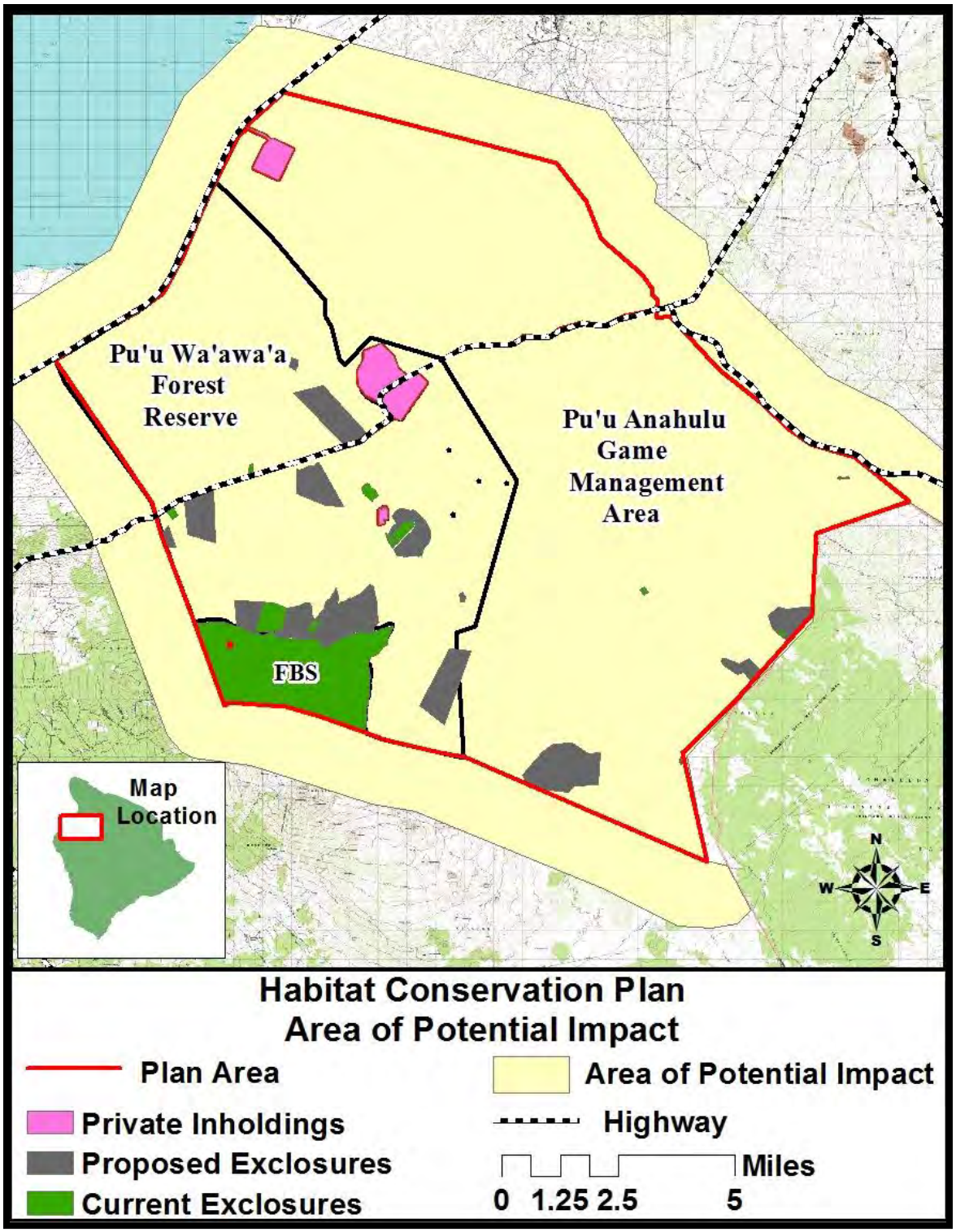

Figure 3.1 The HCP Area of Potential Impact including the 2.25 km buffer around all boundaries with the exception of PTA where a boundary fence prohibits the movement of ungulates.

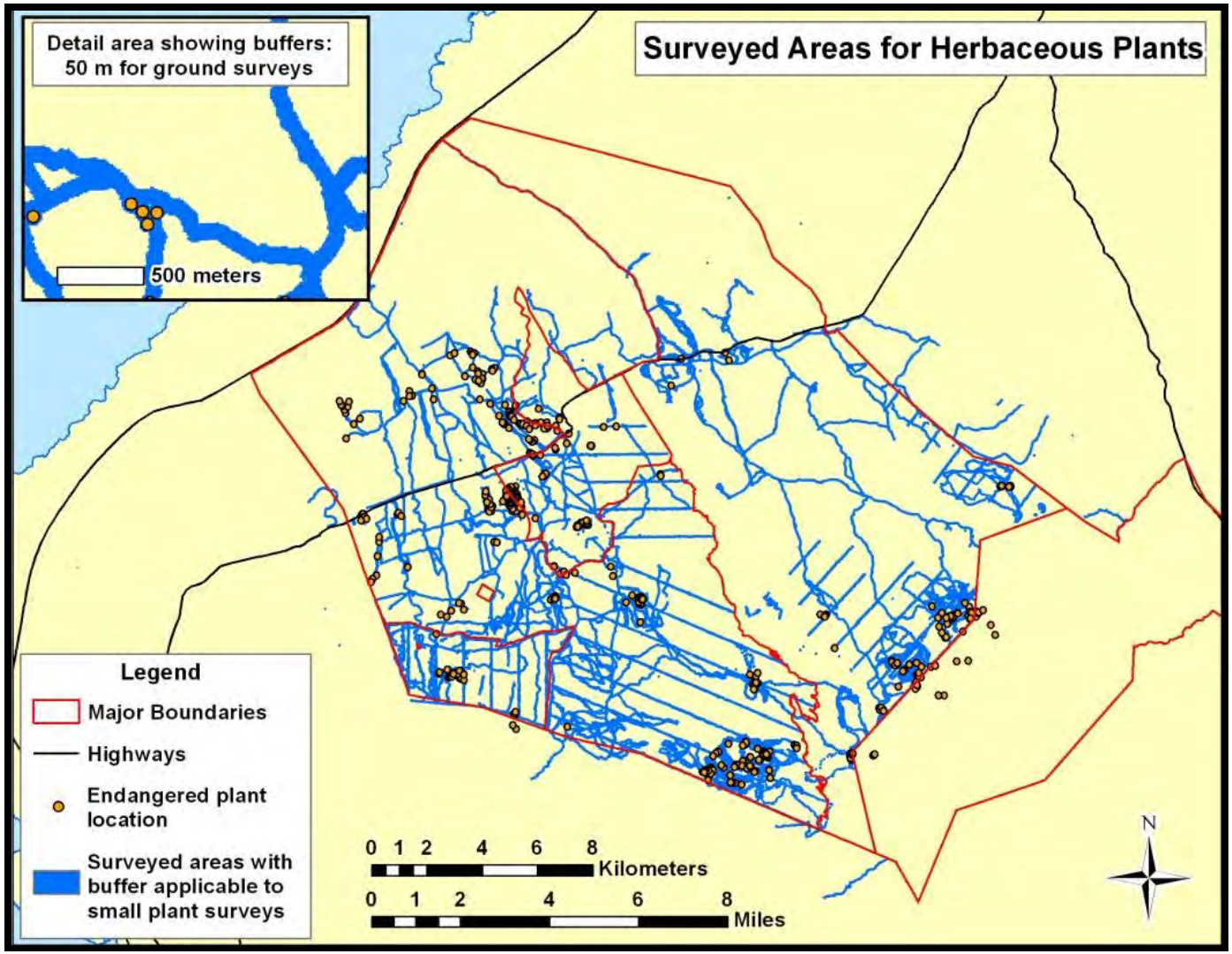

Figure 3.3.2 Surveyed areas within the Action Area including all 4x4 roads and a 50 m buffer around all tracks and guided searches for herbaceous species.

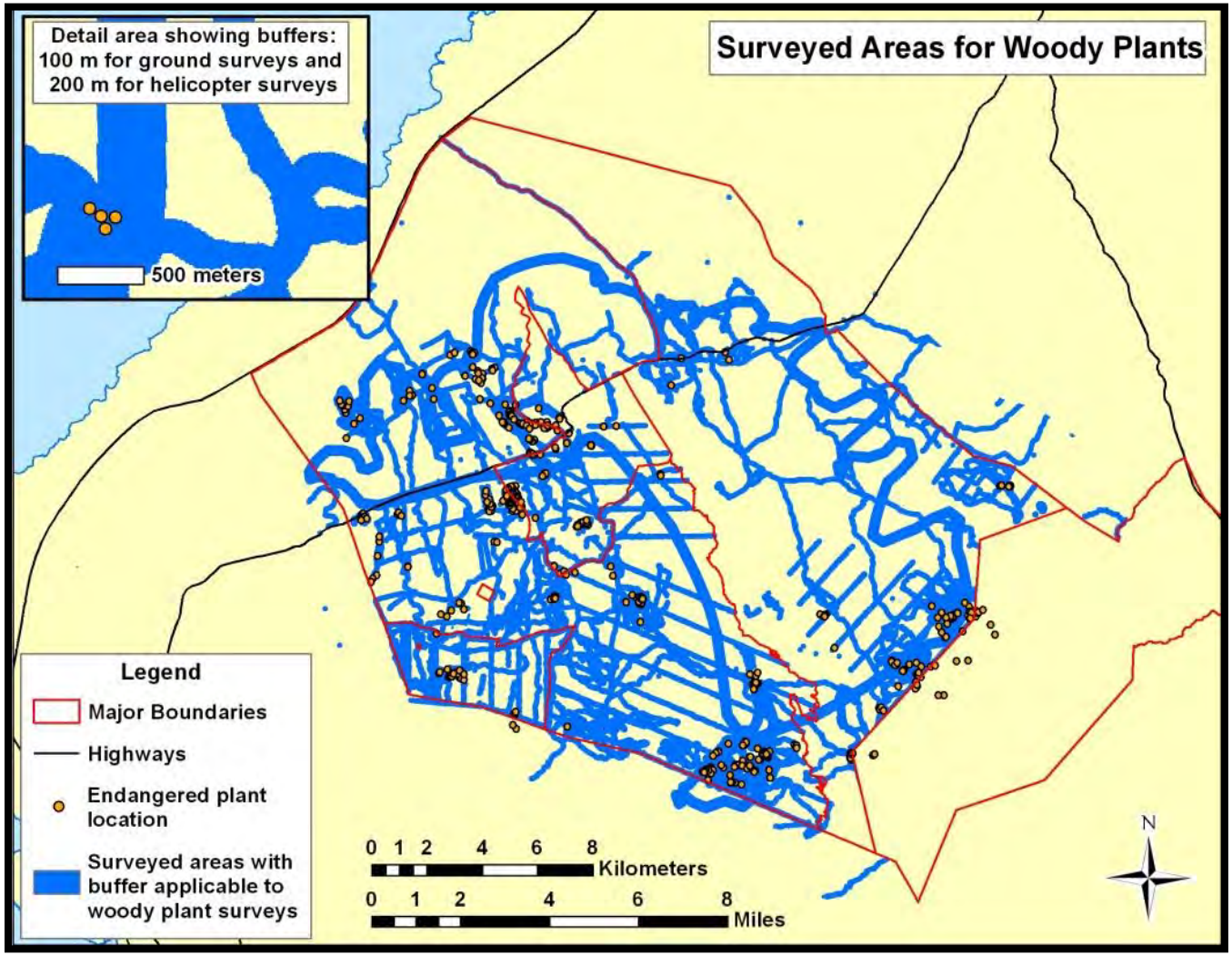

Figure 3.3 Surveyed areas within the Area of Potential Impact including all 4x4 roads and a 100 m buffer for ground and 200 m for helicopter surveys all tracks and guided searches for surveys of woody species.

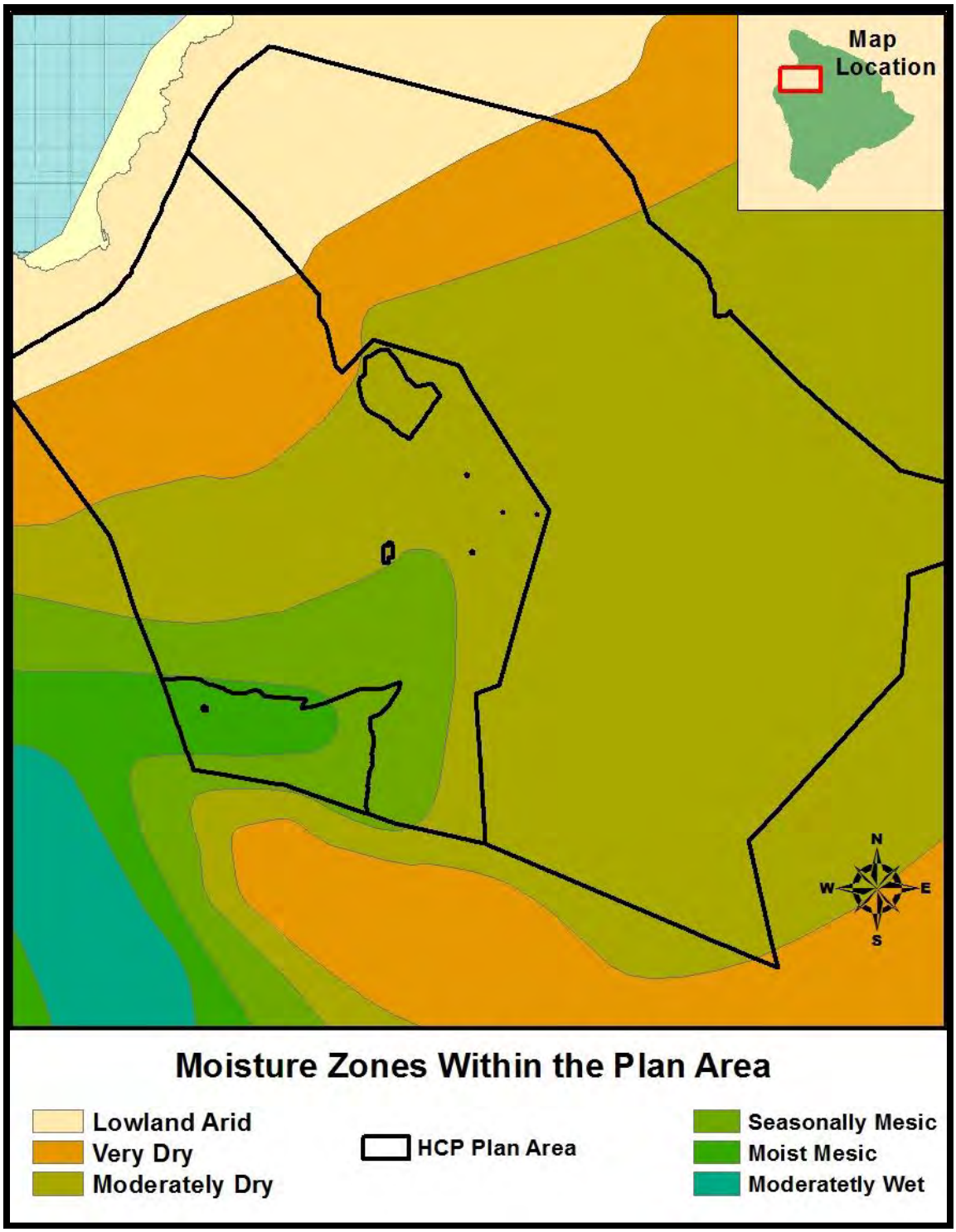

Figure 3.4 Moisture zones found within the Area of Potential Impact. Moisture zones were used as a proxy for elevation in defining habitat types for developing the model used to estimate number of plant individuals found outside of surveyed areas.

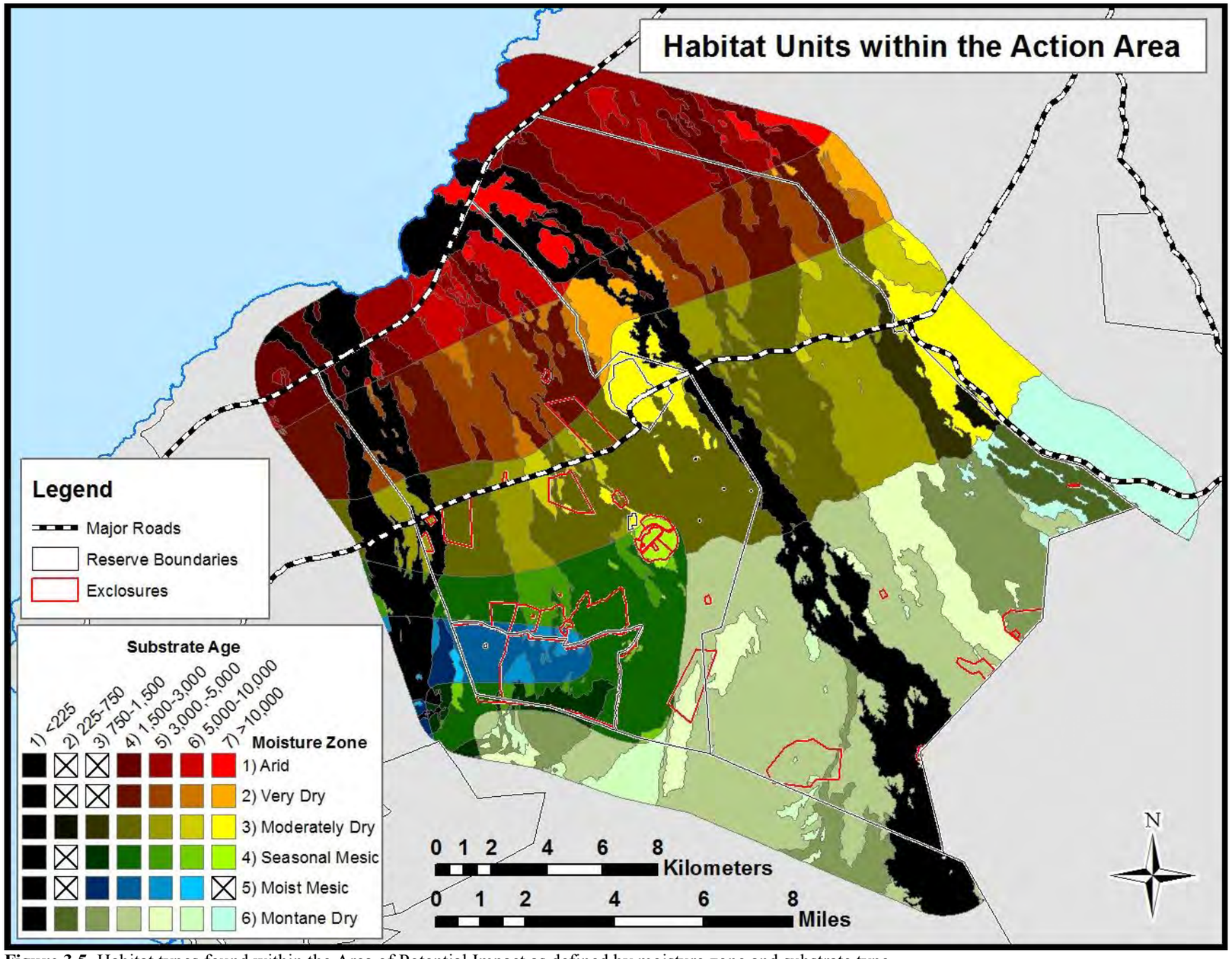

Figure 3.5 Habitat types found within the Area of Potential Impact as defined by moisture zone and substrate type.

3.3.2 Estimating Take of Covered Plant Species

Take estimates were calculated for each of the Covered Plant species using the HCP survey data, 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 3.1 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 2.5.3 for details on botanical surveys*).

Table 3.1 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 3.2 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[13]	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**

[13] 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[13]	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[13]	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**

3.3.3 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 info please see the Monitoring Section 7.2*).

3.3.4 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 not 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 Hawai‘i 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.

3.3.5 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.

1. Obligate outcrossing: 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 3.2) in conjunction with the identification of those factors that may influence effective populations size (Table 3.3) 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 7.1*), 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 3.3 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	Ma‘o hau hele	SP	Unknown
Kokia drynarioides	Koki‘o	SP	Infrequent and inconsistent flowering
Neraudia ovata		SP	Dioecious
Nothocestrum breviflorum	‘Aiea	LP	Unknown
Chrysodracon hawaiiensis	Hala pepe	LP	Unknown
Portulaca sclerocarpa	Po‘e	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	A‘e	LP	Dioecious, large percentage of non-flowering/fruiting plants, low seed set/poor seed viability
Zanthoxylum hawaiiense	A‘e	LP	Dioecious

Table 3.4 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	Maʻo hau hele	3	50	fire, invasive species, ungulates
Kokia drynarioides	Kokiʻo	3	100	fire, invasive species, ungulates
Neraudia ovata		3	100	fire, invasive species, ungulates
Nothocestrum breviflorum	ʻAiea	3	25	fire, invasive species, ungulates
Chrysodracon hawaiiensis	Hala pepe	3	25	fire, invasive species, ungulates
Portulaca sclerocarpa	Poʻe	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	Aʻe	3	50	fire, invasive species, ungulates
Zanthoxylum hawaiiense	Aʻe	3	50	fire, invasive species, ungulates

3.3.6 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 3.6). We then used a subset of this data taken in Pu'u 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 3.6). 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 Pu'u 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).

3.3.7 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 3.7). 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 1,766 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 1,458 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).

3.3.8 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 ʻAiea 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, we estimate that 0.9 percent of Blackburn's sphinx moth larvae and eggs will be taken 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 3.5 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%**

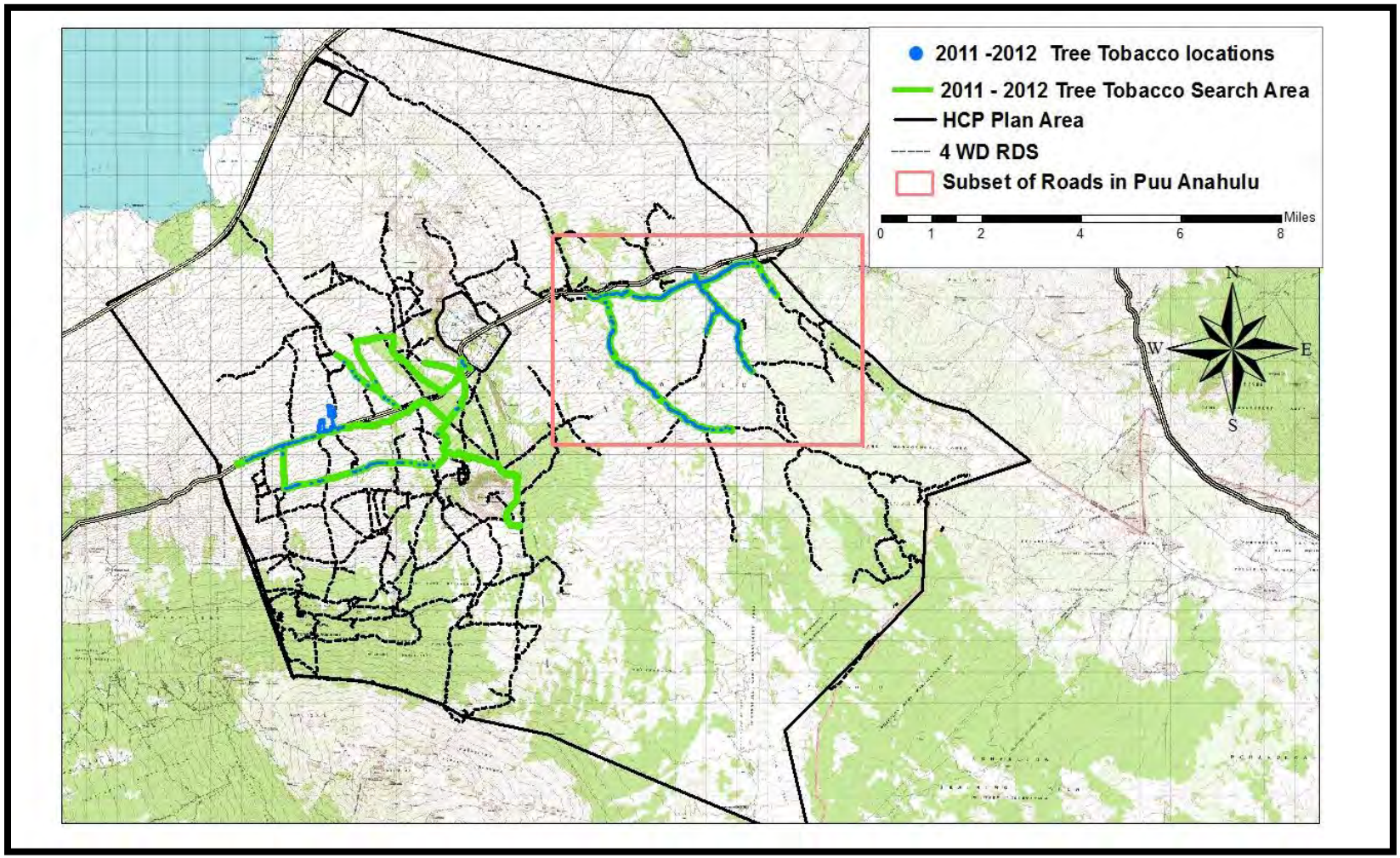

Figure 3.6 2011 and 2012 tree tobacco search area (green line) with mapped tree tobacco locations (blue dots). The area in the red/pink rectangle highlights the subset of roads used to calculate the proportion of occupied habitat.

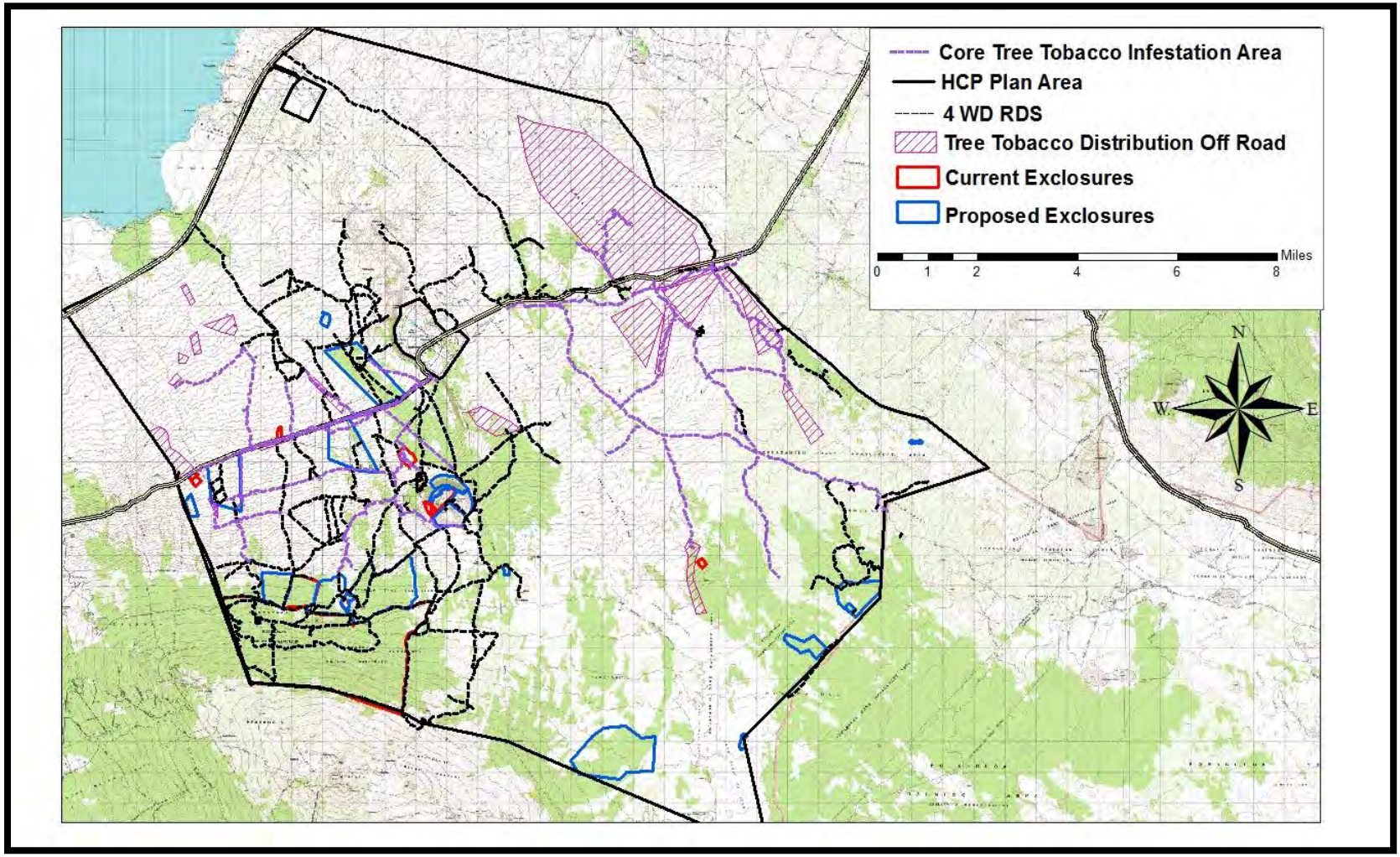

Figure 3.7 Estimated tree tobacco distribution in the Plan Area based on the 2015 helicopter survey (pink hashed area). Roads in purple indicate the CTTIA.

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 take estimate or at least 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.

5.0 AVOIDANCE AND MINIMIZATION MEASURES

Section 195D-21of the Hawai‘i 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.

5.1 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.

5.2 BLACKBURN’S SPHINX MOTH AVOIDANCE AND MINIMIZATION MEASURES

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, wherever feasible.

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. For a detailed description of methods used for clearing roads and breaks, please see section 3.2.2

5.3 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 overall goal within conservation units is to reduce weed cover and fuel loads to prevent the competition and the spread of fire in areas containing Covered Species. Specifically, fountain grass and kikuyu grass[14] will be completely within one meter of an individual (or cluster of) Covered Species and wherever feasible, weed removal will be extended out to three meters. In addition, invasives such as tree tobacco and lantana, and any other species deemed to negatively impact plant survival and reproduction, will be removed from within one meter of Covered Species. Regular staff surveys within conservation units and in adjacent areas will focus on early detection of incipient species and any newly introduced species will slated for removal. Such removal efforts will occur in collaboration with partners such as the Big Island Invasive Species Committee (BIISC) and prioritized and removed on an as needed basis. Spot removal of invasive tree species such as Silver Oak is ongoing across the Plan Area.

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.

[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.

5.4 RAPID ʻŌHIʻA DEATH PREVENTION

A newly identified disease has killed large numbers of mature ʻŌhiʻa trees (Metrosideros polymorpha) in forests and residential areas of the Hilo, Puna, Kāʻu, and Kona 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.

An aerial survey was conducted in January of 2016 surveying 810,000 acres of ʻŌhiʻa forest on Hawaii Island, the current extant of infestation is approximately 34,000 acres. The disease has not yet been reported on any of the other Hawaiian Islands. 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 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.

5.5 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.

5.6 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.

5.6.1 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 5.1. 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 5.1 Fencing priority for fencing units within the Plan Area. Fencing priorty map change based on availability of funding 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 hawaiiense*

Unit #	Fencing Unit	Type	Size[16](acres)	Rationale
1	Henahena	A/M	731	NotBre avoidance of take
2	ʻAiea	A/M	291	NotBre avoidance of take
3	Hala pepe	A/M	92	ChrHaw avoidance of take
4	Honohono	A/M	5	Only known population on State land and PEPP species
5	Solanum Kīpuka	A/M	18	Only known population on State land and PEPP species
6	Kauila Hala pepe	A/M	375	Avoidance of take of ColOpp and ChrHaw
7	Zanthoxylum II	A/M	815	Avoidance of take of ZanHaw
8	Anahulu I	A/M	255	Avoidance of take for NerOva, ZanHaw, SilLan, SteAng
9	Anahulu II	A/M	124	Avoidance of take for ZanHaw and NerOva
10	Stenogyne	A/M	10	Avoidance of take for SteAng
11	Uhiuhi 4	A/M	22	Avoidance of take for MezKav
12	Puʻu Loa	A/M	530	Avoidance of take for ChrHaw, MezKav, ColOpp

[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.

Unit #	Fencing Unit	Type	Size[16](acres)	Rationale
13	Lama Koki‘o	A/M	382	Last known KokDry at PWW. Avoidance of take for ColOpp, NotBre, ChrHaw.
14	PWW CCA (remaining units)	Mit	330	Mitigation for 13 of 15 Cover Species
15	Boundary Kīpuka	Mit	42	Outplanting site for lowland dry forest species (sites lacking)
16	Waihou II	Mit	202	Outplanting site for multiple Covered Species
17	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.

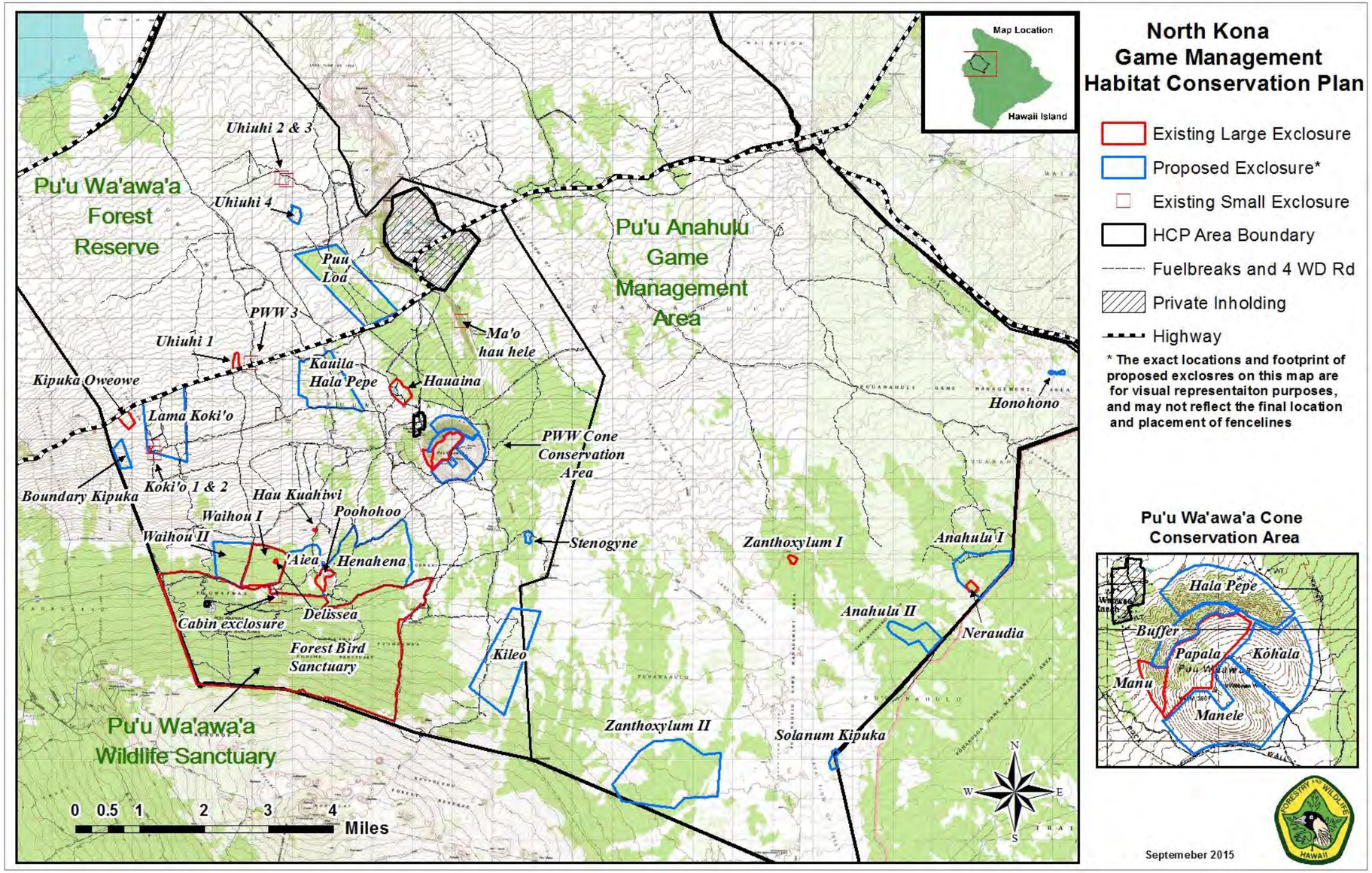

Figure 5.1 Current and proposed exclosures in the Plan Area.

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5.6.2 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 (*See* TABLE 5.2).
- 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 ʻIliahi (sandalwood trees) 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 A‘e (*Z. hawaiiense*) in the area.

Anahulu I – 255 acres

This area contains some of the best remaining dry forest shrubland in the upper Pu‘u Anahulu region. Pu‘u 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: A‘e (*Z. hawaiiense*), 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 Pu‘u Anahulu region. Pu‘u 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: A‘e (*Z. hawaiiense*), 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 ‘Aiea.

Uhiuhi 4 – 22 acres

This unit will protect nine Uhiuhi trees on the makai side of Pu‘u Wa‘awa‘a.

Pu‘u 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 ‘Aiea 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 two individually fenced A‘e (*Z. dipetalum* var. *tomentosum*) trees and the SOC, ‘Akoko.

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 5.2 *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 at the time of last HCP botanical survey. 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
ʻAiea	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 Kokiʻo	382		6	33			4			16							**59**
Puʻu Loa	530		30	5				2									**37**
Neraudia*	12								1								**1**
Poʻohohoʻo *	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**

5.7 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 5.3. Some species overlap with other species because they have wide ranges and can be found in multiple habitat types.

Table 5.3 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 5.4 Proposed and existing conservation units and exclosures categorized by habitat type.

Lowland Dry Forest
Kīpuka Oweowe, Hauaina, Uhiuhi 1, Ma‘o hau hele, Kauila Hala pepe, Boundary Kīpuka, Lama Koki‘o, Pu‘u Loa, Uhiuhi 4
Mixed Mesic/Dry Forest
Waihou I, PWW Cone Conservation Area, Waihou II, Henahena, ‘Aiea, Po‘ohoho‘o
Mesic to Wet Forest
Forest Bird Sanctuary, Po‘ohoho‘o
Upland Dry Shrubland
Anuhulu I & II, Zanthoxylum I & II, Stenogyne, Honohono, Solanum Kīpuka, Kileo

5.8 AVOIDANCE AND MINIMIZATION MEASURES OF SUCCESS

- All avoidance and minimization exclosures will be established by the end of Phase I of implementation (Year 8 after HCP approval, *See Table 5.5*).
- Ungulates[18] will be removed from avoidance and mimimization exclosures within two years of exclosure fencing.
- Fuelbreaks will be established around each avoidance and minimization exclosure within one year of exclosure fencing.
- Weed control will be conducted within each exclosure as deemed appropriate based on exclosure size, native species composition, and weeds present.
- Fuel break and roads maintenance will be conducted on regular schedule (subject to change based on rain fall) to keep roads and fuel breaks clear of tree tobacco and fire fuels.

[18] 90% or greater of the ungulate population will be removed from units within 2 years of fencing with the ultimate goal of 100% ungulate removal.

Table 5.5. Proposed avoidance and minimization conservation units in the Plan Area.

Conservation Unit	Proposed Year of Implementation	Size (acres)	Fence Length (m)[19]
Henahena	2018	731	5119
ʻAiea	2018	291	1589
Hala pepe	2019	92	3005
Kauila Hala pepe	2020	375	5281
Uhiuhi 4	2021	22	1251
Honohono	2021	5	930
Solanum Kīpuka	2021	18	1333
Zanthoxylum II	2023	815	7353
Anahulu I	2024	255	4229
Anahulu II	2025	124	3557
Stenogyne	2025	10	896
Puʻu Loa	2026	530	7070
Lama Kokiʻo	2027	382	5198

[19] Fence length is estimated. The exact unit size, footprint, and length of fence will be determined based on ground surveys prior to fence installation.

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 5.0), 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;

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 7.10 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 5.1 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 Hawai‘i Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawai‘i* (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. hawaiiense*).

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 (*Z. 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 (*Z. dipetalum* var. *tomentosum*). This unit has potential for outplanting of additional

Covered Species including: Hala pepe, Hawaiian Catchfly, *Stenogyne angustifolia*, A‘e (*Z. dipetalum* var. *tomentosum*), and A‘e (*Z. hawaiiense*).

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 (*Z. 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[20]

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 (*Z. 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 ʻIliahi (sandalwood trees) 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. hawaiiense*), Hawaiian Catchfly, *N. ovata*, and *S.*

[20] Acreage for proposed exclosures is estimated and may change in the future based on fence-line ground surveys.

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 hawaiiense*) 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 (*Z. dipetalum* var. *tomentosum* and *Z. hawaiiense*).

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* var. *tomentosum*).

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 (*Z. 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 (*Z. dipetalum* var. *tomentosum*), and Aʻe (*Z. hawaiiense*).

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 (*Z. hawaiiense*).

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. hawaiiense*.

	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**
TOTAL		6	12	9	17	9	8	9	24	23	24	23	21	21	7	20	

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*. Covered Species are highlighted. All other species are common and rare species that have been outplanted in the Plan Area.

Species	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**total**	**Goal[21]**
Aca koa	0	0	1371	3775	1181	922	1261	261	8771	
Aca koaia	0	0	0	0	4	0	7	0	11	
Alb men	1	0	0	0	0	0	0	5	6	
Ale mol	0	0	0	3	46	0	0	0	49	
Bid men	0	0	0	0	0	33	195	137	365	
Can haw	0	0	0	0	0	0	104	208	312	
Cap san	0	0	0	0	0	1	0	1	2	
Cha obo	0	0	0	0	3	0	0	0	3	
Cha olo	0	0	0	87	0	5	0	0	92	
Che oah	0	0	0	6	249	15	9	25	304	
Cle cle	0	0	0	0	0	0	12	2	14	
Coc tri	0	0	0	0	0	0	85	4	89	
Col opp	0	2	1	54	310	57	64	21	509	855
Cop mon	0	0	0	0	49	0	67	0	116	
Dio san	1	7	3	0	19	5	236	190	461	
Dod vis	3	0	25	806	1258	568	496	110	3266	
Dub pla	0	0	0	0	0	0	4	10	14	
Ery san	0	0	8	10	48	285	222	15	588	

[21] Specific to Covered Species and indicates the number of mature, reproducing individuals required for mitigation success.

Hap hap	0	0	0	0	300	13	1	0	314	896
Het con	0	0	1	0	0	0	0	0	1	
Hib bra	0	17	4	0	0	55	129	122	327	250
Hib hua	0	0	0	0	22	22	341	62	447	
Ipo ind	0	0	0	0	0	0	0	4	4	
Kok dry	3	44	137	249	42	35	525	135	1170	500
Lip sub	0	0	0	0	0	131	98	75	304	
Mel haw	0	0	0	0	0	0	83	11	94	
Met pol	0	0	0	0	1	16	61	77	155	
Mez kav	0	54	63	98	207	107	469	101	1099	244
Myo san	0	0	0	0	0	0	0	3	3	
Myr lan	0	0	0	6	0	4	0	0	10	
Myr les	0	1	1	0	0	49	132	0	183	
Ner ova	0	0	3	0	270	0	0	0	273	500
Not bre	1	2	0	47	68	58	86	33	295	365
Not san	0	0	0	0	0	25	0	0	25	
Ost ant	0	0	6	0	0	0	244	0	250	
Pis bru	0	1	0	6	22	0	0	0	29	
Pit hos	0	0	0	0	25	49	90	248	412	
Ple par	0	0	0	0	0	0	0	64	64	
Ple haw	0	84	21	58	319	224	569	20	1295	381
Plu zey	0	0	0	0	0	8	13	6	27	
Por scl	0	0	0	0	300	77	0	31	408	250
Pou san	0	0	4	0	0	0	0	0	4	
Psy odo	0	0	0	0	0	5	0	0	5	
Rey san	0	0	13	0	0	77	75	18	183	
San pan	2	0	0	0	0	1	16	0	19	
Sap sap	0	1	10	0	0	0	0	0	11	
Sen gau	0	0	0	0	0	0	4	40	44	
Ses tom	0	0	0	0	0	2	34	4	40	
Sid fal	0	0	0	0	0	0	9	79	88	

Sil lan	0	0	0	0	350	0	0	79	429	1912
Sop chr	0	2	46	637	283	5	415	36	1424	
Spe haw	0	0	0	0	118	0	0	0	118	
Ste ang	0	0	0	0	300	44	3	26	373	425
Str pen	0	0	0	0	0	0	0	1	1	
Xly haw	4	0	0	0	12	0	0	0	16	
Zan Dip Tom	0	0	0	0	0	0	18	1	19	250
TOTAL	**15**	**215**	**1717**	**5842**	**5806**	**2898**	**6177**	**2265**	**24935**	

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 (*see Section 6.1*). 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 5.0*).

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 the Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** A take estimate using the model to estimate plant population size 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 1,000 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 5.0 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 6.4 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 1,000 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
Pu‘u Loa	No	Avoidance/minimization	30	530
Lama Koki‘o	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 5.0 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 the 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 1,000 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 5.0 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Keamuku Pu‘u 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 the 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 1,000 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
Pu‘u Loa	No	Mitigation		530
Uhiuhi 4	No	Mitigation		22
Solanum Kīpuka	No	Mitigation		18
Kileo	No	Mitigation		533

6.3.5 Ma‘o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 5.0 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 the 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 1,000 m apart.

Table 6.7 Known *in situ* populations and potential reintroduction sites for Ma‘o 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 Koki‘o	No	Mitigation		382
Pu‘u 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 5.0 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 the 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 3.3.4, 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 1,000 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[22]	No	Mitigation	4	382
Puʻu Loa	No	Mitigation		530

[22] 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 5.0 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 the 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 1,000 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 5.0 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 the 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 3.3.4, 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 1,000 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
Po‘ohoho‘o	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 ʻAiea (*Nothocestrum breviflorum*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in Section 5.0 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known 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 the 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 1,000 m apart.

Table 6.11 Known *in situ* populations and potential reintroduction sites for ʻAiea.

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
Poʻohohoʻo	Yes	Avoidance/minimization	6	29
ʻAiea	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 5.0 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 the Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal**: A take estimate based on a population modeling 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 3.3.4. 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 1,000 m apart.

Table 6.12 Known *in situ* populations and potential reintroduction sites for Po‘e. 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
‘Aiea	No	Mitigation		>1
Po‘ohoho‘o	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 Koki‘o	No	Mitigation		382
Pu‘u 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 5.0 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 the 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 1,000 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 5.0 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 the 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 3.3.4, 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 1,000 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[23]	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

[23] *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 5.0 Avoidance and Minimization*).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Pu‘u Anahulu and 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 the 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 1,000 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 5.0 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 the 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 3.3.4. 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 1,000 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 5.0 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 the 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 1,000 m apart.

Table 6.17 Known *in situ* populations and potential reintroduction sites for A‘e (*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
Po‘ohoho‘o	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 Koki‘o	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, Kauila 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, Kauila 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 brackenridgei	65	59	65	Ma‘o hau hele	59	3 populations of 50 plants each	1 population of 50 plants	1 population of 50 plants	**250 plants**
Kokia drynarioides[24]	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**

[24] 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	**1,912 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* var. *tomentosum	13	11	5[25]	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 hawaiiense	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**

[25] 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. 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.

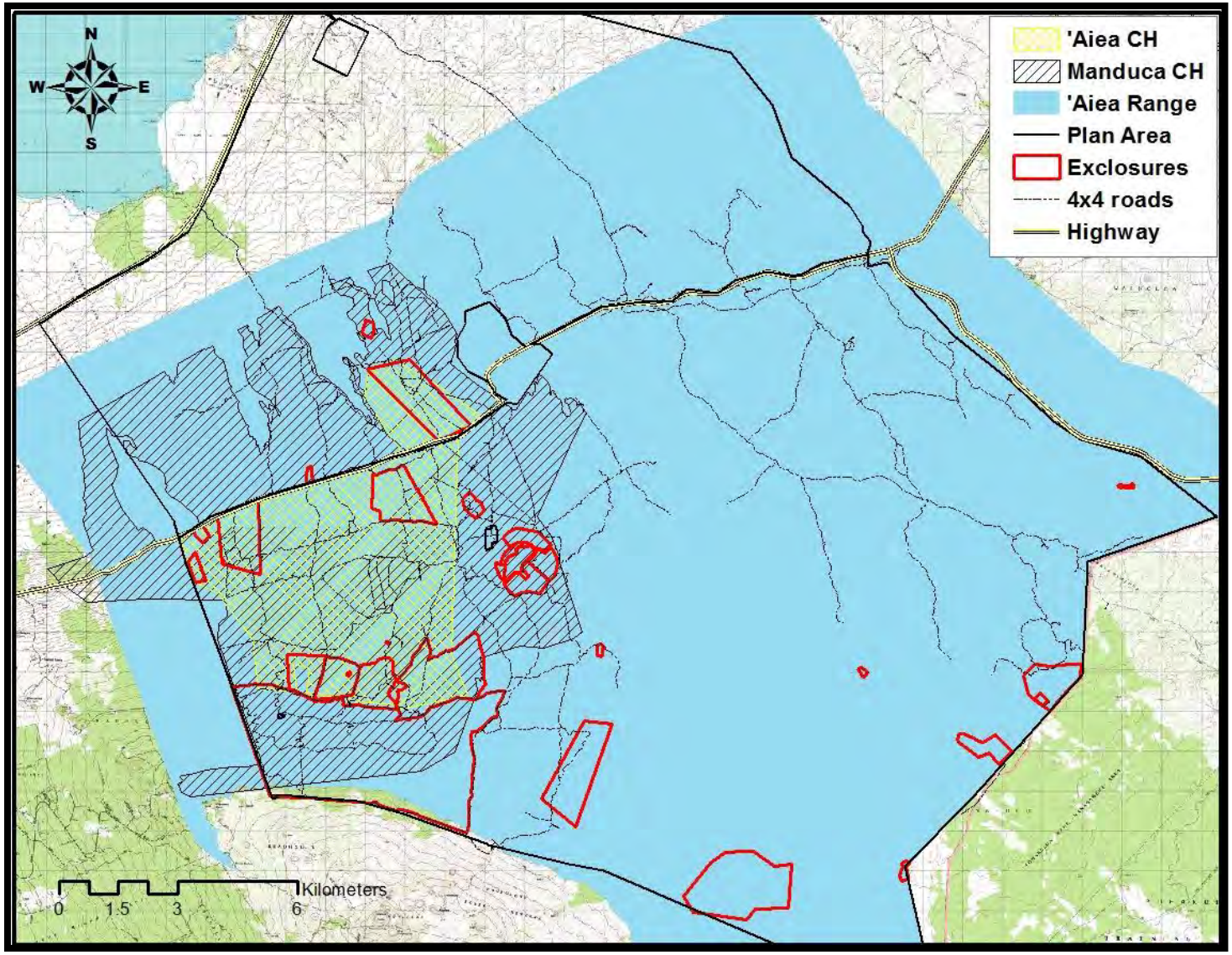

Figure 6.1 Map depicting critical habitat for ‘Aiea and *Manduca blackburni*, exclosure locations, and species range for ‘Aiea within the Plan Area.

6.4 FIRE MITIGATION

Wildfire presents a critical risk to covered species as well as cultural and natural resources in the Plan Area. In particular, severe drought, heavy fire fuel loads from invasive grasses, and numerous fire starts from vehicles as well as lightning strikes pose a significant risk to the 15 *in situ* endangered plant species, six endangered bird species, critical habitat for 13 species, 39 rare and common *ex situ* and *in situ* native plant species, and some of most extensive tracts of remaining tropical dry and mixed mesic forest left in Hawaii. In addition, the landscape is important culturally with numerous plant species gathered by local cultural practitioners, wood workers, and hula dancers, and the area is also considered a historical landscape by the State Historic Preservation Division. All of these values and uses are threatened by wildfire; in the past six years alone there have been over a dozen wildfires at Pu`u Wa`awa`a that have burned thousands of acres.

Fire management is integral to both natural resource management as well game management and hunting in the Plan Area. The primary form of fire mitigation is the reduction of fuels along roads and fuel breaks in the Plan area, as well as over all fuels reduction in conservation units. Fire fuel break management serves not only to reduce the likelihood of fire, it also facilitates rapid response when fires do occur. Currently there are approximately 230 miles of roads and fuel breaks within the Plan Area (*See* Figure 6.2). 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. On average, road width is approximately 15 ft wide. Roads in the lower elevation and arid regions of the Plan Area are both treated with herbicide (*See section 3.2.2*) and mowed to maintain bare ground conditions, wherever feasible. Roads in the mauka or upland, wetter areas of the Plan Area are cleared using mowing only to reduce erosion risk. In addition to firebreaks, larger fuel breaks are maintained in strategic locations along the Māmalahoa Highway and around many fenced conservation units across the Plan Area. Each conservation unit, as it is constructed, will have a fuelbreak of 20 ft minimum width. In some cases, fuelbreaks may be installed prior to fencing actions to delinieate the fence line and protect natural resources within the area until fencing can occur. Fire mitigation and management in the Plan Area will continue to be developed based on the newest guidance from the DOFAW Fire Protection Staff, the Hawaii Wildfire Management Organization, the Pacific Fire Exchange, and other specialists in the field.

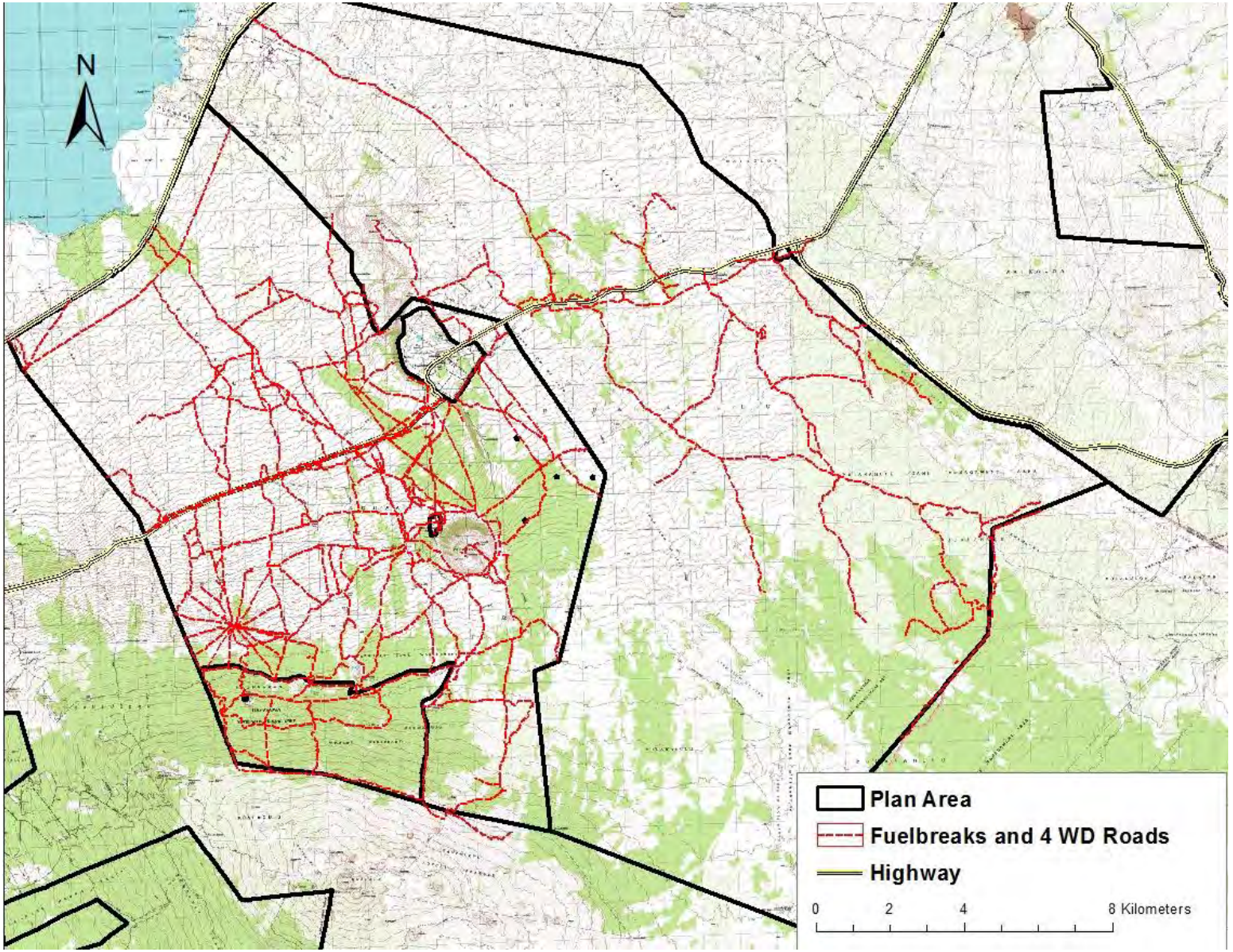

Figure 6.2 Map depicting location of four wheel drive roads and fulebreaks within the Plan Area.

6.5 MEASURES OF SUCCESS

- All mitigation exclosures that remain unfenced by the end of Phase I (Year 10 after HCP approval), will be fenced by the end of Phase II of implementation (Year 15 after HCP approval).
- Ungulates will be removed from mitigation exclosures within two years of exclosure fencing.
- Fuelbreaks will be established and maintained around each mitigation exclosure within one year of exclosure fencing. Fuel break maintenance will be conducted on a regular schedule (subject to change based on rain fall) to keep roads and fuel breaks clear of tree tobacco and fire fuels.
- Weed control will be conducted within each mitigation exclosure as deemed appropriate based on exclosure size, native species composition, and weeds present.
- Test outplanting will be conducted in a minimum of 5 sites identified for population establishment within current and proposed exclosures by Year 10 of Implementation.
- Five populations will be established by Year 15 of Implementation for each of the Covered Plant Species.

Table 6.19. Proposed mitigation conservation units in the Plan Area.

Conservation Unit	Proposed Year of Implementation	Size (acres)	Fence Length (m)[26]
Kohala	2028	88	2534
Manele	2029	121	3542
Buffer	2030	29	2199
Boundary Kīpuka	2031	42	1878
Waihou II	2032	202	1895
Kileo	2033	533	7000

6.6 NET BENEFIT TO COVERED SPECIES

[26] Fence length is estimated. The exact unit size, footprint, and length of fence will be determined based on ground surveys prior to fence installation.

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 6.20 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 6.5). 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 6.4). 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 6.5). Table 6.21 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.

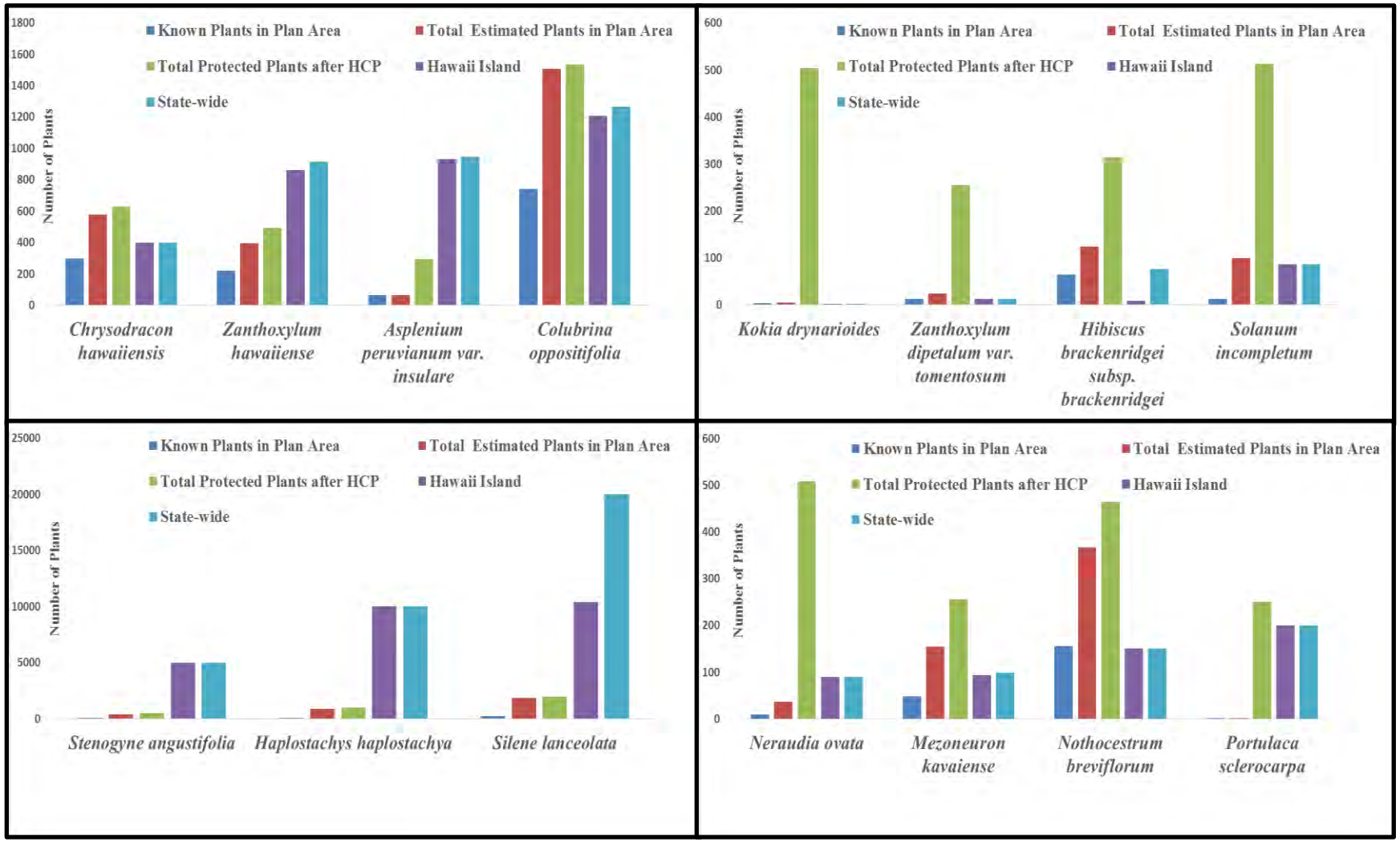

Figure 6.3 A comparison of the number of plants in the Plan Area, with plant numbers from across the island and state. Known plants are those found during surveys, total estimated plants are known plants plus estimated plants from modeling, total protected plants after HCP are both *in situ* and mitigated fenced plants in the Plan Area after implementation. Island and State-wide values come from USFWS 5 year reviews.

Table 6.20 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. X indicates extirpated.

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	1,265	54	1,209	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	5,000		5,000	X			X
Zanthoxylum dipetalum var. *tomentosum*	13	2	13		13				
Zanthoxylum hawaiiense	219	2	916		860	51	2	X	3

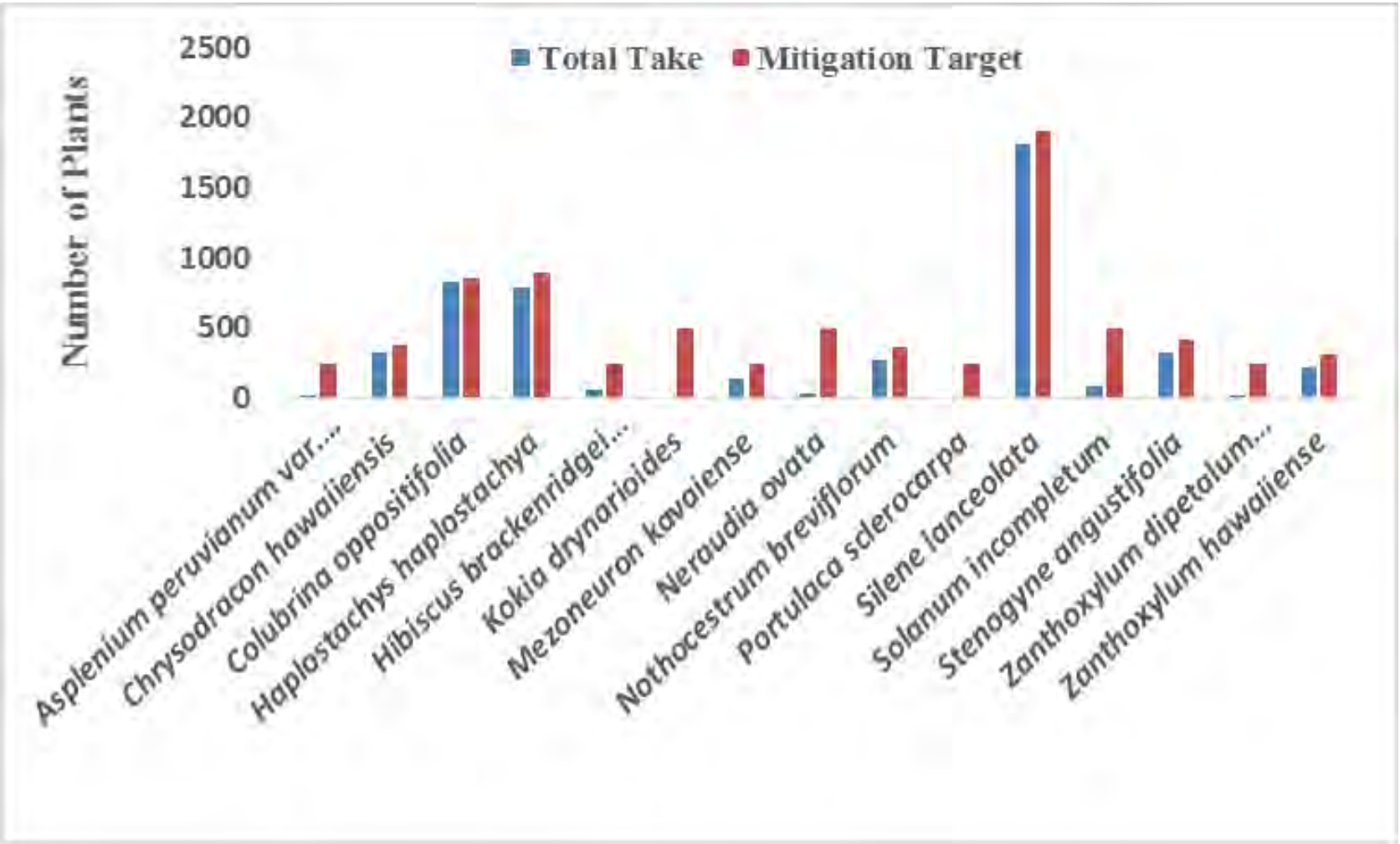

Figure 6.4 Total take (blue bar) values compared to the mitigation target (red bars) for each Covered Species. Total take is calculated based on actual take of known unfenced plants and estimated plants outside of fenced areas.

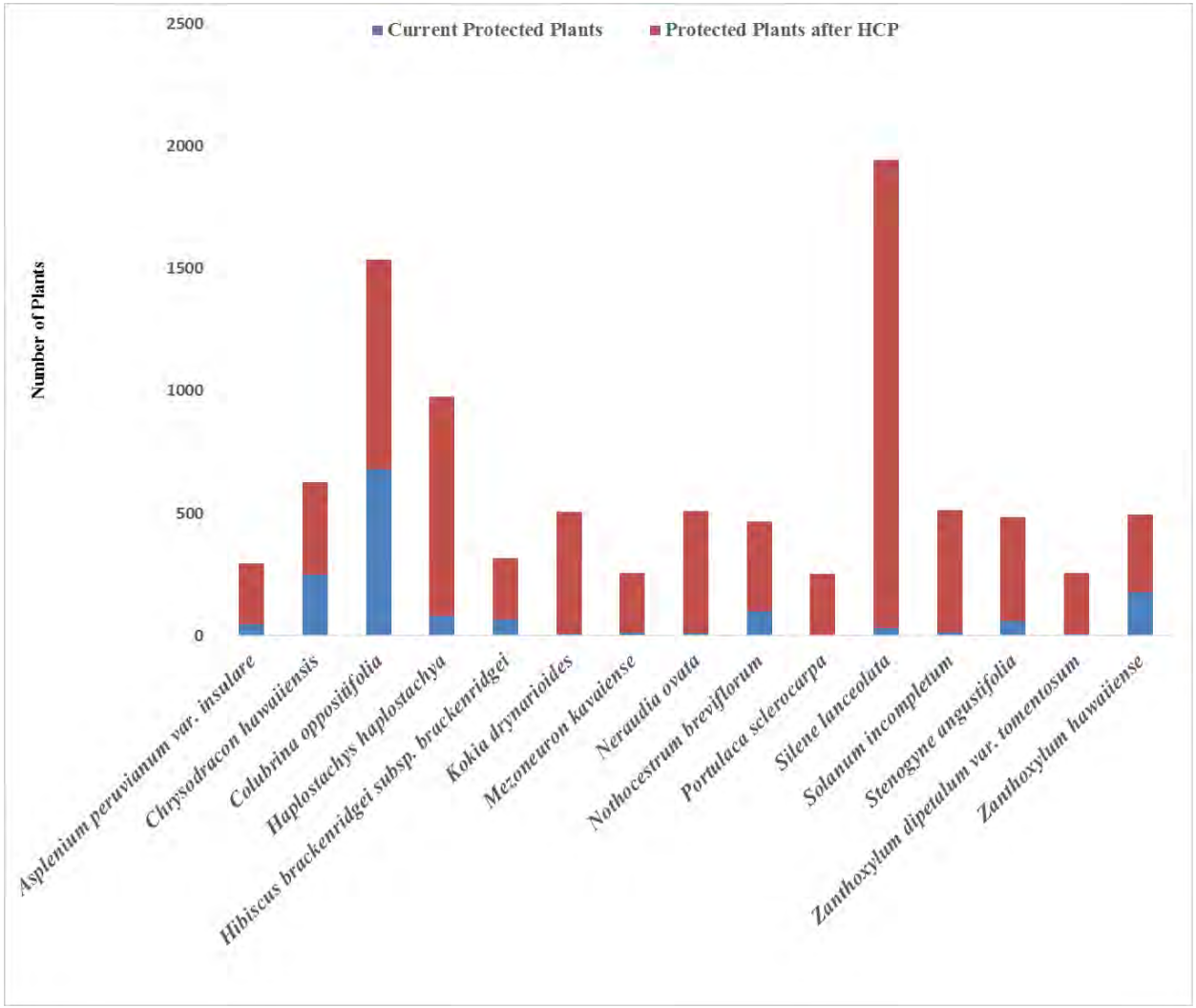

Figure 6.5 Total combined number of protected (fenced) plants after HCP implementation. Blue bars are in situ plants within exclosures and red bars are mitigation (outplanted) plants.

Table 6.21 Percent increase in number of protected plants after HCP implementation.

Species	Protected In Situ	Total Mitigated Individuals	% Increase
Asplenium peruvianum var. insulare	**45**	**250**	**556**
Chrysodracon hawaiiensis	**247**	**381**	**154**
Colubrina oppositifolia	**681**	**855**	**126**
Haplostachys haplostachya	**80**	**896**	**1120**
Hibiscus brackenridgei subsp. brackenridgei	**65**	**250**	**385**
Kokia drynarioides	**4**	**500**	**12500**
Mezoneuron kavaiense	**11**	**244**	**2218**
Neraudia ovata	**9**	**500**	**5556**
Nothocestrum breviflorum	**100**	**365**	**365**
Portulacca sclerocarpa	**1**	**250**	**25000**
Silene lanceolata	**30**	**1,912**	**6373**
Solanum incompletum	**13**	**500**	**3846**
Stenogyne angustifolia	**58**	**425**	**733**
Zanthoxylum dipetalum var. tomentosum	**5**	**250**	**5000**
Zanthoxylum hawaiiense	**175**	**318**	**182**
Total	**1524**		

6.7 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 Hawai‘i. 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 a 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 Pu‘u Wa‘awa‘a 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 Pu‘u Wa‘awa‘a 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 2.5).

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:

- **Koki‘o Unit 1 – <1 acre**: Contains Koki‘o outplants.
- **Uhiuhi 2 – 3 acres**: Contains 2 individuals of Uhiuhi.
- **Uhiuhi 3 – 1 acre**: Contains 1 individual of Uhiuhi.
- **Kokio 2 – <1 acre**: Contains Koki‘o outplants.
- **Pu‘u Wa‘awa‘a 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.
- **‘Aiea Exclosures**: Eight individual exclosures with the proposed ‘Aiea Conservation unit were established in 2008 and 2009.
- **Neraudia exclosures**: Three small exclosures, one that contains six plants, and two individual tree fences.
- **A‘e 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 implement the HCP after BLNR approval and ITL issuance. DDIT reports directly to the Hawaii Island District Manager. A DLNR-DOFAW Administration Team (DDAT) will be comprised of HCP administrative staff reporting under the Wildlife Program Manager will oversee compliance under permit comditions. 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 DDAT. Pursuant to HRS Chapter §195D-26, the DDIT will provide annual updates to the DDAT for review prior to submission 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 DDAT 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 DDAT 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 5.6*). 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 possible (*see Appendix E*).
2. *In situ* plant populations will be monitored annually to follow changes in the population of Covered Species over time. If a full survey of the population is not feasible, a subset of the population will be monitored. Demographic data by life stage including (growth, survival, reproduction, and recruitment data will be analyzed to monitor changes in population structure and status 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 intervals during the first year of planting (e.g. 1 month, 3 months, 6 months, 12 months, dependent on need and staff availability), 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 possible (*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 Hawai‘i. 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 overall goal within conservation units is to reduce weed cover and fuel loads to prevent the competition and the spread of fire in areas containing Covered Species. Specifically, fountain grass and kikuyu grass[27] will be completely within one meter of an individual (or cluster of) Covered Species and wherever feasible, this removal will be extended out to three meters. In addition, invasives such as tree tobacco and lantana, and any other species deemed to negatively impact plant survival and reproduction, will be removed from within one meter 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.

[27] 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.

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.

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 calculate the 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 Hawai‘i 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 1,700 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*), 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*, Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*), Aʻe (*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 1.2 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 the 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**

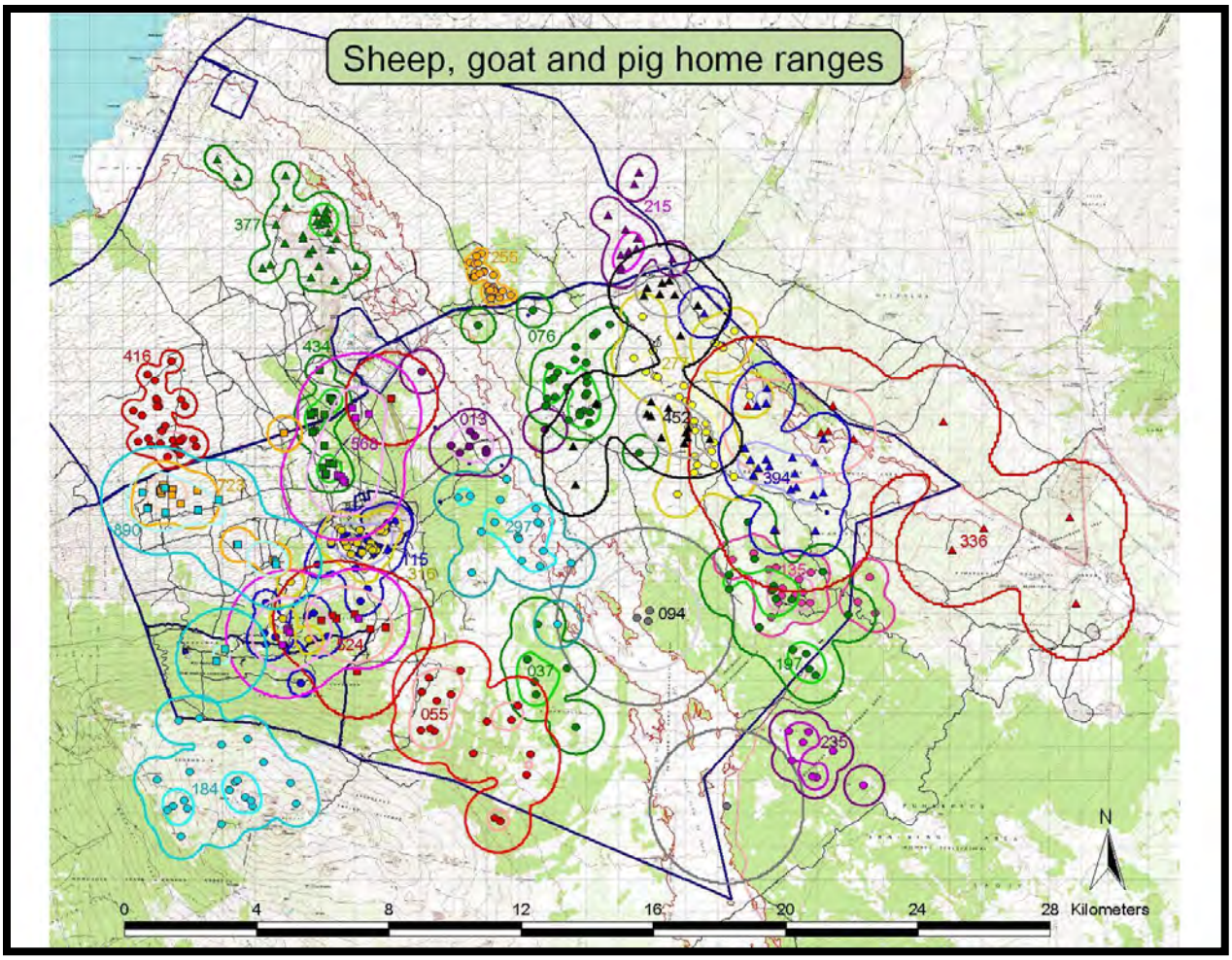

Figure 8.1 Summary of the 95% kernel home range results (km^2) for sheep (circles), pigs (squares), and goats (triangles) in the region. Each color signifies an individual animal.

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 (2003), 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 hawaiiense	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	ʻAkoko	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	ʻOhe makai	Species of Concern
Sisyrinchium acre	Mauʻu lā ʻili	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	ʻIo (Hawaiian hawk)	Endangered
Eretmochelys imbricata	Honu ʻEa (Hawksbill turtle)	Endangered
Himantopus mexicanus knudseni	Aeʻo (Hawaiian stilt)	Endangered
Lasiurus cinereus semotus	ʻŌpeʻapeʻa (Hawaiian hoary bat)	Endangered
Loxops coccineus coccineus	ʻAkepa	Endangered
Oreomystis mana	Hawaiʻi 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**	Koʻokoʻolau	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**	Haʻiwale	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**	ʻAkala	Species of Concern
*Sicyos macrophyllus**	ʻAnunu	Proposed Endangered
Vertebrates		
Anas wyvilliana	Koloa	Endangered
Corvus hawaiiensis	ʻAlalā	Endangered
Hemignathus munroi	ʻAkiapolaʻau	Endangered
Pterodroma phaeopygia sandwicensis	ʻUaʻu	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 arenarium 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 zeylanica	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.	ʻAmaʻu	None
Santalum paniculatum	ʻIliahi	None
Senna gaudichaudii	Kolomona	None
Sicyos lasiocephalus		None
Sophora chrysophylla	Māmane	
Streblus pendulinus	Aʻiaʻi	None
Urera glabra	Ōpuhe	None
Wikstroemia spp.	ʻĀkia	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.

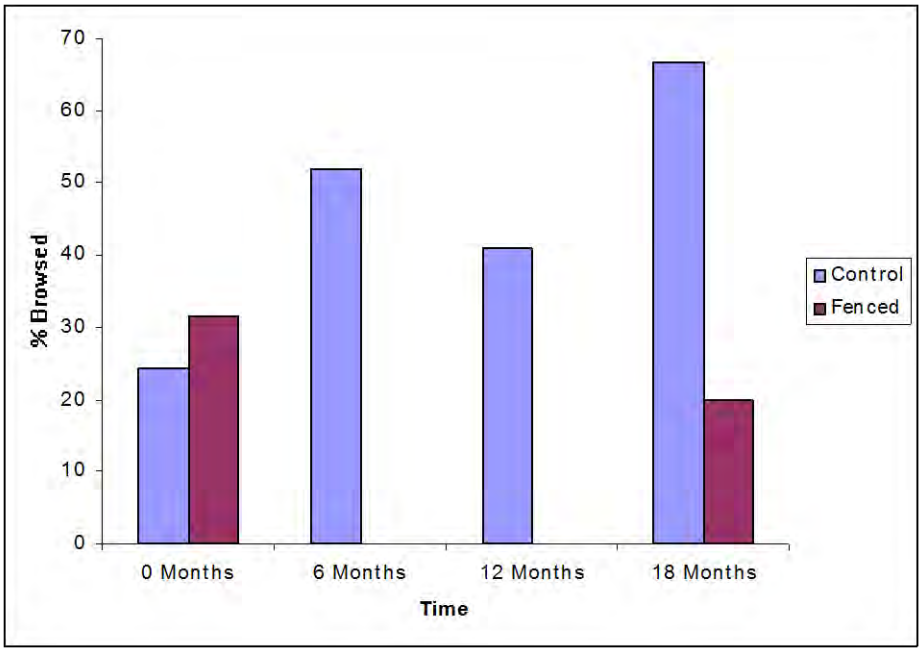

Figure 10.1 Percent ungulate browse activity on *Stenogyne angustifolia* over the 18 month study period.

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).

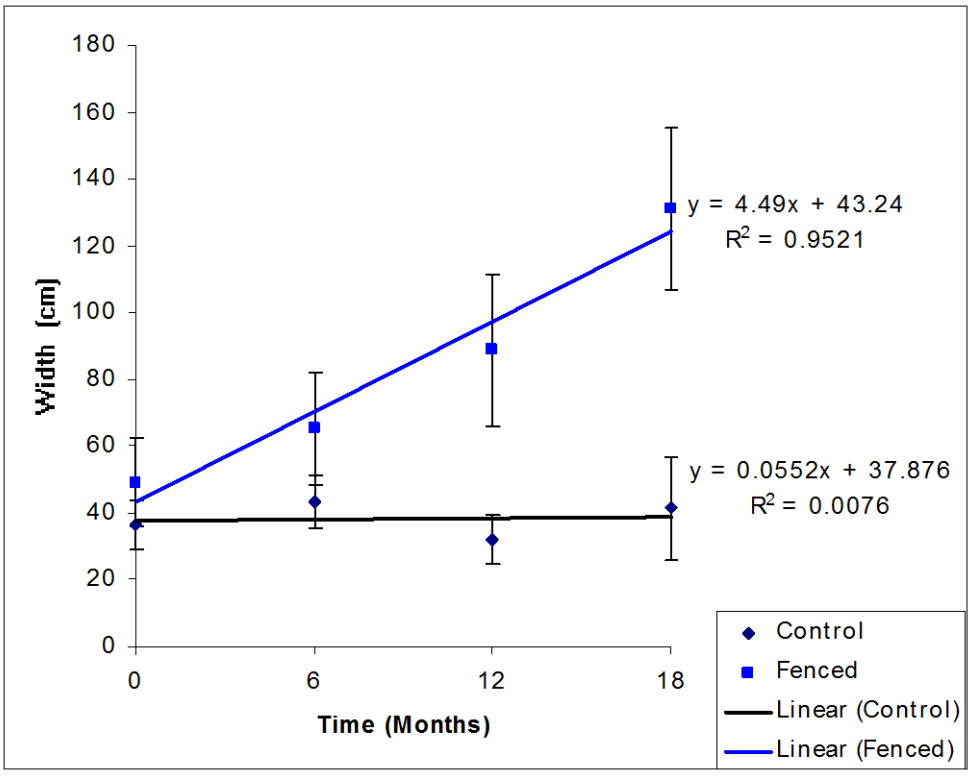

Figure 10.2 Scatter plot of *Stenogyne angustifolia* plant width over time in both fenced and unfenced units.

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).

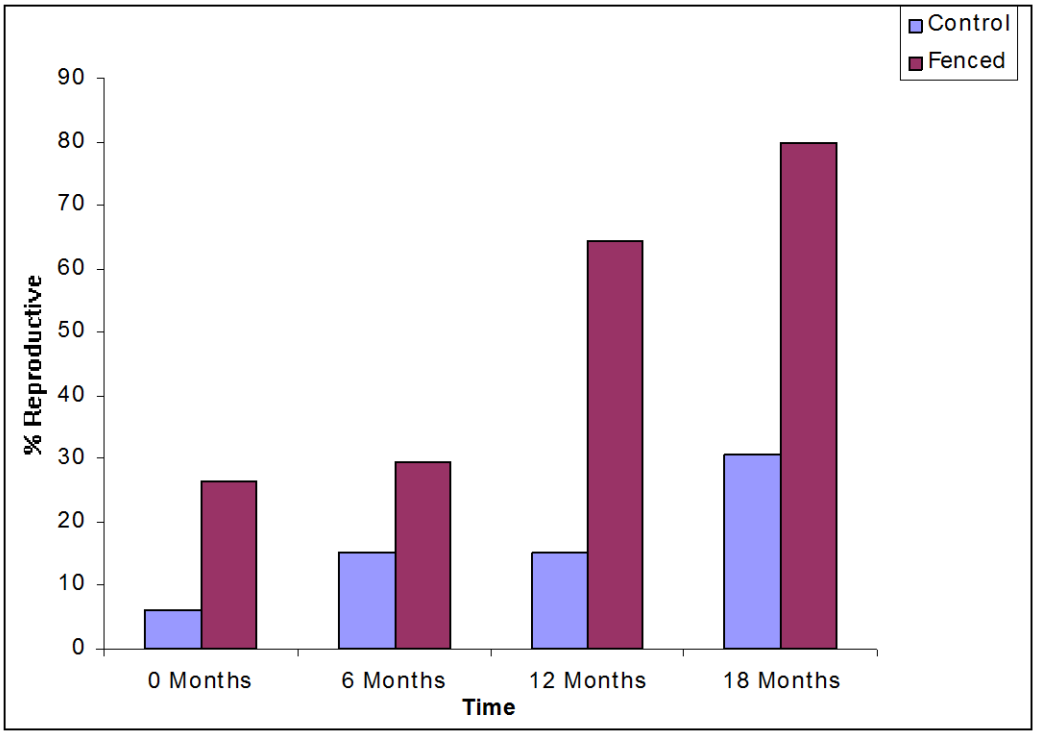

Figure 10.3 Percent of *Stenogyne angustifolia* individuals reproducing over 18 months of the ungulate exclosure study.

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.

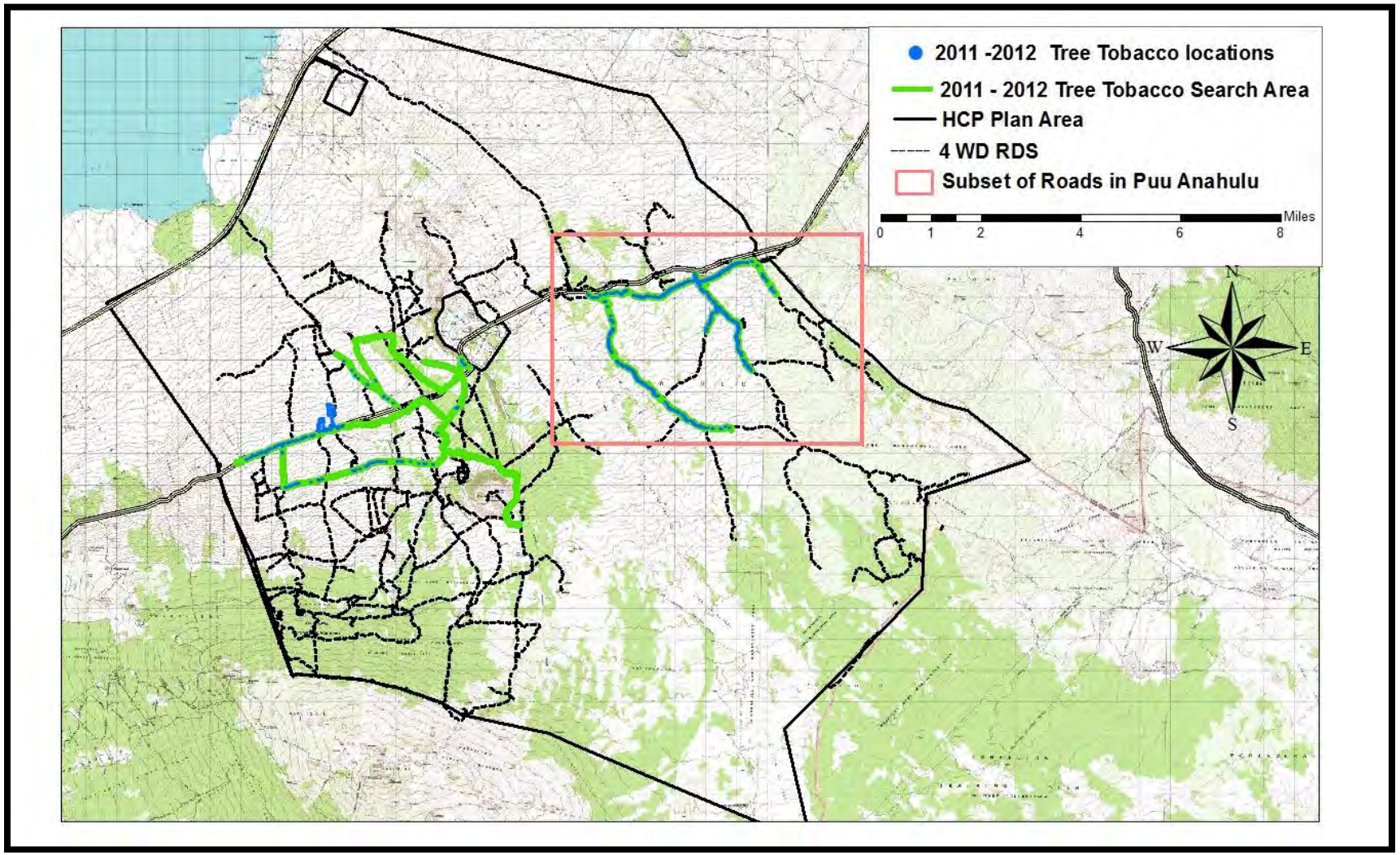

Figure 11.1 2011 and 2012 tree tobacco search area (green line) with mapped tree tobacco locations (blue dots). The area in the red/pink rectangle highlights the subset of roads in Pu‘u Anahulu used to calculate the proportion of occupied habitat.

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 Pu'u 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.

11.1.3 *M. blackburni* Larval Density/Distribution on 'Aiea

We plan to survey for *M. blackburni* eggs and larvae during HCP implementation on a subset of mapped wild 'Aiea (*Nothocestrum breviflorum*) throughout the Plan Area. Thorough surveys of 'Aiea 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 'Aiea trees (e.g. through removal of invasive weeds). Targeted surveys for *M. blackburni* eggs and larvae on 'Aiea 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.

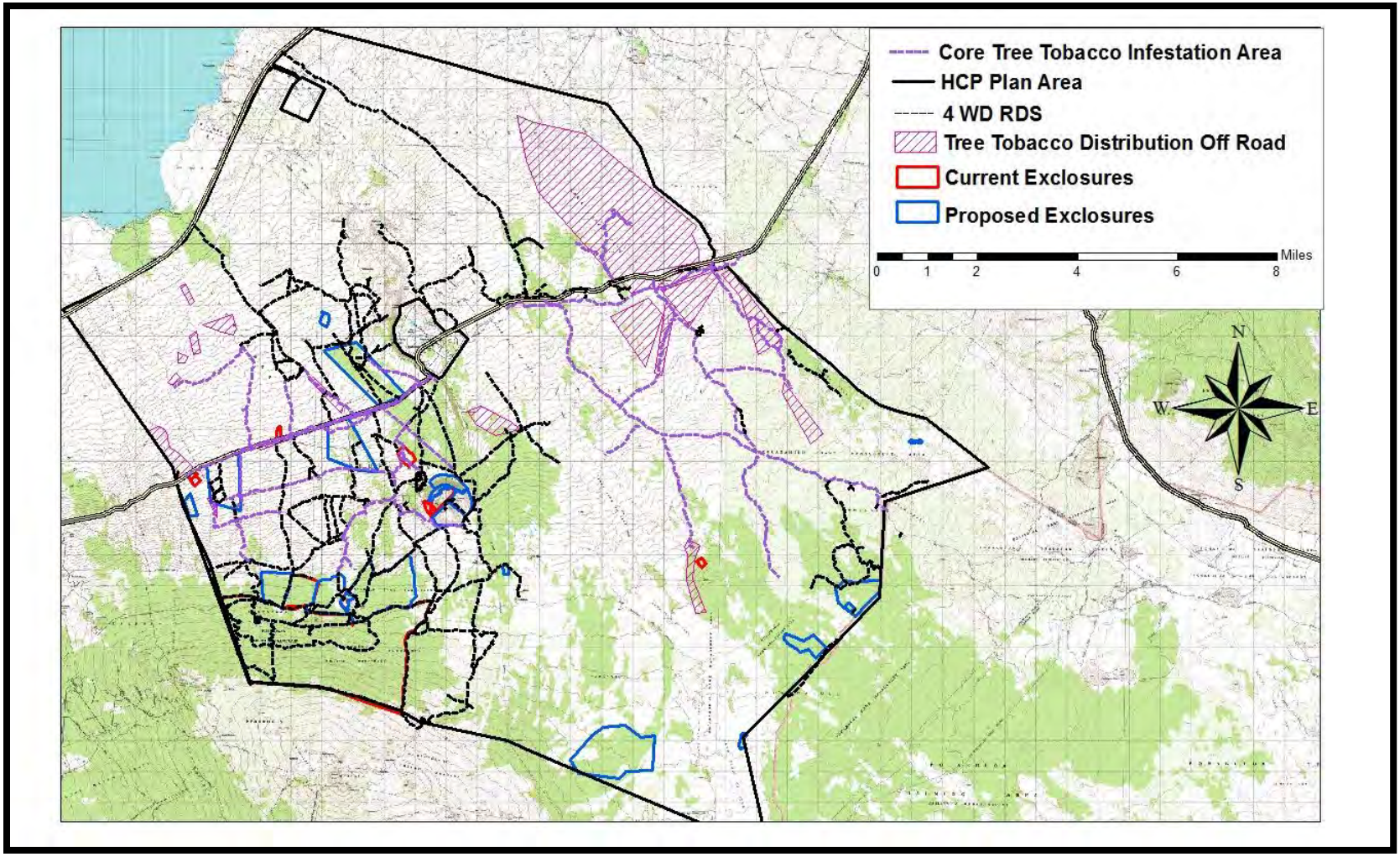

Figure 11.2 Estimated tree tobacco distribution in the plan area based on the 2015 helicopter survey (pink hashed area). Roads in purple indicate the core tree tobacco infestation area

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.

11.1.4 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 Hawai‘i making them easy to identify in the field; they are Hawai‘i’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.

11.2 RESULTS

11.1.1 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

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).

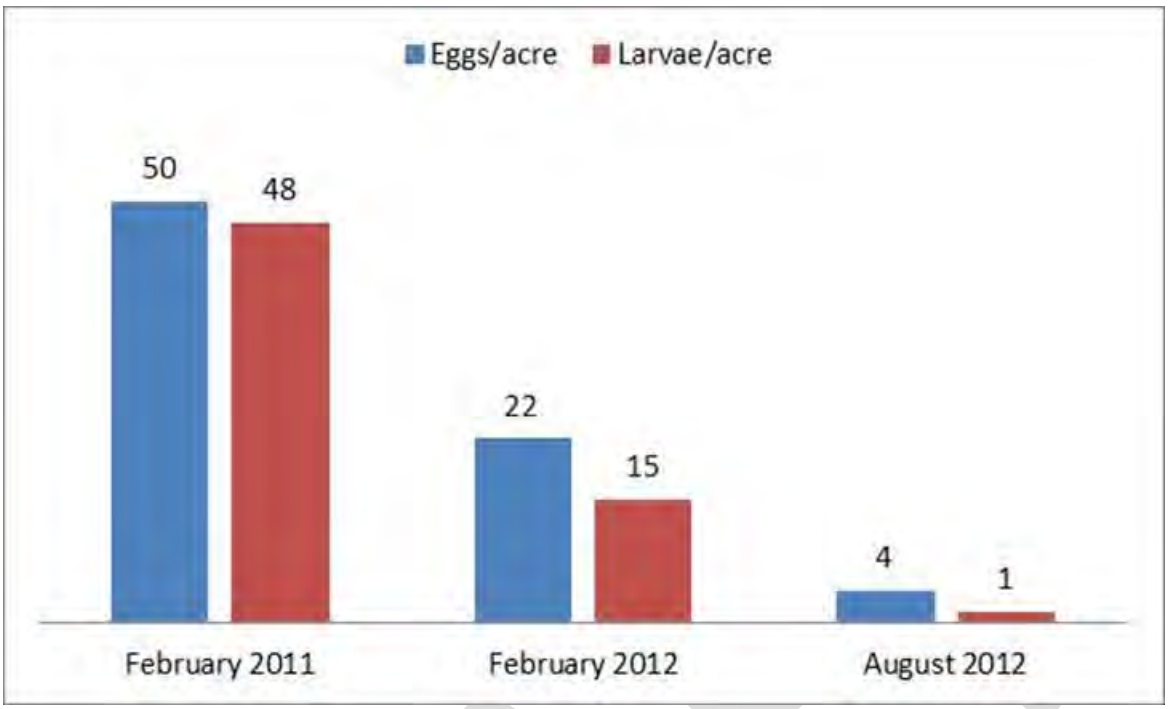

Figure 11.3 Estimate of the number of eggs and larvae per acre of tree tobacco in the Plan Area. Larval surveys were done on transects containing a minimum of 10 trees per 75 m^2.

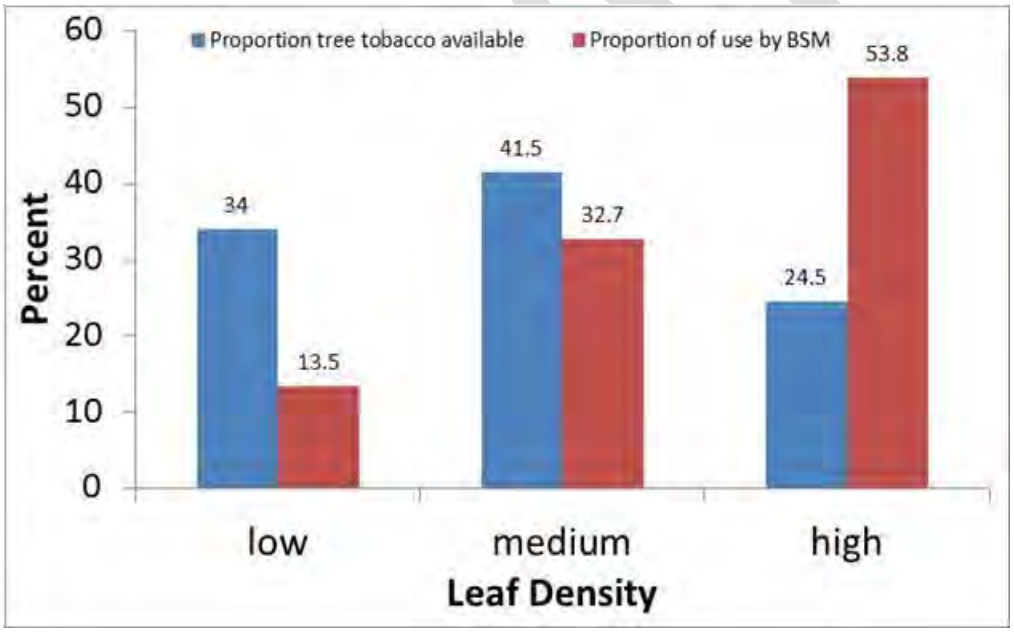

Figure 11.4 Percent of plants containing Blackburn's sphinx moth eggs and larvae. Blue bars represent the proportion of plants that were available for use by Blackburn's sphinx moth of each leaf density category (low, medium, and high, all blue bars sum to 100%). Red bars represent the proportion of the plants actually containing eggs and larvae (all red bars sum to 100%).

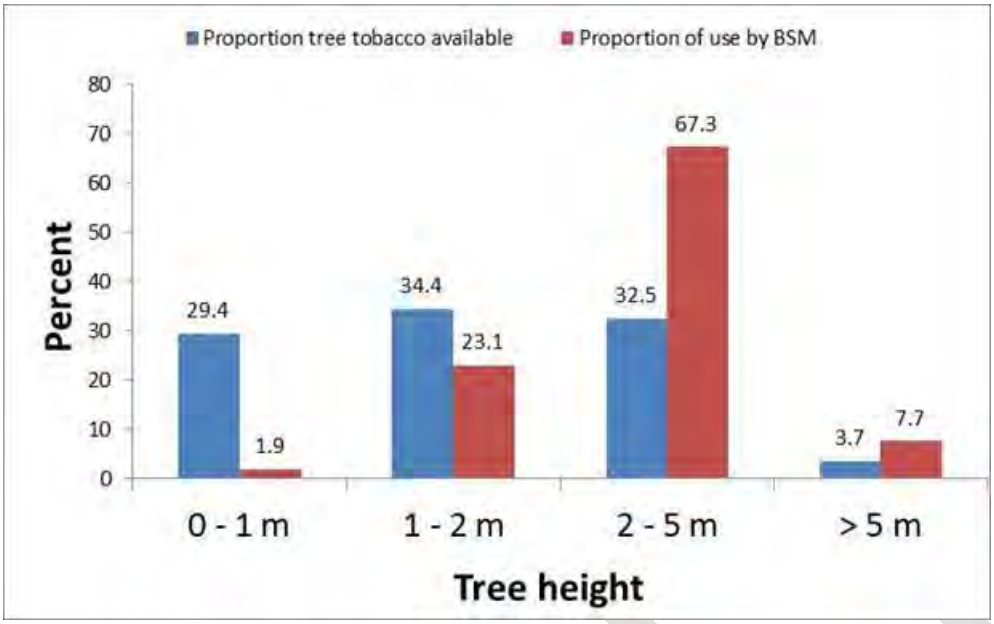

Figure 11.5 Percent of plants in a given size class containing Blackburn's sphinx moth larvae and eggs. Blue bars represent the proportion of plants available of each of the size classes (blue sums to 100%). Red bars are the proportion of the plants that actually contained eggs and larvae (red sums to 100%).

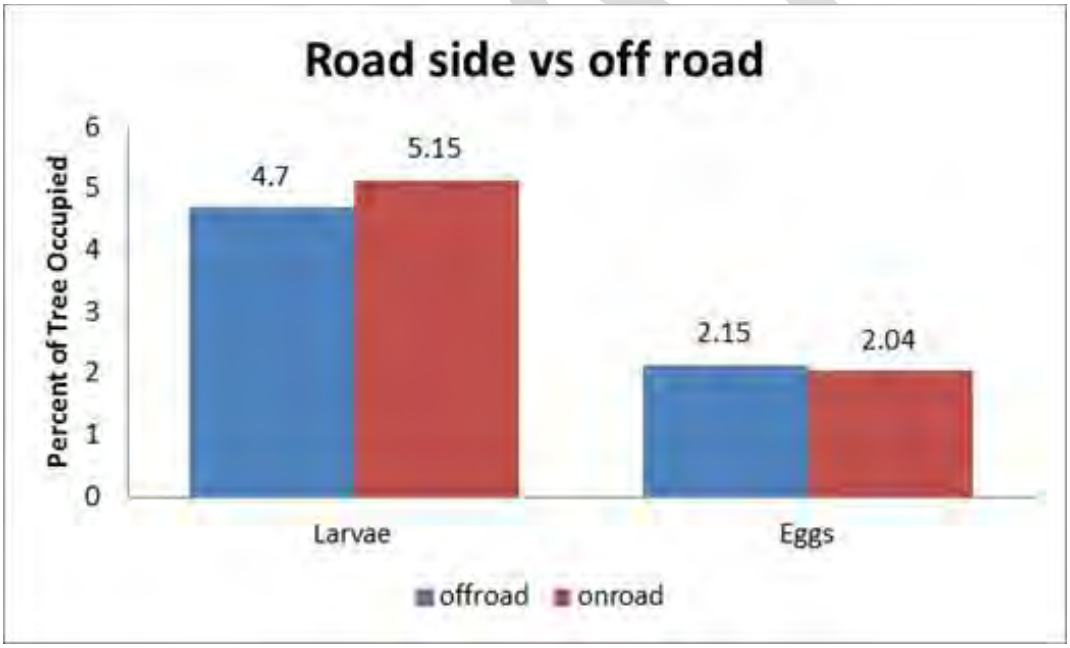

Figure 11.6 A comparison of tree tobacco plants that were occupied by Blackburn's sphinx moth based on location (on road transects (red bars) or on perpendicular off-road transects (blue bars)).

Manduca blackburni larval density/distribution on ʻAiea

To date, 17 ʻAiea 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 ʻAiea on two other instances in recent years, one on a wild individual and the other on an outplant on the Puʻu Waʻawaʻa 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 2,850 m^2 (38 x 75 m^2) and BSM density as 0.006 BSM/m^2 (17/2,850 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 1,766 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 1,458 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).

12 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 is 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 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 an 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 contains 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 fewer 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.

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14 APPENDIX G: GAME MANAGEMENT IN THE PLAN AREA

14.1 BACKGROUND

Hawai‘i’s game mammal management program provides public hunting opportunities across the state and Pu‘u Wa‘awa‘a FR and the Pu‘u Anahulu GMA (collectively the Plan Area) are popular hunting areas on the Island of Hawai‘i. 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 Hawai‘i as a food resource, beginning with the Polynesian introduction of the feral pig. A 10 year ban on the harvest of sheep and “other European animals” was set in 1794 to increase the stock. Mouflon were introduced to Hawai‘i in 1957 to improve the quality of the feral sheep (Tomich, 1986). Today, these game mammals continue to be an excellent source of food, in addition to providing opportunities for both recreational and subsistence hunting. The practice of recreational hunting has evolved in Hawai‘i 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).

Game mammals in Hawai‘i, however, are not native and have negative impacts on sensitive native species and ecosystems (Cabin et al., 2000; Campbell & Long, 2009; Coblentz, 1978; Cole, Litton, Koontz, & Loh, 2012; Miller & Travis, 1996; Nunez, Bailey, & Schweitzer, 2010; Spear & Chown 2009; Thaxton et al., 2010). 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. In particular, rare native plant species can be affected by ungulates and lead to reduced growth, reproduction, and survival leading to declines in the population.

Native plants in Hawai‘i 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 Hawai‘i, 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 & Vitousek, 2000; Brooks, Cordell, & Perry, 2009; Cabin et al., 2002; Cabin et al., 2000; Castillo et al., 2007; Cordell & Sandquist, 2008; Elmore & Asner, 2006; Thaxton et al., 2010). In particular, large-scale wildfires have eliminated large portions of dryland forest in Hawai‘i due to the buildup of alien grass biomass, creating a persistent grass-wildfire cycle (D’Antonio, Hughes, & Tunison, 2011; D’Antonio & Vitousek, 1992; Hughes & Vitousek, 1993; Hughes, Vitousek, & Tunison, 1991). 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 Hawai‘i’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 Hawai‘i, and a summary of game management in the Plan Area.

Public hunting will occur in the Plan Area outside of fenced-off and ungulate free conservation units. All endangered and threatened species which occur outside of the exclosures are considered subject to take through browsing, grazing, and trampling by ungulates. As such, take estimates have been generated based on known plant locations, in addition to model predictions in unsurveyed areas.

14.1.1 Feral Pigs (*Sus scrofa*)

Pigs were the first ungulates (hooved mammals) introduced to the Central Pacific Islands by the earliest colonists to Hawai‘i as a food source over 1000 years ago (Kirch 1982, Hess and Jacobi 2011,Tomich 1986). In 1793, other pig varieties, notably the European boar, were introduced to Hawai‘i and presumably hybridized with the pacific variety (Nogueira-Filho, Nogueira, & Fragoso, 2009; Tomich, 1969; Ziegler, 2002). 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.

14.1.2 Feral Sheep (*Ovis aries*), Mouflon Sheep (*Ovis musimon)*, and Hybrids

Feral 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. Mouflon sheep are native to the Mediterranean region but have become widely distributed throughout Europe through human introductions. They were first introduced to Hawai‘i, on the island of Lāna‘i in 1954 (Medeiros, 1954) and on Hawai‘i Island shortly thereafter. Mouflon generally travel in small herds and are well adapted to dry, rugged regions. Hybrids between feral and mouflon sheep are well known and completely interfertile. Hybridization was intentionally carried out in breeding projects to increase the quality of big game in Hawai‘i. Hybridization also occurs readily in the wild, and crossbred animals tend to flock with feral sheep (Tomich 1986).

Sheep are generally considered grazers, preferentially consuming grass, but they can also browse woody vegetation such as māmane (*Sophora chrysophylla*) (Scowcroft and Giffin 1983). 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. (ISSG, 2010; Ripley, 1974; Scowcroft & Giffin, 1983). A study of sheep movement patterns (*See appendix A*) 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.

14.1.2 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 (Hess & Jacobi, 2011; Scowcroft & Giffin, 1983; C.P. Stone & Anderson, 1988)(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 Pu‘u Wa‘awa‘a Ranch, large goat drives were conducted by early ranchers where goats were pushed to lower elevations at Kīholo Bay and dispatched (Maly & 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 (Hwy 190) surrounding the Hawai‘i Island Country Club in Pu‘u Anahulu, though other populations exist near Pu‘u Wa‘awa‘a itself and along the Māmalahoa Highway. The calculated home range for goats in the Plan Area is 16.3 km^2 (See Appendix A).

14.2 PUBLIC HUNTING FOR GAME MAMMALS

Though introduced game mammals in Hawai‘i can have negative impacts on the environment, they also provide economic and social value. Specifically, game mammal management offers the opportunity for the State of Hawai‘i to uphold its mandate to, “preserve, protect, and promote public hunting,” (HRS § 183D-2(12)). Hunting can be an effective tool to minimize the damaging effects that game species may have on natural ecosystems (Conover 2001). Hunting can also provide a mechanism for establishing elaborate human-human relationships and enhanced social interactions (Tadie and Fischer 2013), for the people of Hawai‘i. It has also been shown that hunting positively contributes to the economy, with over $33 billion spent on hunting and hunting-related activities in the United States in 2011 (Poudel et al. 2016).

Game mammal hunting in the Pu‘u Wa‘awa‘a Forest Reserve and the Pu‘u Anahulu Game Management Area is regulated by the Hawaii Administrative Rules Title 13, Chapter 123, “Rules Regulating Game Mammal Hunting.”(http://files.hawaii.gov/dlnr/dofaw/rules/Chap121a.pdf) Hunting programs, seasons, and bag limits have changed several times over the last two decades, and this is demonstrated by hunter harvest records (Figure 1). On January 25, 2002 the Board of Land and Natural Resources transferred responsibility for State managed lands within the ahupua‘a of Pu‘u Wa‘awa‘a and Pu‘u Anahulu from the Land Division to the Divisions of Forestry and Wildlife (DOFAW) and State Parks.

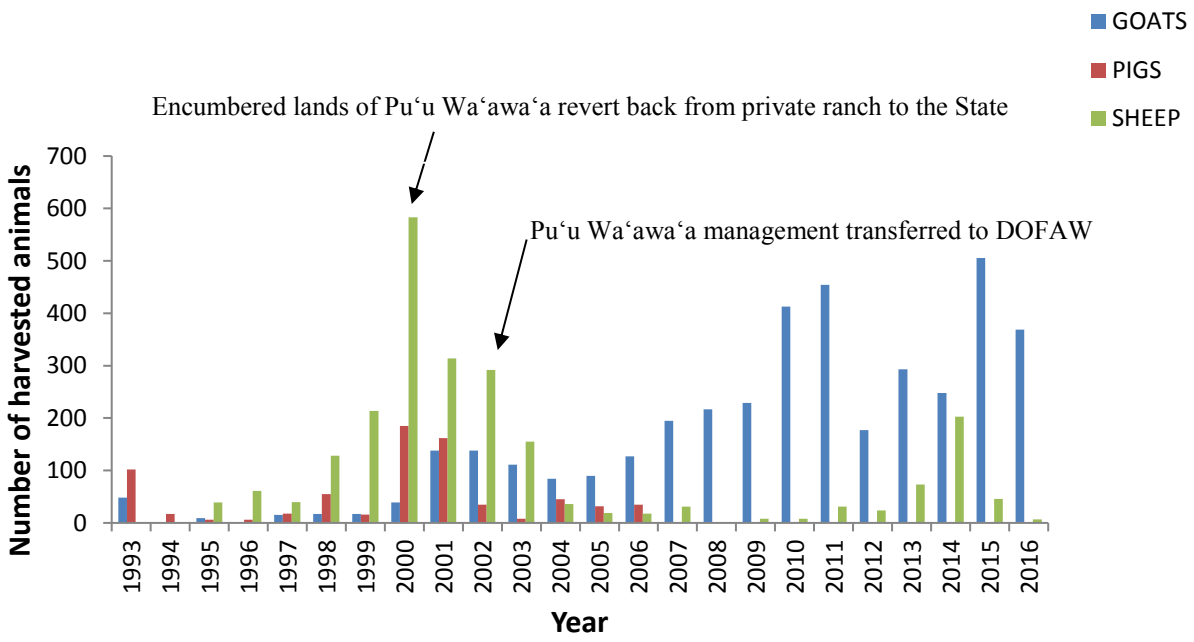

Figure 14.1 Historical trends in number of animals harvested (goat, sheep, and pig) from 1993 to 2016 at Puʻu Waʻawaʻa Forest Reserve (includes both nuisance control permits and regular hunting).

Hunting in the Puʻu Anahulu Game Management Area, East Section (Hunting Unit E, Figure 14.2) is open annually for archery hunting from March through June on weekends and State Holidays. Hunters must buy tags to harvest one ram and two goats of either sex. This is both the daily and season limit. One pig may be harvested with no need to purchase a tag.

Hunting in the Puʻu Waʻawaʻa Forest Reserve and the Puʻu Anahulu Game Management Area, West Section (Hunting Unit F, Figure 14.2) is open for 7 weekends and State holidays, beginning with the first Saturday in August (Table 14.1) The first 4 weekends are open to archery, while the last 3 weekends are open to muzzleloader. In each of these seasons, hunters must buy tags and may harvest one non-typical ram (polled or deformed horned rams) and three goats of either sex. This is both the daily limit and the season limit for each season. There is also a special Youth and Disabled hunting area that is open on weekends and State holidays for the month of August. Hunters in this special hunt must purchase tags and may harvest one typical ram and three non-typical rams. This is both the daily and the season limit (Table 14.1). One pig may be harvested with no need to purchase a tag.

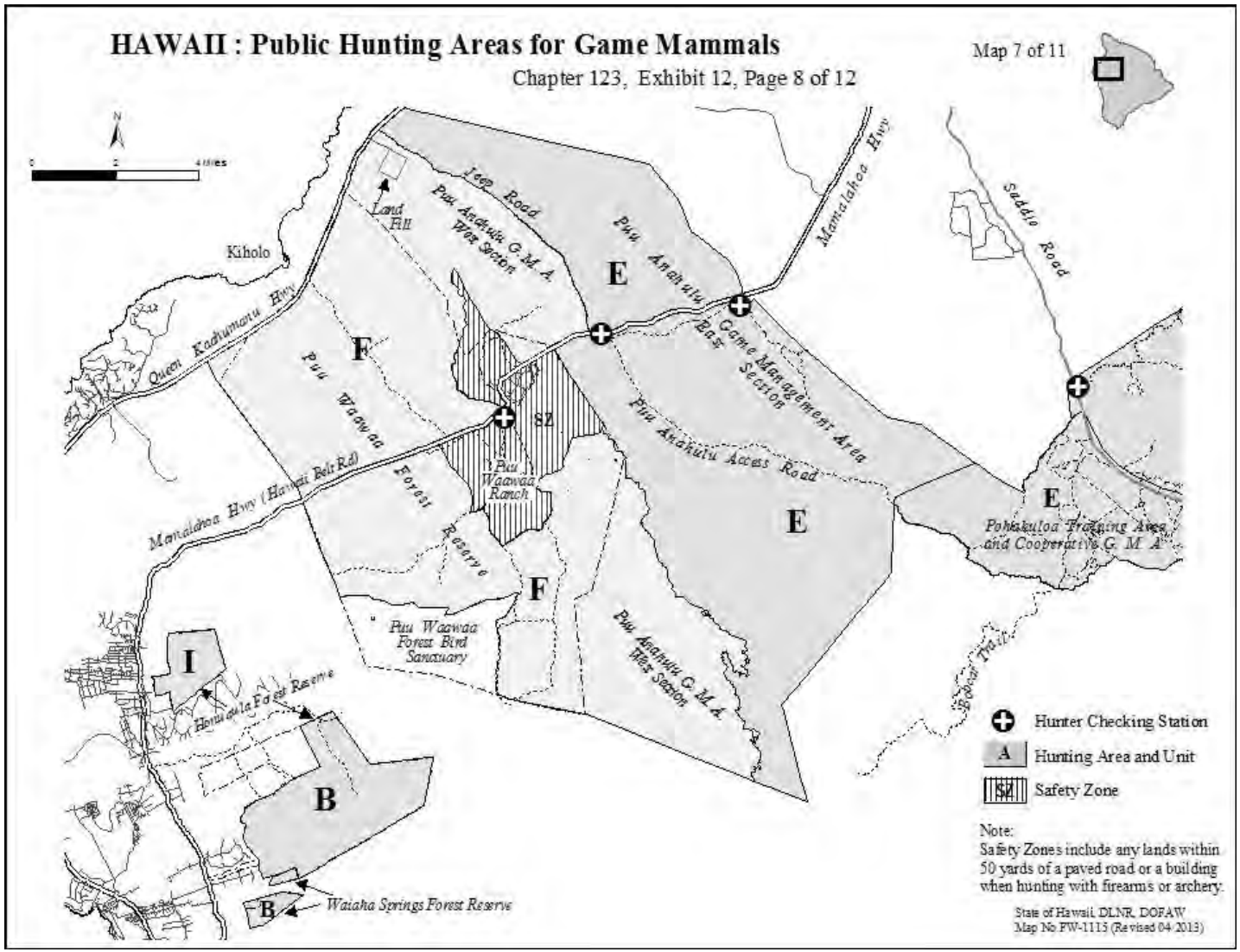

Figure 14.2 Map of public hunting units within the Project Area.

Table 14.1 Summary table of hunting rules for the Project Area.

Hunting Unit	Game Mammals to be Taken	Means of Take	Bag Limits	Open Hunting Periods	Open Hunting Days	Special Conditions and Restrictions
E Pu‘u Anahulu Game Management Area (GMA), East Section	Feral pigs, wild sheep and feral goats	Archery only. Dogs not permitted.	One pig, one ram and two goats per hunter per season	March through June	Saturday, Sunday, and State Holidays	Tags required at Pu‘u Anahulu East Section** Pu‘u Anahulu East Section
F Pu‘u Wa‘awa‘a Forest Reserve (mauka & makai) and Pu‘u Anahulu Game Management Area, West Section	Feral pigs, wild sheep and Feral goats	Special Youth & Disabled Archery (Pu’u Lani Safety Zone). Dogs not permitted.	Three non-typical rams and one typical ram per hunter per day. This is also the season limit.	August	Saturday, Sundays, and State Holidays	Tags required
		General archery (makai only) Dogs not permitted.	One pig, one non-typical ram, and three goats per hunter per day. This is also the season limit	Four consecutive weekends beginning the first weekend in August		Tags required
		Muzzle loader rifles (makai only). Dogs not permitted.		Three weekends following the end of the general archery season		

14.3 GAME ENHANCEMENT ACTIONS

In this Plan, game management actions are designed to improve game population health and genetics, increase distribution and abundance as appropriate and needed, and to minimize and mitigate their impacts on native species and ecosystem processes. These actions will be categorized under four main sections: Game Habitat Enhancement, Game Population Management, Monitoring, and Mitigation.

14.3.1 Game Habitat Enhancement

Healthy game populations are dependent upon the availability of high quality habitat that adequately provides the resources necessary to promote growth and minimize the risk of mortality. These basic resources include cover, nutrition, water, and space. Fencing and removing game mammals from the proposed exclosures in the Plan Area will likely eliminate much of the highest quality game habitat. Thus, game habitat enhancement will be necessary to accommodate for this loss and others (*i.e.,* due to wildfire, drought, invasive species, etc.). It will also be required to accommodate for any other habitat deficiencies that may occur during the duration of the project. The primary habitat improvements that will be covered under this Plan are the establishment of food and cover plots, water unit installation and maintenance, and mineral supplementation.

14.3.1.1 Food and Cover Plots

Food plots are a common habitat management tool used to provide supplemental nutrition for game populations (Yarrow and Yarrow 1999) and to replace undesirable plant species. Food plots will be used to help compensate for reduced food availability during fluctuations in resource abundance. Cover is an important resource for game species that can provide protection from predators, relief from the elements, and facilitate migratory behavior. Current monitoring of sheep in the Plan Area shows that forested areas are the most used habitat (Adams *et al*, unpublished data).

To establish food and cover plots, outplantings of native and non-native plant species will be necessary. Non-native plant species used for these actions will be carefully evaluated for their potential to become invasive or noxious. The Hawai‘i-Pacific Weed Risk Assessment is a rating program that analyzes the risk of non-native species becoming invasive in Hawai‘i if introduced. This is done through an extensive literature review through the University of Hawai‘i (http://www.botany.hawaii.edu/faculty/daehler/wra/). Food and cover plots established in the Plan Area may be planted with both native and/or non-native, non-invasive plant species that have a weed risk assessment rating of <1 (Low Risk via Hawai‘i-Pacific Weed Risk Assessment).

14.3.1.2 Mineral Supplementation

Mineral supplementation is often used increase the nutrition and thus health of game mammals in areas with nutrient deficient or depleted soils which produce nutrient-poor forage. Results of recent blood tests for sheep in the Plan Area showed low levels of essential minerals (Adams *et al*., 2016, unpublished report). Therefore, if reduced mineral availability leads to loss of fitness of game, mineral supplementation may be needed in order to ensure healthy game populations.

Mineral supplements will be provided when needed by placing mineral blocks in the vicinity of water units (see below).

14.3.1.3 Water Guzzlers and Troughs

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 Ka‘ahumanu Highway (Giffin 2009, Giambelluca et al. 2013). Because drought and variable rainfall affect water resources for game mammals and contribute to water scarcity, supplemental water will be needed in order to ensure healthy game populations.

There are currently 48 watering units scattered across different elevations and habitat types within the Plan Areat (Figure 14.4) that provide catchment water for game mammals. There are two types of units, game guzzlers and water troughs. Game guzzlers (Figure 14.3) are watering units 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 container and a float valve shuts off the water when the water reaches a certain level in the container to prevent overflow. Similarly, water troughs are long narrow open tanks with a float valve to refill as it is emptied and are usually attached to waterlines that are found throughout the Forest Reserve and fed by reservoirs, catchment, and wells. Watering units will not be placed near 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 water units will be built until Phase I of the HCP is complete or all avoidance and minimization fences are built. This will help ensure that water units don’t draw game mammals to sensitive resources prior to the completion of the planned exclosures. During the 25 year ITL permit duration, we anticipate a maximum of two new supplemental game watering units installed annually, for a total of 50 new units. These water units will be activated and inactivated as appropriate to influence game mammal movements and distribution. Using water units to change the distribution of game mammals across the landscape will help alleviate pressures caused by high concentration of animals in a given area. All active game guzzlers currently located within proposed exclosures will be either relocated to other locations outside of proposed fence units or will be fenced off to restrict access by feral ungulates, leaving them accessible to game birds only.

Locations for new water units will be selected using the following criteria: 1) does not disturb or destroy culturally sensitive landmarks, structures, or sites, 2) the footprint of the unit does not include any rare, threatened, or endangered plant species or any large native trees (i.e. ‘‘Ōhi‘a and Koa trees, etc.).

Figure 14.3. Game guzzler located in the PAHGMA. Float valve and trough in the foreground, connected to the catchment system pictured in the background.

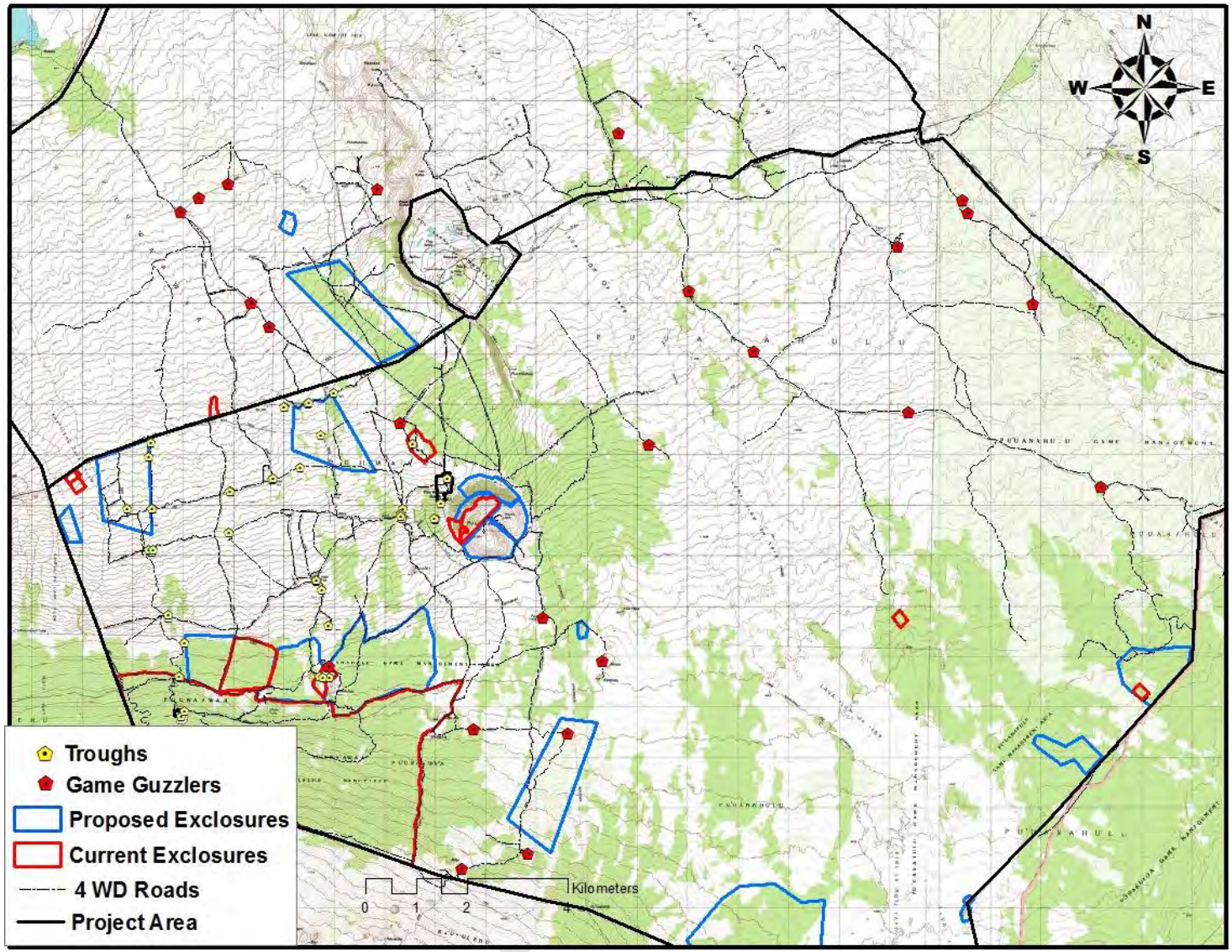

Figure 14.4. Game guzzler and trough locations in the Plan Area.

14.3.2 Game Mammal Population Management

While high quality habitat is the foundation of robust game populations, there are other factors that affect the long-term viability of a population. Population abundance, survival, growth (*i.e.*, reproduction, augmentation, etc.), and mortality (*i.e.*, hunter harvest, predation, etc.) are all important factors that must be documented and managed to achieve and maintain healthy game populations.

14.3.2.1 Measuring Population Abundance, Survival, and Reproduction

Estimating the relative abundance of game species in the Plan Area is critically needed information for making wise management decisions regarding harvest limits and acceptable impacts on habitat. Relative abundance of feral sheep, goats, and pigs will be estimated in the Plan Area by DOFAW staff using roadside and aerial surveys and/or through camera trap studies. These surveys will produce data about sex ratios and offspring-parent ratios. Managers will also use tagged/collared individuals to monitor movements, habitat use, and survival rates. These data will provide an index of changing ungulate abundance over time that can be correlated with environmental variables and habitat impacts.

14.3.2.2 Game Mammal Population Augmentation

Population augmentation using translocation and captive breeding has been a wildlife management tool for as long as humans have been managing game (Seddon et al. 2012). To increase hunter opportunity in the Plan Area, populations of current ungulates species present (specifically mouflon, feral sheep and feral goats) may be supplemented and increased based on estimated relative abundance, hunting pressure, habitat condition, and environmental impacts. Temporary holding pens may be installed to help translocated animals acclimate to the area.

14.3.2.3 Harvest

Public hunting will be the primary tool used to regulate game mammal population abundance. The overall goal will be to provide as many hunting opportunities as the surrounding habitat and the game populations themselves are able to sustain without net negative impacts to overall forest health. This may lead to future changes in the current hunting rules, allowing for additional seasons (*i.e.*, general rifle, ram, ewe, etc.) to be instituted. Hunting seasons and bag limits will be managed to maintain a target abundance for both sheep and goat populations that minimize and avoid habitat degradation. Other restoration actions will also be used to mitigate for the effects of these game mammals on the surrounding habitat (for example, planting other native shrubs and trees inside conservation units).).

Goals for game mammal densities will be based on the demand expressed by the hunting community, as well as results from forest health monitoring. Recent ram archery hunts have received over 400 applications. This demand, coupled with the loss of several other hunting areas across the state, suggests that a rifle season would receive similar numbers of applications as the Lāna‘i sheep hunts (1500 – 2500 applications). Currently, sheep and goat populations are

generally separated by Hawai‘i State Highway 190 (Māmalahoa Highway), with the majority of the sheep population located mauka (east of Highway 190) and the majority of the goat population located makai (west of Highway 190). Small populations of sheep and goats exist on the west and east side of Highway 190, respectively.

14.3.2.4 Predator Control

While there are no native, natural predators of sheep, goats, or pigs in Hawai‘i, dogs (*Canis familiaris*) are known predators and were introduced by the first Polynesian settlers to the islands. Wild dogs were documented on Hawai‘i Island as early as 1890-1892 (Maly and Maly 2005). Predation by wild dogs has been recently found to be the primary cause of mortality of sheep in Pu‘u Wa‘awa‘a and Pu‘u Anahulu (Adams *et al*., 2016, unpublished report). Efforts to reduce predator abundance will include trapping and other opportunistic removals by DOFAW staff.

14.3.2.5 Staff Control

While public hunting will be the preferred method to control game mammal populations, staff control will be used as a last resort, should population densities and their effects on the habitat exceed acceptable limits. This will include, but will not be limited to, DOFAW staff hunts, trapping, and aerial control (DLNR 2007).

14.4 MONITORING

Below is a preliminary description of the monitoring plan for game mammals and their environmental impacts. A more detailed monitoring plan will be developed during Phase 1 of implementation once baseline data has been collected and analyzed from current and ongoing wildlife and vegetation research being conducted in the Plan Area.

14.4.1 Game Mammal Population Modeling

Information gathered through research on game populations and their habitats will be used to assess the level of impact these animals are having on the overall ecosystem. Geospatial information collected from collared individuals will demonstrate which areas game mammals use most and which areas are preferred or avoided. Population surveys will yield relative abundance estimates. This information will then be correlated with environmental variables (see vegetation monitoring protocols listed below) to evaluate if habitat damage is occurring and if mitigation actions are required.

14.4.2 Forest Health, Vegetation & Ungulate Impacts Monitoring

A healthy forest is important for maintaining native biodiversity as well as for maintaining ecosystem services such as water recharge in the aquifer, forest products, game mammals for hunting, and ample native species for cultural gathering. Because non-native game mammals in Hawai‘i can degrade native forests, it is important to monitor their impacts to determine whether

native forest cover is declining, plant community composition and structure is changing, or individual native species are affected by their presence. The Vegetation Monitoring program will be set up to look for and detect trends over time in forest cover, selected ecosystem properties, and native species abundance and distribution so that adaptive management can be used to mitigate harm to native species and ecosystems.

The Vegetation Monitoring program will consist of three steps: 1) establishing a baseline of forest cover across the plan area, 2) creating vegetation association maps of the plan area based on forest cover, and 3) establishing randomly stratified transects within the different vegetation associations where ungulate signs and environmental impacts can be monitored. Once permanent transects are set up they will be monitored every other year for ungulate sign and native cover. Results from monitoring will inform future management of game mammals through adaptive management. Here are the three steps in more detail:

1. **Forest Cover Baseline:** abundant native and non-native plants will be mapped and classified using remote sensing technology including LiDAR and spectrometry across the plan area. Abundant native species will include common species such as Koa, ʻŌhiʻa, Māmane, ʻAʻaliʻi, Kōlea, and others, and abundant non-native species will include Silver Oak, Jacaranda, Pepper tree, and others. Remote sensing will classify trees to individual species and maps will be generated showing the majority of the locations and abundance of trees within the plan area. Future surveys using similar remote sensing data will be used to detect trends in forest cover and individual species over time. These surveys will be performed every 5 years.

2. **Vegetation Association Maps:** using the data from above, maps of individual tree species will be used to create vegetation associations such as native lowland dry forest, mixed mesic forest, native-dominated ʻŌhiʻa forest, invasive silver oak forest, grassland, savannah, etc. These vegetation associations will be converted to polygons in GIS and be used to place random stratified transects for measuring ungulate impacts and plant population trends.

3. **Transects for Ungulate Impacts and Plant Populations:** randomly placed and stratified transects in different vegetation associations will be used to determine ungulate impacts to plants and ecosystem properties in the Plan Area. Transects will be for both ungulate sign as well as for individual species as needed. Measured will include:
    a. Feces, tracks, rubbings, wallows, and signs of erosion due to mammal activities
    b. Bark stripping of native and non-native trees, browsing signs on native plants, grazing of native understory species
    c. Density and cover of vegetation in the understory

The goal of vegetation monitoring will be to determine what direct impacts game mammals are having on plants and ecosystem properties, as well as on erosion in the Plan Area. This information will be tied back into adaptive management so that if mammal populations are too high and impacts are unacceptable (e.g. too much bark stripping of native trees), then population abundance can be brought back down to a lower abundance. Certain plant species will likely be preferred browse and may be able to act as indicators for ungulate density and impacts. These species may be targeted for more intensive sampling along transects to look at plant population abundance or density so that this can be correlated with ungulate relative abundance.

14.5 ADAPTIVE MANAGEMENT

Adaptive management is the process using monitoring tools and data to inform action to maintain a balance between hunter satisfaction, environmental health, game population health, and fire risk management. It will involve constant evaluation of data quality, data collection, and developing innovative solutions to mitigate impacts. 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.

Game mammal management will be an adaptive process where: 1. management goals determine game mammal abundance and distribution, 2. information is gathered on the effects of game mammals on plants and ecosystem properties, and 3. this information is used to determine future game mammal abundance and distribution. This monitoring process is intended to be long term and it is likely that game mammal abundance along with many other factors such as wildfire, drought, pests and disease, and anthropogenic effects will all have important effects on ecosystem structure and function. Game mammal management will be adaptive based on the extent to which game mammal impacts can be separated out from these other impacts through the use of exclosures, monitoring, and transect surveys.

15 APPENDIX G: FUNDING MATRIX

The following pages contain three tables outlining the funding matrix for this HCP. Table 16.1 covers years 0-8 (Avoidance and Minimization), table 16.2 covers years 9-15 (Mitigation), and table 16.3 covers years 16-25 (Maintenance).

Table 16.1

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							
ʻAiea	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				
Puʻu 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							
ʻAiea	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							
Puʻu 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										
ʻAiea	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										
Puʻu 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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