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

Draft North Kona Game Management Habitat Conservation Plan

Island of Hawai‘i

3/2/2015

EXECUTIVE SUMMARY

The Hawaiʻi Department of Land and Natural Resources (DNLR), through the Division of Forestry and Wildlife (DOFAW), manages lands in the Puʻu Waʻawaʻa Forest Reserve (PWW FR) and the Puʻu Anahulu Game Management Area (PAH GMA), in North Kona, on the Island of Hawaiʻi. The area is home to native bird, plant and invertebrate species as well as non-native game mammal and bird species. Current land management in the Puʻu Anahulu Game Management Area is primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat. Puʻu Waʻawaʻa Forest Reserve is a multi-use area where management includes game population maintenance for hunting, natural resource conservation and restoration, and other activites such as cattle grazing and trail use.

This Habitat Conservation Plan (HCP) is intended to consider and mitigate for the potential impacts from DOFAW game mammal management activities on endangered species within the Puʻu Waʻawaʻa and Puʻu Anahulu areas (Plan Area 103,988 acres). Potential negative impacts on Covered Plant species are primarily in the form of direct take from grazing, browsing, and soil disturbance 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. 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, primarily 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, 4114 acres (3.9 % of Plan Area) are fenced within seven exclosures across the Plan Area, and additional 4,066 acres (3.9% 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.

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ACRONYMS

AS	Apparently Secure
ATV	All-terrain Vehicle
BLNR	Board of Land and Natural Resources
BSM	Blackburn's Sphinx Moth
CE	Critically Endangered
CH	Critical Habitat
CTTIA	Core Tree Tobacco Infestation Area
DDIT	DLNRDOFAW Implementation Team
DLNR	Department of Land and Natural Resources
DOFAW	Division of Forestry and Wildlife
EA	Environmental Assessment
ESA	Endangered Species Act
ESRC	Endangered Species Recovery Committee
FBS	Forest Bird Sanctuary
FR	Forest Reserve
FWS	Fish and Wildlife Service
GIS	Geographic Information System
GMA	Game Management Area
GPS	Global Positioning System
HCP	Habitat Conservation Plan
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
NAR	Natural Area Reserve
NEPA	National Environmental Policy Act
NKGMHCP	North Kona Game Management Habitat Conservation Plan
PAH GMA	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	Pohakuloa 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
USFWS	United Stated Fish and Wildlife Service
UTM	Universal Transverse Mercator

1.0 INTRODUCTION AND PLAN OVERVIEW

1.1 SUMMARY

The Hawaiʻi Department of Land and Natural Resources (DNLR), through the Division of Forestry and Wildlife (DOFAW), manages lands in the Puʻu Waʻawaʻa Forest Reserve (PWW FR) and the Puʻu Anahulu Game Management Area (PAH GMA), in North Kona, on the Island of Hawaiʻi.The proposed Plan Area (total of 103,988 acres) is on the western side of North Kona, includes the Puʻu Waʻawaʻa Forest Reserve (TMKs 3-7-1-003-001, 3-7-1-004-001 and 3-7-1-004-018) and Puʻu Anahulu Game Management Area (TMKs 3-7-1-001-001, 3-7-1-001-004, 3-7-1-001-006, 3-7-1-001-007, 3-7-1-002-001, and 3-7-1-002-013)(Figure 1.1). The area is home to native and non-native game, bird, plant and invertebrate species. Current land management in the Puʻu Anahulu Game Management Area is primarily for maintenance of non-native game mammal populations for hunting, in addition to conservation of native habitat. Puʻu Waʻawaʻa Forest Reserve is a multi-use area where management includes game population maintenance for hunting, and natural resource conservation and restoration, as well as other activites 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 federally listed plant species[1]: *Asplenium peruvianum* var. *insulare*, Uhiuhi (*Caesalpinia kavaiensis*), Kauila (*Colubrina oppositifolia*), Honohono (*Haplostachys haplostachya*), Ma'o hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*), Kokiʻo (*Kokia drynarioides*), *Neraudia ovata*, ʻAiea (*Nothocestrum breviflorum*), Hala pepe (*Pleomele hawaiiensis*), Poʻe (*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 soil disturbance associated with the management of game mammals and cattle in the Plan Area. Potential impacts to Blackburn's sphinx moth larvae and eggs are primarily from the clearing and maintenance of fuel breaks and four-wheel drive access roads. No other listed, proposed, or candidate plant or animal species are anticipated to be taken by Plan activities.

State (HRS 195-D) and Federal (Endangered Species Act) law requires provisions for protected species impacted by Plan actions and therefore, DLNR is seeking an Incidental Take License (ITL) in accordance with Chapter 195-D, Hawaiʻi Revised Statutes. This permit is issued by the DLNR.The Habitat Conservation Plan (HCP) supports the issuance of this permit, and describes how the Applicant will avoid, minimize, mitigate, and monitor the incidental take of endangered species that may occur in the Plan Area during the management and maintenance of non-native game mammals and hunting within the PWWFR and PAHGMA. The HCP will integrate components of the Puʻu Wa'awa'a Management Plan (PWWMP) (2003), as well as the developing Game Management Plan for Hawaiʻi. The HCP outlines a monitoring protocol to determine successful mitigation for each species throughout the duration of game management activities in the Plan Area. Additionally, this HCP incorporates

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[1] A number of taxonomic changes have taken place during the development of this HCP. We have compiled a list of taxonimically accepted names for species (Appendix F) that we are aware of and left the commonly used names in the document for ease of understanding and use.

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 and Federal endangered species law.

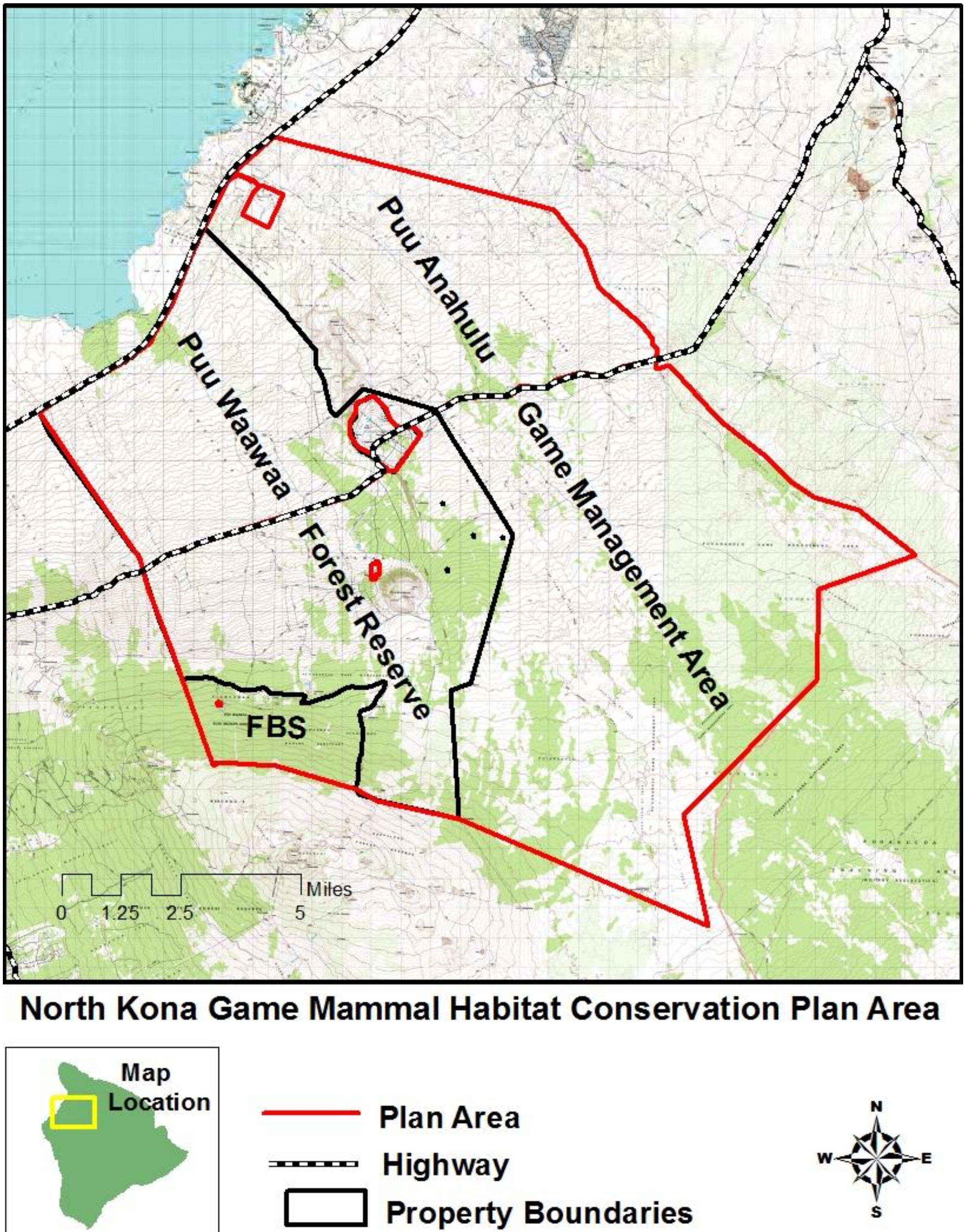

Figure 1.1 Plan Area (103,988 acres), including Puʻu Waʻawaʻa Forest Reserve, Puʻu Anahulu Game Management Area, and the Puʻu Waʻawaʻa Forest Bird Sanctuary, North-Kona, Island of Hawaiʻi. Internal red outlines signify private inholdings and are excluded from the Plan Area.

1.2 REGULATORY SETTING

1.2.1 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] §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 the Big Island Plant Cluster and Blackburn's sphinx moth (USFWS 1996, 2005). The biological goals and objectives identified in Section 4.0 are consistent with these recovery plans.

1.2.2 Chapter 195D, Hawai'i Revised Statutes

The purpose of Chapter 195D of Hawai'i Revised Statutes (HRS) is "to insure 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…" (Section 195D-1). Section 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 [Section 195D-4(e)]. Under Section 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; and
- 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, which are similar to those in federal regulations. According to this section, HCPs submitted in support of an ITL application shall:

- 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;
- 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;
- 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;
- 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;
- 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;
- 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;
- 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; and
- 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 Hawaiʻi (Section 195D-30).

1.2.3 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. The environmental assessment (EA) is currently being drafted.

1.2.4 National Historic Preservation Act

Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §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 to 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 Office on cultural resources and address any potential issues in the EA.

1.3 PLAN DESCRIPTION

1.3.1 Plan History

The PWWFR and lands just northeast within PAHGMA have been identified as the Plan Area (103,988 acres) for the purpose of this HCP. In 2003, DLNR adopted a *Management Plan for the Ahupuaʻa of Puʻu Waʻawaʻa and the Makai Lands of Puʻu Anahulu* (PWWMP). Currently, the lands within the Plan Area are being managed for grazing of non-native mammals, fire management, natural resource management, and public hunting according to the guidelines in the Management Plan. In particular, management for endangered plants involves the construction of fence exclosures, the maintenance of existing exclosures, fence maintenance, outplanting, and weed control for 22 conservation units ranging in size from 10 to approximately 4000 acres for a total of approximately 8,180 acres. Currently, 4,114 acres within seven exclosures are fenced within the Plan Area. Fifteen of the units, an approximate total of 4,066 acres (3.9 % of the Plan Area) will be newly 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, larval Blackburn's sphinx moth surveys, a multi-year game mammal study (Appendix A), and a vegetation monitoring study (Appendix C) have been conducted to identify game mammal home ranges, the location of endangered species within the Plan Area, and 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 extrapolate Covered Species population size to unsurveyed areas. The survey and extrapolation 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 Pohakuloa Training Area (PTA) border where a boundary fence limits ungulate ingress (fig. 1.2).

Background information from the Management Plan applies directly to the HCP, and is therefore repeated here (2003:1-5)[2]. In addition, the coverage area of the Management Plan does not extend into the mauka lands of Puʻu Anahulu, and there is currently no 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.

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

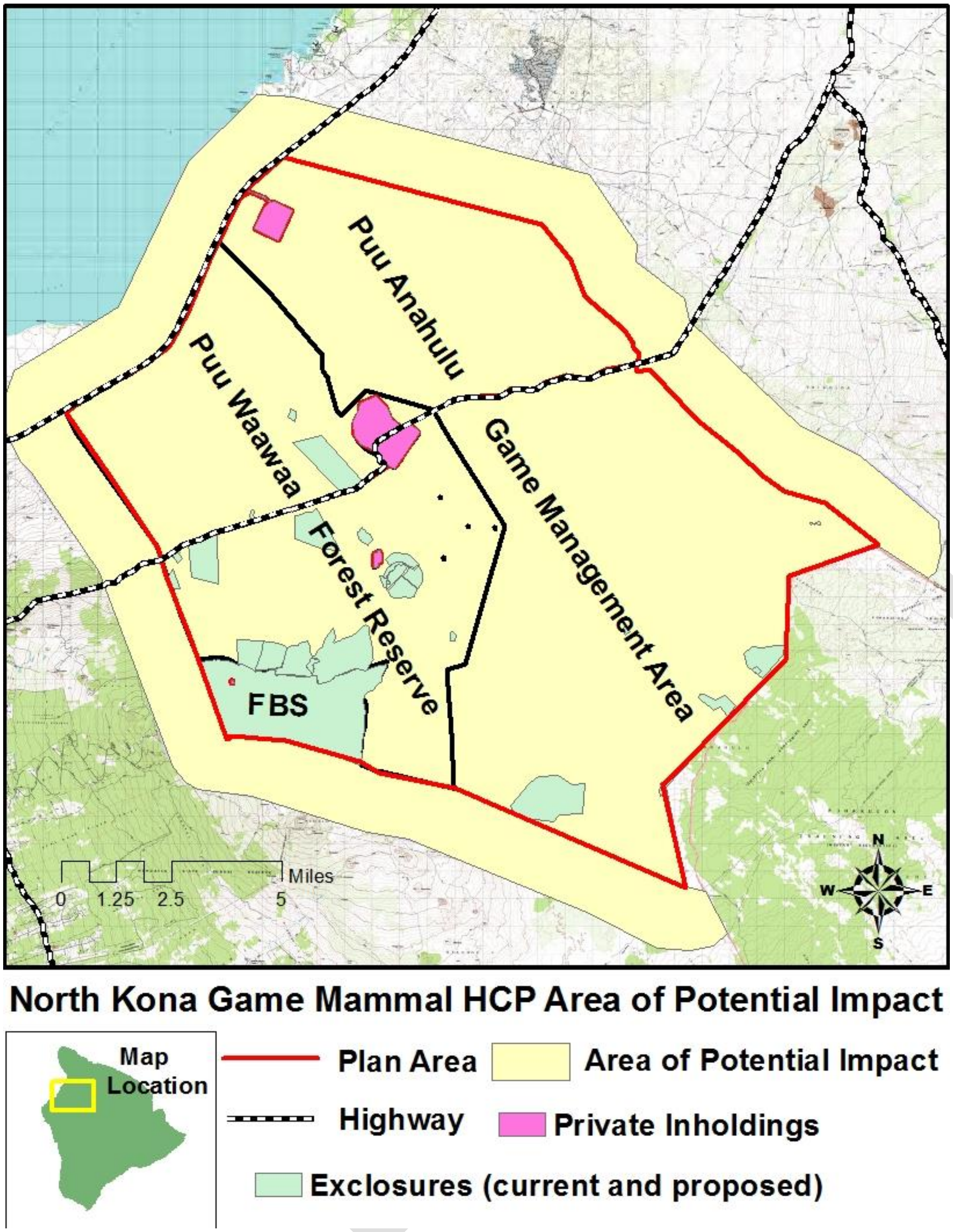

Figure 1.2. Area of Potential Impact (139,783 acres). This area includes the Plan Area with private inholding and exclosure acreages removed plus a 2.25 km buffer to include those areas potentially impacted by ungulates residing in the Plan Area. The buffer is based on empirical evidence from radio collar data. No buffer is included for the uphill ('Mauka') boundary because a fence along that boundary prohibits movement of game mammals in that direction.

1.3.2 Purpose and Need for the Plan

Hawaii'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 Section 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. Section 183D-3 further mandates that the Department shall adopt rules protecting, conserving, monitoring, propagating, and harvesting wildlife and under 183D-4, and that the Department is given the authority to maintain, manage, and operate game management areas, wildlife sanctuaries, and public hunting areas for these purposes. Within the DLNR, DOFAW has been delegated the management responsibility for terrestrial wildlife and the game management component of that program. It is because of this mandate that game mammal management occurs at Puʻu Waʻawaʻa and Puʻu Anahulu. This HCP seeks to strike a balance between the needs of the game management program and the protection of the native biota found in the area.

1.4 COVERED ACTIVITES: Game Management in the Plan Area

Hawaiʻi's game mammal management program provides opportunities for public hunting. However, game mammals in Hawaiʻi are not native and some may have negative impacts on sensitive native species and ecosystems (Coblentz 1978, Cabin *et al*. 2000, Campbell and Long 2009, Spear and Chown 2009, Nunez *et al*. 2010, Thaxton *et al*. 2010, Cole *et al*. 2012). Because of this, management must direct both game and hunting activities towards less sensitive areas. Puʻu Waʻawaʻa FR and the Puʻu Anahulu GMA (collectively the Plan Area) are actively managed for game mammals, and both contain a significant area of tropical dry forest (Giffin 2009), which is a globally endangered ecosystem (Miles *et al*. 2006, Thaxton *et al*. 2010). Game mammals in the Plan Area include feral pigs (*Sus scrofa*), feral sheep (*Ovis aries*) and feral goats (*Capra hircus*). The following is basic information on the history of the introduction of these species, their basic effects on the structure and function of ecosystems in Hawaiʻi, and their current abundance and distribution in the Plan Area.

1.4.1 Background

The only two mammals that are native to Hawaiʻi are the Hawaiian hoary bat (*Lasiurus cinereus semotus*) and the Hawaiian monk seal (*Monachus schauinslandi*) (Tomich 1969). 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 to protect them (Stone 1984). Ungulates can influence plant individuals, populations, communities, and the fluxes and pools of nutrients within ecosystems (Pastor *et al*. 1988, Hobbs 1996, Douglas and Evans 1997, Augustine and McNaughton 1998). Within tropical dry and mixed-mesic ecosystems in Hawaiʻi, the effects of non-native ungulates on the environment interact with other factors including drought, invasive plants (e.g. fountain and kikuyu grasses [*Pennisetum setaceum* and *P. clandestinum*]), wildfire, and anthropogenic disturbances (Allen 2000, Blackmore and Vitousek 2000, Cabin *et al*. 2000, Cabin *et al*. 2002, Elmore and Asner 2006, Castillo *et al*. 2007, Cordell and Sandquist 2008, Brooks *et al*. 2009, Thaxton *et al*. 2010). In particular, large-scale wildfires have eliminated large portions of dryland forest in Hawaiʻi due to the buildup of alien grass biomass, creating a persistent grass-wildfire cycle (Hughes *et al*. 1991, D'Antonio and Vitousek 1992, Hughes and Vitousek 1993, D'Antonio *et al*. 2011). This *grass—fire cycle*, where ecosystems that are heavily invaded by alien grasses are more likely to burn, and consequently are more likely to be further invaded by alien grasses, can limit the re-establishment of natives (Hughes and Vitousek 1993). Furthermore, conversion of forests to grasslands due to fire can degrade and reduce habitat quality for game mammals. The result of these combined factors is often habitat alteration and loss for Hawaiʻi's native flora and fauna and consequent decline in populations and loss of native species.

1.4.1.1 Feral Pigs (*Sus scrofa*)

Pigs were the first ungulates (hooved mammals) introduced to the Central Pacific Islands by the earliest colonists to Hawaiʻi over 1000 years ago (Kirch 1982, Hess and Jacobi 2011). In 1793, other pig varieties, notably the European boar, were introduced to Hawaiʻi and presumably hybridized with the pacific variety (Tomich 1969, Ziegler 2002, Nogueira-Filho *et al*. 2009). Today, feral pigs are abundant in Hawaiʻi's tropical forests. Pigs disturb soil by rooting for invertebrates 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 Puʻu Waʻawaʻa (above 3500 ft elevation), though they do occur as low as 2500 ft in elevation.

1.4.1.2 Feral Sheep (*Ovis aries*)

Sheep were initially introduced to the island of Hawaiʻi by Captain George Vancouver in 1793 (Hess and Banko 2011). Because of a lack of predators, feral sheep populations have increased dramatically in Hawaiʻi since their introduction. Feral sheep are often considered grazers, preferentially consuming grass, but they can also browse woody vegetation such as māmane (*Sophora chrysophylla*) (Scowcroft and Giffin 1983). Feral sheep can cause soil erosion and degradation when herds occur in high densities on steep slopes. On Mauna Kea, damage to native vegetation due to grazing and browsing by feral sheep has been cited as one of the causes for the inclusion of 15 Hawaiian plant species in the list of threatened and endangered species in the U.S. (Ripley 1975, Scowcroft and Giffin 1983, www.issg.org). In the Plan Area, aerial surveys conducted by DOFAW show that feral sheep are widespread in many areas, especially near the Puʻu Lani Ranch subdivision in Puʻu Anahulu. A study of sheep movement patterns (2002-2005) in the Plan Area showed that sheep generally used well-defined ranges, characterized by repeated movements back and forth across their established ranges. There were no instances of clear dispersal from one area to another. Sheep were found more frequently in open areas during the morning and late afternoon periods, feeding in small herds. On cloudy days, sheep tended to remain in more open areas for longer periods. During the hottest portion of the day sheep were often found bedded down beneath the shade of trees or shrubs. The calculated home ranges for sheep in the Plan Area are 9.35 km^2 for ewes and 12 km^2 for rams. See appendix A for a detailed description of this study.

1.4.1.3 Feral Goats (*Capra hircus*)

Feral goats were likely first introduced to the island of Hawaiʻi by Captain James Cook in 1778 (Tomich 1969, Stone and Anderson 1988). They are currently present from sea level to higher elevations on all of the main Hawaiian Islands with the exception of Lānaʻi and Kahoʻolawe where they were successfully eradicated in 1981 and 1990 respectively (Hess and Jacobi 2011). Feral goats are mainly considered browsers, consuming the vegetation of woody plants, but they also consume graminoids (*grasses, sedges, and rushes*) (Williams 1980). By preferentially browsing on palatable tree species, goats limit or prevent the replacement of adult trees that form a native canopy (Scowcroft and Giffin 1983, Stone and Anderson 1988, Hess and Jacobi 2011). For example, by 1900 on the island of Lānaʻi, large areas of the island were deforested due to the activities of sheep and goats that were introduced in the mid-1800s (Hess and Jacobi 2011). Historically at Puʻu Waʻawaʻa, large goat drives were conducted by early ranchers where goats were pushed to lower elevations at Kīholo Bay and dispatched (Springer 2012). In the Plan Area, aerial and roadside surveys conducted by DOFAW show that most of the goat populations occur below Māmalahoa Highway surrounding the Big Island Country Club in Puʻu Anahulu, though other populations exist near Puʻu Waʻawaʻa itself and along the Highwa1.4.2 Habitat Management for Game Resources

In order to provide sustainable public hunting opportunities in the Plan Area, areas outside of current and proposed exclosures will be available for inclusion in public hunting areas and managed as a sustained yield resource. In this context, sustained yield of feral, non-native ungulates will be defined as maintaining sufficient game population abundance and productivity to provide sustained public hunting opportunities (DOFAW Management Guidelines 2001[3]). DOFAW will also take into account the needs of the hunting community when considering management actions in the Plan Area. Management actions that enhance game population abundance (including but not limited to improving habitat quality, installation and maintenance of game guzzlers, and hunter quotas or bag limits) will be used to help facilitate an annual sustainable harvest.

Natural resource management objectives in this HCP mandate that game mammal populations be removed from inside fenced exclosures. Game mammals have been observed utilizing much of the habitat that is located within the proposed fenced exclosure areas, as these areas tend to contain relatively good habitat (Miles Nakahara [formerly Hawaiʻi DOFAW] and David Okita [Volcano Helicopters], *pers. comm.*). It is likely that alternate habitat (habitat outside of proposed fenced areas) will need to be enhanced in order to ensure a sustainable game mammal hunting program, to ensure a quality hunting experience which can be quantified by hunter success rates More quantifiable research gained through the Hawaiʻi Experimental Tropical Forest and other research activities in foraging behavior, seasonal patterns and movements, and habitat suitability will assist in managing these species across the landscape.

1.4.1.4. Harvest and Hunting

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

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

Information from biannual aerial surveys will be used in part to determine acceptable harvest limits that lead to sustained populations of game mammals in the Plan Area. Adaptive management will be used to readjust harvest limits over time if necessary. For example, if sensitive areas are being affected by

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

mammal activities, such as quantifying limiting factors like soil erosion, browsing affects, then bag limits can be raised

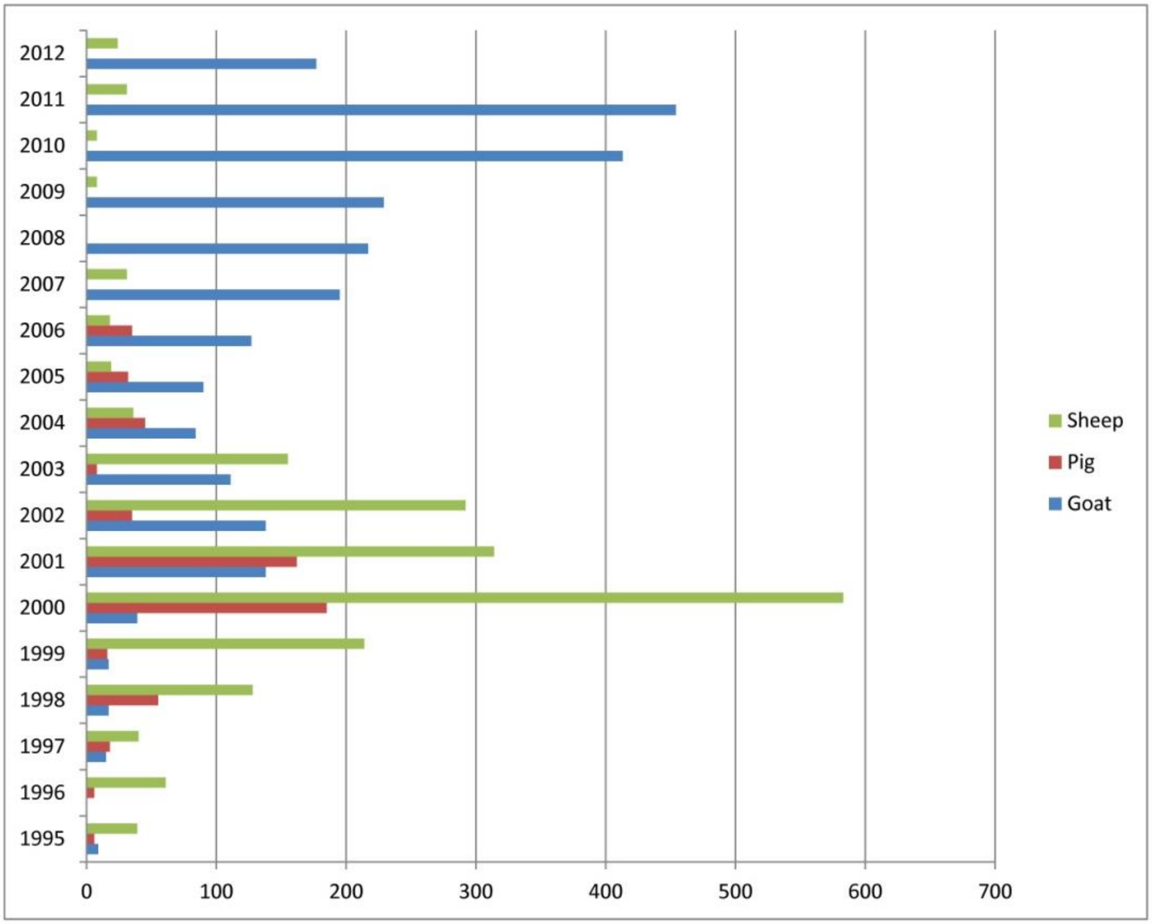

Figure 1.3. Historical trends in number of animals harvested (goat, sheep, and pig) from 1995 to 2012 at Pu‘u Wa‘awa‘a Forest Reserve (includes both nuisance control permits and regular hunting processes).

1.4.2 Habitat Enhancement for Game Mammals

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

1.4.2.1 Food Plots

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

1.4.2.2 Mineral Supplementation

Mineral supplementation is often used to supplement the diet of game mammals in areas with nutrient deficient or depleted soils, which have nutrient-poor forage. Mineral supplementation is usually provided by placing mineral blocks in the vicinity of a water unit. The substrate age of much of the land within the Plan Area is between 2,000 – 15,000 years old (Sherrod *et al.* 2007), and thus soil development is limited and nutrient poor. Moreover, the dominant grass type is fountain grass (*Pennisetum setaceum*) across the landscape until ~2100 m elevation which then transitions into kikuyu (*Pennisetum clandestinum*)-dominated grassland (Wagner *et al*. 1999). Fountain grass is neither highly palatable nor nutritious as a forage grass. It may be grazed intensively by sheep or cattle in early spring while shoots are tender and succulent. However, livestock will usually graze other desirable species first and avoid fountain grass when given a preference (USDA 2012). Kikuyu grass, however, is relatively high in protein and is a preferred foraging grass species for game mammals and other wildlife (Black *et al.* 1994). Therefore, in areas dominated by fountain grass, occasional mineral supplementation may be necessary to maintain healthy game populations. Mineral supplementation can help with growth, development, and also provide critical nutrients for physiological maintenance of body functions, especially in those areas dominated by fountain grass.

1.4.3 Game Mammal Infrastructure

Other game management activities include the installation and maintenance of game guzzlers (watering troughs), clearing and maintenance of 4 wheel-drive roads, and installation and maintenance of informational signage and hunter check stations. These actions are described in greater detail below.

1.4.3.1 Game Guzzlers and Cattle Troughs

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

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

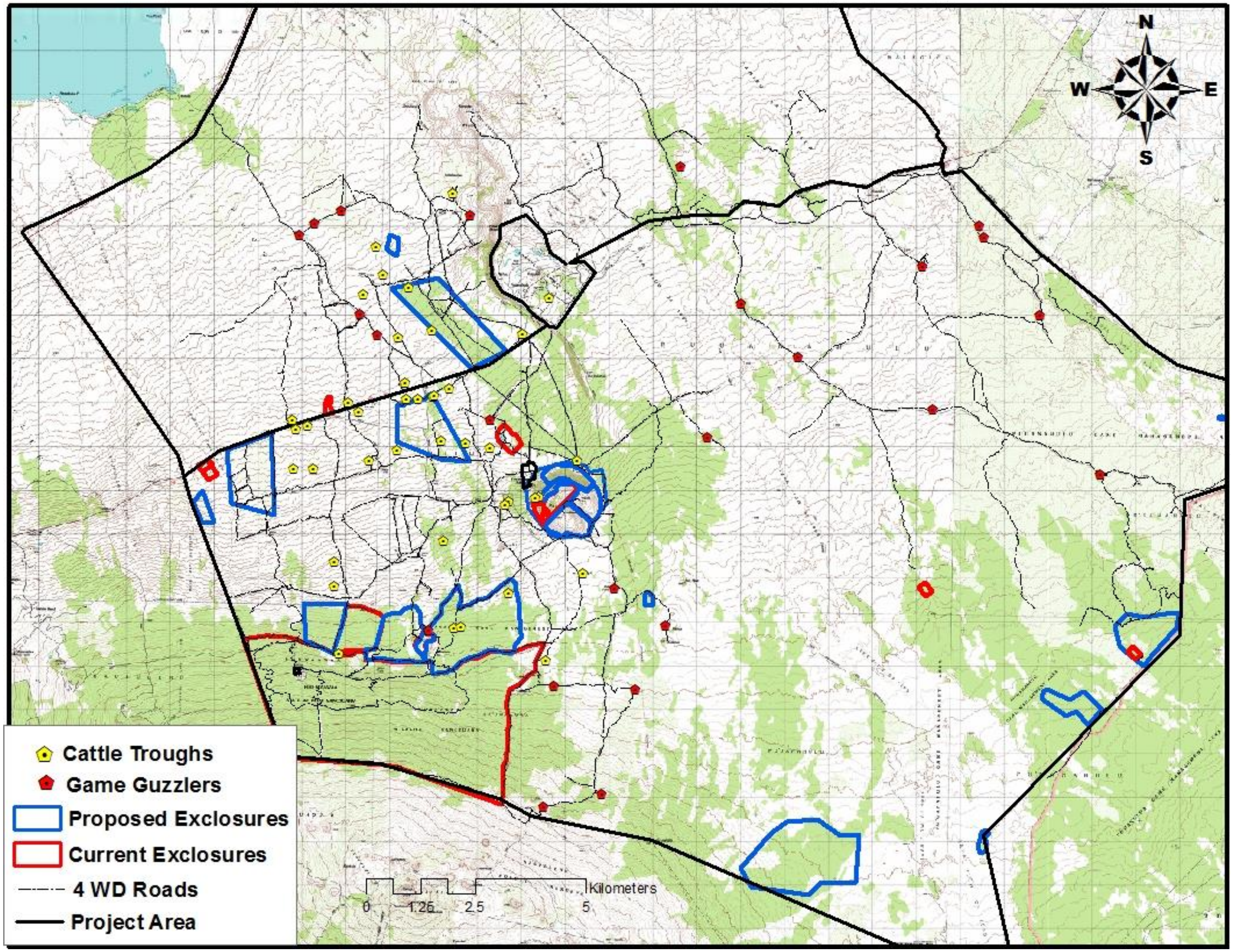

Figure 1.4. Game guzzler and cattle trough locations in the Plan Area.

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1.4.3.2 Maintenance of roads and fuel-breaks

Access to hunting areas in the Plan Area is gained through the use of 4 wheel-drive roads that also act as fire-fuel breaks. Currently there are approximately 370 km of roads and fuelbreaks within the Plan Area. Both fountain grass and tree tobacco, as well as other non-native species such as fireweed (*Senecio madagascarensis*) heavily colonize these roads creating hazardous fuel loads and contributing to fire risk. Previous catastrophic fires in this area have been attributed to ignition from hot catalytic converters from vehicles parked on tall dead grass. To mitigate the threat of wildfire and allow hunting and management access, it is critical that roads be cleared of vegetation as needed through the use of chemical and mechanical removal methods. Specifically, road clearing consists of manually cutting weeds as well as spraying herbicides that are approved for use in forests (*Methods are described in the Impacts section 5.2.2*).

1.4.3.3 Information signage

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

1.4.4 Research on Game Abundance

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

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

2.0 DESCRIPTION OF THE HCP

2.1 PURPOSE AND NEED FOR THE HCP

This HCP has been prepared to meet the requirements of the ESA and the HRS Chapter 195D, which apply to the management of game and maintenance activities associated with the proposed Plan. An HCP is needed because components of the Plan have the potential to result in take of endangered and threatened species that inhabit or utilize the Plan Area, including: Blackburn's sphinx moth and 15 plant species. Under HRS Section 195D-4(g), DLNR will authorize take through the issuance of an ITL. An HCP must be prepared in support of the application 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) determine the potential impacts that the Plan may have on the listed species or species under consideration for listing; 2) address the potential incidental take of the listed species by setting forth measures that are intended to ensure that any take caused by the Plan will be incidental; 3) ensure that the impacts of the take will, to the maximum extent practicable, be minimized and mitigated; 4) provide procedures to deal with changed and unforeseen circumstances; 5) ensure that adequate funding for the HCP will be provided; and 6) ensure that the take of the listed species will not appreciably reduce the likelihood of the survival and recovery of these species in the wild. Implementation of the HCP will provide a conservation benefit to the Covered Species.

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

2.2 SCOPE AND TERM

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

2.2.1 List of Preparers

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

2.3 SCHEDULE

Implementation of this HCP will be done in three phases. Phase 1: Avoidance and Minimization Phase, years 0-5. Phase 2: Mitigation Phase, years 6-15, and Phase 3: Maintenance, years 16-25. There is considerable overlap between fencing exclosures that are used for avoidance/minimization and mitigation. In most cases, these fences 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 8.2*).

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

Phase 1: 0-5 years: Avoidance and Minimization:

- Installation of Avoidance and Minimization fence exclosures (protection of *in situ* (naturally occurring wild individuals) Covered Species)
- Initiate exclosure management:
    - Upon the completion of fence construction, ungulates will be removed following ungulate control methods as outlined in State of Hawaiʻi Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawaiʻi* (DOFAW 2007). Ungulate removal will begin by driving the animals out, to the extent possible, followed by opening the units to controlled public hunting. Finally, DOFAW staff will trap, snare, and shoot any remaining ungulates.
    - Reduce overall alien plant cover
    - Conduct rodent and slug control (if necessary)
    - Maintain fuel breaks 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 species not currently occurring within the exclosures.
- Begin annual monitoring of *in situ* populations.

Phase 2: 6-15 years: Mitigation:

- Install of remaining Mitigation fence exclosures
- Initiate exclosure management:
    - 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* (DOFAW 2007). Ungulate removal will begin by driving the animals out, to the extent possible, followed by opening the units to controlled public hunting.
    - Reduce overall alien plant cover
    - Outplant to mitigation goal (+ expected % mortality) in appropriate exclosure for each Covered Species
    - Conduct rodent and slug control (if necessary)
    - Maintain fuel breaks around fence lines.
    - Conduct quarterly fence line and ungulate ingress checks
- Initiate mitigation outplanting and monitoring

Phase 3: 16-25 years: Maintenance

- Continue monitoring
- Initiate adaptive management based on monitoring results

3.0 ENVIRONMENTAL SETTING

3.1 GEOLOGY

The Island of Hawaiʻi is relatively young on a geological time scale. Geologists estimate that the oldest lava flows are less than 500,000 years old (McDougall and Swanson, 1972). Hualālai, an active shield volcano, is the third oldest (130,000 years old) of the five volcanoes on the Island (Moore and Clague, 1992). The summit caldera is buried, but the mountain rises to a height of 8,271 ft above sea level. Three major rift zones radiate from the top of Hualālai. One of these, a poorly defined northern rift, extends through the Kalamalu area of Puʻu Waʻawaʻa, and is about 10 km long and 5 km wide. Lavas of Hualālai are primarily Holocene in age, but some deposits date to late Pleistocene (Moore and Clague, 1991). The last eruption of Hualālai occurred in 1801 creating the Huehue lava flow. Another eruption is highly probable in the next 200 years, but could occur in the next few decades (Moore *et al*. 1987). Walker (1990) considered Hualālai as potentially the most dangerous Hawaiian volcano.

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

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

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

3.1.1 Cinder Cones

An extinct volcanic vent known as Puʻu Waʻawaʻa cone and its associated 900-ft-thick lava flow (Puʻu Anahulu ridge) are the oldest geologic formations on Hualālai (100,000 + years old). This distinctive hill is over 1 mile in diameter and rises 1,220 ft above the surrounding landscape to a height of 3,967 ft elevation. Erosion, following a radial drainage pattern, has cut many gullies and ridges on the cone's slopes. This geologically unique landform is composed of trachyte pumice and contains scattered blocks of trachyte obsidian or black volcanic glass. Trachyte is one of the most silicic lavas known in Hawaiʻi (Walker, 1990). Due to its older age, high degree of soil development, and complex topography, Puʻu Waʻawaʻa cone has greater botanical diversity and supports a different plant community than the surrounding area.

Vegetation on the cone can be classified as an Olopua (*Nestegis*) montane forest (Wagner *et al*., 1990). 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 have been fitted with rubber liners to store water for ranch use. An asphalt catchment system collects water for the reservoirs. Many more small volcanic vents and cinder cones are scattered throughout the area, but most are unnamed (Giffin 2003).

3.2 SOILS

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

The ages of Hualālai lava flows have been summarized using correlations between soil depth and age (Moore and Clague, 1991). Little or no soil cover (except in wet forest areas) occurs on lavas less than 5,000 years old. On lavas between 5,000-10,000 years old there is 10-20 cm of soil. Flows over 10,000 years old accumulate soils more than 20 cm deep.

3.3 CLIMATE

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

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

3.4 HYDROLOGY

Infiltration of rainwater, fog drip, and dew are the primary fresh water inputs in the Puʻu Waʻawaʻa and Puʻu Anahulu Ahupuaʻa. Rainfall in the Project Area varies by topography and elevation. In general the southwest corner of the Project Area, the Forest Bird Sanctuary, receives the most rainfall. Precipitation gradually decreases when moving northeast as the elevation decreases. Precipitation in the Project Area ranges from 27.9 inches of mean annual rainfall at the Waihou I rain shed area near the Forest Bird Sanctuary, to less than 10 inches on the northern borders along Kaʻahumanu Highway (Giffin 2009; Giambelluca et al. 2013). Differences in precipitation occur with increasing elevation (fig. 3.1). The rainfall zone changes from mesic at mid elevations to xeric at the upper and lower boundaries. Evaporation is relatively high, with over 100 inches of annual pan evaporation in the driest portion of the Plan Area (Ekern and Chang 1985).

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

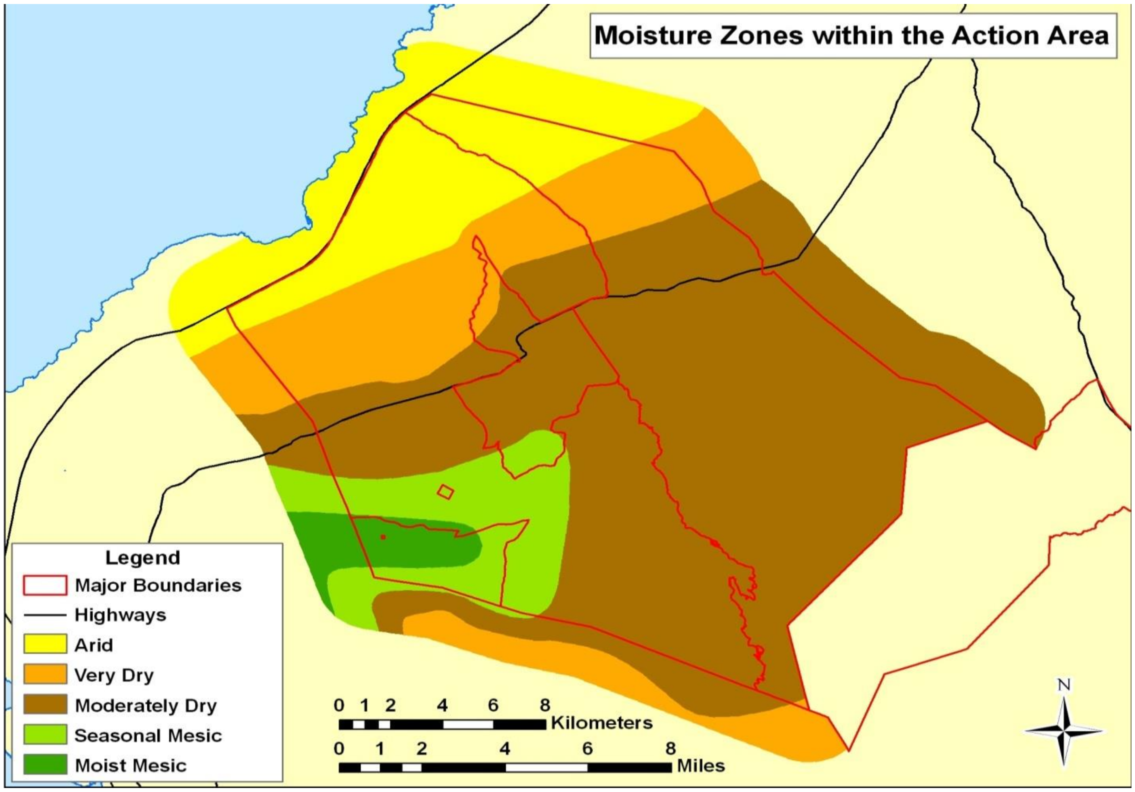

Figure 3.1. Moisture zones within the Area of Potential Impact. The Plan Area is outlined in red.

3.5 FLORA

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

3.5.1 Vegetation Zones (Giffin 2003)

Several different ecological regions are present at Puʻu Waʻawaʻa and Puʻu Anahulu. Starting on the upper slopes of Hualālai and continuing downward, the following zones can be recognized: subalpine (generally above 6,000 ft.), montane (2,500-6,000 ft.), lowland (below 2,500 ft.) and coastal (sea level). A variety of vegetation communities occur within each zone. At mid elevations, montane dry woodlands dominate the eastern side of Puʻu Waʻawaʻa while moister montane mesic forests lie to the west.

Rare plants are found in all vegetation zones at Puʻu Waʻawaʻa and Puʻu Anahulu. At least 40 rare plant taxa have been reported from the area to date. Of these, 22 are officially listed as endangered or are proposed endangered species. Botanical surveys reveal that a great number of plants have been extirpated at Puʻu Waʻawaʻa in recent years. These include the endangered and threatened *Bonamia menziesii*, *Asplenium dielerectum*, *Gardenia brighamii*, *Ochrosia kilaueaensis*, *Dissochondrus biflorus*, *Mariscus fauriei*, and *Nesoluma polynesicum*. Many of these species still exist on adjacent lands, particularly at Kaʻūpūlehu. Some rare plants, such as *Asplenium peruvianum* var. *insulare*, have only been found in lava tube openings where they are protected from ungulate damage.

Subalpine Zone

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

Days are typically hot and nights cold. These forests at 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 SOC is scattered throughout the Plan Area above 4,000 ft 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 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, 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 4,200 ft elevation. This latter woodland is a transitional vegetation type that descends to about 3,000 ft 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 (*Santalum paniculatum*), 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)*, mint (*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 (*Pleomele hawaiiensis*), and Kauila. The 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 W. Takeuchi (1991) and The Nature Conservancy (l992).

Endangered plants of the lowland dry forest are Maʻo hau hele , Uhiuhi, Kokiʻo, Kauila and Hala pepe. Koaiʻa (*Acacia koaia*) is a species of concern.

3.5.2 Previous Botanical Surveys in the Plan Area

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

1. The Heritage Database (Hawaiʻi Natural Heritage Program/Hawaiʻi Biodiversity and Mapping Program): Maps the occurrences of listed species in Puʻu Waʻawaʻa and Puʻu Anahulu. The primary source of these data is from botanical surveys conducted along DOFAW Forest Bird Survey transects in the early 1980s. The landscape has been greatly altered in the 30 years since these surveys and many of the individuals are no longer extant.
2. Shaw, Castillo, and Close; Puʻu Anahulu, 1997: This was a general botanical survey with an emphasis on threatened and endangered species. These data focused search efforts within Puʻu Anahulu and upper Puʻu Waʻawaʻa during subsequent HCP surveys. In the years since this survey, frequent wildfires and the subsequent invasion of fountain grass (*Pennisetum setaceum*) have profoundly altered plant communities. Soil kīpuka located on the Keamuku flow, which were relatively free of fountain grass in 1997, are now overgrown by fountain grass. The result is a drastic reduction of available habitat for listed species. For example, Shaw *et al*. (1997) mapped the distribution of 12 individuals of *Melicope hawaiiensis* on the Keamuku flow. None of these individuals were found during subsequent HCP surveys and no recruitment of *Melicope hawaiiensis* has since been observed.
3. Lyman Perry, Hawaiʻi District Botanist (DOFAW), 1999-2004: Rare plant locations mapped during periodic surveys within Puʻu Anahulu and Puʻu Waʻawaʻa.
4. Steve Evans (U.S. Army Pohakuloa Training Area): Locations of rare plants on adjacent Pohakuloa Training Area (data property of U.S. Army and not included as appendix). This information guided survey efforts in the upper Puʻu Anahulu region.
5. Arnett survey, 2002: Survey of the recently-acquired Keamuku Parcel.

3.5.3 Plan Specific Botanical Surveys

3.5.3.1 2003-2007 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 stratified systematic sampling scheme was utilized. Survey areas were stratified 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 and Lyman Perry (Hawaiʻi DOFAW), Mick Castillo (Hawaiʻi Natural Resource Services), and James Kwon (USFWS) also assisted in identification of these areas of high likelihood. These areas of potential habitat for listed species were then subject to systematic survey by a trained botanical survey crew.

Large portions of Puʻu Anahulu and Puʻu Waʻawaʻa (particularly makai of Highway 190) have suffered repeated wildfires in the past two decades and prior (fig. 3.2). The fires and subsequent fountain grass invasion have virtually eliminated native species from most of these areas. Plan survey efforts were therefore focused on remaining intact kīpuka in upper Puʻu Anahulu and Puʻu Waʻawaʻa. In most cases, the surveyed areas have been spared from fires because the substrate is rough ʻaʻā lava and does not yet support a blanket of fire-carrying fountain grass.

A large portion of the HCP surveys were carried out along systematic transects (fig. 3.3). Survey teams were comprised of two trained botanists who walked roughly parallel lines along each transect, navigating between waypoints with a hand-held Garmin 12 XL GPS unit. Transects were positioned 1 km apart oriented along the contour of the land in most 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. Approximately 144 km of transects were surveyed (fig. 3.3). Results from systematic transects are included in baseline population estimate calculations.

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

Botanical surveys focused on endangered and threatened species. However, the location of locally rare species and SOC were also mapped. For all endangered and threatened species, the following data were recorded: date, time, UTM, 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, 2002). For non-listed locally rare species, the following data were recorded: number, UTM, date, time, vigor, reproductive status, height, dbh, and notes.

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

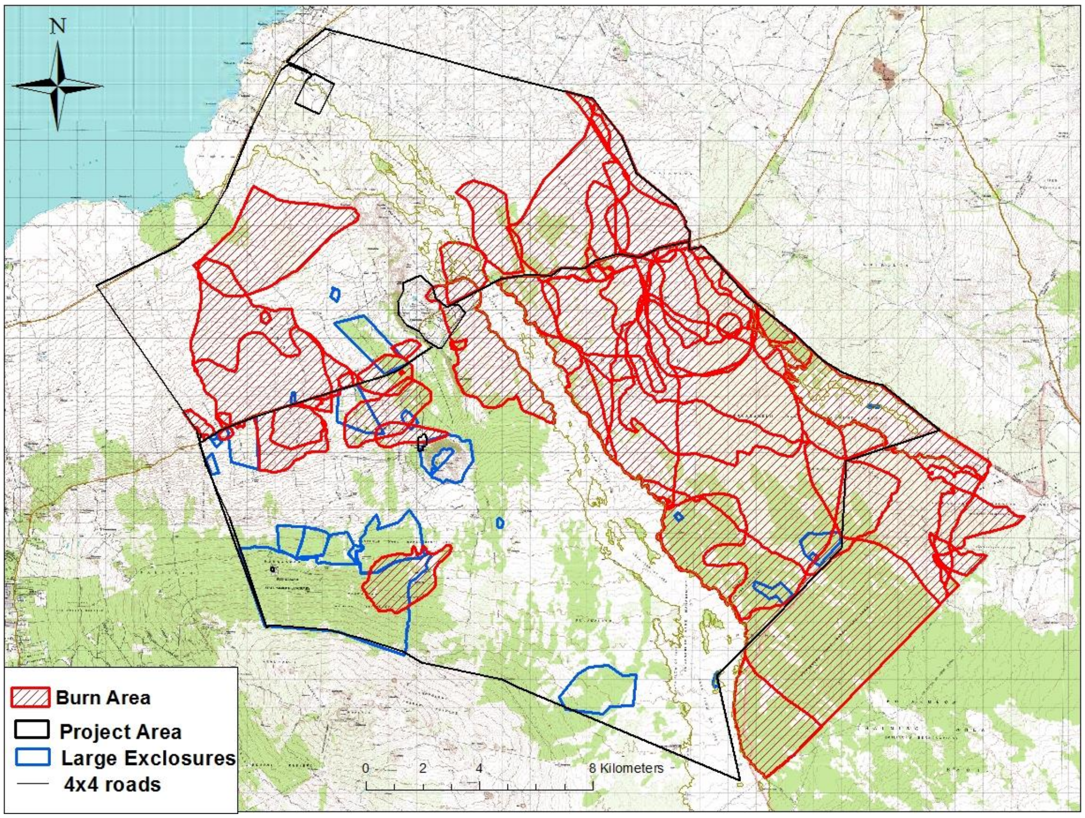

Figure 3.2. Locations of historical fires in the Plan Area.

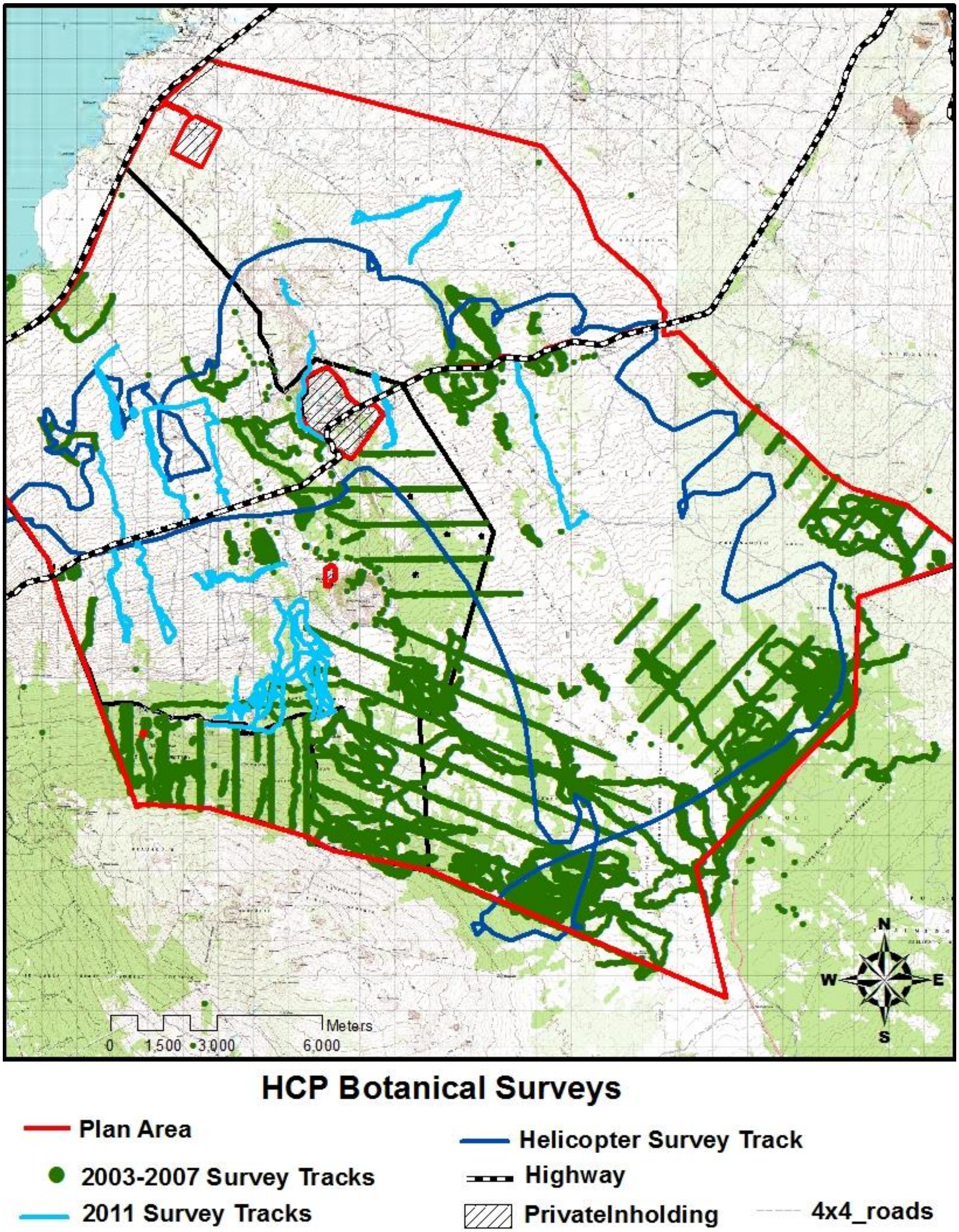

Figure 3.3. Ground (transects and guided searches) and aerial (helicopter) botanical survey tracks completed during the 2003-2007 and 2011 survey periods totaling 144 km survey transects.

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

Scientific Name	Common Name	# of Individuals
Endangered		
Asplenium peruvianum	n/a	65
Caesalpinia kavaiensis	Uhiuhi	50
Colubrina oppositifolia	Kauila	735
Haplostachys haplostachya	Honohono	126
Hibiscus brackenridgei	Ma‘o hau hele	65
Kokia drynarioides[4]	Koki‘o	2
Neraudia ovata	n/a	7
Nothocestrum breviflorum	‘Aiea	47
Pleomele hawaiiensis	Hala pepe	320
Phyllostegia velutina[5]	n/a	35
Silene lanceolata	Hawaiian Catchfly	419
Solanum incompletum	Pōpolo kū mai	14
Stenogyne angustifolia	n/a	97
Vicia menziesii	n/a	4
Zanthoxylum dipetalum var. *tomentosum*	A‘e	14
Zanthoxylum hawaiiense	A‘e	234
Species of Concern		
Alphitonia ponderosa	Kauila	42
Eragrostis deflexa	n/a	732
Chamaesyce olowaluana	‘Akoko	473
Erythrina sandwicensis	Wiliwili	11
Exocarpus gaudichaudii	Hulumoa	35
Fragaria chiloensis	‘Ōhelo papa	9
Melicope hawaiiensis	Manena	34

[4] *Kokia drynariodes:* The 2 individuals found during surveys have since died.
[5] *Phyllostegia velutina* and *Vicia menziesii* are both located within the FBS where no game management occurs, and are therefore not Covered Species.

Scientific Name	Common Name	# of Individuals
Reynoldsia sandwicensis	‘Ohe makai	21
Sisyrinchium acre	Mau‘u lā‘ili	64
Stenogyne macrantha	n/a	1
Tetramalopium consanguineum	n/a	8000+
Tetramalopium humile	n/a	2

3.5.3.2 2011 Surveys

The data collected during the 2003-2007 botanical surveys (table 3.2) were used to create a model (in conjunction with habitat type, species ranges, and moisture regime) to predict where within the Plan Area it is most likely to find Covered plant species in unsurveyed areas (*see Modeling Section for further details*). 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 (fig. 3.4). The data collected during these surveys was used to update the plant population model and assist in developing more accurate take values for a number of the Covered Species (*please see section 5.3 Estimating Plan Related Impacts for more information*).

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

Scientific Name	Common Name	# of Individuals
Endangered		
Colubrina oppositifolia	Kauila	88
Nothocestrum breviflorum [6]	‘Aiea	46
Pleomele hawaiiensis	Hala pepe	18

[6] Number of individuals found does not necessarily reflect previously undetected individuals as some of the areas surveyed in 2011 were previously surveyed in the 2003-2007 surveys.

3.5.4 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, currently 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 (K. Bio, *personal communication).* Those Covered Species which are considered PEP species are defined within this section (table 3.3).

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.

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 2-6 in (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, 9-16 in (23-41 cm) long, 0.8 in (2 cm) wide above the middle, and pinnate with 20-30 pinnae or leaflets on each side. The pinnae are rhomboidal, 0.3 in (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. On the island of Hawai'i, this fern was found historically below Kalaieha, Laumaia, Keanakolu, and Umikoa on Mauna Kea; Pu'u Wa'awa'a on Hualālai; west of Keawewai, above Kīpuka Ahiu on Mauna Loa; and near Hilo.

This species has eight extant populations on the island of Hawai‘i at elevations between 5,250 and 7,800 ft (1,600 and 2,400 m). A ninth occurrence was recently reported from East Maui, in Hanawi NAR. The current populations on Hawai‘i are located at Pu’u Huluhulu, Pohakuloa Training Area (nine subpopulations), Kulani Correctional Facility, Keauhou, the Mauna Loa Strip Road in Hawai‘i Volcanoes National Park, Kapapala Forest Reserve, Ka‘ū Forest Reserve, and the summit area of Hualālai. The largest population of this fern occurs at Pohakuloa Training Area; monitoring in 1995 put total numbers at about 200 plants, a slight reduction in numbers from 1992. The nine known populations on Federal, state, and private land totaled approximately 278 plants in 1995. At Pu‘u Wa‘awa‘a, this species was only found in moist lava tubes or pit craters at 4,200-6,500 ft elevation, with most individuals occurring above 5500 ft.

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, associated with mosses and liverworts. This fern has been found growing infrequently on the interface between younger lava flows and much older pahoehoe 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 2003).

Uhiuhi (*Caesalpinia kavaiensis*)

Description: Uhiuhi, a member of the pea family (Fabaceae), is a tree that can grow up to 10 meters (33 ft) 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 seedpods that are winged on one side, making this a very attractive tree (Wagner *et al.* 1999).

Historic and Current Distribution: Uhiuhi is endemic tree to the Hawaiian Islands and was once widespread on the islands of Kaua‘i (Waimea Canyon), O’ahu (Wai’anae Mountains), west Maui, North Kona District, Hawai‘i, and Lāna‘i. Today, Uhiuhi is extinct on Lāna‘i and is now found only on O‘ahu (Central Wai’anae Mountains), Hawai‘i (Hualālai), and one wild plant was recently found on Kaua‘i in Waimea Canyon (NTBG 2013). Wagner (1999) reported there were fewer than 50 individuals known, however recent surveys indicate many more individuals persist. 50 Individuals were found in Pu‘u Anahulu makai from 800-1,600 ft elevation during the 2003-2007 HCP surveys. A small population also occurs at similar elevation south of Waikoloa.

Habitat: Uhiuhi is restricted to dry or mesic forests between 80 to 920 m (262 to 3,018 ft) elevation. Associated native species include ‘A‘ali‘i, Lama, ‘Ōhi‘a, Alahe‘e, Wiliwili, ‘Āweoweo, and Kauila*C.*. Critical habitat has been proposed but not yet designated for this species (fig. 3.4).

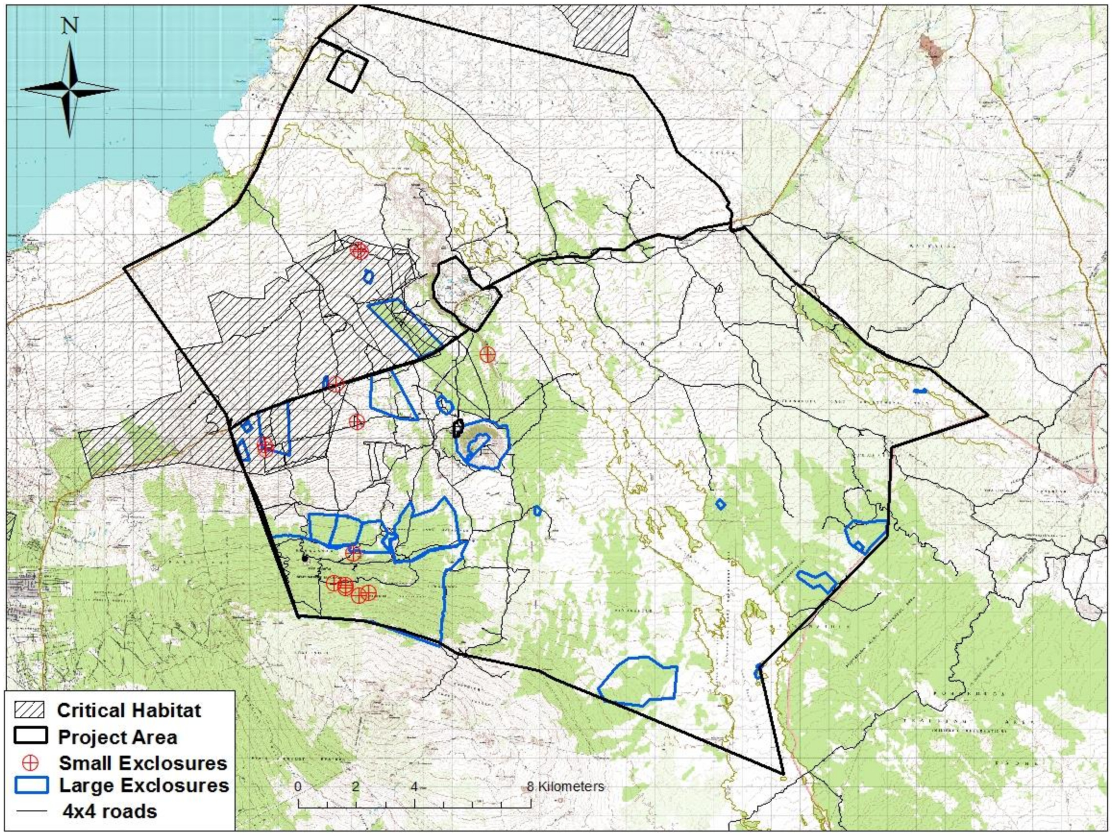

Figure 3.4. Proposed critical habitat for Uhiuhi within the Plan Area.

Kauila (*Colubrina oppositifolia*)

Description: Kauila, a member of the buckthorn family (Rhamnaceae) is a tree approximately 16-40 ft (5-13 m) tall, with extremely hard red wood. Opposite, oval-shaped leaf blades are 2.4-4.7 in (6-12 cm) long and 1.2-2.8 in (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 0.6-1.2 in (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 0.1-0.3 in (3-8 mm) long. Each flower is subtended by a flower stalk 0.07-0.1 in (2-3 cm) long, which increases in length as the fruit matures. Five sepals are triangular and about 0.06-0.08 in (1.5-2 mm) long. Five green-yellow petals are about 0.06 in (1.5 mm) long. Fruits are brown, almost round, about 0.3-0.4 in (8-11 mm) long, and explosively split apart, discharging oval or oblong, black, shiny, hump-back seeds, 0.2-0.3 in (6-8 mm) long and 0.1-0.2 in (4-5 mm) in diameter.

This species is readily distinguished from the other species in Hawaiʻi by several characters: opposite leaf position, dull leaf surface, and entire leaf margins (Wagner *et al*. 1990).

Historic and Current Distribution: Kauila is known from Oʻahu, Maui and the Big Island. Historic populations are known from the central and southern Waianae Mountains on Oʻahu, and from the Kohala mountains; western, southwestern, and southern slopes of Mauna Loa; and northern slopes of Hualālai on the Big Island. Six populations on the Big Island are distributed on the northern slope of Hualālai and near the extreme southern part of the island, on State and privately owned land. Previously there were thought to be 200-300 individuals at Puʻu Waʻawaʻa, however, recent HCP surveys indicate the population at Puʻu Waʻawaʻa consists of at least 735 individuals. This species was found primarily at 1,600-2,800 ft elevation in Puʻu Waʻawaʻa, with some individuals at higher elevation on the Puʻu Waʻawaʻa cinder cone, and three individuals found in Puʻu Anahulu at 2,400 ft.

Habitat: Kauila occurs in lowland dry and mesic forests. The dominant species of these forests is Lama. Individuals are found at elevations between 800 and 3,000 ft (240-910 m), sometimes on ʻaʻā lava flows and associated with Alaheʻe and ʻOhe makai. Critical habitat was designated for this species in 2003 (fig. 3.5) (USFWS 2003).

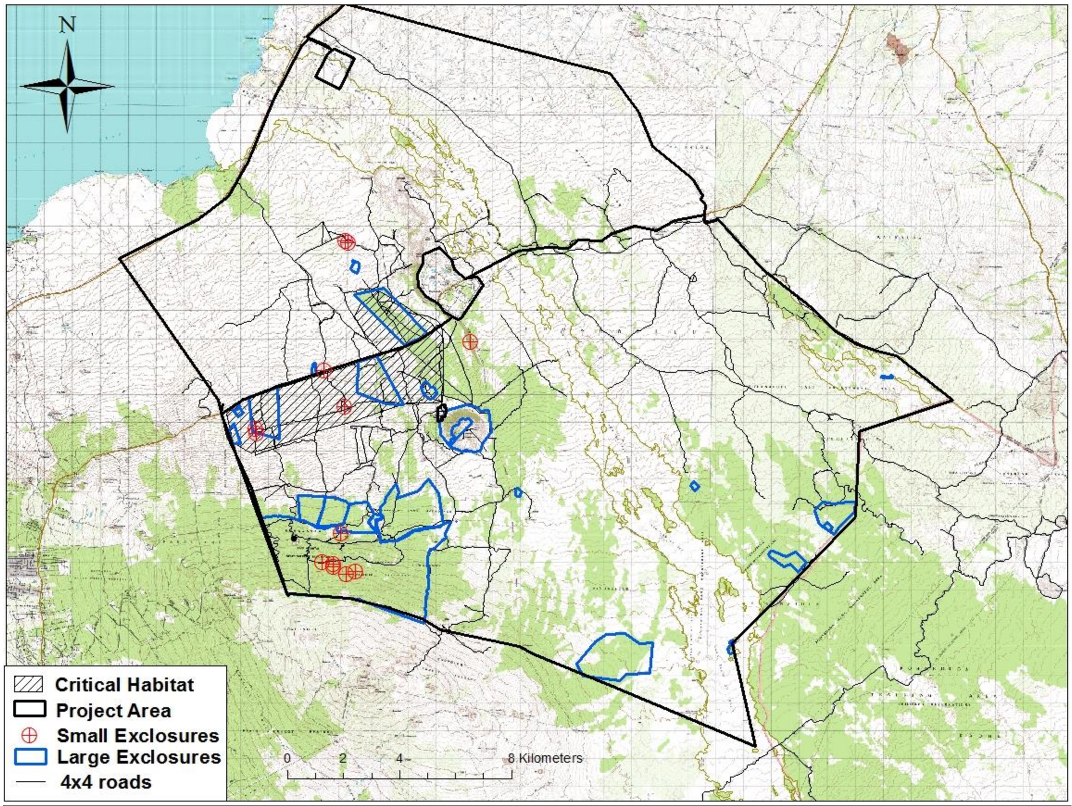

Figure 3.5. Critical habitat for Kauila within the Plan Area.

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 puberlent. Leaf lower surfaces are densely white tomentose. The inflorescence is racemose with white tubular flowers. Reproduction is through seed and basal sprouting (Wagner *et al* 1999).

Historic and Current Distribution: Honohono was once present on the islands of Kauai, Maui, and Hawaiʻi. It is found at Pohakuloa Training Area and at Puʻu Anahulu. In the Plan Area, Honohono is found at 4,200 ft 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. This species is currently under evaluation to determine PEPP status (Table 3.3).

Habitat: Honohono grows in dry exposed areas on lava, shallow soils, and lava outcrops. Historic accounts indicate it was once found as component within the upper forest zone along with stunted vegetation (USFWS 2003). 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 (U.S. Army 2003). Critical habitat has not been designated for this species.

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

Description: Maʻo hau hele is a shrub in the malvaceae and can sometimes become a small tree growing up to 30 ft tall. When planted as an ornamental, it is most often a 3 to 15 foot tall shrub with a diameter of 8 to 15 ft. 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 6 inches long and equally wide. The large flowers are 4 to 6 inches 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. Garnett reports that the flowers open between 2 and 4 p.m. and close between 9 a.m. and 1 p.m. 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 400 to 2,600 ft.

Historic and Current Distribution: Maʻo hau hele is endemic to the Hawaiian Islands, it is found on all the main Hawaiian Islands except Ni'ihau and Kaho'olawe, but it is not common in any location (Wagner 1990). This species has three recognized subspecies: *H. b.* ssp. *brackenridgei*, *H.b.* ssp. *mokuleianus*, and *H.b.* ssp. *molokaianus*. *Hibiscus brackenridgei* ssp. *brackenridgei* is known from the islands of Molokaʻi, Lānaʻi, Maui, and Hawaiʻi Island. Subspecies *mokuleianus* is only known from Kauaʻi and Oahu and subspecies *molokaianus* is only known from Molokai. Currently, the only known wild population of Maʻo hau hele is found in one exclosure on the top of Puʻu Anahulu bluff across from the hunter check station at Puʻu Waʻawaʻa at 2,400 ft elevation.

Habitat: Maʻo hau hele occurs in lowland dry to mesic forest and shrubland from 425-2,625 ft (130-800 m) in elevation. Associated plant species include ʻAʻaliʻi, Alaheʻe, Wiliwili, ʻOhe makai, and ʻIlima. Critical habitat was designated for this species in 2003 (fig. 3.6) (USFWS 2003).

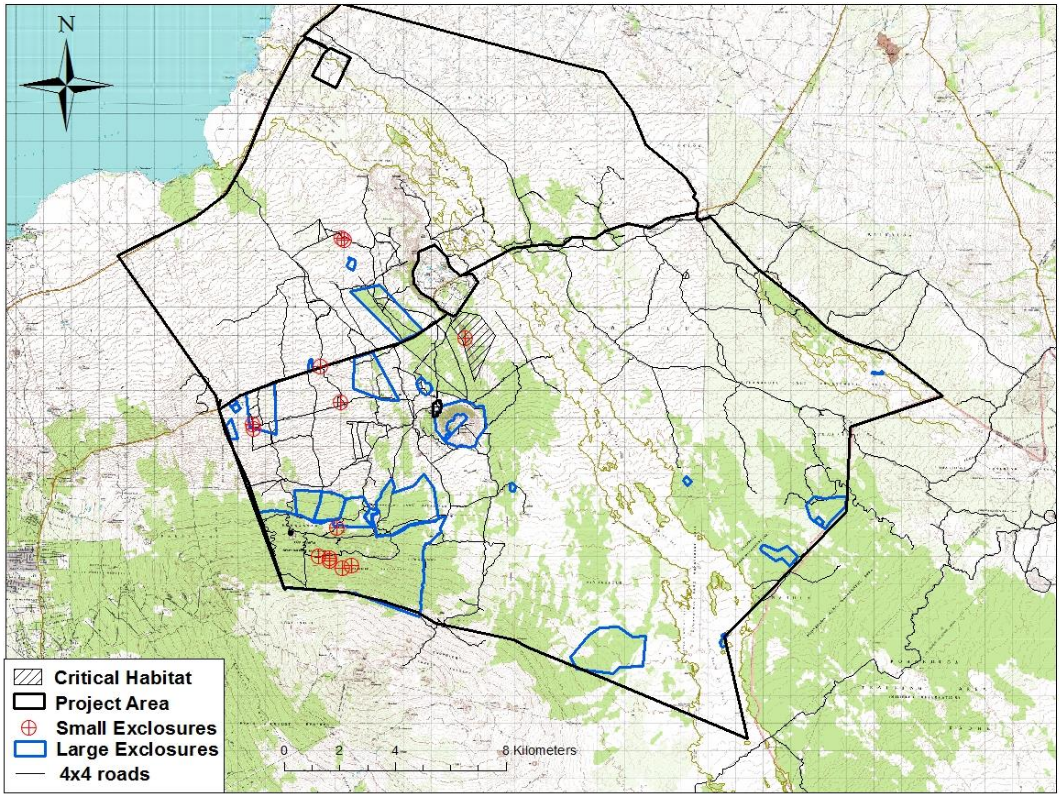

Figure 3.6. Critical habitat for Maʻo hau hele within the Plan Area.

Koki‘o (*Kokia drynarioides*)

Description: A tree in the malvaceae 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 to treat thrush. 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. Only six plants are known, although three may have been destroyed in fires. Many other plants have been out-planted in exclosures managed by the State of Hawai‘i and private conservation groups. The last four individuals occurred in 2 fences along the edge of the Ka‘upulehu flow above the 25 mile road entrance to Pu’u Wa’awa‘a. There were two senescent plants alive at the beginning of this Plan and both have since died. This species is considered a PEPP species (Table 3.3).

Habitat: Associated native species include Aweoweo, ‘A‘ali‘i, Hala pepe, Wiliwili, Kulu’i, ‘Ohe makai, Māmane, and Maua. Alien species that have invaded this habitat include fountain grass, tree tobacco, fireweed and lantana. Critical habitat was designated for this species in 1984 (fig. 3.7) (USFWS 1984).

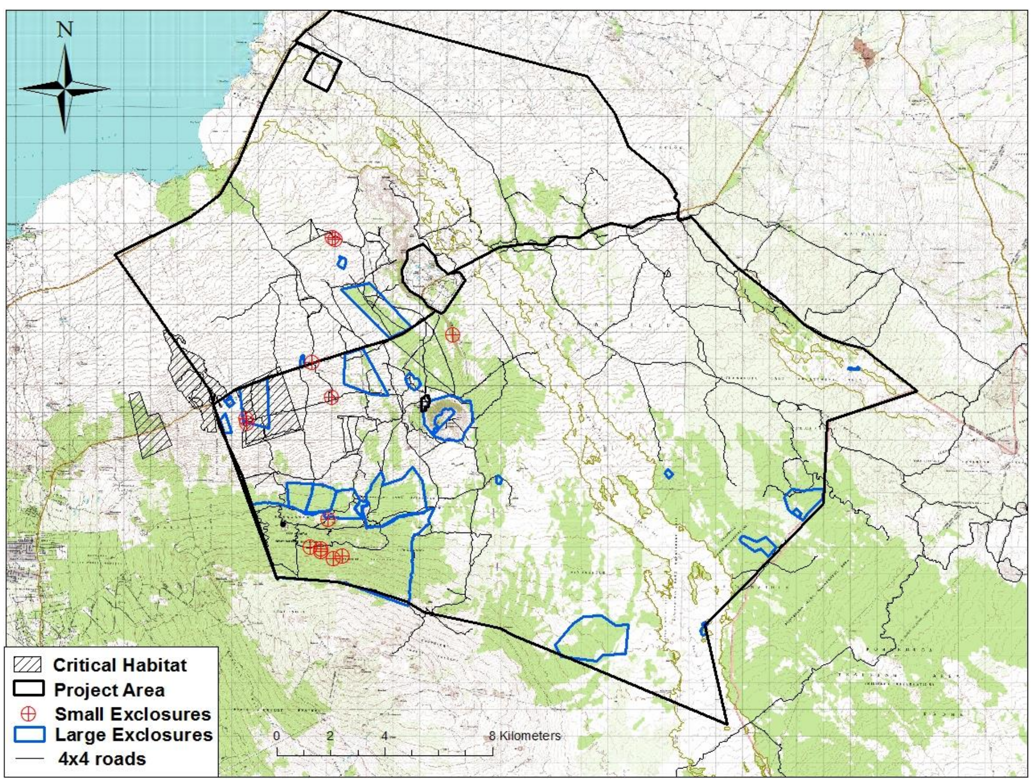

Figure 3.7. Critical habitat for Koki‘o within the Plan Area.

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 (3 to 10 ft) long, and branches bearing short, somewhat erect hairs. The alternate, thin, stalked leaves are smooth-margined, grayish on the undersurface, 5 to 14 cm (2 to 5.5 in) long and 2 to 6.5 cm (0.8 to 2.6 in) 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 Kau. 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 of 8 individuals was surveyed in late 1995 and again in 1997 by Colorado State University personnel. This population is located at the boundary of the PTA and Puʻu Anahulu, owned by the State (Shaw *et al.* 1997) and was resurveyed by the HCP botanical crew. A third population, which is located within PTA, has not been surveyed since 1980. It is unknown how many plants occur at this site. One individual is known to occur in the Manuka Natural Area Reserve (L. Perry, pers. comm.), and a final population has been located in windward Kohala. This species is considered a PEPP species (Table 3.3).

Habitat: *Neraudia ovata* grows in open Ohiʻa and Māmane dominated lowland and montane dry forests at elevations of 115 m (380 ft) at Kaloko and 1,325 and 1,520 m (4,350 to 5,000 ft) at Pohakuloa Training Area. Associated taxa include ʻOhe makai, Naio, Huehue, Kōlea species, and christmas berry, 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 (fig. 3.8) (USFWS 2003).

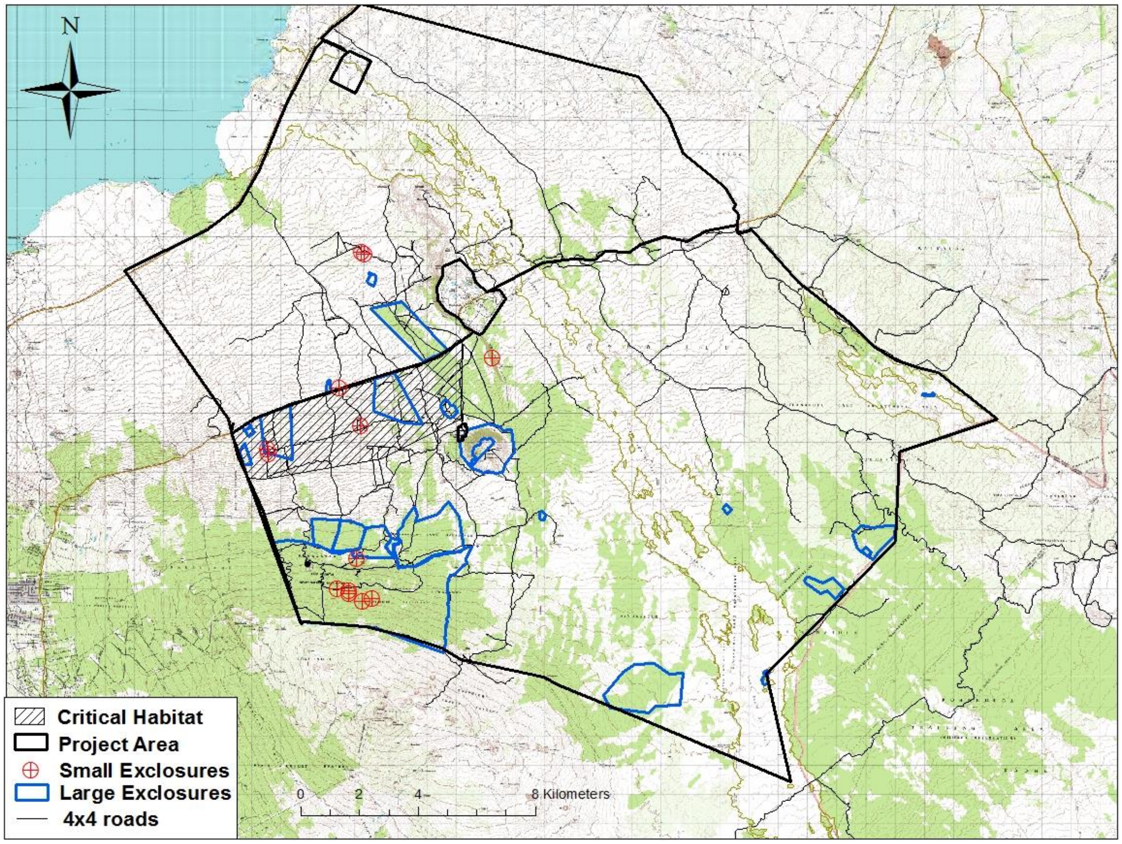

Figure 3.8. Critical habitat for *Neraudia ovata* within the Plan Area..

‘Aiea (*Nothocestrum breviflorum*)

Description: ‘Aiea is a stout tree 33-39 ft (10-12 m) tall int eh night shade family (Solanaceae). The trunk, about 18 in (45 cm) in diameter, has a soft, sappy wood with dark brown bark. Oblong to elliptic, toothless, stalked leaves, 2-4.7 in (5-12 cm) long and 1.2-2.4 in (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) 0.2-0.4 in (4-10 mm) long. The 4-lobed, tube-shaped calyx, 0.2-0.4 in (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 0.2-0.3 in (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 the Big Island from South Kohala to Kamaoa-Puueo. Recent HCP surveys indicate that at least 47 individuals are known to exist within the Pu‘u Wa‘awa‘a Forest Reserve.

Habitat: Habitats of ‘Aiea are lowland dry forest, montane dry forest, and montane mesic forest dominated by ‘Ōhi‘a, Koa, and or Lama. Individuals occur on ‘a‘ā lava substrates at elevations ranging from 260 to 6,000 ft (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 (fig. 3.9) (USFWS 2003).

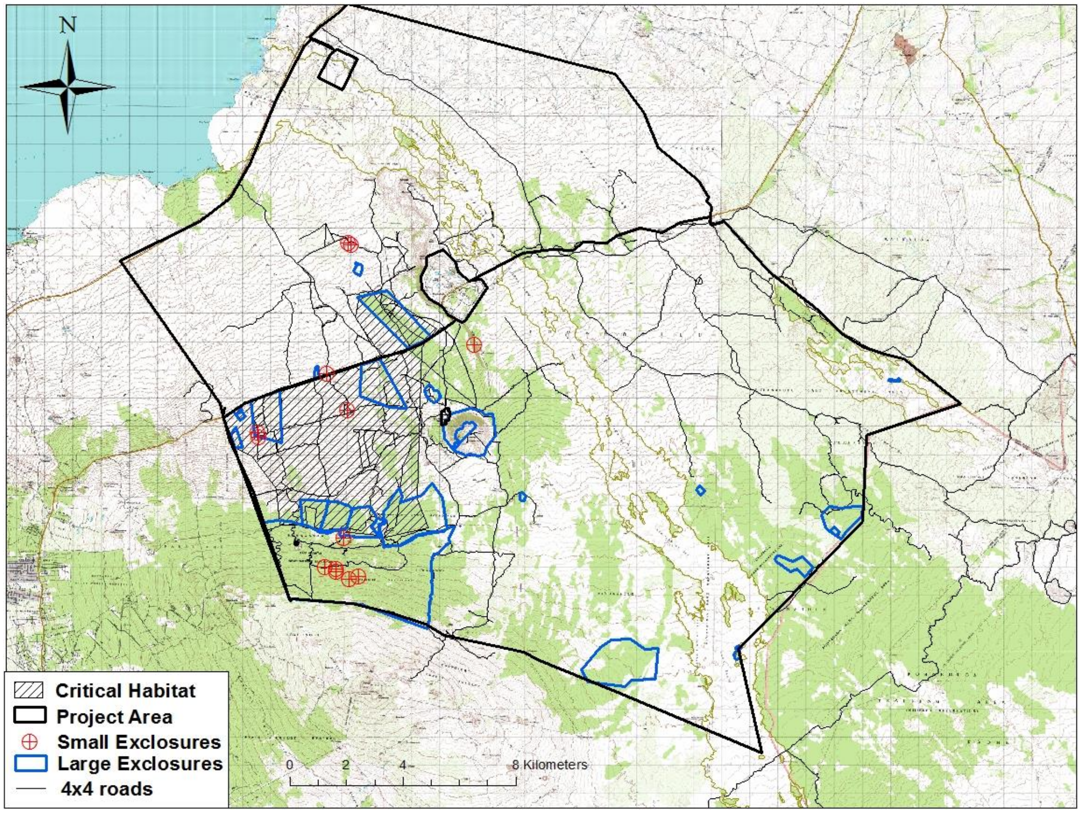

Figure 3.9. Critical habitat for ʻAiea.within the Plan Area.

Hala pepe (*Pleomele hawaiiensis*)

Description: Hala pepe, in the Asparagus family (Asparagaceae), is a branching tree, 5 to 6 m (16 to 20 ft) 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 (9 to 15 in) long and 1.4 to 2.7 cm (0.6 to 1 in) wide. Flowers are numerous in terminal clusters with a main stalk 6 to 13 cm (2 to 5 in) long and individual flower stalks 5 to 12 mm (0.2 to 0.5 in) long. The three sepals and three petals of the flower are similar and pale yellow, 33 to 43 mm (1.3 to 1.7 in) long, with a constricted base. The fruit is a red berry about 10 to 13 mm (0.4 to 0.5 in) 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 (Service 1996a).

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), Kaʻupulehu (no information available), and Kaloko (11 individuals); two in the South Kona area at Manukā and Kahuku (11 individuals); and two populations in Hawaiʻi Volcanoes National Park (HVNP). These populations total 284-334 individuals. During the 2003-2007 HCP surveys, 320 individuals were mapped in the Plan Area.

Habitat: Hala pepe typically grows on open ʻaʻā lava in diverse Lowland Dry Forests at elevations between 300 and 800 m (1,000 and 2,700 ft). Associated taxa include ʻŌhiʻa, Lama, Māmane, Alaheʻe, Hue hue, Naio, Olopua, Kuluʻi, ʻIlima, Wiliwili, ʻIliahi, Ulei, 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 and Koʻokoʻolau *(Bidens micrantha* ssp. *ctenophylla*). Critical habitat was designated for this species in 2003 (fig. 3.10) (USFWS 2003).

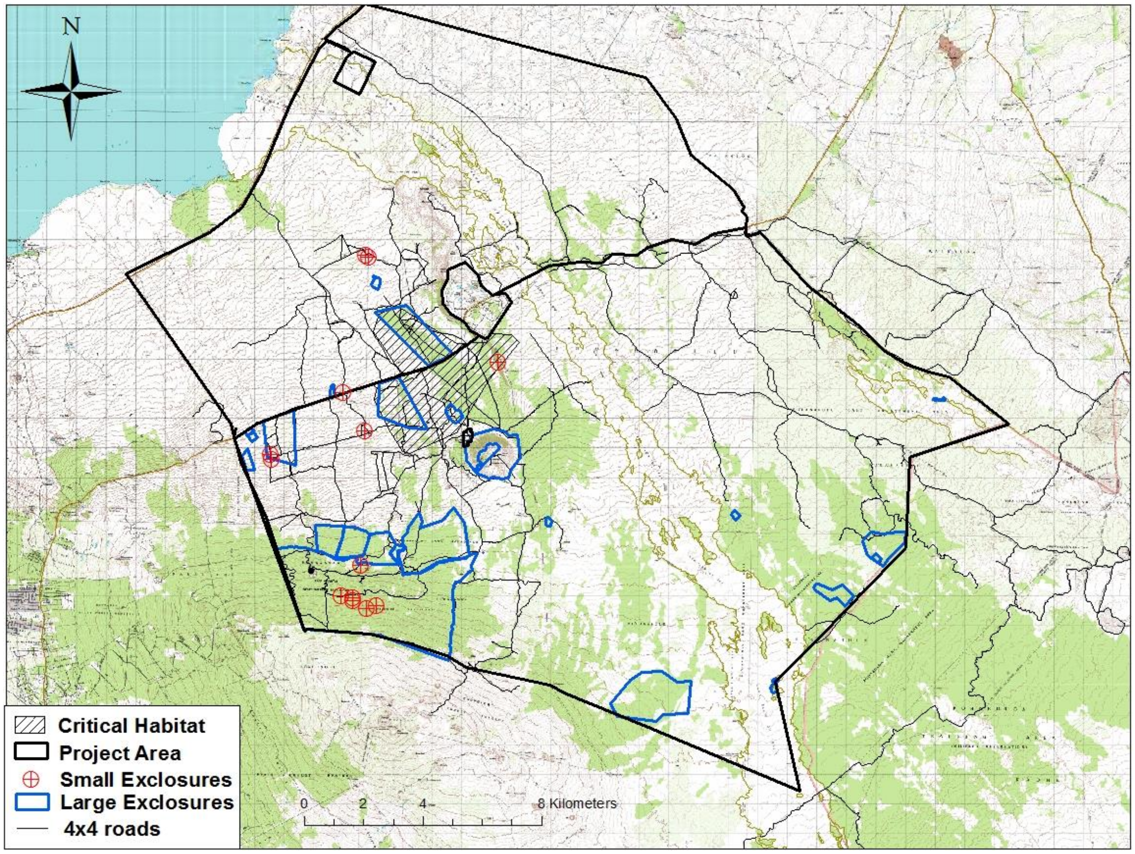

Figure 3.10. Critical habitat for Hala pepe within the Plan Area.

Poʻe (*Portulaca sclerocarpa*)

Description: Poʻe is a perennial with a fleshy, tuberous tap root that becomes woody with maturity (Wagner *et al.* 1990). 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 Kiauea Crater on the Big Island (USFWS 1996). At the time this species was listed as federally endangered in 1994, there were 11 known extant populations totaling 72-122 individuals on private, state, and federal lands on the island of Hawaiʻi (USFWS 1996). One individual was found in upper Puʻu Anahulu in January 2014 by Josh VanDeMark (Hawaiʻi Island PEPP Coordinator).

Habitat: Occurs in montane dry shrubland. The taxon often is found on bare cinder, near steam vents, and in open Ohiʻa dominated woodlands, at elevations between 3,380 and 5,340 ft (Gagne and Cuddihy 1990, Wagner *et al*. 1990). Associated taxa are Māmane, ʻŌhiʻa, and Naio (USFWS 1996). Critical habitat was designated for this species in 2003; however CH does not occur within the Plan Area.

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: Known from Molokaʻi, Oʻahu, and Hawaiʻi; historically also known from Kauaʻi and L ā naʻi. On the island of Hawaiʻi, eight occurrences are known from Pohakuloa Training Area, and on the island of Oʻahu, one occurrence is known at Makua Military Reservation. During HCP surveys, 419 individuals were mapped in Puʻu Anahulu.

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.

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: Historically known to occur from 600-2,200 m on the islands of Maui, Lānaʻi, and Hawaiʻi. Fourteen individuals were recently discovered on the island of Hawaiʻi in the upper Puʻu Anahulu region, along the PTA border, this is the only population known to occur on State land. At least 70 individuals are also known to occur within PTA (L. Perry, pers. comm.). Previous to this, the species was last seen in 1949 and thought extinct. This species is considered a potential PEPP species (Table 3.3).

Habitat: Dry and mesic shrublands and forests on ridges and in gulches. On Hawaiʻi island, on cinder cones or on older lava flows. Critical habitat was designated for this species in 2003 (fig. 3.11) (USFWS 2003).

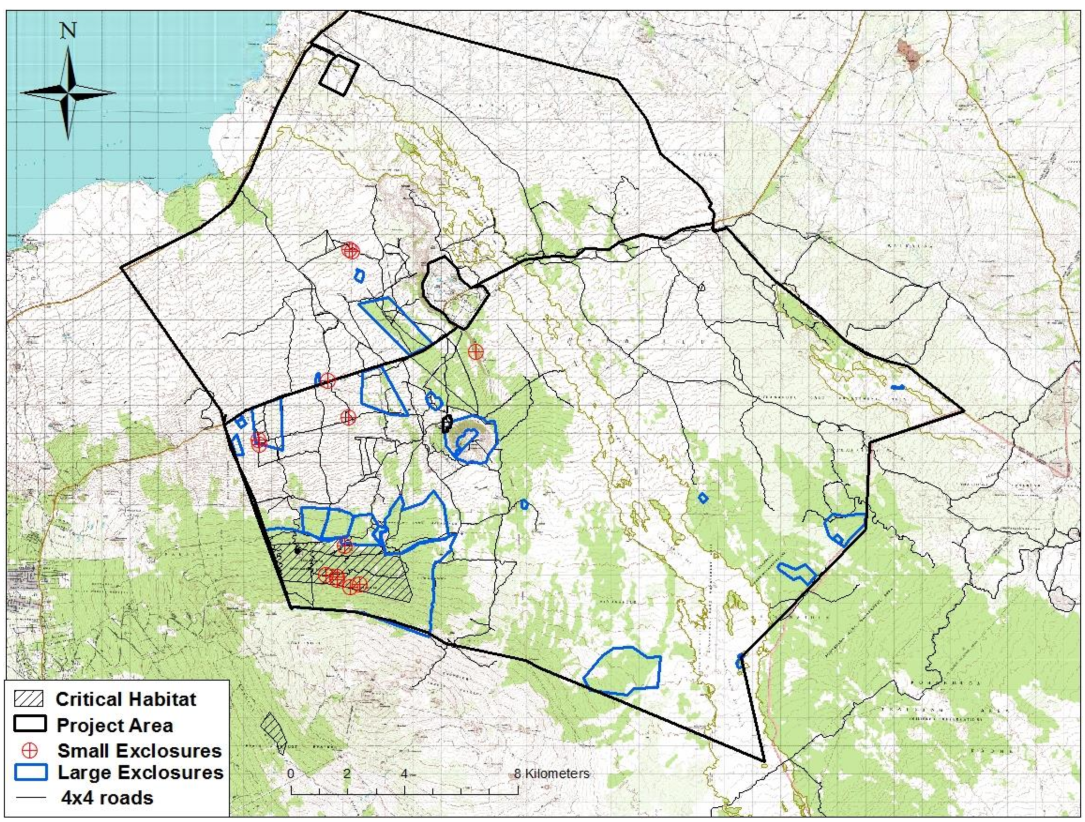

Figure 3.11. Critical habitat for Pōpolo kū mai within the Plan Area.

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 2 in long and 0.5 in wide. The narrow, tubular flowers are approximately 0.75 in 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. Currently, estimated 5,000-7,500 individuals occur only on the Island of Hawaiʻi, at Pohakuloa Training Area (U.S. Army 2003) and 97 individuals were mapped at Puʻu Waʻawaʻa and Puʻu Anahulu during the HCP surveys.

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.

Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*)

Description: Aʻe *(Z. dipetalum* var. *tomentosum),* in the citrus family (Rutaceae), is a thornless tree 4 to 15 m (13 to 49 ft) tall with a trunk up to 30 cm (12 in) in diameter. It has alternate leaves comprised of three to seven leathery, elliptical, gland-dotted, smooth-edged leaflets usually 6 to 36 cm (2.4 to 12 in) long and 2.5 to 13.5 cm (1 to 5.3 in) 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 (0.4 to 0.7 in) long, have a main flower stalk 10 to 40 mm (0.4 to 1.6 in) long and individual flower stalks 3 to 8 mm (0.1 to 0.3 in) long. Each flower has four broadly triangular sepals about 1 to 1.5 mm (0.04 to 0.06 in) long and two or four yellowish-white petals, sometimes tinged with red, 6 to 10 mm (0.2 to 0.4 in) long. The fruit is an oval follicle (dry fruit that opens along one side) 15 to 33 mm (0.6 to 1.3 in) long, containing one black seed about 10 to 26 mm (0.4 to 1 in) 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 (Service 1996a).

Historic and Current Distribution: Only one population of Aʻe (*Z. dipetalum* var. *tomentosum)* has ever been known, located at Puʻu Waʻawaʻa. Thirteen previously known and one new individual were mapped during the HCP surveys. Recent monitoring (2010 and 2011) indicates that 11 individuals persist and three have died. This species is considered a PEPP species (Table 3.3).

<u>Habitat:</u> Aʻe *(Z. dipetalum* var. *tomentosum)* grows in degraded ʻŌhiʻa -dominated montane mesic forest, often on ʻaʻā lava, at elevations between 915 and 1,040 m (3,000 and 3,400 ft). Associated species include Māmane, Lama, ʻĀlaʻa, ʻIliahi, Ohe, Kōlea, and Kōpiko. Critical habitat was designated for this species in 2003 (fig. 3.12) (USFWS 2003).

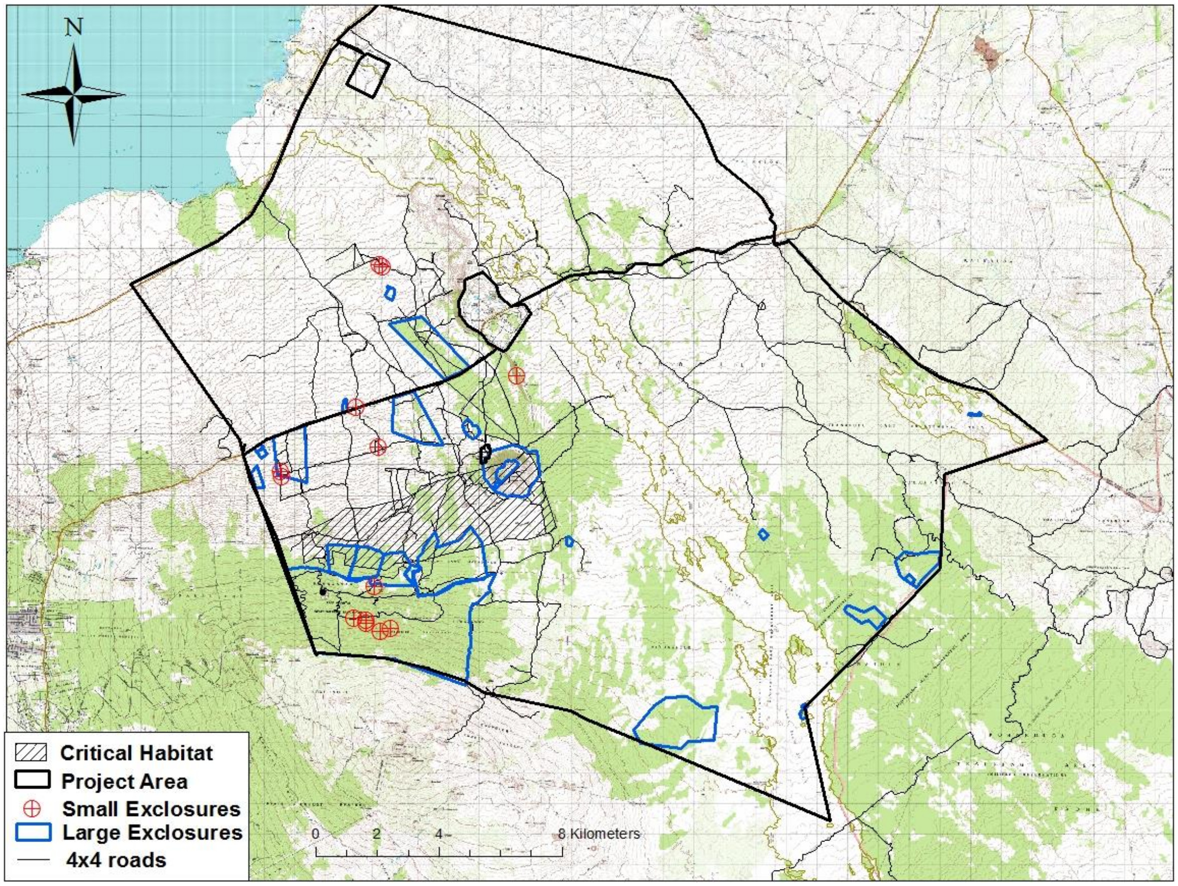

Figure 3.12. Critical habitat for Aʻe *(Zanthoxylum dipetalum* var. *tomentosum)* within the Plan Area

A'e (*Zanthoxylum hawaiiensis)*

Description: A medium-size tree 10 - 26 ft (3 - 8 m) tall, with a trunk 10 in (25 cm) in diameter (Stone *et al.* 1990). The bark is pale to dark gray, and the leaves are lemon-scented. Alternate leaves are composed of three small leaves (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, 1.6 - 3.1 in (4 - 8 cm) long, which are subtended by main flower stalks 0.8 - 2 in (20 - 50 mm) long. Each flower is subtended by a flower stalk, 0.08 - 0.2 in (2 - 4 mm). Usually, all flowers on a tree are of one sex, either male or female. A sickle-shaped, round-tipped fruit, 0.3 - 0.4 in (8 - 10 mm) long, opens on one side to release one round, slightly compressed seed. The seed covering is pitted and sculptured, about 0.27 - 0.31 in (7 - 8 mm) long, distinguished from other Hawaiian members of the genus by several characters: three leaflets all of similar size, one joint on lateral leaf stalk, and sickle-shape fruits with a rounded tip (Stone *et al*. 1990).

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 Haleakala, Maui; and the Kohala mountains, northern slopes of Hualālai, and northwestern slope of Mauna Loa, Hawai'i (Stone *et al.* 1990). Since 1975, A'e *(Z. hawaiiense)* has been identified as extant on at least four of the five islands on which it originally occurred, with at least 11 known populations and over 250 individuals. On Kaua'i, one extant individual is found in Waimea Valley. On Moloka'i, at least two populations occur, one in Pelekunu Valley and one near Pu'u Kolekole. On eastern Maui, three extant populations are located at Auwahi, Lualailua, and Kanaio. On the Big Island, five populations are located at Pu'u Wa'awa'a, Pu'u Anahulu, and the Pohakuloa Training Area. In addition, Shaw and Giffin have found numerous individuals located between Pu'u Wa'awa'a and Pohakuloa Training Area, and on the western periphery of Pohakuloa Training Area. During the HCP surveys 234 individuals were mapped.

Habitat: A'e *(Z. hawaiiense)* occurs in lowland dry and mesic forests, and montane dry forest, at elevations between 1,800 and 5,710 ft (550 and 1,740 m) (Gagne and Cuddihy 1990, Stone *et al.* 1990). The taxon grows in forests dominated by 'Ōhi'a, Lama, and Hala pepe. Other associated species include Hame (Kaua'i), A'ia'i, Kōlea, Māmane, and Naio. Critical habitat was designated for this species in 2003; however CH does not occur within the Plan Area (USFWS 2003).

Table 3.3. Species distribution, PEPP Status (PEPP: Less than 50 individuals remain in the wild, ROI: rare on island, AS: assumed stable, apparently 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	n/a	Aspleniaceae	Hawai‘i and Maui	none	E
Caesalpinia kavaiensis	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	n/a	Urticaceae	Hawai‘i	PEP	E
Nothocestrum breviflorum	‘Aiea	Solanaceae	Hawai‘i	None	E
Pleomele hawaiiensis	Hala pepe	Agavaceae	Hawai‘i	None	E
Portulaca sclerocarpa	Po‘e	Portulacaceae	Hawai‘i and Lāna‘i		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	n/a	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	n/a	Poaceae	Hawai‘i, Maui, Lāna‘i, and Moloka‘i,	None	SOC
Erythrina sandwicensis	Wiliwili	Fabaceae	All the main Hawaiian islands	None	SOC
Chamaesyce olowaluana	‘Akoko	Euphorbiaceae	Hawai‘i and Maui	None	SOC
Exocarpus gaudichaudii	Hulumoa	Santalaceae	All the main Hawaiian islands except Kaua‘i	None	SOC
Fragaria chiloensis	‘Ōhelo papa	Rosaceae	Hawai‘i and Maui	None	SOC
Melicope hawaiensis	Manena	Rutaceae	Hawai‘i, Maui, Lāna‘i, and Moloka‘i,	None	SOC
Reynoldsia sandwicensis	‘Ohe makai	Araliaceae	Ni‘ihau, Hawai‘i, Lāna‘i, Moloka‘i, O‘ahu, Kaua‘i	None	SOC
Sisyrinchium acre	Mau‘u lā‘ili	Iridaceae	Hawai‘i and Maui	None	SOC
Stenogyne macrantha	n/a	Lamiaceae	Hawai‘i	None	SOC
Tetramolopium consanguineum	n/a	Asteraceae	Hawai‘i and Kaua‘i	None	SOC
Tetramolopium humile	n/a	Asteraceae	Hawai‘i and Maui	None	SOC

3.5.5 Plant Species of Concern

Plant SOC were also documented during the HCP surveys (Table 3.4). While these species are not 'Covered Species' for the purposes of licensing; exclosures and outplanting of SOC will benefit Covered Species by working towards creating more functional communities composed of a diverse array of plant species. SOC species will be outplanted in existing and planned exclosures, along with appropriate common native species, to increase species diversity, provide synergistic and functional gains between species, and benefit native species, within the limitation of the HCP. Gains for these species provide additional net environmental benefit, and assist in protection and restoration of natural communities within the Plan Area.

Table 3.4. 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
Chamaesyce olowaluana	'Akoko
Eragrostis deflexa	Love Grass
Erythrina sandwicensis	Wili wili
Exocarpus gaudichaudii	Hulumoa
Fragaria chiloensis	'Ōhelo papa
Melicope hawaiensis	Manena
Reynoldsia sandwicensis	'Ohe Makai
Sisyrinchium acre	Mau'u lā'ili
Stenogyne macrantha	n/a
Tetramolopium consanguineum	n/a
Tetramolopium humile	n/a

3.6 WILDLIFE

3.6.1 Covered Species

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*) is one of Hawai'i's largest native insects, with a wingspan of up to 12 centimeters (5 inches) and is one of four federally listed insects in the State of Hawai'i (USFWS 2003). 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 (5,000 ft) 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 possibly Jimson weed (*Datura stramonium*).

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 which 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 *N. glauca* in July and September (Adkins, pers. obs.). 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 *N. glauca* in areas of high disturbance such as near fire-fuel breaks 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, 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 U.S. Fish and Wildlife Service 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 HCP Plan Area, specifically within Puʻu Waʻawa ʻa Forest Reserve (Figure 3.13). Critical habitat designation requires the Service to consult under section 7 of the ESA with regard to actions carried out, funded, or authorized by a federal agency when those actions may harm endangered species.

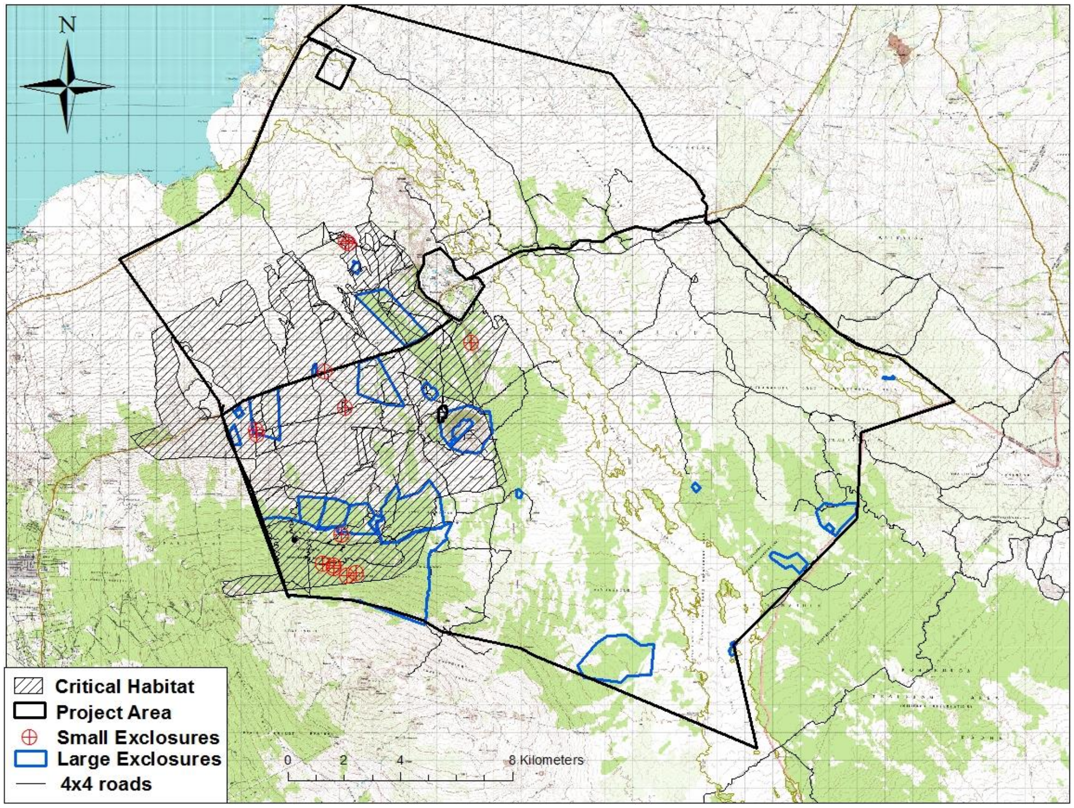

Figure 3.13. Blackburn's sphinx moth critical habitat within the Plan Area**.**

M. blackburni within the Plan Area

Blackburn's sphinx moth has been identified as being potentially impacted through the maintenance and creation of fuel breaks and four-wheel drive access roads. There is no expected take of adult *M. blackburni* due to fuel break and road maintenance; however, while take of eggs, larvae, and pupae can be largely avoided, 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 (*See map 6.9*). 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 fuel breaks 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 (off-road or on-road). 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 1 meter tall. Finally, surveys were conducted on roads as well as in 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) are more important to BSM *(See Appendix D for detailed information on surveys and results*).

3.6.2 Non-Covered Species

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 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; they may also receive some benefit in reduced trampling of nests and/or goslings as they begin nesting 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 8,900 ft 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 (*Eretmochelys imbricata*)

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 Hauaina fenced unit. 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 (L. Perry, pers. comm.). 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 within the fenced Pu‘u Wa‘awa‘a Forest Bird Sanctuary, which is already protected. Habitat loss is listed as the greatest threat to these birds; both species should gain habitat, nesting and foraging opportunities through Plan actions, resulting in a net gain to these endangered species. No direct or indirect take from Plan activities is anticipated. These and other forest bird species will receive net benefit from HCP activities, particularly as forests within the exclosures become more established.

Drosophila heteroneura

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

4.0 BIOLOGICAL GOALS AND OBJECTIVES

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

4.1 GOALS

Biological goals are intended to be broad, guiding principles that clarify the purpose and direction of the HCP (USFWS and NMFS 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 on the Covered Species associated with game mammal management and maintenance activities of the Plan;
- Increase the knowledge and understanding of the occurrence and distribution of the Covered Species in the Plan Area;
- Adhere to the goals of the recovery plans for each of the Covered Species; and
- Provide a net conservation benefit to each of the Covered Species.

4.2 OBJECTIVES

The biological objectives for achieving the HCP goals are:

- Offset the potential direct and/or indirect effects of the Plan on the 15 Covered Plant Species through protection and maintenance of a minimum of at least three populations of each covered plant species with a total number of individuals equaling the <u>take estimate</u> or <u>at least</u> the minimum number of individuals required for stabilization (whichever value is greater) as put forth by the Hawaiʻi and Pacific Plants Recovery Coordinating Committee (HPPRCC). As well as propagate additional populations as needed to provide net environmental benefit, genetic representation, and increase 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 firebreak 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, assessment, and implementation of appropriate adaptive management measures.

4.3 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; the primary measures include pre-fencing surveys and timing considerations before conducting maintenance activities and the construction of ungulate proof exclosures around Covered Species (plants).

4.3.1 General Plan Development Measures

- The spread of invasive, non-native plant species caused by fence construction will be minimized through cleaning and inspecting equipment coming to the site and by replanting disturbed areas with native species or pasture grasses to be compatible with continued grazing (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 issues that may arise.

4.3.2 Pre-Road Clearing Surveys and Timing Considerations

- To minimize impacts to Blackburn’s sphinx moth habitat, all known ‘Aiea (the native host plant) within the Plan Area will be permanently protected from ungulates.
- Blackburn’s sphinx moth larvae have been documented on tree tobacco between the months of September and May, with highest numbers found to date from December to March. Surveys have shown that larvae primarily use trees larger than 1 m in height (*See Appendix D for detailed description of data*). To minimize impacts to Blackburn’s sphinx moth, intensive control or removal of tree tobacco along roadsides and fuel breaks 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 fire breaks free of vegetation. By maintaining a consistent road clearing schedule, take of larvae and eggs will be minimized as trees cleared will primarily be less than one meter in height (*see section 3.5.1)*. For a detailed description of methods used for clearing roads and fuel breaks, please see section 5.2.2.

- Tree tobacco within exclosures will be surveyed for Blackburn's sphinx moth 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 1 m tall will be removed by pulling, while plants greater than 1 m 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.Road clearing surveys and associated plant removal and moth relocation will help to reduce the likelihood of take of the Blackburn's sphinx moth that could occur during firebreak or road maintenance.

4.3.3 Invasive Plant Species Management

DLNR will work actively to minimize and reduce the ingress of additional undesirable invasive plant species in to 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, t-posts) will be inspected, and the import of materials from sites that are known or likely to contain seeds or propagules of 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.

4.3.4 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 be transported to the site along existing access roads by vehicle or by helicopter.

4.3.4.1 Fencing Unit Priority

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

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

Fencing Unit	Type	Size[7](acres)	Rationale
Henahena	A/M	711	NotBre avoidance of take
PWW Cone Conservation Area (Hala pepe Unit)	A/M	92	PleHaw avoidance of take
‘Aiea	A/M	275	NotBre avoidance of take
Haplostachys	A/M	5	Only known population on State land and PEPP species
Solanum Kīpuka	A/M	18	Only known population on State land and PEPP species
Kauila Hala Pepe	A/M	418	Avoidance of take of ColOpp and Ple Haw
Zanthoxylum II	A/M	814	Avoidance of take of ZanHaw (large population)
Anahulu I	A/M	267	Avoidance of take for NerOva, ZanHaw, SilLan, SteAng
Anahulu II	A/M	124	Avoidance of take for ZanHaw and NerOva
Stenogyne	A/M	12	Avoidance of take for SteAng
Caesalpinia	A/M	22	Avoidance of take for CaeKav
Lowland ‘Ōhi‘a	A/M	530	Avoidance of take for PleHaw, CaeKav, ColOpp
PWW Cone Conservation Area (remaining units)	Mit	246	Mitigation for 13 of 15 Cover Species
South Kīpuka	Mit	42	Outplanting site for more

[7] Exclosure size and footprint may vary upon installation based on plant locations and geography.

			dry forest species (sites lacking)
Waihou II	Mit	202	Outplanting site for multiple Covered Species
Lama w/ Koki‘o	Mit	382	Site of last known KokDry at Puu Waawaa
Total Proposed Mitigation Acreage		**872**	**0.08% of the Plan Area**
Total[8] Proposed Avoidance/Minimization Acreage		**3,287**	**3.1% of the Plan Area**

[8] Exclosure size and footprint may vary upon installation based on plant locations and geography.

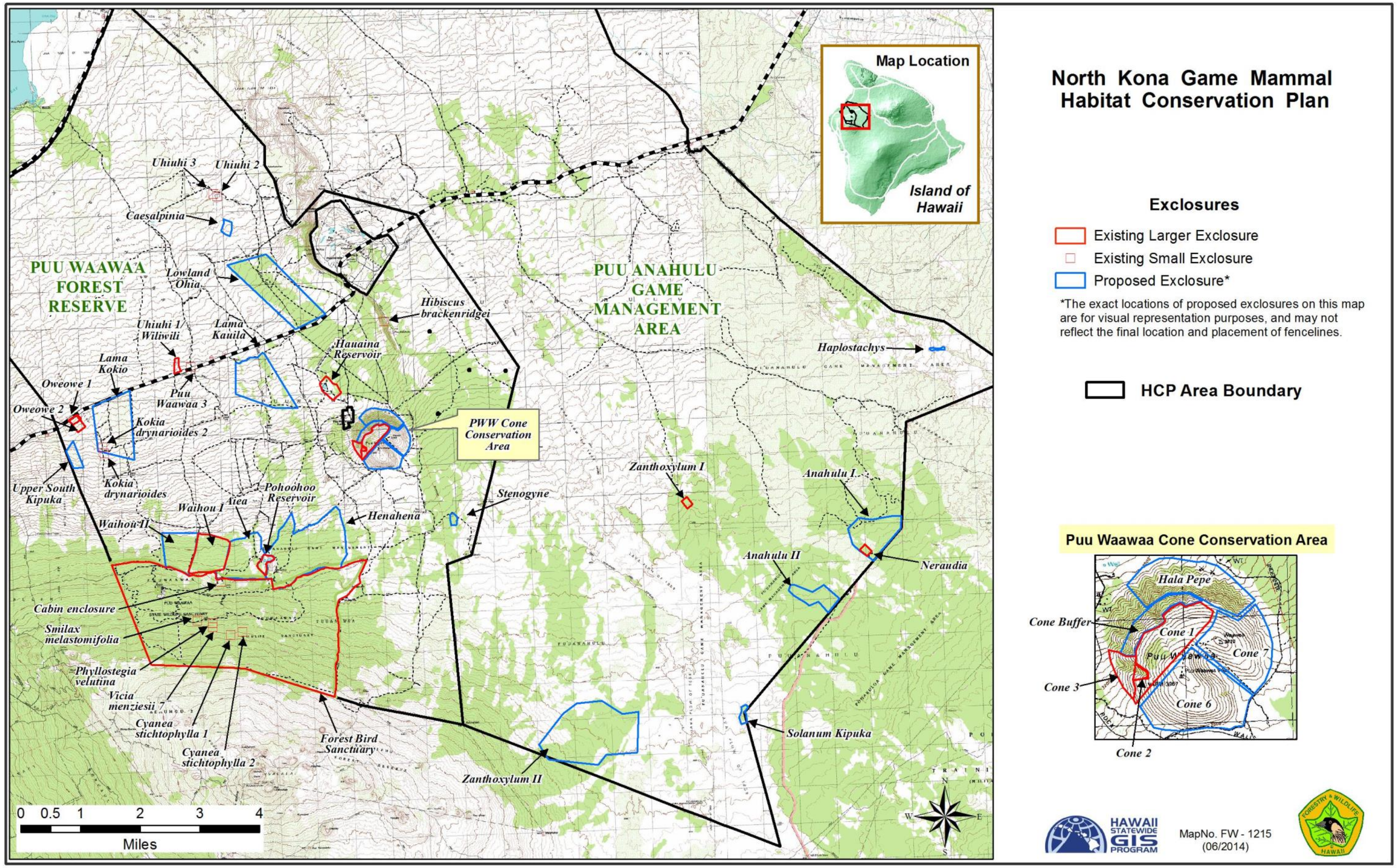

Figure 4.1. Current and proposed exclosures in the Plan Area.

4.3.4.2 Proposed Exclosures

The proposed exclosures were designed based on the following approach:

- To provide for the protection of the plant species included in the incidental take license.
- To minimize negative effects on game mammal management on Covered Species.
- To promote functional natural 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 fence lines, both to minimize cost and to minimize effect on game mammal management.

Henahena – 711 acres

Forests of ʻŌhiʻa predominate in this area. The Henahena region contains numerous sandalwood trees (ʻIliahi) and ʻAiea which are hosts for the endangered Blackburn's sphinx moth. Fencing of this area will protect remaining ʻŌhiʻa forest stands and the fragile lava tube ecosystems that occur underneath this forest type by preventing animals from damaging vegetation over the lava tube ecosystem.

PWW Cinder Cone Conservation Area – (4 units totaling 338 acres)

A number of tree species can be found within the the furrows of the cinder cone including Hala pepe and Aʻe (*Zanthoxylum dipetalum* var. *tomentosum).*

ʻAiea Exclosure – 275 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, M ā mane and Naio and contains scattered individuals of the endangered ʻAiea, and the SOC ʻAkoko.

Haplostachys Exclosure – 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 approximatelynine Pōpolo kū mai plants. The entire kīpuka should be enclosed to further protect these remaining plants. The PTA boundary fence could be utilized as one side of the fencing unit.

Kauila Hala pepe Exclosure – 418 acres

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

Zanthoxylum II Exclosure – 814 acres

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

Anahulu I – 267 acres and 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. hawaiiensis),* Hawaiian Catchfly, *Neraudia ovata,* and *S. angustifolia.*

Stenogyne Exclosure – 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.

Caesalpinia Exclosure – 22 acres

This unit will protect nine Uhiuhi trees on the makai side of Puu Wa’awa’a.

Lowland ‘Ōhi‘a Exclosure – 530 acres

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

Upper South Kīpuka Exclosure – 42 acres

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

Waihou Forest Phase II – 202 acres

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

Lama with Koki‘o Exclosure – 382 acres

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

4.3.5 Ignition Prevention

Hot catalytic converters, exhaust systems, sparks, cigarettes, and other ignition sources may be present while staff and the public access the Plan Area. Proper ignition prevention procedures will be followed by all workers.

Vehicles will not be parked in vegetation of any kind whenever possible. In some locations this may not be feasible. In these locales, vehicles will not park in vegetation greater than 10 cm (4 in) 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.

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

	Size (acres)	***Asp Per***	***Cae Kav***	***Col Opp***	***Hap Hap***	***Hib Bra***	***Kok Dry***	***Ner Ova***	***Not Bre***	***Ple Haw***	***Por Scl***	***Sil Lan***	***Sol Inc***	***Ste Ang***	***Zan Dip***	***Zan Haw***	**# Species /Unit**
‘Aiea	275								1								**1**
Waihou II	202														1		**1**
Henahena	711								1								**1**
Kauila Hala pepe	418			1					1	1							**3**
Upper S. Kīpuka	42																**0**
Lama with Koki‘o	382								1								**1**
Lowland ‘Ōhi‘a	530		1	1						1							**3**
Caesalpinia	22		1														**1**
Anahulu I	267							1			1	1		1		1	**5**
Anahulu II	124							1								1	**2**
Zanthoxylum	814															1	**1**
Stenogyne	12													1			**1**
Haplostachys	5				1												**1**
Solanum Kīpuka	18												1				**1**
PWW Cone Conservation Area	338									**1**					1		**2**
Total Acreage	**4152**																

4.3.6 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.

Table 4.3 lists Covered Species and their associated habitat types. Some species overlap with other species having wider range and can be found in multiple habitat types. Table 4.4 list fencie exclosures and the habitat types in which they exist. Factors such as species composition and assemblages, presence of pollinators and dispersers will drive the selection of exclosures that satisfy provisions for natural community maintenance and provide overall net benefit to a maximum number of species.

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

Lowland Dry Forest
Caesalpinia kavaiensis, Colubrina oppositifolia, Hibiscus brackenridgei, Kokia drynarioides, Neraudia ovata, Nothocestrum breviflorum, Pleomele hawaiiensis, Silene lanceolata, Solanum incompletum, Reynoldsia sandwicensis
Mixed Mesic/Dry Forest
Hibiscus brackenridgei, Kokia drynarioides, Nothocestrum breviflorum, Pleomele hawaiiensis, Silene lanceolata, Solanum incompletum, Zanthoxylum hawaiiense, Zanthoxylum dipetalum var. tomentosum, Chamaesyce olowaluana, Melicope hawaiiensis, Reynoldsia 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, Chamaesyce olowaluana, Eragrostis deflexa, Fragaria chiloensis, Sisyrinchium acre

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

Lowland Dry Forest
Upper Kīpuka Oweowe, Hauaina Reservoir Unit, Uhiuhi/Wiliwili Unit, Koki‘o Unit 1, Uhiuhi 2, Koki‘o 2, HibBra Unit, PWW 3, Lama/Kauila Forest, Upper South Boundary Kīpuka, Lama Forest w/ Koki‘o, Lowland ‘Ōhi‘a Forest, Caesalpinia
Mixed Mesic/Dry Forest
Waihou Forest I, PWW Cinder Cone, PWW Cinder Cone Extension, Waihou Forest II, Henahena
Mesic to Wet Forest
Forest Bird Sanctuary,
Upland Dry Shrubland
Anuhulu I & II, Zanthoxylum I & II, Stenogyne, Haplostachys, Solanum Kīpuka

5.0 POTENTIAL IMPACTS

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

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

5.1 IMPACTS TO PLANTS

5.1.1 Grazing, Browsing, and Soil Disturbance

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. Ungulates can influence plant individuals, populations and communities through their activities and also the fluxes and pools of nutrients within ecosystems. Within tropical dry and mixed-mesic ecosystems in Hawai‘i, the effects of non-native ungulates interact with other factors including invasive plants (e.g. fountain and kikuyu grasses), wildfire, and human modification/disturbance. Fire is one of the primary threats to dry forest systems. Both cattle and game mammal grazing act to reduce fuel loads in the Plan Area. The result of these combined threats is often habitat alteration for Hawai‘i's native flora and fauna and consequent decline in populations and loss of native species. In order to help mitigate these threats in the Plan Area, information on the composition, abundance, location, and behavior of game mammals is critically needed.

Potential negative impacts from game mammal management activities on Covered Plant species are primarily in the form of direct take from grazing, browsing, and soil disturbance. Appendix C describes a study done within the Plan Area that investigated the effects of ungulates on a number of the Covered Plant species. Those individuals not protected by ungulate proof fences are considered subject to take and are covered under this HCP.

5.1.2 Hunting and Recreation

Both pedestrian and motorized traffic (from hunter and hiker access) may result in direct take of protected species by unintentional trampling. However, as protected plant species do not occur within existing roadways, direct take from increased traffic would be expected to occur in the pathway of planned (future) roads and trails. This take can be avoided through road and trail planning (Figure 5.1). Any take that may occur will fall within the areas identified as impacted by grazing.

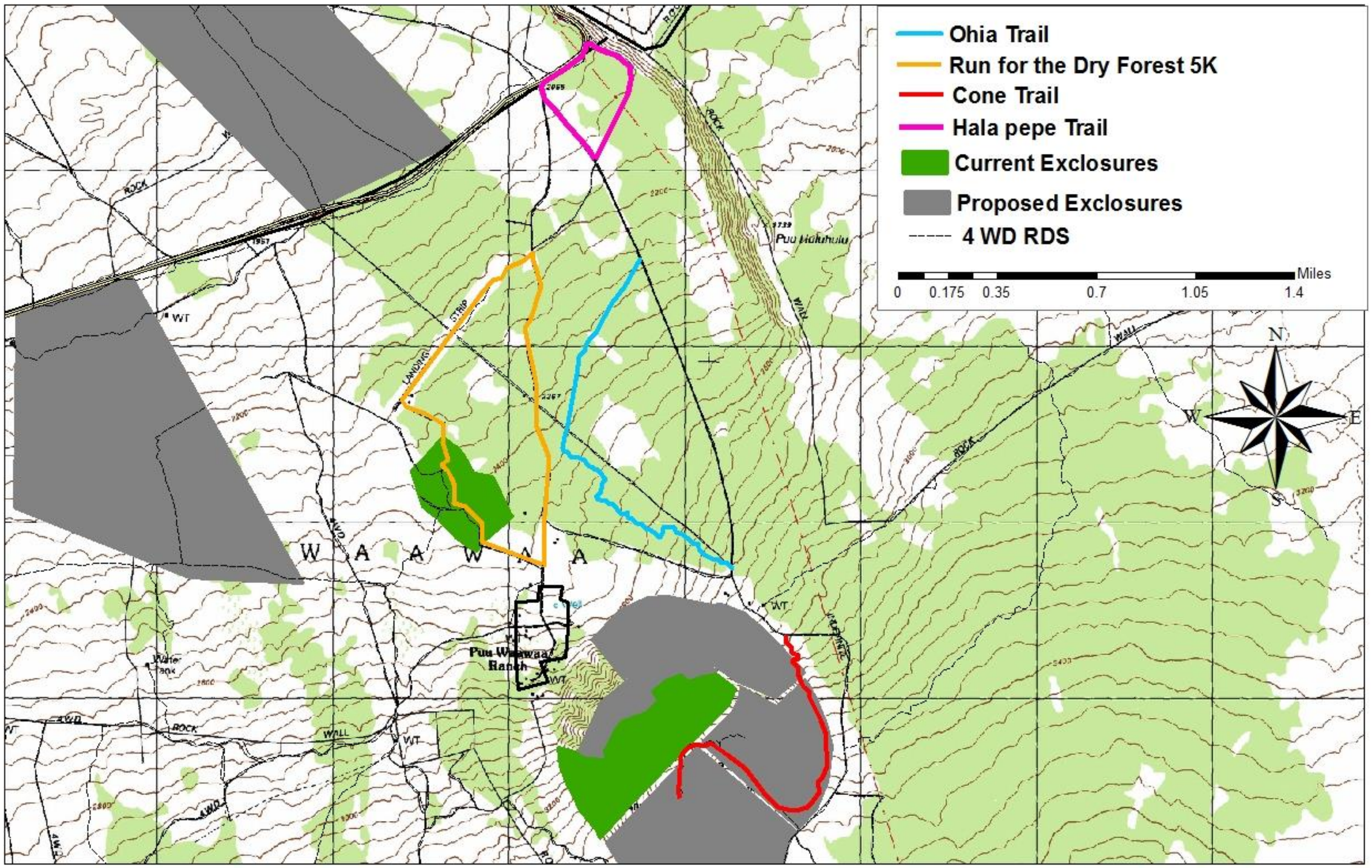

Figure 5.1. Existing trails in the Plan Area.

5.2 IMPACTS TO BLACKBURN'S SPHINX MOTH

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

5.2.1 Grazing, Browsing, and Soil Disturbance

Take of larvae on its native host plant, ʻAiea, 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 ʻAiea. By the time an ʻAiea tree has senesced due to ungulate grazing or soil disturbance adult moths will no longer lay eggs on the tree.

5.2.2 Clearing and Maintaining Fuel Break Roads

Roadside and fuel break 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. The primary shrub being cleared on the roads and fuel breaks is the non-native tree tobacco, which is a host plant for the Blackburn's sphinx moth. Clearing of roads and fuel breaks (if not timed correctly) could potentially lead to the direct take of Blackburn's sphinx moth through loss of eggs and larvae. However, provisions put forth in this HCP (*see Section 4.3*) will avoid and minimize take to the greatest extent feasible. Fuel break roads need to be maintained free of vegetation year-round. 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 (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
- Bulldozing

Fuel break 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 zero (in drought years like 2010) to four times a year. If vegetation has already consumed a large portion of the road or fuel break, 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 fuel break 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 fuel break 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.

5.3 ESTIMATING PLAN RELATED IMPACTS

This section focuses on methods used for estimating populations within the Plan Area. For plant populations, a model has been developed to predict abundance in the unsurveyed areas and uses those data 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 fire break maintenance. These estimates were used to create a mitigation strategy for each of the Covered Species (*See Section 7 for more information*).

5.3.1 Estimating Rare Plant Population Size

In order to estimate the approximate sizes of Covered Plant Species populations within the Plan Area, we used a method to extrapolate based on 1) the number of plants found during HCP surveys, 2) the amount of area surveyed, and 3) the types of physical environments within which surveys took place. Because the Area of Potential Impact (Figure 1.2) includes all areas within 2.25 km of Puʻu Waʻawa ʻa and Puʻu Anahulu, we generated a 2.25 km buffer to reflect the entire action area (Figure 5.2). The Area of Potential Impact is defined as the Plan Area plus the buffer zone (*See section 1.3.1 for a full description of the Area of Potential Impact*). The buffer size was calculated using the home range data (see Appendix A) collected for pigs, sheep, and goats. Of the three game mammals that occur within the Plan Area, goats have the largest home range, 16.3 km. This 2.25 buffer area is used to project the number of Covered Plant species potentially affected by game mammal management activities outside the boundary of Puʻuwaʻawaʻa and Puʻuanahulu. These projections 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 during 2003 -2007 were focused in areas where rare species had been found in the past, and areas with the best remaining habitat. The 2003 -2007 survey data were used to create a model to predict the areas with the highest probability of harboring Covered Plant species within the Plan Area. The predictions were used to focus new plant surveys in 2011 (see Figure 3.4). Both data sets were combined to create a new model. This model allows us to predict 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, 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 (Figures 5.3 and 5.4).

The Plan Area is characterized by a large elevational gradient, a moderate range of moisture (relative to other areas in Hawai‘i - see Figure 5.5), 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 basis 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, 1997) 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 2000 m elevation; we used a digital elevation model to divide all combinations involving that moisture zone at 1100 m. The result is habitat units with different combinations of moisture, age, and elevation. In total, 36 habitat units were recognized (Figure 5.6).

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. 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-projection of potential habitat in the action area.

For each species, the potential number of occurrences outside the survey areas and proposed or current exclosures was estimated. To do this, we first calculated the number of detections of each Covered Species within the surveyed portion of each habitat unit. A detection is defined to be any 10 by 10 meter grid square that contains at least one known (surveyed) plant location. Then the average density of individuals recorded within each habitat type was estimated by dividing the number of detections by the area of each habitat type surveyed. The average density was then projected into the areas of the same habitat unit that were not surveyed. For example, imagine a habitat unit occupies 100 ha total, of which 20% (20 ha) was surveyed. If 10 detections were recorded in the surveyed portion of the unit we would calculate a density of 10 individuals divided by 20 ha equaling 0.5 individuals/ha. Extrapolating this to the unsurveyed portion of the unit (80 ha), we would estimate multiply the density of 0.5 individuals/ha times 80 ha, which equals 40 individuals. We obtained the total take estimate by summing the estimated the potential number of individuals within the take area of each habitat, which in this example totals 50 individuals.

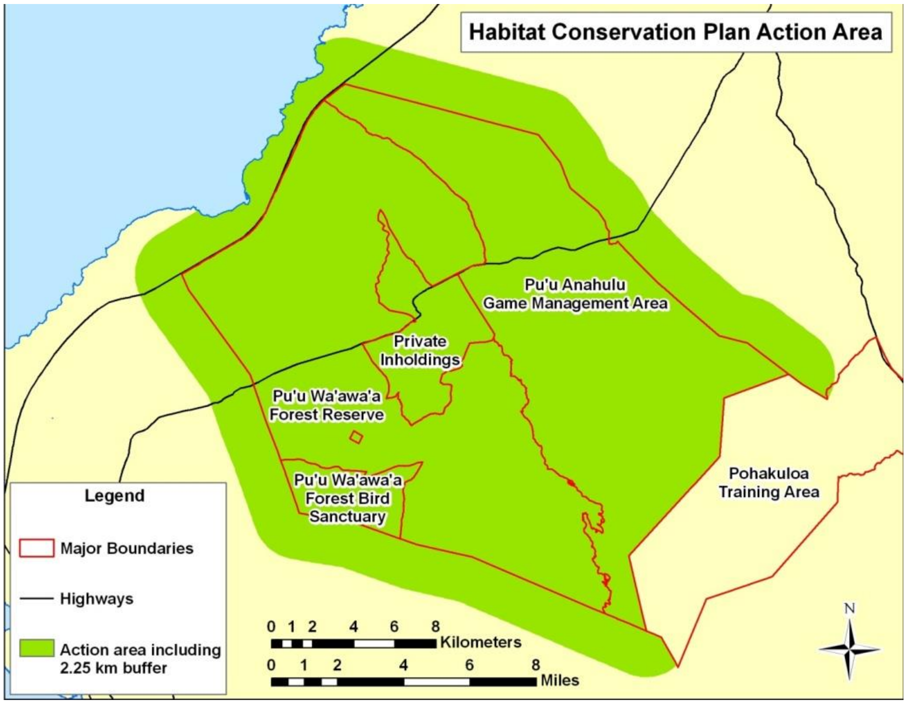

Figure 5.2. The HCP Area of Potential Impact including the 2.25 km buffer around all boundaries with the exception of PTA where a boundary fence prohibits the movement of ungulates.

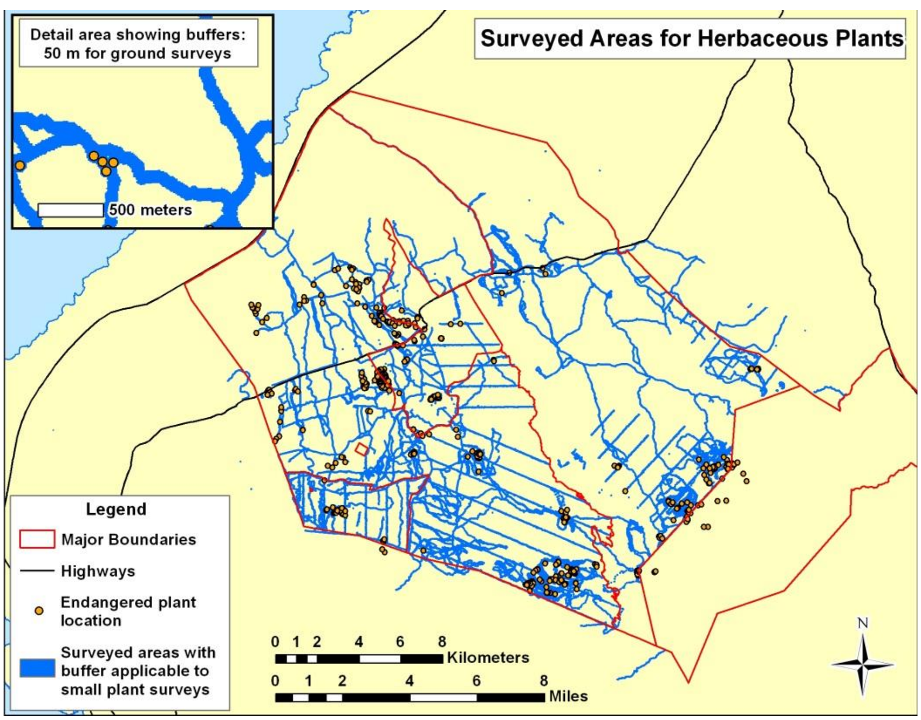

Figure 5.3. Surveyed areas within the Action Area including all 4x4 roads and a 50m buffer around all tracks and guided searches for herbaceous species.

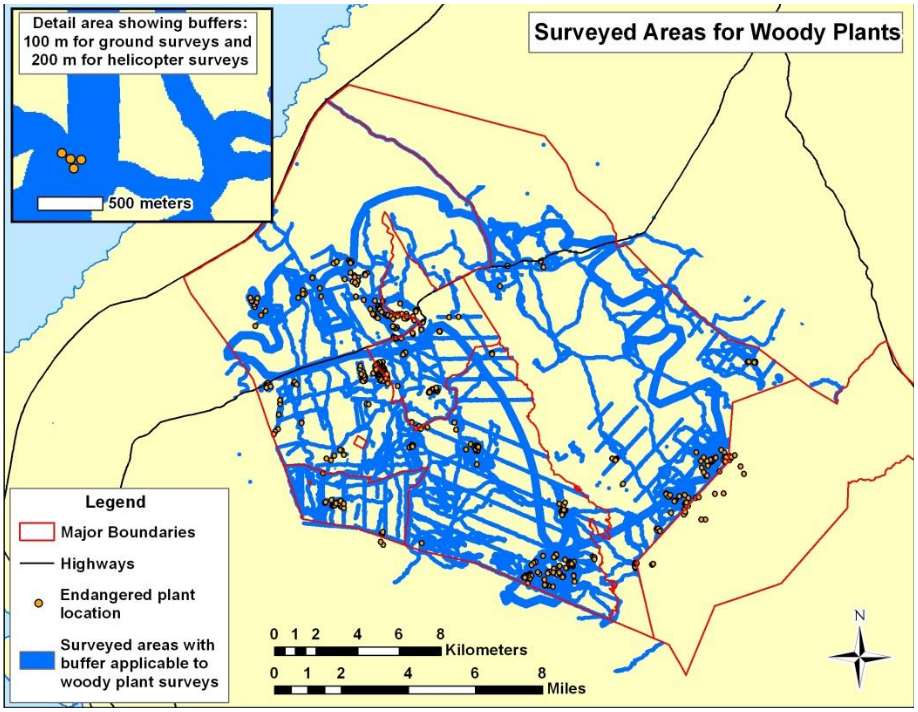

Figure 5.4. Surveyed areas within the Area of Potential Impact including all 4x4 roads and a 100m buffer for ground and 200m for helicopter surveys all tracks and guided searches for surveys of woody species.

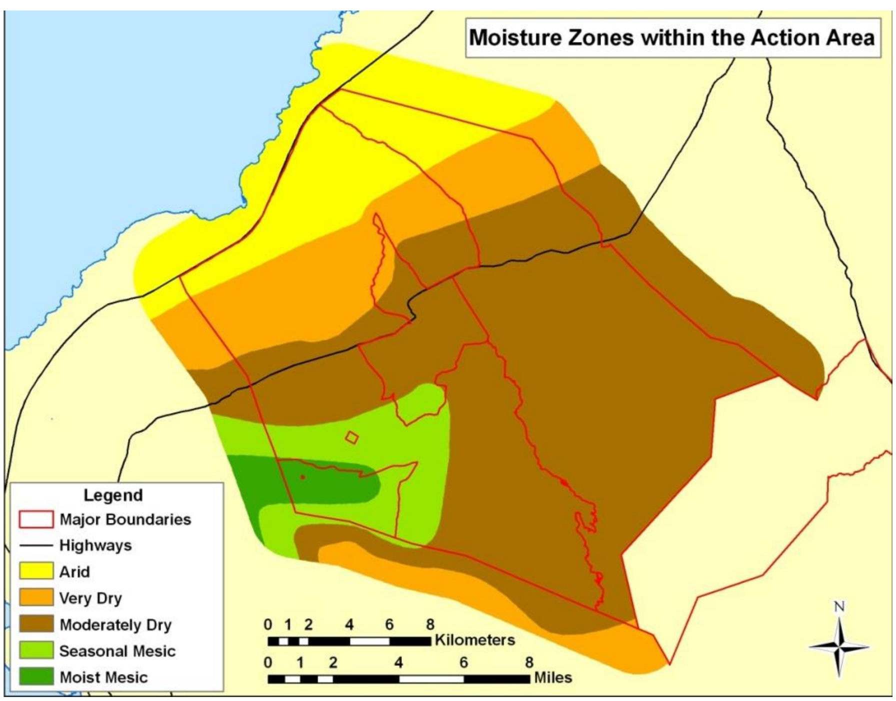

Figure 5.5. The moisture zones found within the Area of Potential Impact. Moisture zones were used as a proxy for elevation in defining habitat types for developing the model of projected values outside of surveyed areas.

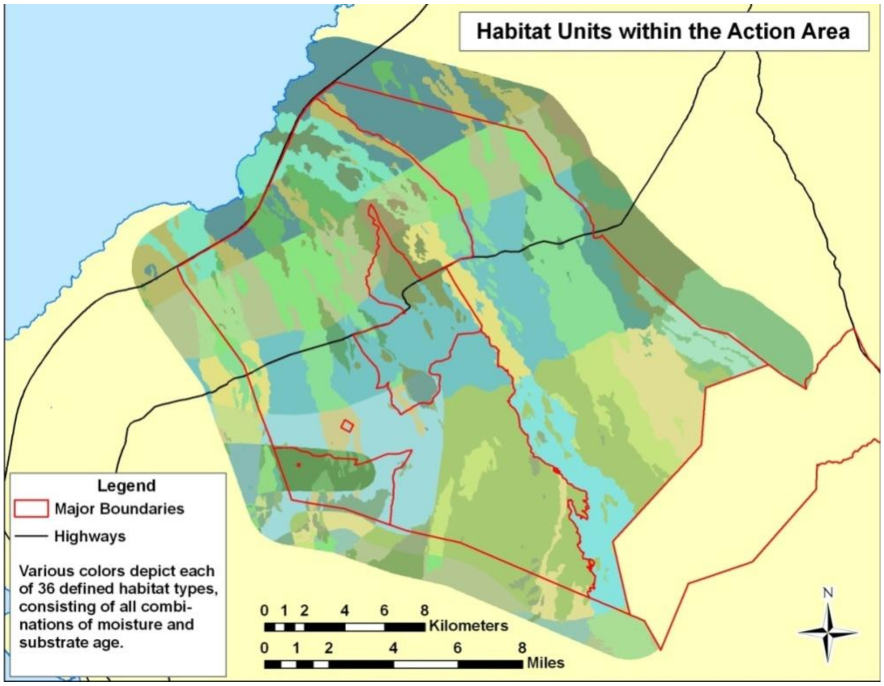

Figure 5.6. Habitat types found within the Area of Potential Impact as defined by moisture zone and substrate type.

5.3.2 Estimating Take of Covered Plant Species

Take estimates were calculated for each of the covered plant species using the HCP survey data, the projected values estimated from the model, and the location and size of proposed and current and exclosures. The number of known (surveyed) individuals is added to the projected number of individuals (based on model predictions) to give a total population estimate. This information is summarized in Table 5.1 and details for each Covered Species and the corresponding exclosures are described below.

Table 5.1. Estimated take of plant Covered Species. Projections were only made within habitat types the species was documented within, 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 consider a detection 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. Projected numbers of undetected plants represent the density of individuals detected in a given habitat multiplied by the unsurveyed take area.

Species[9]	Habitat Type	% of habitat surveyed	Amount of habitat surveyed (km^2)	Number of detections in habitat	Density of individuals (per km^2)	Unsurveyed take area (km^2)	Projected number of undetected plants in take area	Number of detections in take area	Total projected take
Caesalpinia kavaiensis	24	29.0	9.0	27	3.0	21.9	66	16	82
	25	34.1	9.3	18	1.9	18.0	35	18	53
	34	51.1	25.3	2	0.1	23.1	2	0	2
	Total	**40.4**	**43.7**	**47**	**1.1**	**63.0**	**103**	**34**	**137**
Colubrina oppositifolia	24	32.1	8.7	2	0.23	18.2	4	1	5
	34	49.8	29.5	791	26.8	28.6	767	82	849
	35	30.5	10.6	4	0.38	23.9	9	4	13
	36	21.0	1.7	11	6.4	6.3	40	7	47
	44	45.7	2.8	1	0.36	3.1	1	1	2
	Total	**39.4**	**53.3**	**809**	**15.2**	**80.1**	**821**	**95**	**916**
Haplostachys	62	29.6	2.1	1	0.5	5.0	2	0	2

9 *A. peruvianum* and *P. sclerocarpa* are absent from this table. *A. peruvianum* is known to occur in caves and lava tube openings, while the overall range for the species is known, the actually available habitat has not been mapped, making it difficult to extrapolate to the entire Plan Area. *P. sclerocarpa* is known from only location and was therefore excluded from modeling.

Species[9]	Habitat Type	% of habitat surveyed	Amount of habitat surveyed (km^2)	Number of detections in habitat	Density of individuals (per km^2)	Unsurveyed take area (km^2)	Projected number of undetected plants in take area	Number of detections in take area	Total projected take
haplostachya									
	67	9.0	1.8	29	16.3	17.9	292	0	292
	Total	**14.5**	**3.9**	**30**	**7.7**	**23.0**	**294**	**0**	**294**
Hibiscus brackenridgei	34	51.5	25.3	4	0.2	22.7	4	0	4
	Total	**51.5**	**25.3**	**4**	**0.2**	**22.7**	**4**	**0**	**4**
Kokia drynariodes	34	92.6	20.3	4	0.2	1.3	0	3	3
	Total	**92.6**	**20.3**	**4**	**0.2**	**1.3**	**0**	**3**	**3**
Neraudia ovata	63	23.3	4.1	4	0.9	13.2	13	1	14
	64	25.7	13.7	3	0.2	39.1	9	0	9
	65	18.7	3.2	1	0.3	13.9	4	0	4
	Total	**23.9**	**21.0**	**8**	**0.4**	**63.0**	**26**	**1**	**27**
Nothocestrum breviflorum	124	27.1	9.3	1	0.1	25.1	3	1	4
	131	12.6	2.0	2	1.0	13.8	14	1	15
	134	49.0	30.5	54	1.8	30.6	54	23	77
	135	31.1	11.3	7	0.6	24.8	15	2	17
	141	1.9	0.1	2	27.0	3.8	101	2	103
	144	60.4	16.8	106	6.3	8.2	52	34	86
	145	37.2	2.0	6	3.1	2.5	8	0	8
	146	51.2	0.6	2	3.4	0.5	2	2	4
	147	41.5	0.8	1	1.1	0.1	0	1	1
	154	70.4	5.4	11	2.0	0.3	1	1	2
	155	59.5	1.4	2	1.4	0.4	1	0	1
	Total	**40.3**	**80.3**	**194**	**2.4**	**107.2**	**251**	**67**	**318**
Pleomele	24	29.0	9.0	9	1.0	21.9	22	1	23

Species[9]	**Habitat Type**	**% of habitat surveyed**	**Amount of habitat surveyed (km^2)**	**Number of detections in habitat**	**Density of individuals (per km^2)**	**Unsurveyed take area (km^2)**	**Projected number of undetected plants in take area**	**Number of detections in take area**	**Total projected take**
hawaiiensis									
	34	49.0	30.5	299	9.8	30.6	301	53	354
	35	31.1	11.3	6	0.5	24.8	13	5	18
	36	21.0	1.7	8	4.6	6.3	29	3	32
	37	24.9	6.2	2	0.3	15.7	5	2	7
	44	50.9	4.7	1	0.2	4.0	1	1	2
	47	47.6	0.5	35	66.5	0.1	4	0	4
	Total	**36.9**	**63.9**	**360**	**5.6**	**106.6**	**375**	**65**	**440**
Silene lanceolata	61	7.6	1.6	2	1.2	20.0	24	2	26
	63	21.8	4.7	7	1.5	16.4	25	2	27
	64	27.4	19.0	20	1.0	49.6	52	20	72
	Total	**22.5**	**25.3**	**29**	**1.1**	**86.0**	**101**	**24**	**125**
Solanum incompletum	61	7.6	1.6	4	2.4	20.0	48	0	48
	65	21.2	4.1	4	1.0	15.0	15	0	15
	Total	**14.0**	**5.7**	**8**	**1.4**	**35.0**	**63**	**0**	**63**
Stenogyne angustifolia	63	19.8	4.7	8	1.7	18.7	32	0	32
	64	26.5	19.1	39	2.0	52.1	107	13	120
	Total	**24.8**	**23.7**	**47**	**2.0**	**70.8**	**139**	**13**	**152**
Zanthoxylum dipetalum	44	57.7	10.5	8	0.8	6.1	5	5	10
	45	35.9	1.7	4	2.3	2.5	6	1	7
	47	40.4	0.8	1	1.3	0.1	0	0	0
	Total	**52.1**	**13.0**	**13**	**1.0**	**8.7**	**11**	**6**	**17**
Zanthoxylum hawaiiense	61	18.8	4.1	1	0.2	17.6	4	1	5

Species[9]	Habitat Type	% of habitat surveyed	Amount of habitat surveyed (km^2)	Number of detections in habitat	Density of individuals (per km^2)	Unsurveyed take area (km^2)	Projected number of undetected plants in take area	Number of detections in take area	Total projected take
	63	47.0	10.1	10	1.0	11.3	11	1	12
	64	49.5	33.9	118	3.5	24.4	120	18	138
	Total	**43.1**	**48.0**	**129**	**2.6**	**63.3**	**135**	**20**	**155**

5.3.3 Loss of Recruitment

Those individuals that occur outside of current and proposed fencing units are considered unprotected and will be included within the take estimate. 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 loss of recruitment. Monitoring will be done to estimate the level of potential take of seeds that germinate around unprotected plants. 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 5 years) to count the number of recruited individuals and estimate an average recruitment for that species. An estimated rate of loss of recruitment will be calculated for each species. Should values calculated from monitoring data exceed those proposed for in the stabilization criteria, the additional values will be added to the overall take estimate (*For more detailed description of methods please see the Monitoring Section)*.

5.3.4 Strategies for Stabilization of Covered Species

The focus for the stabilization of threatened and endangered species occurring within Pu‘u Wa‘awa‘a and Pu‘u Anahulu Game Management Areas will be on restoration and protection of functional plant 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. 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 will 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 utilize areas within the Plan Area that contain established 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.

The U.S. Fish and Wildlife Service (USFWS) defines plant stabilization according to the recommendations put forth by the HPPRCC, a group of botanical experts gathered together by the USFWS to offer guidance on the recovery of listed plants in the Pacific (Army 2003). 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 1998b). A population in this context is defined and used here as a given number of individuals found less than 1,000 m apart, that are presumably genetically similar and therefore capable of crossing, and are equally affected by localized stochastic events such as fire (Army 2003). It is important to note that the requirements for stabilization are far below those required for delisting or downlisting, and that stabilization is not synonymous with recovery.

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 believes that sustaining populations with these numbers of reproducing individuals over the short-term ensures 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 2003).

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 be done taking into consideration using the guidelines put forth by the Hawaiʻi Rare Plant Restoration Group (HRPRG) (1999). 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 2003, HRPRG 1999). 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 2003, HRPRG 1999). In both cases a number of considerations must be taken, particularly relating to genetic integrity. Specific guidelines will be developed to ensure mitigation efforts will not harm or endanger current extant populations of listed species.

5.3.5 Factors Influencing Effective Population Size

The effective population (N_e) 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 to reach an equivalent N_e. For this reason, these factors will be considered during mitigation planning on a species by species basis (Table 5.2).

1. 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. 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. Therefore, for taxa that are obligately outcrossing, 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 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 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. The N_e is much lower than the N in this case, and the population target is doubled.

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

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

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

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

Table 5.2. 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	n/a	SP	Unknown
Caesalpinia kavaiensis	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	n/a	SP	Dioecious
Nothocestrum breviflorum	‘Aiea	LP	Unknown
Pleomele 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	n/a	SP	Unknown
Zanthoxylum dipetalum	A‘e	LP	Dioecious, large percentage of non-flowering/fruiting plants, low seed set/poor seed viability
Zanthoxylum hawaiiensis	A‘e	LP	Dioecious

Table 5.3. Species stabilization goals for each of the Covered Species.

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

5.3.6 Estimating Blackburn's Sphinx Moth Habitat Affected by Road and Fuel Break Maintenance

In 2011 and 2012 the distribution of tree tobacco on roadsides and fuel breaks 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. These locations were used to create a preliminary map of the distribution of tree tobacco across the surveyed area (Figure 5.7). We then used a subset of this data taken in Puu Anahulu, to calculate what proportion of the roads that are expected to contain tree tobacco actually are occupied by tree tobacco. For a stretch of road 37,402 m long and 7 m wide (261,814 m^2), 649 tree tobacco location survey points were recorded. Each survey point represents a 25 m x 3 m long belt transect that contains tree tobacco. For the subset of road used in this calculation, the total area actually occupied by tree tobacco was 48,675 m^2 or approximately 18.6% of the surveyed roads.

Next, a map of the Core Tree Tobacco Invasion Area (CTTIA) was created to indicate which roads in the Plan Area currently contain, have contained in the past, or may contain tree tobacco in the future (Figure 5.8). 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).

We are requesting take of Blackburn's sphinx moth based on following a schedule that allows DOFAW to clear the roads and fuel-breaks every two months, 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). Because of this variability we divided the years into two season, winter and summer, and used the data collected in summer and winter of 2012 to estimate take year round with three winter clearings and three summer clearings.

5.3.6.1 Winter Take Estimate

A total of 73 Blackburn's sphinx moth detections (larvae and un-hatched eggs) were found on 2323 tree tobacco plants across 93 transects during the winter 2012 surveys. Using these data, we calculated: 73 BSM/2323 trees = 0.03142 BSM/tree. We surveyed 93 transects with a total of 2323 trees: 2323/93 = 24.98 individual tree tobacco plants per transect. Given a density of 0.03142 BSM per tree, we then get a density of 0.7849 BSM per transect (0.03142 x 24.98 trees per transect). One transect has an area of 75 m^2 (25 m x 3 m). Therefore overall BSM density for the winter is 0.7849/75 m^2 = 0.0105 BSM/m^2. Based on the Occupied Area calculated above from above (156,144.467 m^2), estimated take for one winter clearing period rounds up to 1640 Blackburn's Sphinx moth individuals (larvae plus un-hatched eggs).

5.3.6.2 Summer Take Estimate

A total of 4 Blackburn's sphinx moth detections (larvae and un-hatched eggs) were found on 1329 tree tobacco plants across 49 transects during the winter 2012 survey. Using these data, we calculated: 4 BSM/1329 trees = 0.003 BSM per tree. We surveyed 49 transects with a total of 1329 trees: 1329 trees/49 transects = 27.122 individual tree tobacco plants per transect. Given a density of 0.003 BSM per tree, we then get a density of 0.0814 BSM per transect (0.003 x 27.122 trees per transect). One transect has an area of 75 m^2 (25 m x 3 m). Therefore overall BSM density for the summer is 0.0814/75 m^2 = 0.001 BSM/m^2. Based on the Occupied Area calculated above from above (156,144.467 m^2), take for one summer clearing period rounds up to 157 Blackburn's Sphinx moth individuals (0.001 x 156,144.467 = 156.144 larvae plus un-hatched eggs).

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

We estimated the location and distribution of tree tobacco in the Plan Area based on a helicopter survey conducted in January 2015 (see Figure 5.8). 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 approximately 6462 acres of the Project Area (outside of roads) contain tree tobacco. The winter 2012 off-road BSM survey data was then used to estimate BSM density (24 BSM/acre) across the entire area colonized by tree tobacco (24 x 6462 = 155,088 BSM). Based on this calculation, the population estimate for Blackburn's sphinx moth larvae and un-hatched eggs outside of roads is 155,088 BSM. We then added the winter 2012 on-road population estimate (1640 BSM) for a total winter Blackburn's sphinx moth population estimate of 156,728 individuals (larvae plus un-hatched eggs).

5.3.6.4 Total annual take estimate

If we assume we will clear all tree tobacco plants 6 times a year, three times during summer or dry months and three times during winter or rainy months, the overall annual take estimate is 5,391 individual BSM (1,640 x 3 = 4,920 +_157 x 3 (471) = 5,391) un-hatched eggs and larvae) which is 3.44 % of the estimated Blackburn's sphinx moth population in the Plan Area (5,391/156,728) x 100 = 3.44%).

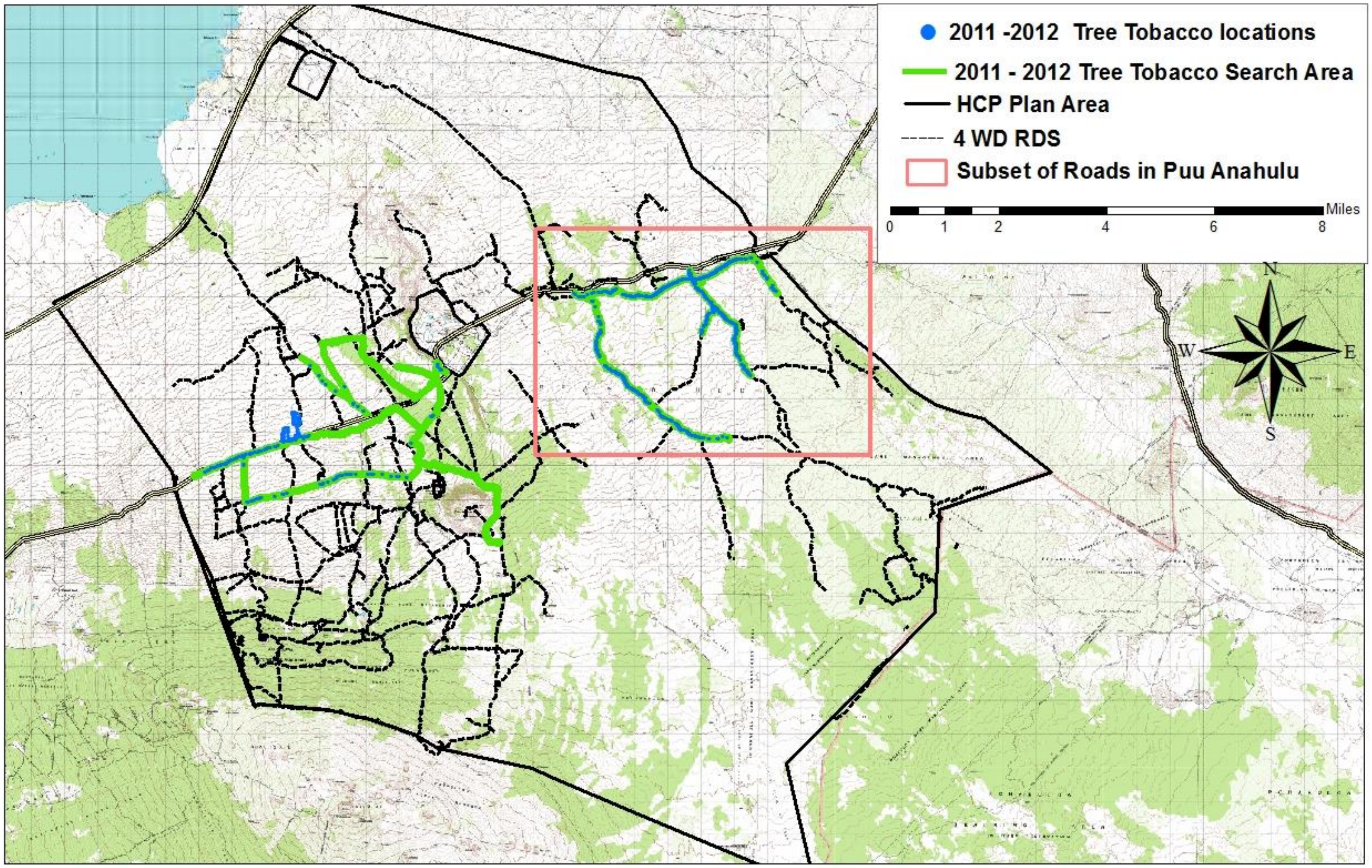

Figure 5.7. 2011 and 2012 tree tobacco search area (green line) with mapped tree tobacco locations (blue dots). The area in the red/pink rectangle highlights the subset of roads used to calculate the proportion of occupied habitat.

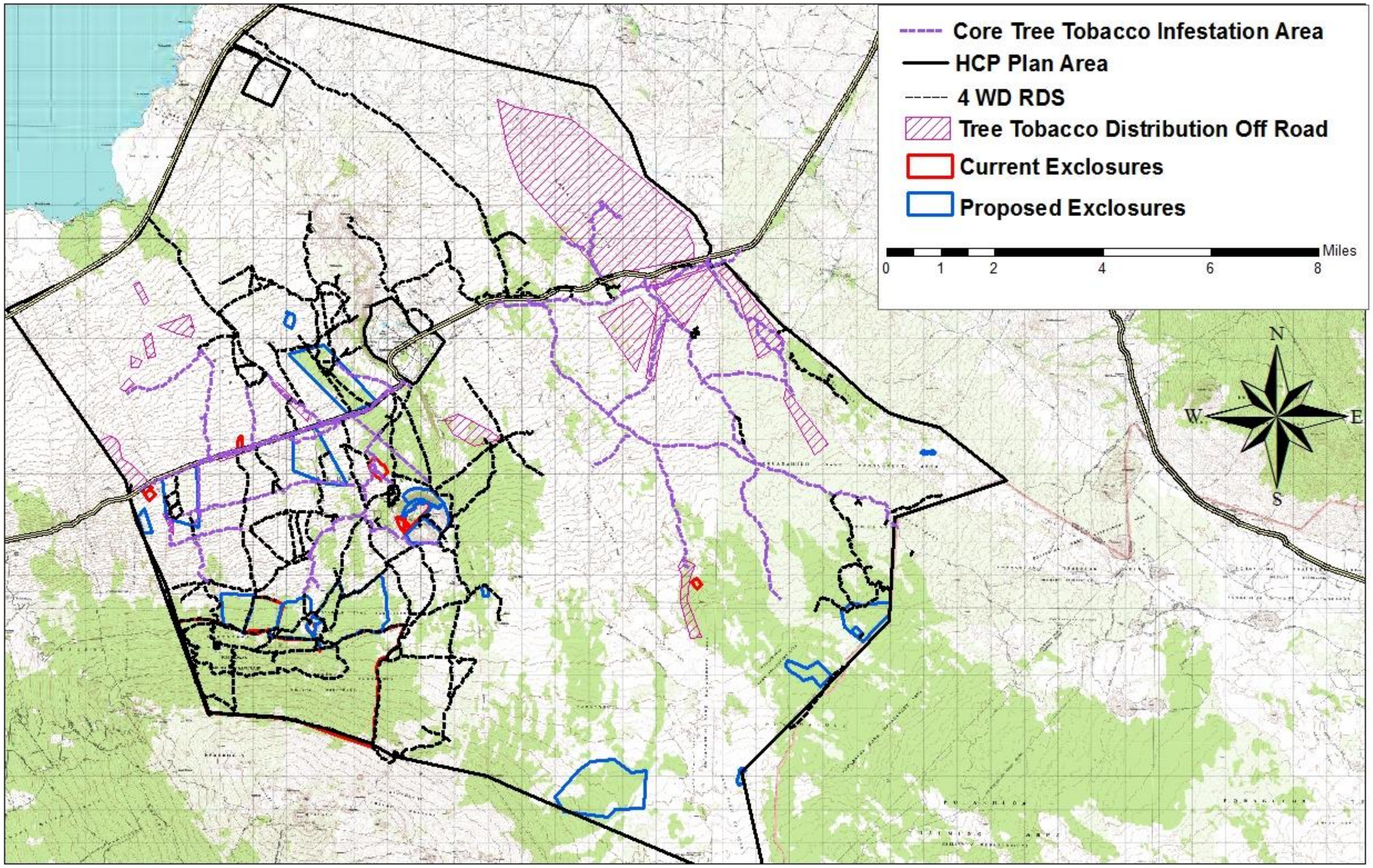

Figure 5.8. Estimated tree tobacco distribution in the Plan Area based on the 2015 helicopter survey (pink hashed area). Roads in purple indicate the CTTIA.

6.0 MITIGATION

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

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

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

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

6.1 MITIGATION LOCATIONS

Our main approach for mitigating for the take of Covered Species in the Plan Area is through the management of conservation units, large exclosures, and small exclosures. Conservation units are defined as fenced areas larger than 100 acres, large exclosures are 10-100 acres, and small exclosures are less than 10 acres. Table 6.1 summarizes the existing and proposed exclosures, their sizes, and appropriate Covered Species to be planted in each exclosure. See Figure 6.2 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 exclosures outlined in the Puʻu Waʻawaʻa Management Plan and in this HCP target areas to provide protection to relatively good quality remnant dryland forest, mesic forest, and shrub land that is currently not under protection. Larger units allow for the restoration of ecological functions of natural communities and can serve as islands, 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, and there may be a greater chance of damage to fence lines from tree falls or seismic activity.

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

- Management in conservation units should address not only listed species but also their more common and locally rare native cohorts. 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 a matrix of trees allowing for more contiguous habitat to facilitate gene flow between populations.
- All ungulates will be removed from inside fenced units which will be monitored at least quarterly for ungulate ingress or fence line damage. Ungulates will be removed following the ungulate control methods as outlined in State of Hawaiʻi Technical Report No. 07-01, *Review of Methods and Approach for Control of Non-native Ungulates in Hawaiʻi* (DOFAW 2007). Ungulate removal will begin by driving the animals out, to the extent possible, followed by opening the units to controlled public hunting. Finally, DOFAW staff will trap, snare, and shoot any remaining ungulates.
- Strict sanitation guidelines should 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.
- Encourage research into factors beneficial to community restoration: ungulate ecology and behavior, pollination, phenology, mycorrhizae, dispersal, seed ecology, macroinvertebrates, etc.
- Encourage education and outreach, and access to areas appropriate for traditional use of the area by native Hawaiians, in a way that minimizes negative impact, but maximizes appreciation for these resources. Direct access should be controlled to minimize impact to the species, as well as to minimize accidental introduction or re-introduction of invasive species.

6.1.1 Available Exclosures for Outplanting

Puʻu Waʻawaʻa Forest Bird Sanctuary (FBS) – 3,806 acres

Currently, the 3,800-acre Forest Bird Sanctuary Unit contains remnant mesic forest, high elevation native shrub land, and numerous sensitive lava tube ecosystems above 3,800 ft 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 ʻAiea and fragile fern (*Asplenium peruvianum*). Species of concern that occur within this unit and were mapped during surveys include ʻAkoko (*Chamaesyce olowaluana*), Mauʻu laʻili (*Sisyrinchium acre*), and ʻŌhelo papa (*Fragaria chiloensis* var. *sandwicensis*). Opportunities exist for creating new populations of the following covered plant species: *Asplenium peruvianum*, Pōpolo kū mai, ʻAiea, *Stenogyne angustifolia,* Hawaiian Catchfly, Poʻe, and both species of Aʻe (*Z.dipetalum* var. *tomentosum* and *Z. hawaiiensis).*

Waihou Forest Phase I – 204 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 ʻŌhiʻa, Koa, Māmane, Naio, and ʻAkoko. 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 Puʻu Waʻawaʻa. 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 Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*) and ʻAiea. Species of concern include ʻAkoko (*Chamaesyce olowaluana*), and ʻAnunu (*Sicyos macrophyllus*). Opportunities exist for creating new populations of the following covered plant species: ʻAiea, Poʻe, Hawaiian Catchfly, Pōpolo kū mai, *S. angustifolia*, and both species of Aʻe.

Puʻu Waʻawaʻa Cinder Cone Unit – 70 acres

The Puʻu Waʻawaʻa 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 the big island from Kīpuka Puaulu and Kīpuka Ki in Hawaiʻi Volcanoes National Park and from one region at Puʻu Waʻawaʻa. Though this species is not considered rare, it is uncommon and deserves protection at this locale.

No Covered Species currently naturally occur within the Cinder Cone Unit; however, a number of species have been outplanted in the unit, including: ʻAiea , *Neraudia ovata,* Pōpolo kū mai, and Aʻe (*Zanthoxylum dipetalum* var. *tomentosum).* This unit has potential for outplanting of additional Covered Species including: Hala pepe, Hawaiian Catchfly, *Stenogyne angustifolia,* A'e (*Zanthoxylum dipetalum* var. *tomentosum),* and A'e (*Zanthoxylum hawaiiensis).*

Kīpuka Oweowe – 17 acres

This forest is dominated by Lama, but also contains the endangered kauila 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 'Ohe makai, Pōpolo kū mai, and *Silene lanceolata.*

Hauaina Reservoir Unit – 50 acres

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

6.1.2 Future Exclosures for Outplanting

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

Waihou Forest Phase II – 202 acres

An additional 202 acres of remnant forest and endangered species habitat adjacent to the 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 'Aiea, at least two individuals of the endangered A'e tree (*Zanthoxylum dipetalum* var. *tomentosum*), the SOC 'Akoko (*Chamaesyce olowaluana*), the SOC *Melicope hawaiensis*, and has some of the better tree cover in the Pu'u Wa'awa'a ranch lease. Species appropriate for otplanting in this unit include: 'Aiea, *N. ovata*, Hala Pepe, Po'e, Hawaiian Catchfly, *S. angustifolia,* and Pōpolo kū mai.

Henahena – 711 acres

This unit will provide protection to remaining 'Ōhi'a forest and the fragile lava tube ecosystems that occur underneath this forest type by building fences to prevent animals from damaging vegetation over the lava tube ecosystem. Forests of 'Ōhi'a predominate in this area. The Henahena region contains numerous sandalwood trees ('Iliahi) and a few of the endangered 'Aiea 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 otplanting in this unit include: 'Aiea, *N. ovata,* both species of A'e (*Z. dipetalum* var. *tomentosum* and *Z. hawaiiense*), Po'e, Hawaiian Catchfly, *S. angustifolia,* and Pōpolo kū mai.

Kauila Hala pepe – 418 acres

Fencing this unit will protect the remaining highest quality Lama/Kauila dominated forest and exclude goats, pigs, cattle and sheep. 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 with kokiʻo – 382 acres

This forested area dominated by Lama on old substrate once contained two of four last remaining wild Kokiʻo (*Kokia drynarioides*) trees. This forest type is similar to the Lama/Kauila forest but does not have Kauila 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 267 acres and Anahulu II – 124 acres

This area contains some of the best remaining dry forest shrubland in the upper Puʻu Anahulu region. Puʻu Anahulu has been plagued by fires in recent years resulting in a drastically altered landscape. Without management actions including fencing to protect plants from ungulates, fire control, and invasive species management this area will likely burn in the future resulting in the loss of many species including: Aʻe (*Z. hawaiiensis),* Hawaiian Catchfly, *N. ovata,* and *S.angustifolia.* Species appropriate for outplanting in these units include: *A. peruvianum, H. haplostachya,* ʻAiea, Poʻe, and Pōpolo kū mai.

Zanthoxylum II Exclosure – 814 acres

This area contains the highest concentration and largest population of Aʻe *(Zanthoxylum hawaiiensis)* in the area. Species appropriate for outplanting in this unit include: Hawaiian Catchfly, *N. ovata,* Pōpolo kū mai, and *S. angustifolia.*

ʻAiea Exclosure – 275 acres

A small 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 cattle in this area. The area contains one of the smaller concentrations of ʻAiea trees in grazed areas of Puʻu Waʻawaʻa. The forest here is dominated by ʻŌhiʻa, Koa, Māmane, and Naio and contains scattered individuals of the endangered ʻAiea, 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.

Upper South Boundary Kīpuka – 42 acres

Fencing this unit will protect this small portion of a kīpuka that is dominated by Lama and contains 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 Ka‘upulehu lava flow as a natural firebreak on one side. Species appropriate for outplanting in this unit include: Kauila, Honohono, Ma‘o hau hele, Koki‘o, *N. ovata,* ‘Aiea, Hala pepe, Po‘e, Hawaiian Catchfly, Pōpolo kū mai, *S. angustifolia,* and A‘e (*Z. hawaiiense*).

Stenogyne Exclosure – 12 acres

This area contains some of the highest concentration of *Stenogyne angustifolia* in the Plan Area. Species appropriate for outplanting in this unit include: Honohono, ‘Aiea, Hala pepe, Po‘e, Hawaiian Catchfly, *N. ovata,* Pōpolo kū mai, and A‘e (*Z. dipetalum*).

Solanum Kīpuka – **18 acres**

Currently eight individual fences occur in this kīpuka enclosing approximately nine Pōpolo kū mai plants. The entire kīpuka should be enclosed to further protect these remaining plants. The PTA boundary fence could be utilized as one side of the fencing unit. Species appropriate for outplanting in this unit include: *A. peruvianum,* Honohono, Po‘e, *S. angustifolia*, *N. ovata,* and Hawaiian Catchfly.

Puu Waawaa Cone Conservation Area (4 units) – 338 acres

A number of tree species can be found within the the furrows of the cinder cone, including Hala pepe and A‘e *(Zanthoxylum dipetalum* var. *tomentosum).* This area is highly visible and provides a good opportunity for education and outreach to the public. Thirteen of the fifteen Covered Species are appropriate for outplanting on the cinder cone: Uhiuhi, Kauila, Honohono, Koki‘o, *Neraudia ovata,* ‘Aiea, Hala pepe, Hawaiian Catchfly, Po‘e, Pōpolo kū mai, *Stenogyne angustifolia,* A‘e *(Zanthoxylum dipetalum),* and A‘e *(Zanthoxylum hawaiiensis).*

Caesalpinia Unit – 22 acres

This unit will protect nine Uhiuhi trees on the makai side of Pu‘u Wa‘awa ‘a. The protected Uhiuhi trees within the unit will serve as propagule sources for mitigation outplanting in adjacent areas in the future.

Haplostachys Exclosure – 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*.

Table 6.1. Potential mitigation sites for populations within current and proposed conservation units and exclosures. Species codes are: AspPer = *A. peruvianum*, ColOpp = *C.oppositifolia*, HapHap = *H. haplostachya*, HibBra = *H.s brackenridgei*, KokDry = *K. drynarioides*, CaeKav = *C. kavaiensis*, NerOva = *N. ovata*, NotBre = *N. breviflorum*, PleHaw = *P. hawaiiensis*, PorScl = *P. sclerocarpa*, SilLan = *S.lanceolata*, SolInc = *S. incompletum*, ZanDip = *Z. dipetalum*, ZanHaw = *Z. hawaiiensis*.

	Size (acres)	***Asp Per***	***Cae Kav***	***Col Opp***	***Hap Hap***	***Hib Bra***	***Kok Dry***	***Ner Ova***	***Not Bre***	***Ple Haw***	***Por Scl***	***Sil Lan***	***Sol Inc***	***Ste Ang***	***Zan Dip***	***Zan Haw***	**# Species /Unit**
Current Units																	
FBS	3806	1							1		1	1	1	1	1	1	**8**
Waihou I	204							1	1	1	1	1	1	1	1	1	**9**
Oweowe I & II	22		1	1	1	1	1	1	1	1	1	1	1	1		1	**13**
Hauaina	50		1	1	1	1	1	1	1	1	1	1	1	1		1	**13**
Uhiuhi/Wiliwili	12		1	1	1	1	1	1	1	1	1	1					**10**
Zanthoxylum I	10				1			1	1		1	1	1	1		1	**8**
Neraudia					1			1	1		1	1	1	1		1	**8**
Proposed Units																	
‘Aiea	275							1	1	1	1	1	1	1	1	1	**9**
Waihou II	202							1	1	1	1	1	1	1	1	1	**9**
Henahena	711							1	1		1	1	1	1	1	1	**8**
Kauila Hala pepe	418		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 with Kokio	382		1	1	1	1	1	1	1	1	1	1	1	1		1	**13**
Lowland ‘Ōhi‘a	506		1	1	1	1	1	1	1	1	1	1				1	**11**
Caesalpinia	22		1	1	1	1		1	1	1	1	1					**9**
Anahulu I	267	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	814	1			1			1	1		1	1	1	1			**8**
Stenogyne	12				1			1	1		1	1	1	1		1	**8**
Haplostachys	5										1		1	1			**3**
Solanum Kīpuka	18	1			1			1	1		1	1	1	1		1	**9**
PWW Cone units	338		1	1	1	1	1	1	1	1	1	1	1	1	1	1	**14**

6.2 OFF-SETTING TAKE PRIOR TO HCP APPROVAL

DLNR has already begun offsetting 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 locations. DLNR will be subtracting these numbers from their anticipated take in order to substantiate a net benefit for each Covered Species.

Table 6.2. Outplanting of Covered Species from 2000 to 2014. Species codes are: ColOpp = *C. oppositifolia*, HapHap = *H.haplostachya*, HibBra = *H. brackenridgei*, KokDry = *K. drynarioides*, CaeKav = *C. kavaiensis*, NerOva = *N. ovata*, NotBre = *N. breviflorum*, PleHaw = *P. hawaiiensis*, ZanDip = *Z. dipetalum.*

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**Total**
CAEKAV	6	2		6	1		25		3		39	87	37	17	207	**430**
COLOPP	22	36	18				6				1	1	1	46	310	**441**
HAPHAP								2								**2**
HIBBRA	30	5	5		93		7	31	6	1	1	21	4			**204**
KOKDRY	8	2	15		12				23	37	9	162	209	77	42	**596**
NEROVA			11							15		4				**30**
NOTBRE	20	2	119	55	176	40	131		22		2	3		39	68	**677**
PLEHAW			24	5	57		8				47	123		24	319	**607**
STEANG										16						**16**
ZANDIP			2	10	1		2			14	7					**36**
Total	**86**	**47**	**194**	**76**	**340**	**40**	**179**	**33**	**54**	**83**	**106**	**401**	**88**	**203**	**946**	**3039**

6.3 SPECIES SPECIFIC MANAGEMENT GOALS

Each individual Covered Species has a mitigation goal based on take estimates and avoidance and minimization strategies. Exclosure descriptions provide further detail on exclosure size, habitat type, and species composition. Whenever possible, mitigation exclosures are designed to provide mitigation opportunities for multiple species to increase management efficiency and benefit. Table 6.19 summarizes take estimates, avoidance and minimization strategies, and mitigation goals for each of the Covered Species.

6.3.1 *Asplenium peruvianum var. insulare*

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (*as described in the Avoidance and Minimization Section 4.3*).

2. DOFAW will propagate a (as feasible) complete genetic representation through spores from the Forest Bird Sanctuary populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal**: As discussed in Section 5.3.1, a take estimate is difficult to calculate for this species as it occurs in lava tubes and cave openings. The occurrence and location of this habitat type has not been mapped within the Plan Area. Because of this gap in knowledge, we defer to the species stabilization goals put forth by the HPPRCC (1994) 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) 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.

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 exclosures are potential sites for reintroduction.

Potential Exclosures	Fenced	Management Type	# of Individuals	Unit Size (acres)
FBS Unit	Yes	Avoidance/minimization	44	3,806
Anahulu I	No	Mitigation		267
Anahulu II	No	Mitigation		123
Zanthoxylum II	No	Mitigation		814
Solanum Kīpuka	No	Mitigation		18

6.3.2 Uhiuhi (*Caesalpinia kavaiensis*)

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

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and air layers from the known makai Pu‘u Wa‘awa‘a populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW tree nursery in Kamuela. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** In addition to the 12 known fenced individuals (which occur within small exclosures (1, 3, and 45 acres), **three populations** will be created and maintained within fenced suitable habitat types to total the take estimate (**137 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 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 effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines.

Table 6.4. 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)
Caesalpinia	No	Avoidance/minimization	9	22
Uhiuhi 2	Yes	Avoidance/minimization	2	3
Uhiuhi 3	Yes	Propagule	1	1
Oweowe	Yes	Mitigation		22
Kauila Hala Pepe	No	Mitigation		368
Lama w Koki‘o	No	Mitigation		382
Lowland ‘Ōhi‘a	No	Mitigation		530

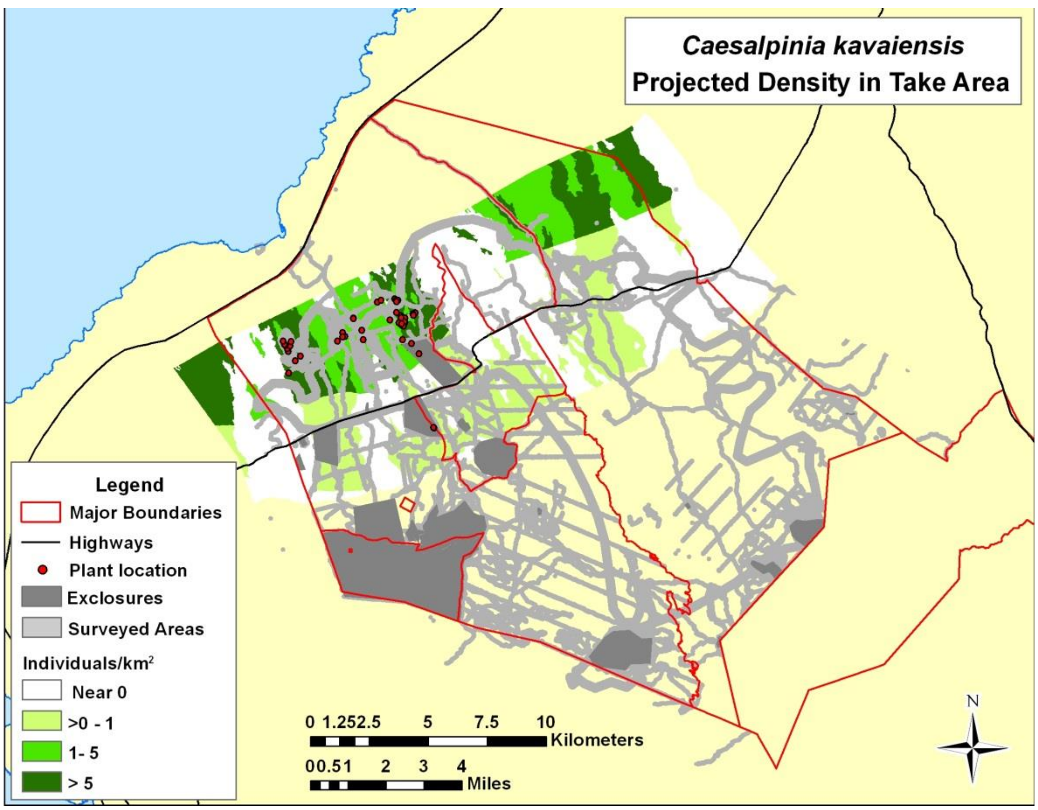

Figure 6.1. Map of the Plan Area showing known Uhiuhi locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of white and green indicate areas the species is most likely to be found.

6.3.3 Kauila (*Colubrina oppositifolia*)

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

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puu Wa'awa'a populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain **three populations** within fenced suitable habitat types to total the take estimate (**916 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) 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.

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)
Lowland ʻŌhiʻa	No	Avoidance/minimization	5	530
Kauila Hala Pepe	No	Avoidance/minimization	293	368
Oweowe	Yes	Mitigation		22
Upper S. Kīpuka	No	Mitigation		42
Lama w/ Kokiʻo	No	Mitigation		382
PWW Cone Conservation Area	No	Mitigation		338
Caesalpinia	No	Mitigation		22

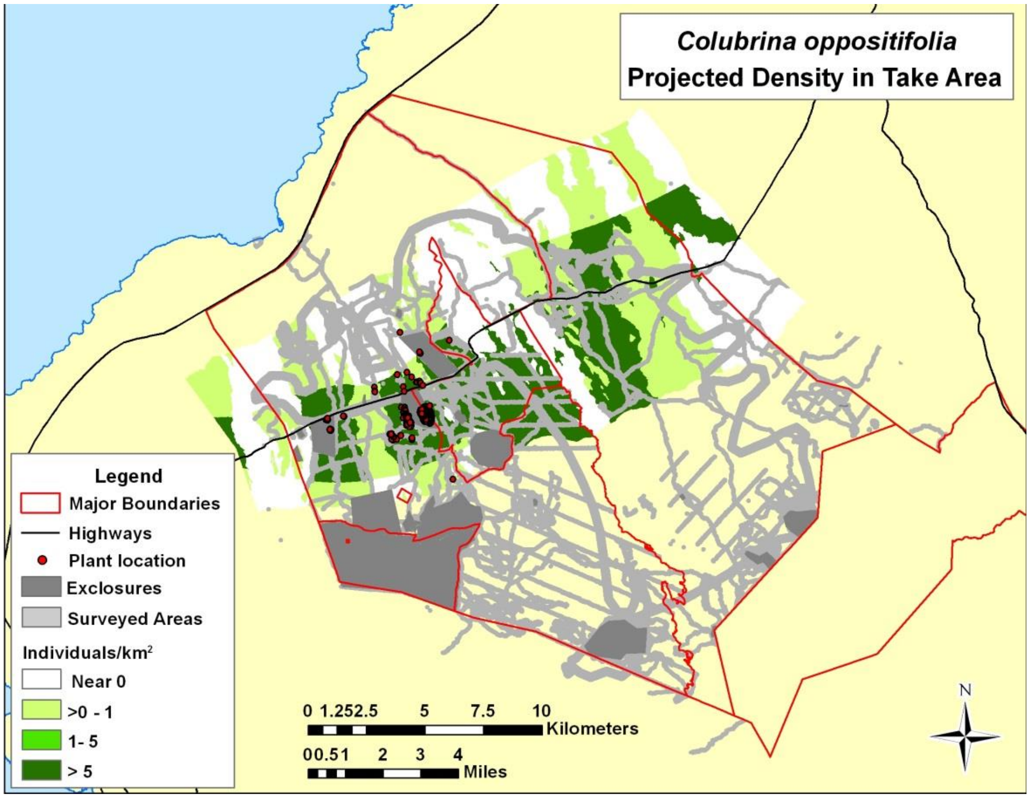

Figure 6.2. Map of the Plan Area showing known Kauila locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.4 Honohono (*Haplostachys haplostachya*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in the Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Keamuku Puʻu Anahulu population. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a minimum of **three additional populations** within fenced suitable habitat types to total the take estimate (**294 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) 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.

Table 6.6. Known *in situ* populations and potential reintroduction sites for Honohono. Bold units contain extant population(s).

Potential Exclosures	Fenced	Management Type	# of Individuals	Unit Size(acres)
Haplostachys	No	Avoidance/minimization	126	5
Anahulu I	No	Mitigation		267
Anahulu II	No	Mitigation		123
Stenogyne	No	Mitigation		12
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lowland ʻŌhiʻa	No	Mitigation		530
Caesalpinia	No	Mitigation		22
Solanum Kīpuka	No	Mitigation		17

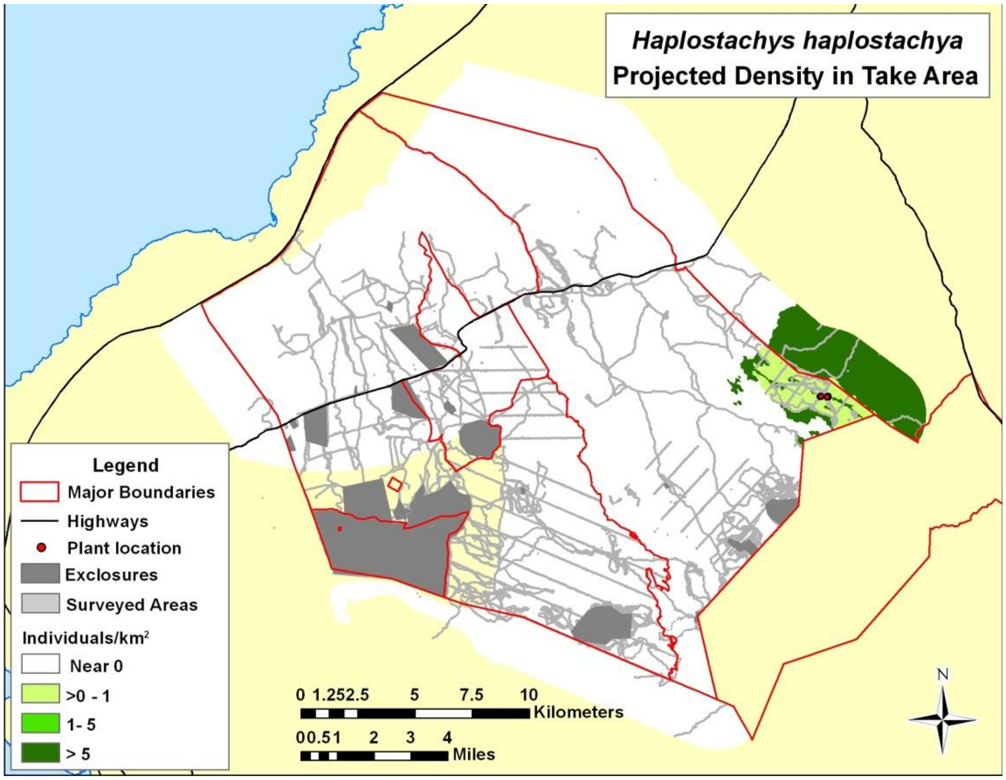

Figure 6.3. Map of the Plan Area showing known Honohono locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.5 Maʻo hau hele (*Hibiscus brackenridgei* ssp. *brackenridgei*)

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

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puu Wa'awa'a populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is four 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 species stabilization guidelines. Based on species stabilization criteria put forth by the HPPRCC (1994) 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.

Table 6.7. Known *in situ* populations and potential reintroduction sites for Maʻo hau hele. Bold units contain extant population(s)

Potential Exclosures	Fenced	Management Type	# of Individuals	Unit Size (acres)
Hib. Brackenridgei	Yes	Avoidance/minimization	65	1
Oweowe	Yes	Mitigation		22
Hauaina	Yes	Mitigation		50
Uhiuhi/Wiliwili	Yes	Mitigation		12
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lama with Kokiʻo	No	Mitigation		382
Lowland ʻŌhiʻa	No	Mitigation		530
Caesalpinia	No	Mitigation		22

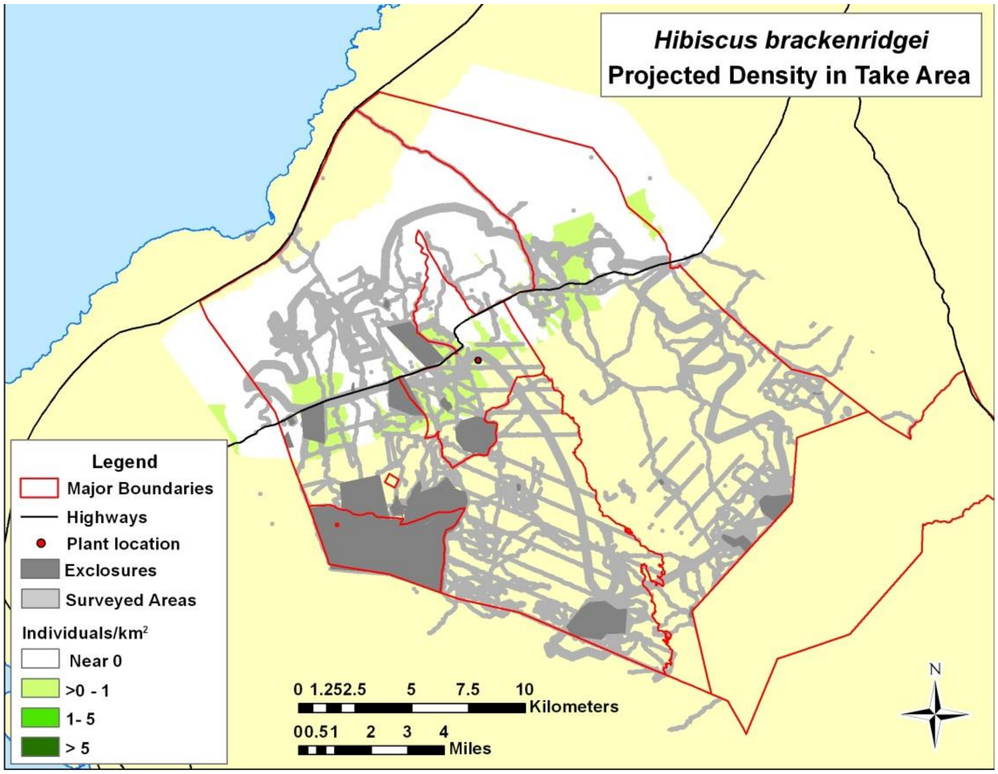

Figure 6.4. Map of the Plan Area showing known Maʻo hau hele locations, areas surveyed the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.6 Koki‘o (*Kokia drynarioides*)

1. DOFAW will maintain outplanted individuals through maintenance of fences, monitoring, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. This species is considered extinct in the wild, the last two wild individuals documented by the HCP botanical crews have since senesced. DOFAW will propagate a (as feasible) complete genetic representation through seeds and cuttings from plant stock that has been collected over the years from the few remaining koki‘o at Pu‘u Wa‘awa ‘a. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is three 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 species stabilization guidelines. Based on species stabilization criteria put forth by the HPPRCC (1994) and defined in Section 5.3.4, DOFAW will create and maintain **three populations of 100 individuals** each within fenced suitable habitat types. Table 6.8 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 100 individuals** (following stabilization criteria) will be created to mitigate for the potential loss of recruitment for those individuals outside of exclosures. Should values calculated from monitoring data exceed those put forth by the stabilization criteria, those values will be added to this mitigation goal.

5. **Net benefit goal**: In effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 100 individuals** following species stabilization guidelines.

Table 6.8. Known *in situ* populations and potential reintroduction sites for for Koki‘o.

Potential Exclosures	Fenced	Management Type	# of Individuals	Unit Size (acre)
Oweowe	Yes	Mitigation		22
Koki‘o 1	Yes	Propagule	2	>1
Koki‘o 2	Yes	Propagule	2	>1
Waihou I	Yes	Mitigation		204
Hauaina	Yes	Mitigation		50
Uhiuhi/Wiliwili	Yes	Mitigation		12
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lama with Koki‘o	No	Mitigation		382
Lowland ‘Ōhi‘a	No	Mitigation		530

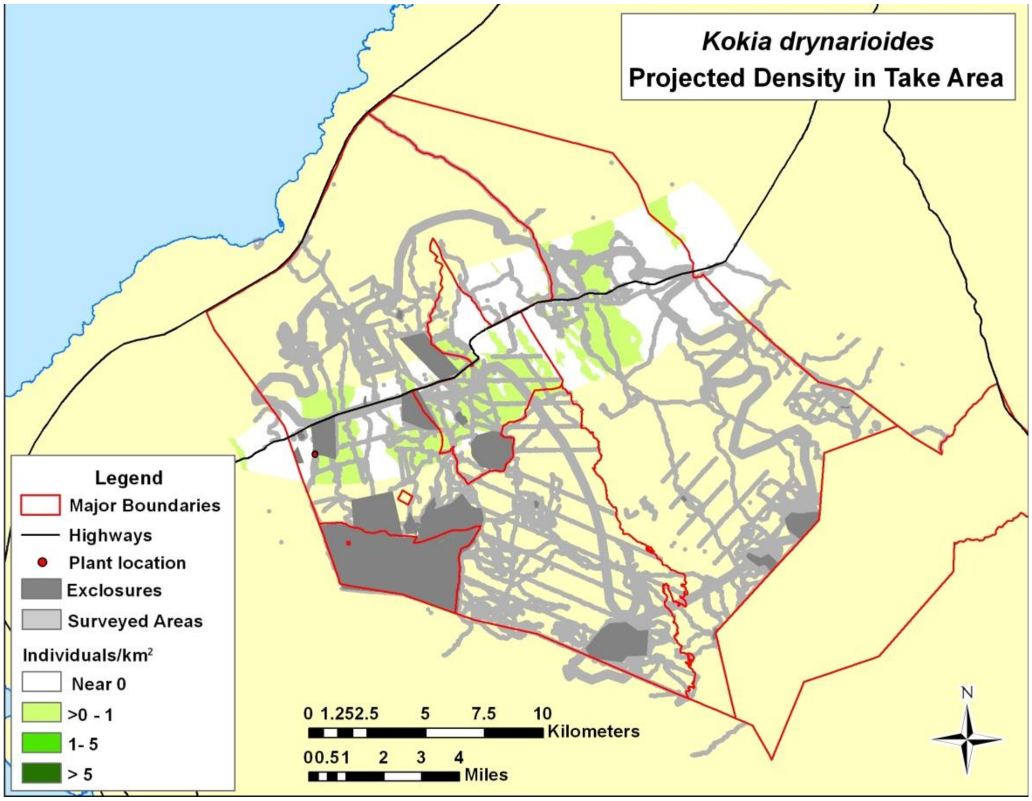

Figure 6.5. Map of the Plan Area showing known Koki'o locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.7 *Neraudia ovata*

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

2. DOFAW will propagate a (as feasible) complete genetic representation through seeds and cuttings from the known Puu Anahulu individuals. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is 27 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 species stabilization guidelines. Based on species stabilization criteria put forth by the HPPRCC (1994) and defined in Section 5.3.4, DOFAW will create and maintain **three populations of 100** individuals each within fenced suitable habitat types. Table 6.9 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 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 effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 100 individuals** following species stabilization guidelines.

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?	?	10
Anahulu I	No	Avoidance/minimization	6	267
Anahulu II	No	Avoidance/minimization	3	123
Oweowe	Yes	Mitigation		22
PWW Cone	Yes	Mitigation		70
Waihou I	Yes	Mitigation		204
Hauaina	Yes	Mitigation		50
Uhiuhi Wiliwili	Yes	Mitigation		12
Zanthoxylum	Yes	Mitigation		10
Waihou II	No	Mitigation		202
Henahena	No	Mitigation		711
Kauila Hala	No	Mitigation		368

Pepe				
Lowland ‘Ōhi‘a	No	Mitigation		530
Caesalpinia	No	Mitigation		22

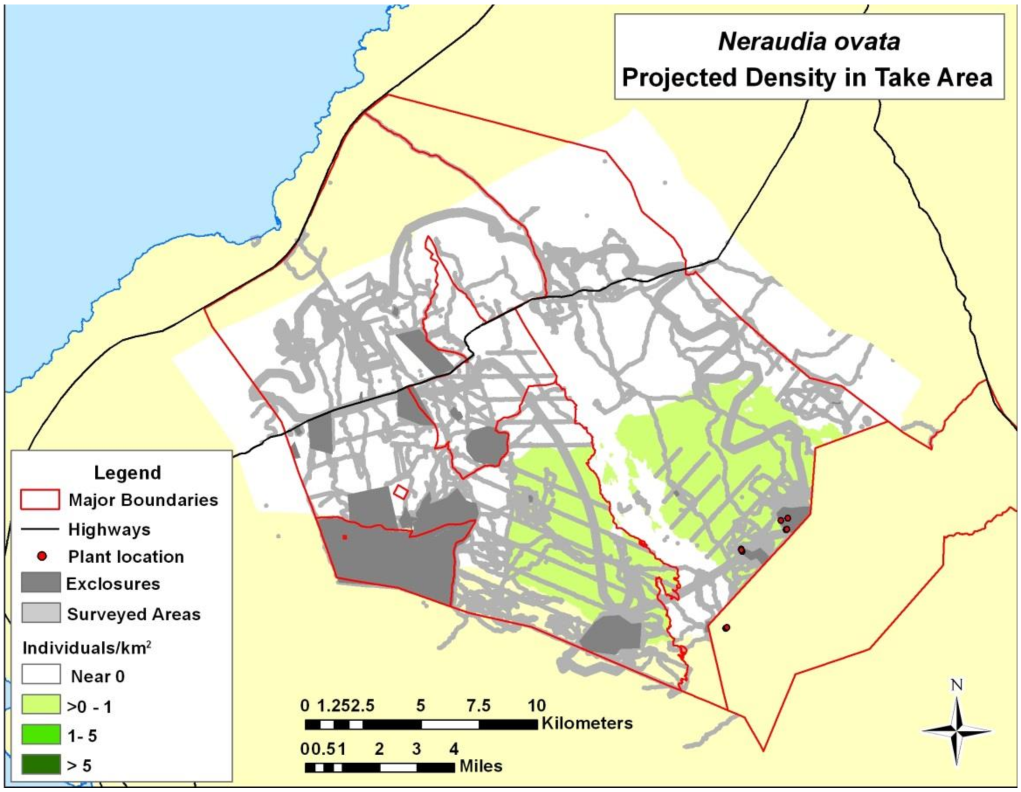

Figure 6.6. Map of the Plan Area showing known *Neraudia ovata* locations, areas surveyed, species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.8 ‘Aiea (*Nothocestrum breviflorum*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puu Wa’awa’a populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility and the DOFAW Tree Nursery in Kamuela. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a **minimum of three populations** within fenced suitable habitat types to total the take estimate (**318 individuals**). 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 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 effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 50 individuals** following species stabilization guidelines.

Table 6.10. Known *in situ* populations and potential reintroduction sites for ‘Aiea.

Exclosure	Fenced	Management Type	# of Individuals	Unit Size (acre)
Henahena	No	Avoidance/minimization	7	711
Kauila Hala Pepe	No	Avoidance/minimization	16	368
Oweowe	Yes	Avoidance/minimization	5	22
‘Aiea	Yes- individual fences	Propagule	8	>1
PWW Cone	Yes	Mitigation		70
FBS	Yes	Mitigation	1	3806
Waihou I	Yes	Mitigation		204
Waihou II	No	Mitigation		220
Hauaina	Yes	Mitigation		50
Uhiuhi/Wiliwili	Yes	Mitigation		12
Neraudia	Yes	Mitigation		10
Zanthoxylum	Yes	Mitigation		10
Kauila Hala Pepe	No	Mitigation		368

Upper S. Kīpuka	No	Mitigation		42
Lama with Koki‘o	No	Mitigation		382
Lowland ‘Ōhi‘a	No	Mitigation		530
Caesalpinia	No	Mitigation		22
Anahulu I	No	Mitigation		267
Anahulu II	No	Mitigation		123
Zanthoxylum II	No	Mitigation		814
Stenogyne	No	Mitigation		12
Haplostachys	No	Mitigation		5
Solanum Kīpuka	No	Mitigation		18
PWW Cone Conservation Area	No	Mitigation		338

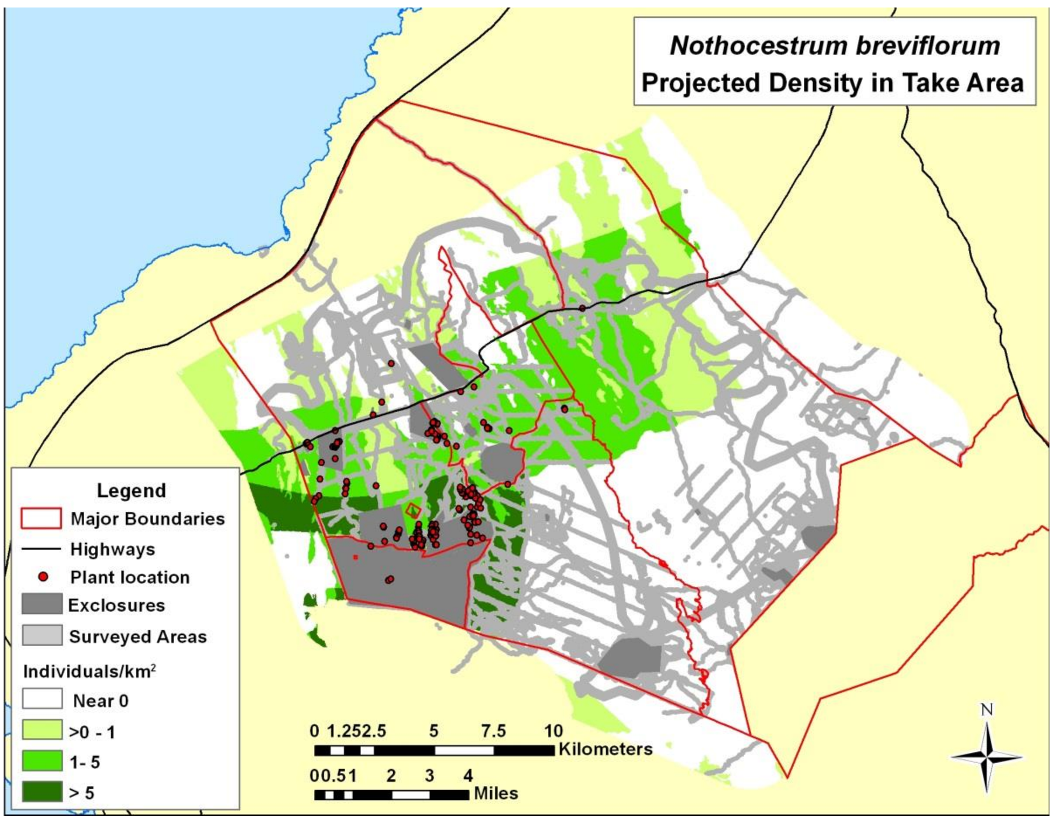

Figure 6.7. Map of the Plan Area showing known ‘Aiea locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.9 Hala Pepe (*Pleomele hawaiiensis*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds from the known Puu Wa'awa'a and Puu 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 (**440 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 25 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 effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 25 individuals** following species stabilization guidelines.

Table 6.11. 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	173	368
Lowland ‘Ōhi‘a	No	Avoidance/minimization	35	530
Lama/Koki‘o	No	Avoidance/minimization	2	400
PWW Cone Conservation Area	No	Avoidance/minimization	43	338
Oweowe	Yes	Avoidance/minimization	1	22
Waihou I	Yes	Mitigation		204
Hauaina	Yes	Mitigation		50
Uhiuhi Wiliwili	Yes	Mitigation		12
Waihou II	No	Mitigation		202
Upper S. Kīpuka	No	Mitigation		42
Caesalpinia	No	Mitigation		22

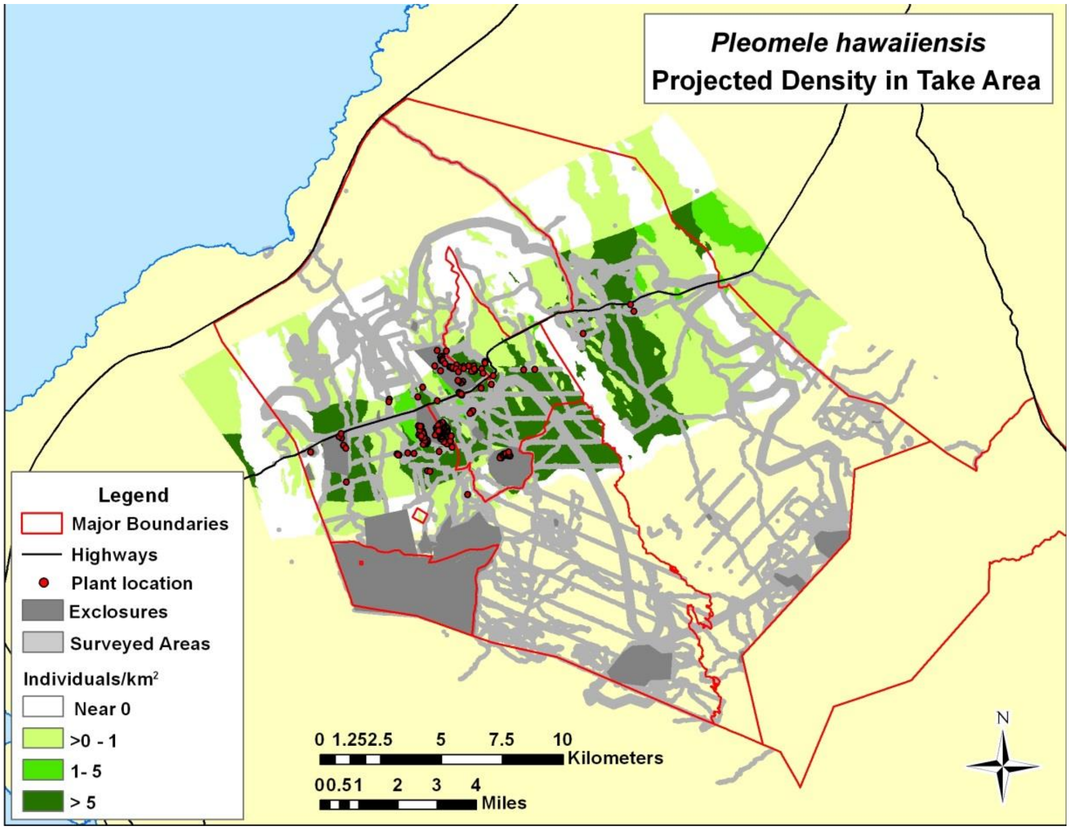

Figure 6.8. Map of the Plan Area showing known Hala pepe locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.10 Po'e (*Portulaca sclerocarpa)*

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

2. DOFAW will propagate a (as feasible) complete genetic representation from the individual(s) in the Anahulu I unit. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG recommendations (*see Appendix E*).

3. **Mitigation goal**: As discussed in Section 5.3.1, a take estimate is difficult to calculate for this species as only one individual was found. Because of this gap in knowledge, we defer to the species stabilization goals put forth by the HPPRCC (1994) and defined in Section 5.3.4**.** DOFAW will create and maintain **three populations of 50 individuals** each within fenced suitable habitat types. Table 6.12 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation: DOFAW will create and maintain one additional population of 50 individuals** (following stabilization criteria) 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.

Table 6.12. Known *in situ* populations and potential reintroduction sites for 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	267
Henahena	No	Mitigation		711
Kauila Hala Pepe	No	Mitigation		368
Oweowe	Yes	Mitigation		22
'Aiea	No	Mitigation		>1
PWW Cone	Yes	Mitigation		70
FBS	Yes	Mitigation		3806
Waihou I	Yes	Mitigation		204
Waihou II	No	Mitigation		220
Hauaina	Yes	Mitigation		50
Uhiuhi/Wiliwili	Yes	Mitigation		12
Neraudia	Yes	Mitigation		10
Zanthoxylum	Yes	Mitigation		10
Upper S. Kīpuka	No	Mitigation		42

Lama with Koki‘o	No	Mitigation		382
Lowland ‘Ōhi‘a	No	Mitigation		530
Caesalpinia	No	Mitigation		22
Anahulu II	No	Mitigation		123
Zanthoxylum II	No	Mitigation		814
Stenogyne	No	Mitigation		12
Haplostachys	No	Mitigation		5
Solanum Kīpuka	No	Mitigation		18
PWW Cone Conservation Area	Partially	Mitigation		338

6.3.11 Hawaiian Catchfly (*Silene lanceolata*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puu Anahulu populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a **minimum of 3 populations** within fenced suitable habitat types to total the take estimate (**176 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) 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.

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	29	267
Oweowe	Yes	Mitigation		22
Waihou I	Yes	Mitigation		204
PWW Cone	Yes	Mitigation		70
Oweowe	Yes	Mitigation		10
Hauaina	Yes	Mitigation		50
Uhiuhi Wiliwili	Yes	Mitigation		12
Zanthoxylum	Yes	Mitigation		10
Neraudia	Yes	Mitigation		10
Waihou II	No	Mitigation		202
Henahena	No	Mitigation		711
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lama with Koki‘o	No	Mitigation		382
Lowland ‘Ōhi‘a	No	Mitigation		530
Caesalpinia	No	Mitigation		22

Population Unit	Fenced	Management Type	# of Individuals	Unit Size (acre)
Anahulu II	No	Mitigation		123
Zanthoxylum II	No	Mitigation		814
Stenogyne	No	Mitigation		12
Haplostachys	No	Mitigation		5
Solanum Kīpuka	No	Mitigation		17
PWW Cone Conservation Area	No	Mitigation		338

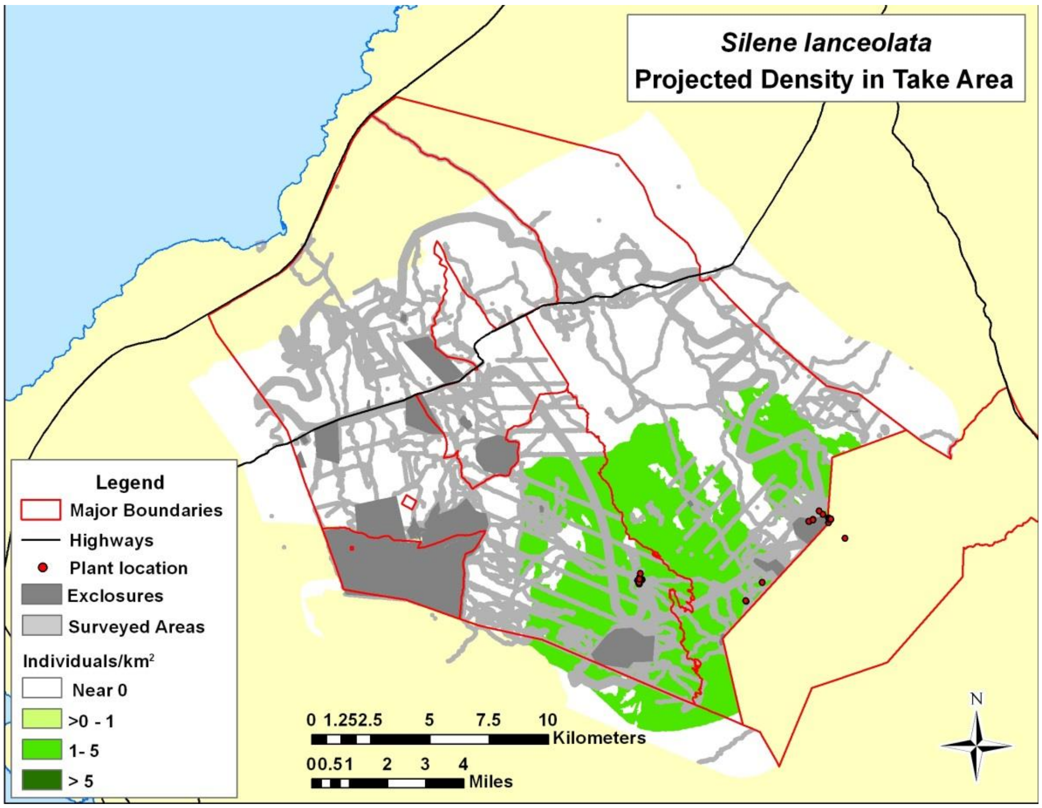

Figure 6.9. Map of the Plan Area showing known Hawaiian Catchfly locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.12 Pōpolo kū mai (*Solanum incompletum*)

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a (as feasible) complete genetic representation through seeds and cuttings from the known Puu Anahulu individuals. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is 63 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 species stabilization guidelines. Based on species stabilization criteria put forth by the HPPRCC (1994) and defined in Section 5.3.4, DOFAW will create and maintain a **minimum of three populations of 100 individuals** each within fenced suitable habitat types. Table 6.14 lists the potentially suitable outplanting sites. Priority will be given to those sites already fenced.

4. **Loss of recruitment mitigation:** DOFAW will create and maintain **one additional population of 100 individuals** (following stabilization criteria) 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 effort to provide net benefit to Covered Species beyond replacement mitigation, DOFAW will create **one additional population of 100 individuals** following species stabilization guidelines.

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	17
Oweowe	Yes	Mitigation		22
PWW Cone	Yes	Mitigation		70
Hauaina	Yes	Mitigation		50
Zanthoxylum	Yes	Mitigation		10
Neraudia	Yes	Mitigation		10
Waihou II	No	Mitigation		202
Henahena	No	Mitigation		711
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lama with Kokiʻo	No	Mitigation		382
Anahulu I	No	Mitigation		267
Anahulu II	No	Mitigation		123

Zanthoxylum II	No	Mitigation		814
Stenogyne	No	Mitigation		12
Haplostachys	No	Mitigation		5
PWW Cone Conservation Area	No	Mitigation		338

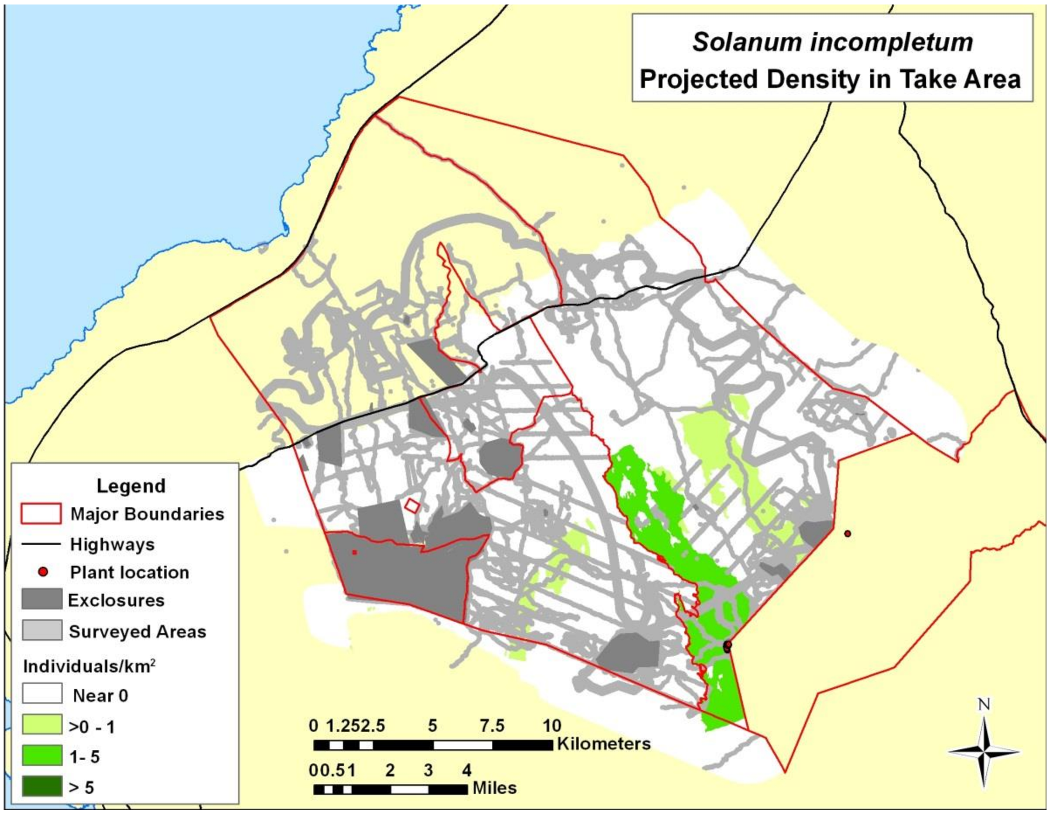

Figure 6.10. Map of the Plan Area showing known Pōpolo kū mai locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.13 *Stenogyne angustifolia*

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puu Anahulu populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** DOFAW will create and maintain a **minimum of three populations** (in addition to *in situ)* within fenced suitable habitat types to total the take estimate (**202**

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) 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.

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	267
Stenogyne	No	Avoidance/minimization	45	12
Oweowe	Yes	Mitigation		22
PWW Cone	Yes	Mitigation		70
Hauaina	Yes	Mitigation		50
Zanthoxylum I	Yes	Mitigation		10
Neraudia	Yes	Mitigation		10
Waihou II	No	Mitigation		202
Henahena	No	Mitigation		711
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lama with Kokiʻo	No	Mitigation		382
Anahulu II	No	Mitigation		123
Zanthoxylum II	No	Mitigation		814
Haplostachys	No	Mitigation		5
Solanum Kīpuka	No	Mitigation		18
PWW Cone Conservation Area	No	Mitigation		338

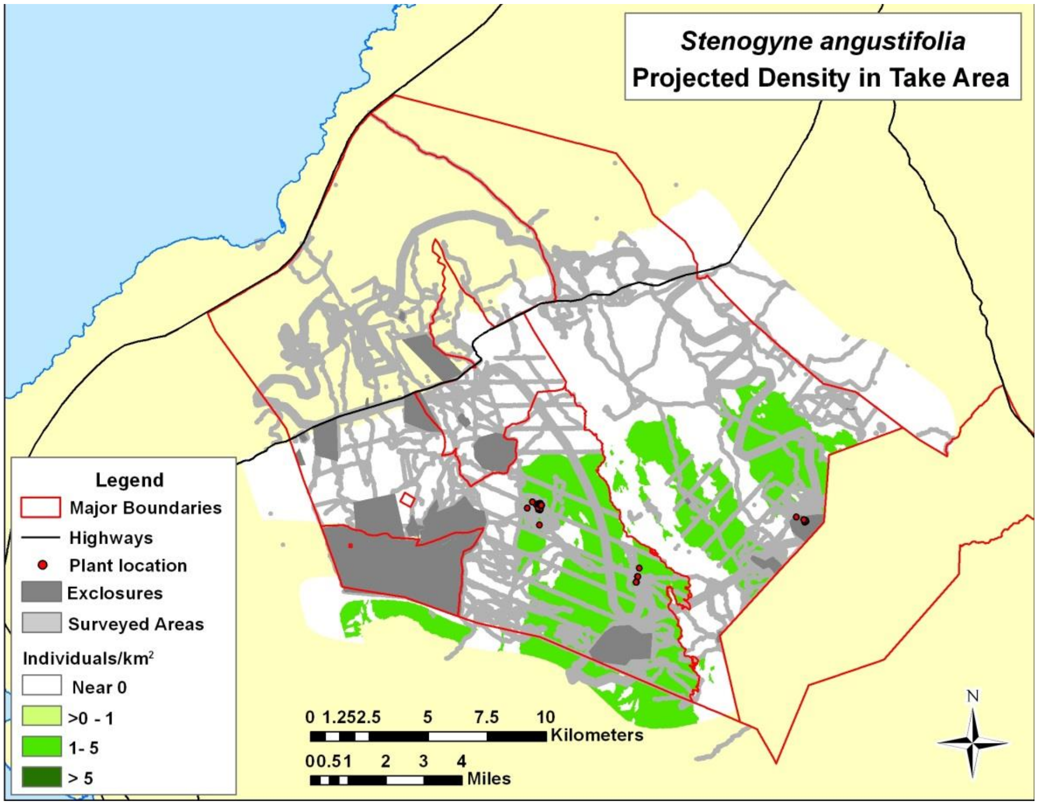

Figure 6.11. Map of the Plan Area showing known *Stenogyne angustifolia* locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found**.**

6.3.14 A‘e (*Zanthoxylum dipetalum* var. *tomentosum*)

1. DOFAW will maintain *in situ* individuals through individual fences, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization) to be used as propagule sources for mitigation outplanting.

2. DOFAW will propagate a (as feasible) complete genetic representation through seeds and air layers from the known Puu Wa'awa'a individuals. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal:** The take estimate for this species is 17 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 species stabilization guidelines. Based on species stabilization criteria (See Section 5), 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) 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.

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	204
Waihou II	No	Avoidance/minimization	4	202
PWW Cone Conservation Area	No	Avoidance/minimization and Mitigation	1	338
FBS	Yes	Mitigation		3806
PWW Cone	Yes	Mitigation		70
Henahena	No	Mitigation		711

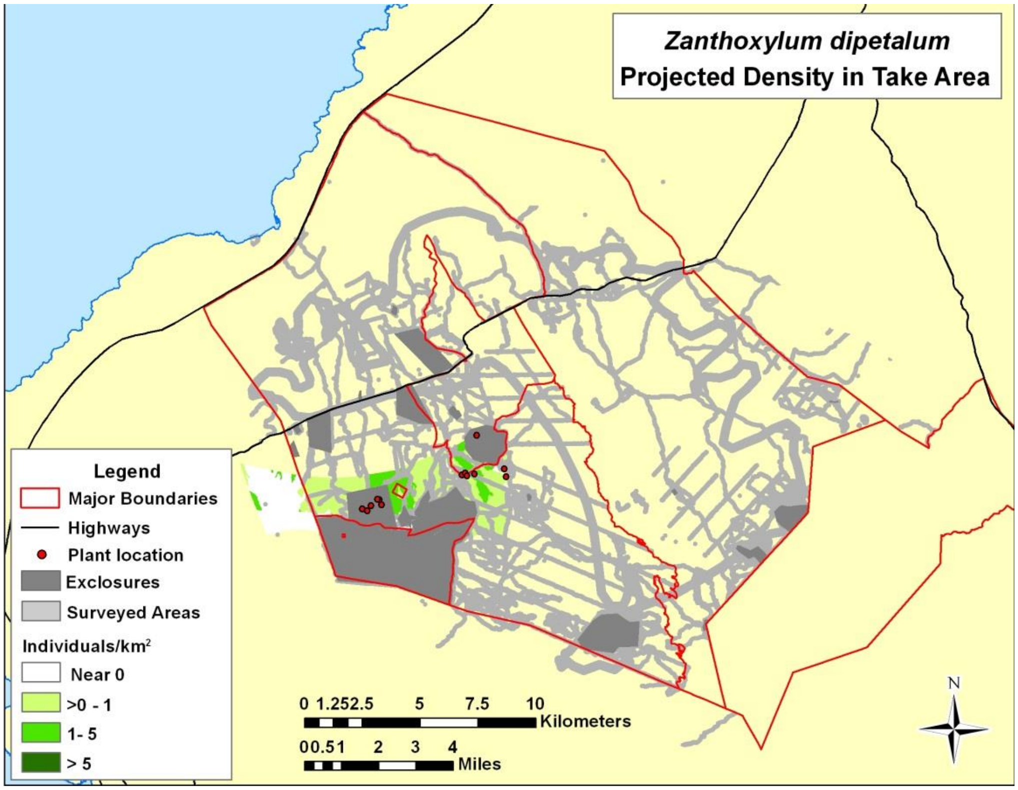

Figure 6.12. Map of the Plan Area showing known A'e (*Z. dipetalum var. tomentosum*) locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

6.3.15 A‘e (*Zanthoxylum hawaiiense)*

1. DOFAW will maintain *in situ* populations through fencing, monitoring, maintenance, and fire protection (as described in Section 4.3 Avoidance and Minimization).

2. DOFAW will propagate a complete genetic representation (as is feasible) through seeds and cuttings from the known Puu Anahulu populations. These plants will be used to maintain genetic representation of stock and will provide stock for outplanting purposes. This species is currently in propagation at Volcano Rare Plant Facility. Seed and propagule collection will be done following HRPRG (*see Appendix E*).

3. **Mitigation goal**: DOFAW will create and maintain a minimum of **three additional populations** (in addition to *in situ)* within fenced suitable habitat types to total the take estimate (**155 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) 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.

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	131	814
Anahulu I	No	Avoidance/minimization	10	267
Anahulu II	No	Avoidance/minimization	31	123
FBS	Yes	Mitigation		3806
Waihou I	Yes	Mitigation		204
PWW Cone	Yes	Mitigation		70
Oweowe	Yes	Mitigation		22
Hauaina	Yes	Mitigation		50
Zanthoxylum I	Yes	Mitigation		10
Neraudia	Yes	Mitigation		10
Waihou II	No	Mitigation		202
Henahena	No	Mitigation		711
Kauila Hala Pepe	No	Mitigation		368
Upper S. Kīpuka	No	Mitigation		42
Lama with Koki‘o	No	Mitigation		382
Stenogyne	No	Mitigation		12
Haplostachys	No	Mitigation		5

Solanum Kīpuka	No	Mitigation		17
PWW Cone Conservation Area	No	Mitigation		338

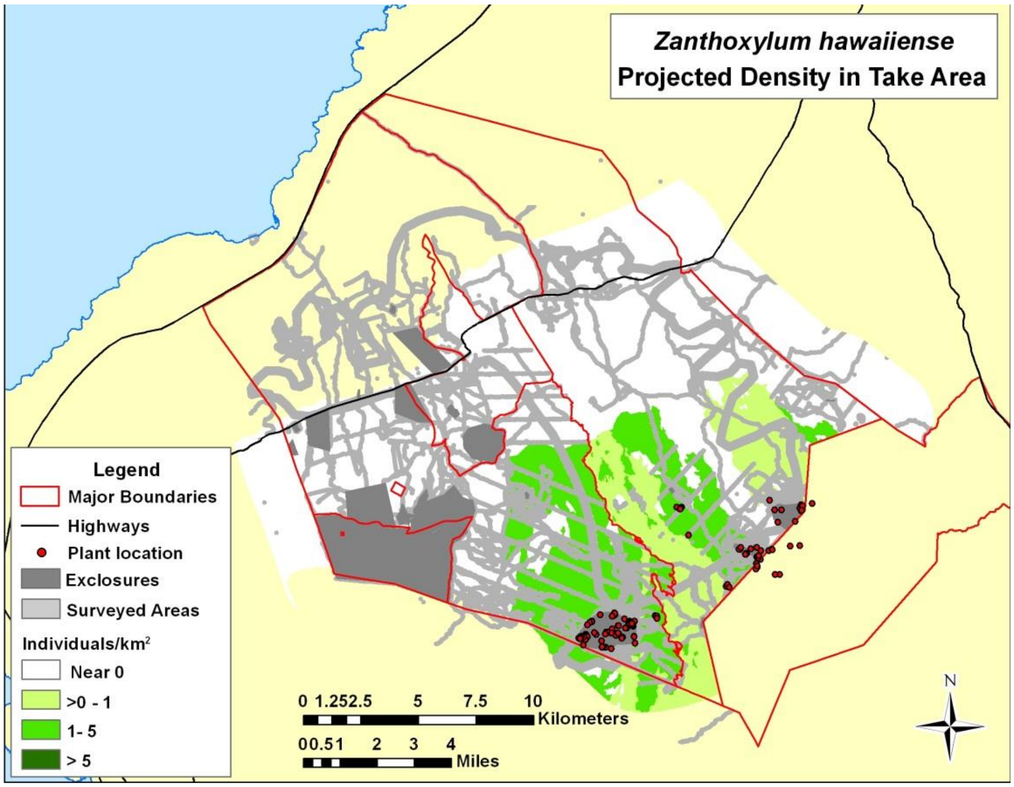

Figure 6.13. Map of the Plan Area showing known A‘e (*Z. hawaiiense)* locations, areas surveyed, the species range, and projections into unsurveyed areas. Species range is depicted by all colors except tan; shades of shades of white and green indicate areas the species is most likely to be found.

Table 6.18. Summary of Covered Species, avoidance and minimization measures, take estimates, mitigation goals, and net benefit 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	65	n/a	44	**FBS Unit**	**21**	**3 populations of 50 plants each**	**1 population of 50 plants**	**1 population of 50 plants**	**250 plants**
Caesalpinia kavaiensis	50	103	12	**Caesalpinia Uhiuhi 1, Uhiuhi 2**	**137**	**A minimum of 3 populations totaling take estimate**	**1 population of 50 plants**	**1 population of 50 plants**	**237 plants**
Colubrina oppositifolia	735	821	298	**Lowland ʻŌhiʻa and Lama hala pepe**	**916**	**A minimum of 3 populations totaling take estimate**	**1 population of 25 plants**	**1 population of 25 plants**	**1103 plants**
Haplostachys haplostachya	126	294	126	**Haplostachys**	**294**	**A minimum of 3 populations totaling take estimate**	**1 population of 50 plants**	**1 population of 50 plants**	**394 plants**
Hibiscus brackenrdgei	65	4	65	**HibBra**	**4**	**3 populations of 50 plants each**	**1 population of 50 plants**	**1 population of 50 plants**	**250 plants**
Kokia drynarioides	2*	0	0	**All known individuals are fenced in individual fences**	**0**	**3 populations of 100 plants each**	**1 population of 100 plants**	**1 population of 100 plants**	**500 plants**
Neraudia ovata	7	26	12	**NerOva 1 and 2, Neraudia, Anahulu I & II**	**27**	**3 populations of 100 plants each**	**1 population of 100 plants**	**1 population of 100 plants**	**500 plants**
Nothocestrum breviflorum	47	251	36	**Henahena, Lama Kauila, Oweowe (fenced),, ʻAiea**	**318**	**A minimum of 3 populations totaling take estimate**	**1 population of 50 plants**	**1 population of 50 plants**	**418 plants**
Pleomele hawaiiensis	320	375	253	**Lowland ʻŌhiʻa, Lama Kauila, PWW cone (proposed), , Oweowe**	**440**	**A minimum of 3 populations totaling take estimate**	**1 population of 25 plants**	**1 population of 25 plants**	**490 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**

Species	Surveyed	Model Projection	Fenced Individuals	Avoidance & Minimization Exclosures	Take Estimate	Mitigation Goal	Net Benefit Goal	Recruitment Loss Mitigation	Total Mitigation Target
Silene lanceolata	419	101	29	**Anahulu I**	**176**	**A minimum of 3 populations totaling take estimate**	**1 population of 50 plants**	**1 population of 50 plants**	**276 plants**
Solanum incompletum	14	63	13	*Solanum*	**63**	**3 populations of 100 plants each**	**1 population of 100 plants**	**1 population of 100 plants**	**500 plants**
Stenogyne angustifolia	97	139	41	**Anahulu I and Stenogyne**	**202**	**A minimum of 3 populations totaling take estimate**	**1 population of 50 plants**	**1 population of 50 plants**	**302 plants**
Zanthoxylum dipetalum tomentosum	14	11	7	**Waihou I , Waihou II, PWW Cone**	**17**	**3 populations of 50 plants each**	**1 population of 50 plants**	**1 population of 50 plants**	**250 plants**
Zanthoxylum hawaiiensis	234	135	172	**Zanthoxylum II, Anahulu I & II**	**155**	**A minimum of 3 populations take estimate**	**1 population of 50 plants**	**1 population of 50 plants**	**255 plants**

6.3.16 Blackburn's Sphinx Moth (*Manduca blackburni*)

Fuel break creation and maintenance provides protection from fire to native habitat potentially used by *M. blackburni*. While removal of *N. glauca* on fuel breaks may reduce available non-native host plants, the overall result is a net benefit to the species. Mitigation of covered plant species will include the creation of large conservation units and exclosures for the outplanting of the native host plant ʻAiea, other covered plant species, and potential and known native nectar plant species. The USFWS is currently recommending a 5 to 1 offset ratio for loss of degraded habitat for Blackburn's sphinx moth. For every five acres of degraded habitat lost, one acre of native habitat will be restored. Approximately 38.6 acres of fuel-break and 4x4 roads are currently occupied by *N. glauca* and are actively cleared (through herbicide and/or manual cutting). Applying the 5 to 1 ratio suggested by the USFWS, 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 *N. glauca* colonizes all of the roads and fuel-breaks within the Plan Area (totaling aproximately 370 km or 640 acres) we have calculated, using the same ratio as above, that 128 acres will be need to be restored for mitigation. Figure 6.14 shows the Plan Area with overlays of ʻAiea range data and critical habitat for both ʻAiea and Blackburn's sphinx moth. 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. Mitigation for losses to Covered Plant species will provide and enhance native habitat known to be used by Blackburn's sphinx moth.

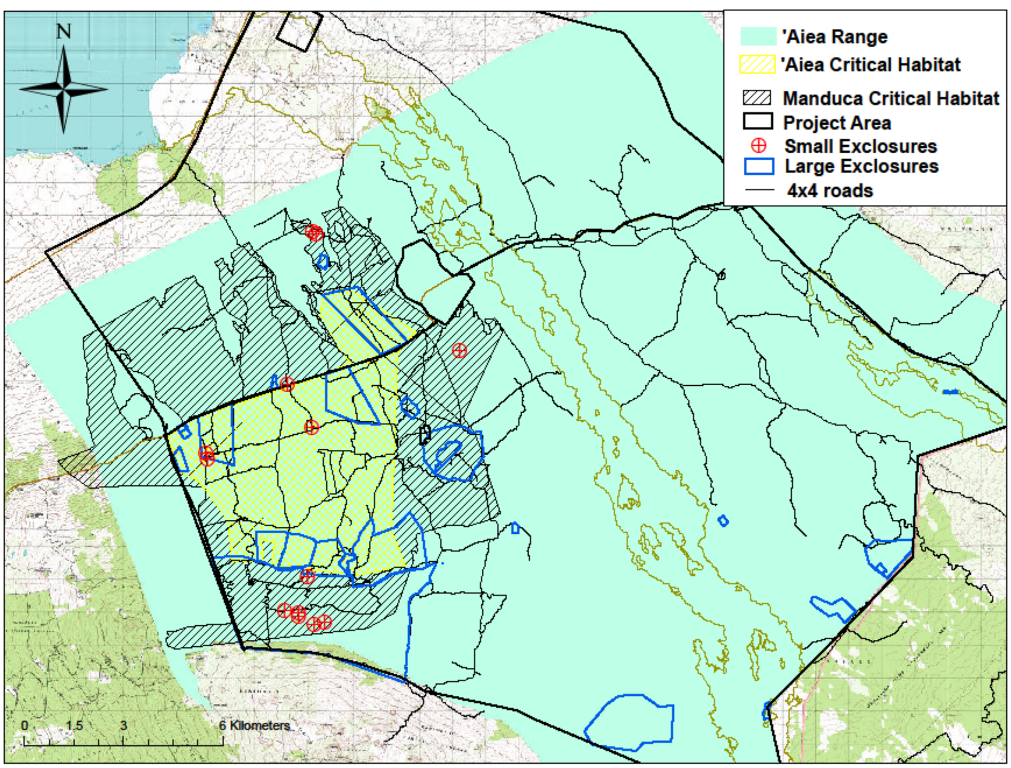

Figure 6.14. Map depicting critical habitat for ʻAiea and *Manduca blackburni*, exclosure locations, and species range for ʻAiea within the Plan Area.

6.4 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, on a whole, is seen as less damaging demographically than taking vegetative matter, and secondly, it is typically much easier and more economical to store seeds than continued maintenance of growing plants in botanical garden or the like (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 the Hauaina Reservoir Unit, will allow for air layers and/or cuttings to be outplanted onsite for future reproductive crosses and monitoring. The Hauaina Reservoir exclosure is a 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 small greenhouse and nursery for onsite propagation for species covered under this HCP. Having an onsite nursery reduces the need for acclimatizing plants to the Plan Area prior to outplanting. A technician will be onsite for nursery needs, as well as seed collection, and may provide additional assistance to field crews when necessary.

Individual plant exclosures are the smallest type of exclosure being used within the Plan Area. They are generally intended to protect only a single or few individuals of a single species that are very isolated and typically surrounded by invasive species. Because many of these fences are placed around individuals occurring in highly degraded habitat, they are not contributing to the perpetuation of the species in the wild, and are not seen as a long-term management option. The fences do, however, provide protection for individuals of species that cannot be reproduced elsewhere, while cuttings, air layers, seeds, or seedlings are collected and propagated for outplanting in other locations. In addition, these small units can be put in place fairly quickly to protect individuals in locations where larger fencing units will be constructed in the future. Because of the small size of these units and limited grazing or watering opportunities, ungulates are rarely observed to enter the fences, therefore avoiding incidents of direct take from grazing and traffic. However, they offer little opportunity for recruitment of new individuals and population growth if left unattended. In cases where the number, location, or characteristics of a protected plant species is such that management in one of the functional community exclosures is infeasible, we have recommended smaller exclosures to protect the existing plants *in situ* for the purposes of propagule collection.

The following exclosures containing Covered Species will be used as a seed and/or cutting source for outplantings as well as Covered Species found in existing and proposed exclosures described in Section 6.1.1 and 6.1.2:

- **Uhiuhi/Wiliwili Unit – 12 acres**: contains a variety of lowland dry forest species.
- **Koki'o Unit 1 – 1 acre**: Contains Koki'o outplants
- **Uhiuhi 2 – 3 acres**: contains a 1-2 individuals of Uhiuhi
- **Uhiuhi 3 – 1 acre**: contains a 1-2 individuals of Uhiuhi
- **Kokio 2 – 1 acre**: Contains Koki'o outplants
- **Hibiscus Brackenridgei – 1 acre:** Contains the last remaining wild population of Ma'o hau hele on Hawai'i Island.
- **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 – 10 acres**: Established in 2005 by Pono Pacific in coordination with USFWS.
- **Neraudia Unit – 10 acres**: Established in 2005 by Pono Pacific in coordination with USFWS
- **'Aiea Exclosures**: Eight individual exclosures with the proposed 'aiea Conservation unit have been established in 2008 and 2009
- **Solanum Kīpuka**: Thirteen small exclosures containing 14 plants.
- **Neraudia exclosures**: Three small exclosures; one contains six plants, and two individual tree fences.

7.0 IMPLEMENTATION

7.1 HCP ADMINISTRATION

A DLNR-DOFAW Implementation Team (DDIT) on the island of Hawai‘i will be established to administer and implement the HCP after BLNR approval ITL issuance. Other experts may be consulted as needed, including scientists or consultants from other agencies (e.g. USDA Forest Service, USFWS), conservation organizations, or academic institutions. HCP-related issues may also be brought before the ESRC for formal consideration when deemed appropriate by the DDIT and DLNR. Pursuant to HRS Chapter 195D-26, DLNR will provide annual updates to the ESRC on the status of all covered species and the effectiveness of implementation under this HCP. The purpose of the regular meetings will be to evaluate the efficacy of monitoring methods, compare the results of monitoring to 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 called by the DLNR to address immediate concerns on the implementation or compliance of the HCP. Additional meetings may also be requested by the ESRC at any time to address immediate questions or concerns.

7.2 MONITORING AND REPORTING

Pursuant to Chapter 195D, monitoring and reporting by the DDIT will address both compliance with and effectiveness of monitoring and mitigation measures outlined in the HCP. Compliance monitoring will verify the Applicant’s implementation of the HCP terms and conditions. Annual reports and other deliverables as described below will be provided to the ESRC via DOFAW HCP staff and/or the DDIT to allow the committee to independently verify that required activities and tasks under this HCP are continuing and on schedule. Monitoring will document take relative to authorized levels and the success of the HCP’s mitigation program.

In order to meet the HCP requirements, and to provide an effective and efficient response to changing needs or circumstances, the DDIT will monitor avoidance and minimization measures, and mitigation efforts and results; assess impacts to covered species and compliance with obligations set forth under the HCP; and evaluate potential adaptive management measures.

Roles and responsibilities are defined in this section, and the adaptive management strategy is explained as it pertains to regular evaluation of conservation measures and compliance requirements.

7.2.1 Avoidance and Minimization and Mitigation Monitoring

7.2.1.1 Avoidance and Minimization:

Each existing and proposed exclosure designated for avoidance and minimization loss, will be surveyed for baseline conditions. DDIT staff will monitor the survival of existing *in situ* populations. If population numbers drop 25% lower than the established baseline, additional management efforts will be initiated.

1. Establish baseline: A full survey of the Covered Species will be done within each of the proposed (upon completion of fencing) and existing exclosures (following HCP approval) with the exception of the FBS unit. Due to the density of vegetation and large size of the

FBS unit, regular surveys will be limited to the known Covered Species populations and additional surveying for additional individuals will be done when staff time permits (*for full description of exclosures see Section 4.3*). Data to be collected include: location, life stage, vigor, phenological state, and any evidence of ungulate damage. Monitoring data to be collected will follow the recommendations of the HRPRG as closely as possibly (*see Appendix E*).

2. Exclosures will be surveyed (or sub-sampled) annually to follow changes in the population over time. Demographic data by life stage including (growth, survival, reproduction, and recruitment will be analyzed to monitor changes in population abundance over time (declining, stabilizing, or increasing).

3. Rain and temperature gauges will be placed in each fenced unit to track changes over time and potentially correlate with any fluctuation in Covered Plant populations.

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 the HCP will include outplantings of non-covered native plant species, enhanced forest structure for native species, and potential increase in native invertebrate and vertebrate composition. Monitoring will include the following:

1. Monitoring survival of outplanted plants:
    a. A subset of the outplanted individuals will be monitored at 1 month, 3 months, 6, months, 12 months, and then annually.
    b. Data to be collected include: location, life stage, vigor, phenological state, and any evidence of ungulate damage. Monitoring data to be collected will follow the recommendations of the HRPRG as closely as possibly (*see Appendix E*).
2. At the end of year one, 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 quadrats around randomly chosen individuals to investigate recruitment.
3. Rain and temperature gauges will be placed in each unit to track changes over time and be used to correlate collected abiotic data with any fluctuation in Covered Plant populations.

4. 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

Competition, increased threat of wildfire, and alteration of micro-site conditions have all been identified as potential negative impacts of alien plant invasions in Hawaiʻi. In order to minimize these risks, invasive species need to be controlled and introductions of new pest species avoided. In order to understand how to best mitigate the threat of invasive species, monitoring will be conducted. The goal for invasive species control for this HCP is to remove 90% of fountain grass and kikuyu grass[10] from within 5 meters of an individual (or cluster of) Covered Species and,maintain a 25-50 m buffer of less than 50% invasive grass coverage around an individual(or cluster of) Covered Species.

Methods include:

1. Baseline monitoring: systematic transects with random quadrats will be used (concurrent with Covered Species monitoring) to establish and monitor the composition and abundance of alien plant species in the Plan Area. Monitoring will cover alien plant presence, frequency, cover, and density.
2. Baseline surveys will assist with identifying priority species for control. Initial work will rely on the results and experiences of previous restoration projects and experiments by professional managers and scientists. Pilot trials will also be done to assess the best method(s) of control for a given species.
3. After control is conducted, the presence, frequency, cover, and density of alien plants will be monitored semi-annually or annually to assess the efficacy and efficiency of previous control efforts.
4. Protocols to minimize introduction of new weed species will be developed (Appendix to be developed)

7.2.1.4. Fence line Monitoring:

Fence line checks will be done quarterly to ensure fencing integrity and regular inspection of ungulate ingress occurs. In addition, fence-lines will be checked more frequently if there are

[10] Fountain and kikuyu grass have been identified as the most damaging invasive species in the Plan Area. Additional weed species will be controlled on a case by case basis. Some alien species provide shade or hinder the encroachment of more aggressive species allowing for better outplanting success and can be left in place until outplants become established.

sufficient reasons to believe a fence may have been damaged (e.g. after a storm). If fences are found to be breached, fence line will be repaired and ungulates will be removed.

7.2.2 BSM and Tree Tobacco Monitoring

1. Annual monitoring of ʻAiea outplants will begin 5 years post-out planting. A minimum of three outplanting sites will be chosen to monitor for presence of larvae during the peak larval season (Dec-Feb).

2. 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 drone. Dependent upon the methodology employed, a map and distribution estimate will be calculated after each survey. This data will be used to calculate annual take estimates for Blackburn's sphinx moth larvae within the Plan Area.

7.2.3 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 impact to the species does not result in jeopardy to the species, 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.

7.2.4 Compliance Monitoring

Compliance monitoring is intended to document timely 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 action specific, and depend on the goals and measures of success for that activity under the HCP. Specific protocol 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.

7.2.5 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 change in funding or costs, or drastic change in 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.
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; identification of problems and solutions, as applies; requests for technical advice and recommendations for changes through adaptive management, as applies. The report should identify any planned changes or additions to facilities or actions which has 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; and
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 ESRC and DLNR. Regardless, the avoidance and minimization efforts will remain for the duration of the HCP.

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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 are assured of a suitable 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 estimated rates of take to the 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 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; and

4. Incorporate feedback loops linking implementation and monitoring to appropriate changes in management.

7.4.2 Adaptive Management for Blackburn's Sphinx Moth

As more information is learned about the density, distribution, and biology of BSM within the Plan Area, avoidance, minimization, and mitigation measures will be adjusted accordingly. For example, we may find through survey that BSM occur only in certain elevations, plant communities, times of year, or other factors which we can utilize to allow removal of invasive tree tobacco, while encouraging native habitat which maximizes immature BSM survival. Likewise, information gained on predator or parasitoid interaction with BSM 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 recommendation 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 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 will request funding in every biennial budget to support the proposed monitoring and mitigation measures for the life of the ITL.

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 change 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 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 some limited 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 (IPCC 2007). In some instances, climate change may cause populations of Covered Species to decline. Covered Plant Species are likely to be affected through 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; U.S. Climate Change Science Program 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 1 m in Hawaiʻi by the end of the 21st Century (Fletcher 2009). Given this prediction, any rise in sea level experienced during the life of the Plan would likely be less than 3 ft (1 m). As the Plan Area ranges in elevation from approximately 20 m to 1700 m, these sites are unlikely to be impacted by sea level rise in the next 25 years Plan life.

It has been predicted that wet season (winter) precipitation will decrease by 5% to 10%, while dry season (summer) precipitation will increase by about 5% (Timm and Diaz, 2009, Giambelluca *et al*. 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 with decreased precipitation or increased temperatures and wildfire threat. 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. Any changes in the implementation of mitigation measures for any of the Covered Species due to climate change will be performed 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 with the DLNR. These actions will be implemented if mitigation actions have not 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 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 Blackburn’s sphinx moths or their habitat 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*, Uhiuhi, Kauila, Honohono, Maʻo hau hele, Kokiʻo, *Neraudia breviflorum*, Hala pepe, *Silene lanceolata*, Pōpolo kū mai, *Stenogyne angustifolia*, Aʻe (*Zanthoxylum dipetalum* var. *tomentosum*), and Aʻe (*Zanthoxylum hawaiiense*).

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 the 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, 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 written notification to the DLNR administrative staff requesting an amendment to the HCP addressing the new circumstance(s). Such applications typically require a revised HCP, a revised implementing agreement, and may require environmental review documents in accordance with HEPA. 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 provide a description of 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.

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APPENDIX A: MAMMAL TRACKING STUDY

A.1 INTRODUCTION

A study was initiated to track to the movement patterns of game mammals in the Plan Area in 2004. The primary objectives were to capture and monitor the movements of wild sheep, goats, and pigs and to establish the "Area of Potential Impact" of game mammals produced on or using the Plan Area (*See section 1.3.1 for a full description*).

A.2 METHODS

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 capture 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. Expired produce and bakery products were donated by KTA Super Stores (a local grocery chain) in Waimea. Macadamia nuts were also used in some instances. Following the attachment of radio collars, each animal was given a brief physical examination. Approximate age, based on dental eruption patterns and horn length or physical size and sex were recorded.

Selection of animals

We intentionally captured only one sheep or goat from a particular herd in order to maximize information collected on the behavior, composition and movements of different herds. We targeted animals of different age classes and sexes. We attempted to select animals from all portions of the study area. This was fairly easy to accomplish with sheep, except in the makai areas below Māmalahoa highway, where sheep densities have been low in recent history. Goats tended to occupy more discrete areas within the study site, primarily on rough a'a flows and near areas with numerous caves. The capture locations for goats reflect this distribution pattern. Pigs are also 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 some sheep and goats near borders with adjacent land owners.

Tracking protocol

For all ungulates, 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). To report average home range sizes within the present study, and for comparison to other studies, we excluded animals with fewer than 15 locations.

A.3 RESULTS

Home Range

Ungulate descriptions, tracking data, and the fate of study animals followed during the tracking study are summarized in Table A-1. 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. Figures A-1 –A3 summarize the current home range results for sheep, pigs, and goats in the region.

Table A-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 A-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 A-2. 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**

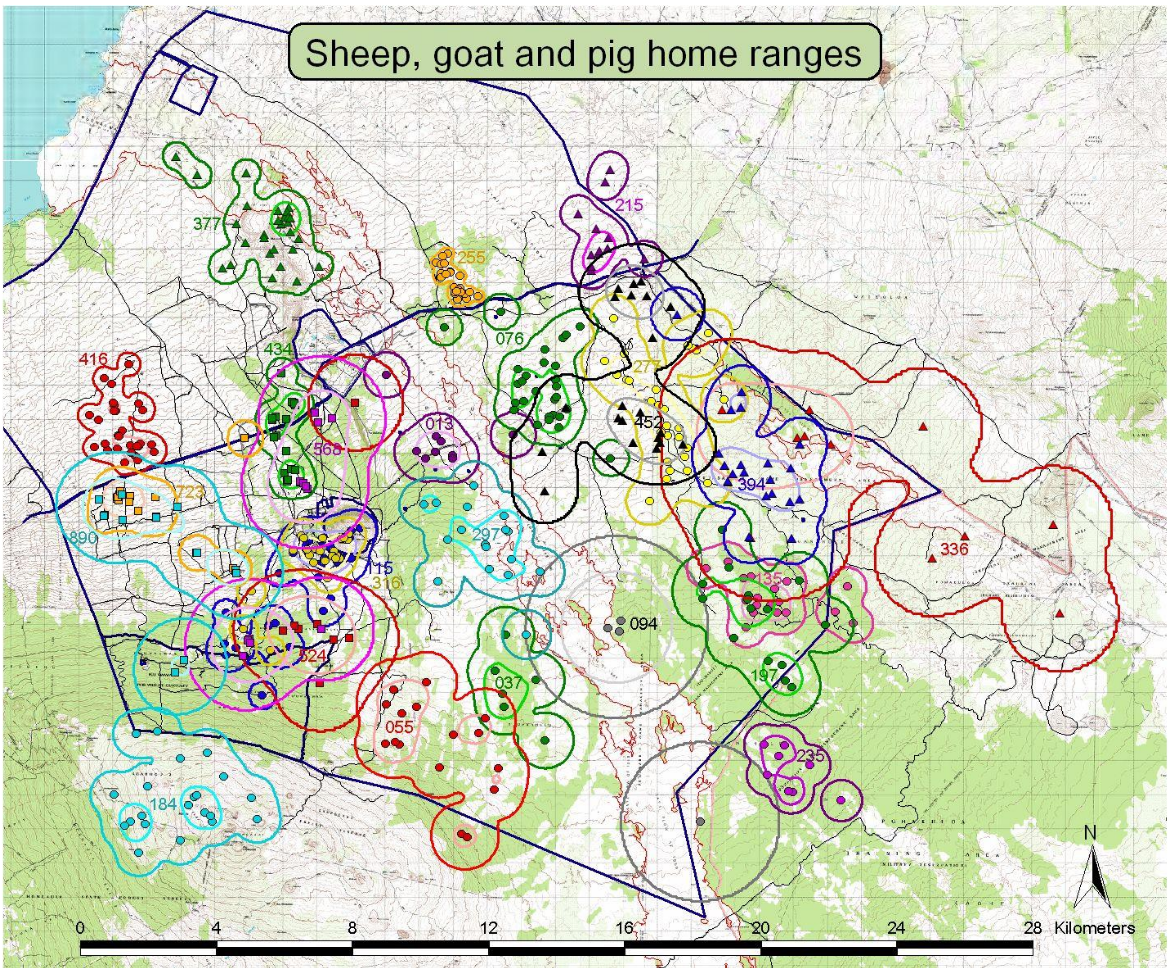

Figure A-1. Summary of the 95% kernel home range results (km^2) for sheep (circles), pigs (squares), and goats (triangles) in the region. Each color signifies an individual animal.

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.

APPENDIX B: LIST OF PROTECTED SPECIES IN THE PLAN AREA

The the Puʻu Waʻawaʻa 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 (2003:63-65) to include Puʻu Anahulu) are listed in Table B-1. This list includes both plant and animal species. Note that not all of the listed plants are likely to be negatively impacted by Plan 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 (2003:66), modified to include data from HCP surveys), are included in Table B-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 B-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 B-1. Endangered and threatened species currently existing in the Plan Area (modified from Management Plan 2003:63-65 to include Puʻu Anahulu species). *Indicates species *not* found during HCP botanical surveys.

Scientific name	**Common name**	**Status**
Flora		
Asplenium peruvianum var. *insulare*	n/a	Endangered
Caesalpinia kavaiensis	Uhiuhi	Endangered
Colubrina oppositifolia	Kauila	Endangered
*Cyanea stictophylla**	Hāhā	Endangered
Haplostachys haplostachya	Honohono	Endangered
Hibiscus brackenridgei ssp. *brackenridgei*	Maʻo hau hele	Endangered
Kokia drynarioides	Kokiʻo	Endangered
Neraudia ovata	n/a	Endangered
Nothocestrum breviflorum	ʻAiea	Endangered
Phyllostegia velutina	n/a	Endangered
*Plantago hawaiiensis**	Laukahi kuahiwi	Endangered
Pleomele hawaiiensis	Hala pepe	Endangered
Silene lanceolata	Hawaiian catchfly	Endangered
Solanum incompletum	Pōpolo kū mai	Endangered

Scientific name	Common name	Status
Stenogyne angustifolia	Creeping mint	Endangered
Vicia menziesii	Hawaiian vetch	Endangered
Zanthoxylum dipetalum var. *tomentosum*	A‘e	Endangered
Zanthoxylum hawaiiensis	A‘e	Endangered
Bidens macrantha subsp. *ctenophylla**	Ko‘oko‘olau	Candidate
*Acacia koaia**	Koai‘a	Species of Concern
Alphitonia ponderosa	Kauila	Species of Concern
Capparis sandwichiana	Maiapilo	Species of Concern
Chamaesyce olowaluana	‘Akoko	Species of Concern
*Crytandra menziesii**	Ha‘iwale	Species of Concern
Eragrostis deflexa	n/a	Species of Concern
Exocarpus gaudichaudii	n/a	Species of Concern
Fragaria chiloensis	n/a	Species of Concern
Melicope hawaiensis	Manena	Species of Concern
*Phytolacca sandwicensis**	Pōpolo kū mai	Species of Concern
Reynoldsia sandwicensis	‘Ohe makai	Species of Concern
*Rubus macraei**	‘Akala	Species of Concern
*Sicyos macrophyllus**	n/a	Species of Concern
Sisyrinchium acre	Mau‘u la‘ili	Species of Concern
Stenogyne macrantha	n/a	Species of Concern
Tetramalopium consanguineum	n/a	Species of Concern
Tetramalopium humile	n/a	Species of Concern
Vertebrates		
Branta sandvicensis	Nēnē (Hawaiian goose)	Endangered
Buteo solitarius	I‘o (Hawaiian hawk)	Endangered
Eretmochelys imbricata	‘Ea (Hawksbill turtle)	Endangered
Himantopus mexicanus knudseni	Ae‘o (Hawaiian stilt)	Endangered
Lasiurus cinereus semotus	‘Ope‘ape‘a (Hawaiian hoary bat)	Endangered

Scientific name	**Common name**	**Status**
Loxops coccineus coccineus	‘Akepa	Endangered
Oreomystis mana	Hawai‘i creeper	Endangered
Chelonia mydas	Honu	Threatened
Asio flammeus sandwichensis	Pueo	Species of Concern
Invertebrates		
Manduca blackburni	Blackburns’s sphinx moth	Endangered
Drosophila heteroneura		Candidate
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
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 B-2. Endangered and threatened species known to be in the Plan Area historically (from Management Plan 2003:66 modified to include data from HCP surveys).

Scientific name	**Common name**	**Status**
Flora		
Bonami menziesii		Endangered
Delissea undulata ssp. *undulata*		Endangered
Diellia erecta		Endangered
Gardenia brighamii	Nān ū	Endangered
Hibiscadelphus hualalaiensis	Hau kuahiwi	Endangered
Isodendrion pyrifolium	Wahine noho kula	Endangered
Ochrosia kilaueaensis	H ō lei	Endangered
Phyllostegia racemosa	Kiponapona	Endangered
Portulaca sclerocarpa	‘Ihi	Endangered
Dissochondrus biflorus		Species of Concern
Nesoluma polynescium	Keahi	Species of Concern
Vertebrates		
Anas wyvilliana	Koloa	Endangered
Corvus hawaiiensis	‘Alala	Endangered
Hemignathus munroi	‘Akiapola‘au	Endangered
Pterodroma phaeopygia sandwicensis	‘Ua‘u	Endangered
Invertebrates		
Partulina confusa		Species of Concern

Table B-3. Endangered, threatened, and common species likely suited for restoration efforts in the Plan Area not covered under this HCP (Modified from Management Plan 2003:67-68).

Scientific name	Common name	Status
Flora		
Abutilon menziesii	Koʻoloaʻula	Endangered
Achyranthes mutica		Endangered
Cyperus faurei		Endangered
Fluggea neowawraea	Mehamahame	Endangered
Gouania vitifolia		Endangered
Hedyotis coriacea	Kioʻele	Endangered
Isodendrion hosakae		Endangered
Isodendron pyrifolium	Wahine noho kula	Endangered
Lipochaeta venosa		Endangered
Pritchardia affinis	Loulu	Endangered
Sesbania tomentosa	ʻOhai	Endangered
Spermolepis hawaiiensis		Endangered
Tetramolopium arenariun var. *arenarium*		Endangered
Vigna o-wahuensis		Endangered
Silene hawaiiensis		Threatened
Ranunculus hawaiiensis		Candidate
Bidens campylotheca ssp. *Campylotheca*		Species of Concern
Bobea timonioides	ʻAhakea	Species of Concern
Dissonchondrous biflorus		Species of Concern
Festuca hawaiiensis		Species of Concern
Phyllostegia stachyoides		Species of Concern
Alyxia olivaeformis	Maile	None
Antidesma pulvinatum	Hame	None
Diplazium sandwichianum	Hō ʻiʻo	None
Bidens menziesii		None
Canavalia hawaiiensis	ʻĀwikiki	None

Scientific name	**Common name**	**Status**
Charpentiera obovata	Pāpala	None
Cheirodendron trigynum	ʻOlapa	None
Chenopodium oahuense	*ʻĀweoweo*	None
Cibotium spp.	Hāpuʻu	None
Claoxylon sandwicense	Poʻola	None
Clermontia clermontioides	ʻŌha wai	None
Cocculus trilobus	Huehue	None
Coprosma cymosa		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
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 sandwicensis	Pāpala	None
Pittosporum terminaloides	Hōʻawa	None
Plumbago zeylandica	ʻIlieʻe	None
Polystichum hillibrandii		None
Pouteria sandwicensis	ʻĀlaʻa	None

Scientific name	Common name	Status
Psychotria hawaiiensis	Kōpiko	None
Psydrax odoratum	Alaheʻe	None
Rauvolfia sandwicensis	Hao	None
Rumex giganteus	P ā wale	None
Sadleria spp.	ʻAmaʻu	None
Santalum paniculatum	ʻIliahi	None
Senna gaudichaudii	Kolomona	None
Sicyos lasiocephalus		None
Streblus pendulinus	Aʻiaʻi	None
Urera glabra	Ōpuhe	None
Wikstroemia spp.	ʻ*Ā*kia	None
Xylosma hawaiiense	Maua	None

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 function (i.e. reproduction and growth). *Stenogyne angustifolia* is used here as an example to illustrate the effect game mammals may have on native species.

Methods

Four species (Honohono, *Phyllostegia velutina*, Hawaiian Catchfly, *Stenogyne angustifolia*) were monitored over the course of this study. For each species, an exclosure (approximately 20 by 20 m, four ft hogwire fencing) and a corresponding control site were created. For Hawaiian Catchfly and *Stenogyne angustifolia*, both the exclosure and a 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, 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 quadrants and each of the four species were labeled and flagged. For each individual, 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, and/or trampling).

Results

Changes in Level of Browsing

A comparison of control (non-fenced) to exclosure populations of the *Stenogyne angustifolia* indicates a marked decrease in the amount of ungulate damage in the fenced populations over time (Figure C-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.

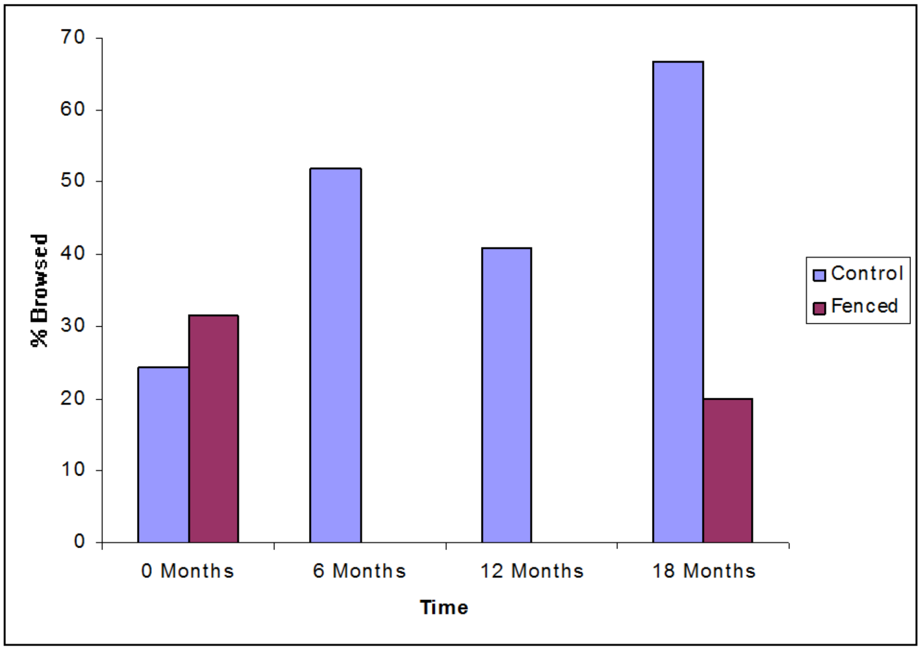

Figure C-1. Percent ungulate browse activity on *Stenogyne angustifolia* over the 18 month study period.

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 C-2).

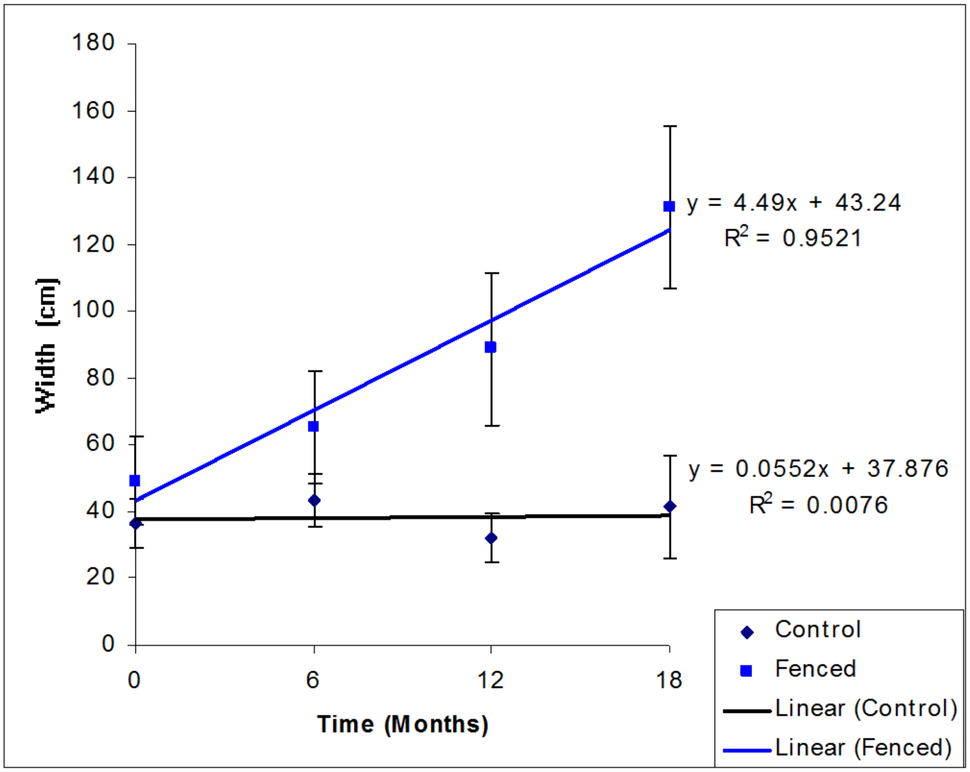

Figure C-2. Scatter plot of *Stenogyne angustifolia* plant width over time in both fenced and unfenced units.

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 C-3).

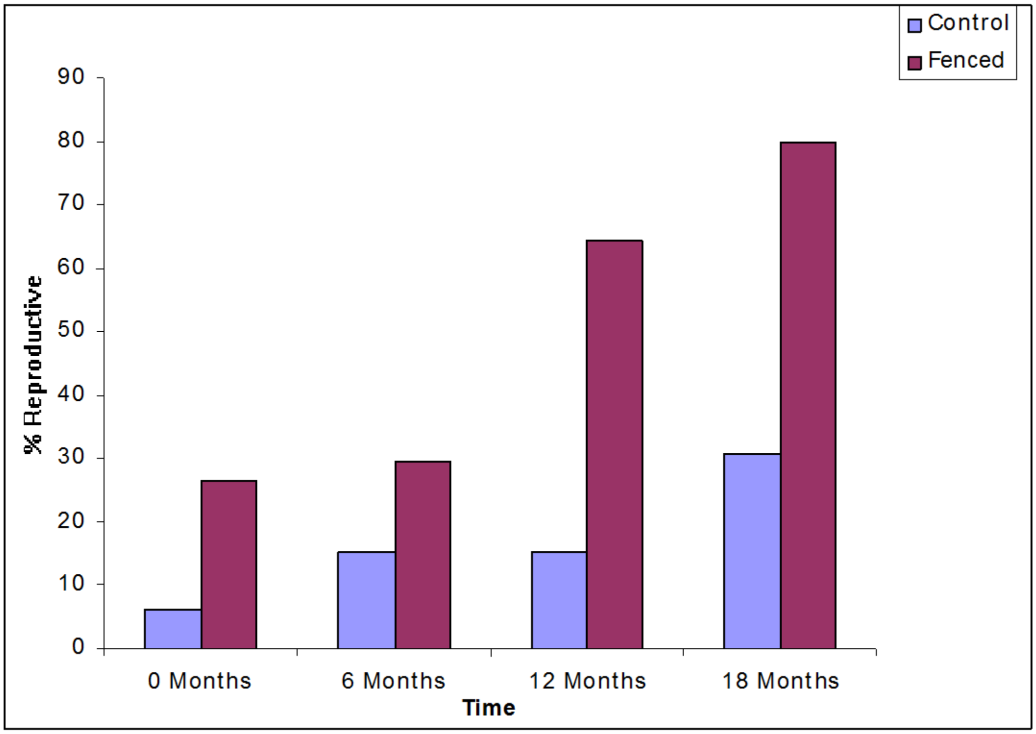

Figure C-3. Percent of *Stenogyne angustifolia* individuals reproducing over 18 months of the ungulate exclosure study.

Discussion and Conclusions

The one-year 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 versus the negative growth rates of non-exclosure plants. 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.

The results of this study suggest that exclosures are highly effective means of minimizing negative impacts from grazing at Pu‘u Wa‘awa‘a and Pu‘u 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 exclosure populations may be critical to population survival and species recovery.

APPENDIX D: Blackburn's Sphinx Moth Surveys and Results

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, *personal 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.

Tree Tobacco Distribution on Roadsides and Fuel Breaks:

To quantify the distribution of tree tobacco on roadsides and fuel breaks 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 D-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 Puu Anahulu (Figure D-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.

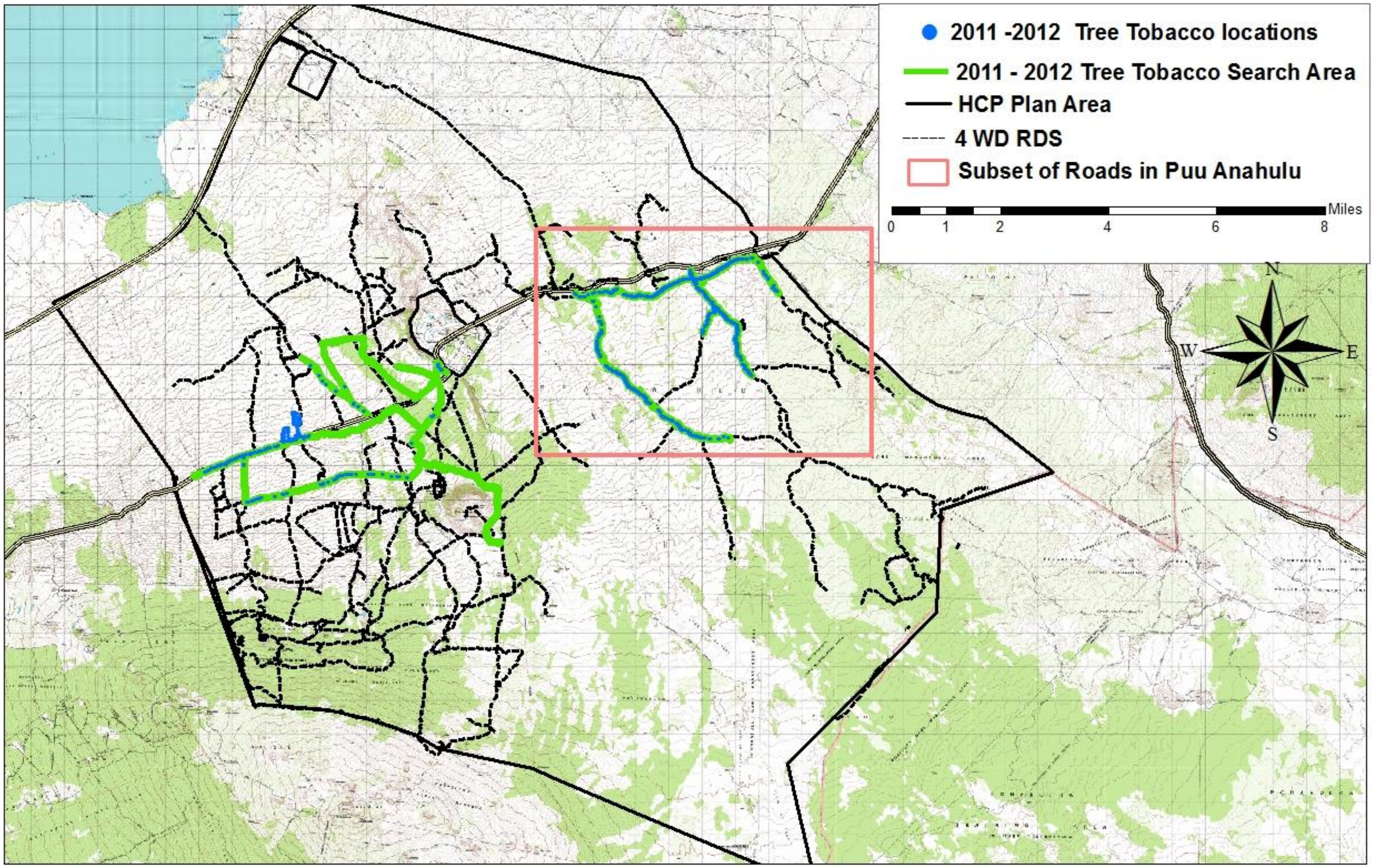

Figure D-1. 2011 and 2012 tree tobacco search area (green line) with mapped tree tobacco locations (blue dots). The area in the red/pink rectangle highlights the subset of roads in Puʻu Anahulu used to calculate the proportion of occupied habitat.

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 D-2). Based on this map, we estimate the CTTIA to be 839,486.38 m^2 or approximately 207 acres. If we assume that the coverage measured above in general characterizes the density of tree tobacco as a whole across the Plan Area (and this is likely a conservative estimate as Puʻu Anahulu tends to have high density), then we can apply this value to the CTTIA (839,486.38 m^2 x 0.186), to calculate the area occupied by tree tobacco (Occupied Area = 156,144.467 m^2).

***M. blackburni* Larval Density/Distribution on Tree Tobacco:**

We conducted *M. blackburni* surveys on a portion of the roads, fuel breaks, 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, *N. glauca* 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.

***M. blackburni* Larval Density/Distribution on ʻAiea:**

We plan to survey for *M. Blackburni* eggs and larvae during HCP implementation on a subset of mapped wild ʻAiea (*Nothocestrum breviflorum*) throughout the Plan Area. Thorough surveys of ʻAiea are difficult because the wood is extremely brittle, making the plants impossible to climb, and thus leaving much of the tree inaccessible to searchers. Additionally, many of the trees in the Plan Area are in poor health with reduced foliage (likely due to many factors including drought, insect pests, and competition with invasive plants) which limits the available substrate for the larvae. Where possible, these threats will be controlled around individual ʻAiea trees (e.g. through removal of invasive weeds). Targeted surveys for *M. blackburni* eggs and larvae on ʻAiea will be completed during regularly scheduled intervals to be determined during HCP implementation to establish the presence or absence and distribution of the species on the native host plant. Reporting will include the total number and average density of *M. blackburni* eggs and larvae per host plant as well as distribution within the Plan Area.

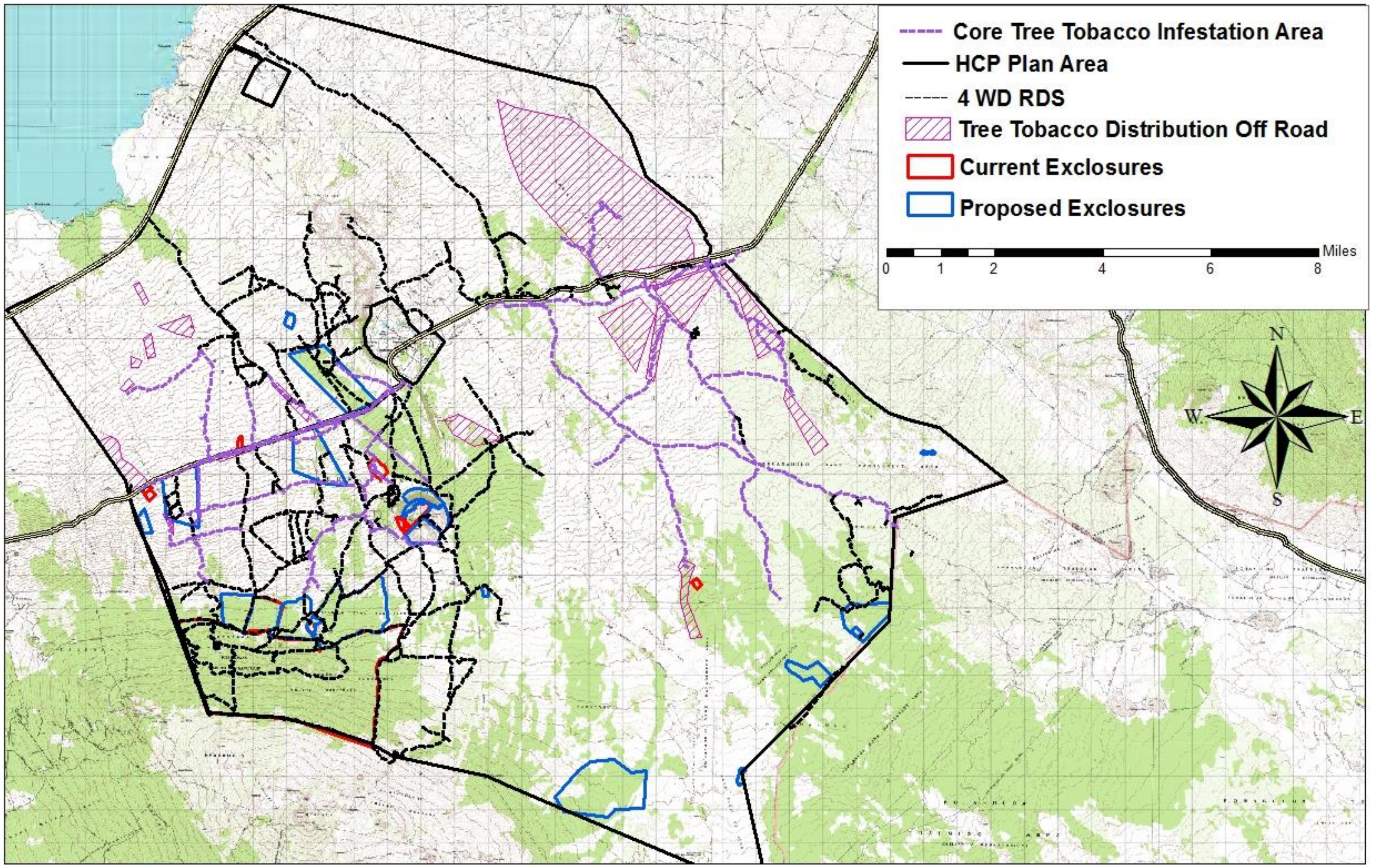

Figure D-2. Estimated tree tobacco distribution in the Plan Area based on the 2015 helicopter survey (pink hashed area). Roads in purple indicate the Core Tree Tobacco Infestation Area.

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.

Adult *M. blackburni* Surveys:
We used black-light traps to survey for the presence of adult moths at five different locations within the Plan Area on four separate occasions. The vegetation at these survey locations varied between areas dominated by native plants and areas dominated by alien species. Light traps consisted of an 18 inch ultra-violet light bulb (powered by a 12-volt battery) placed in front of a white bed sheet suspended vertically from a clothesline. Individual moths that land on the sheet can be visually identified or photographed. The morphology of the adult M. blackburni is unique among moths in Hawaiʻi making them easy to identify in the field; they are Hawaiʻi's largest native insect with a wingspan of up to five inches, and they have distinctive spindle shaped bodies with five orange spots along each side of the abdomen (USFWS – www.usfws.gov). 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, average, and distribution of adult *M. blackburni* will be reported for each sampling location, plant community type, elevation, and as Plan cumulative totals.

Results

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 *N. glauca* (Table D-1).

Table D-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

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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 preformed. 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 D-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 fuel breaks.

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 D-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 D-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 D-6).

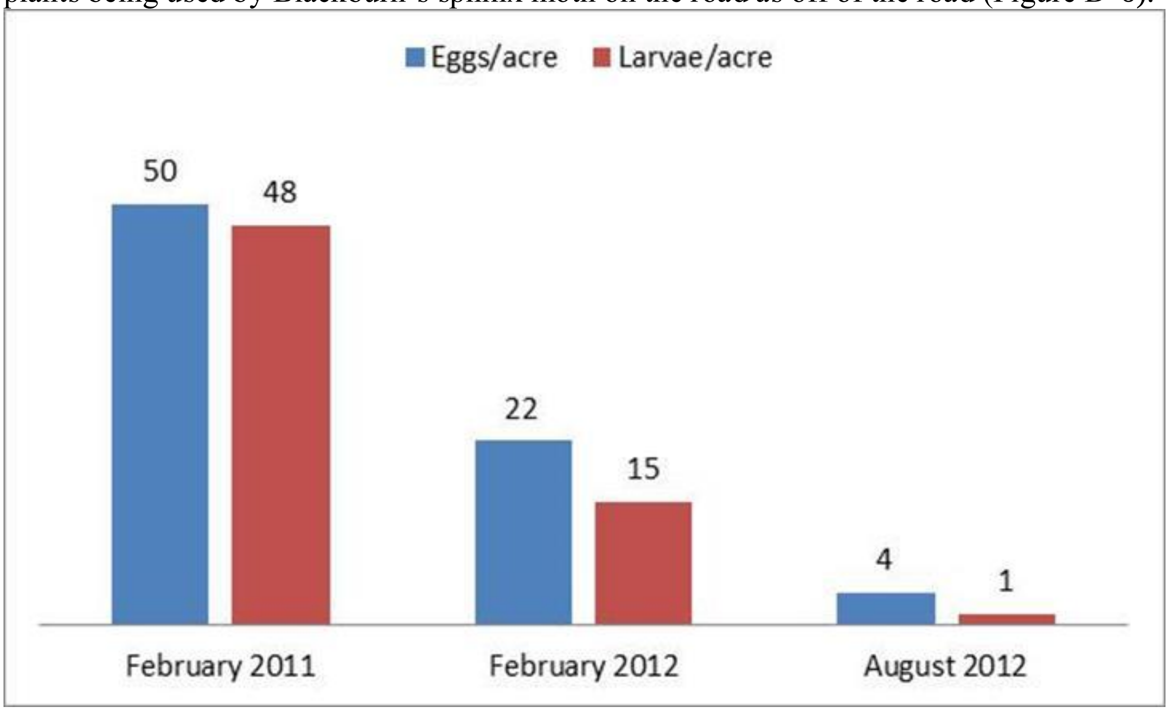

Figure D-3. Estimate of the number of eggs and larvae per acre of tree tobacco in the Plan Area. Larval surveys were done on transects containing a minimum of 10 trees per 75 m^2.

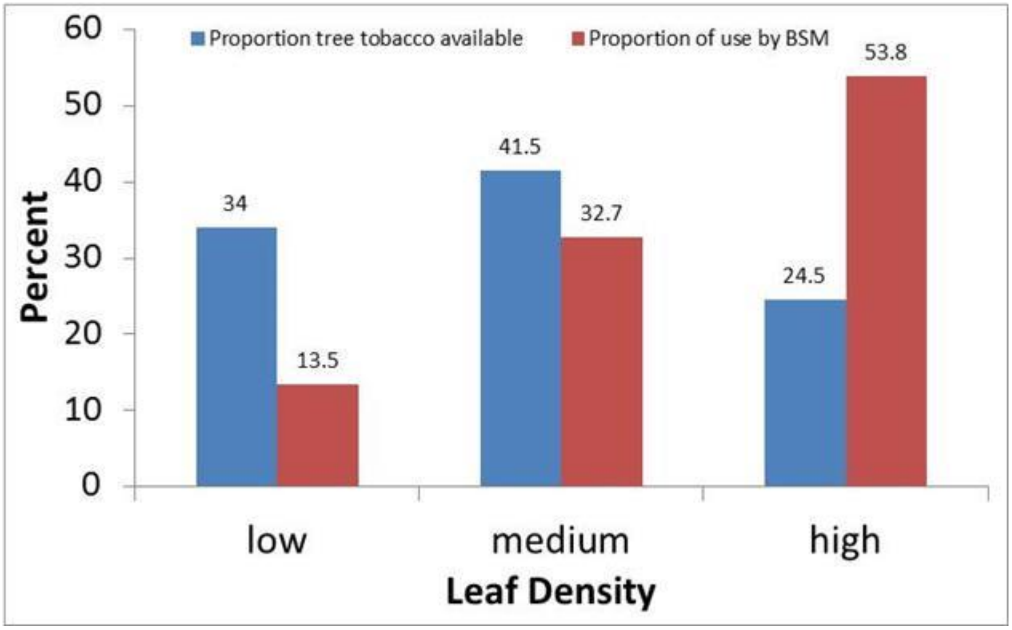

Figure D-4. Percent of plants containing Blackburn's sphinx moth eggs and larvae. Blue bars represent the proportion of plants that were available for use by Blackburn's sphinx moth of each leaf density category (low, medium, and high, all blue bars sum to 100%). Red bars represent the proportion of the plants actually containing eggs and larvae (all red bars sum to 100%).

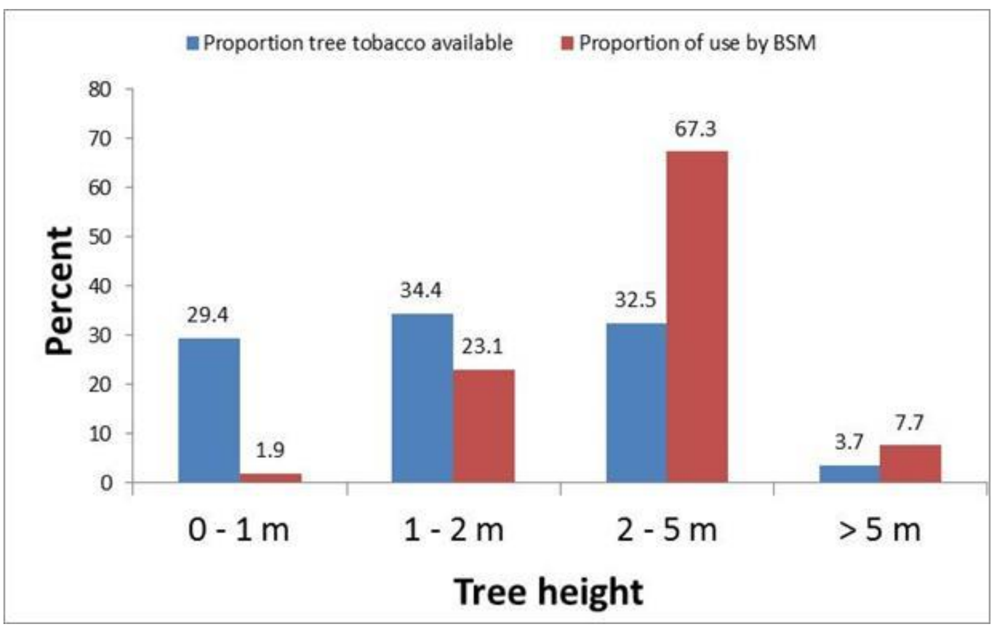

Figure D-5. Percent of plants in a given size class containing Blackburn's sphinx moth larvae and eggs. Blue bars represent the proportion of plants available of each of the size classes (blue sums to 100%). Red bars are the proportion of the plants that actually contained eggs and larvae (red sums to 100%).

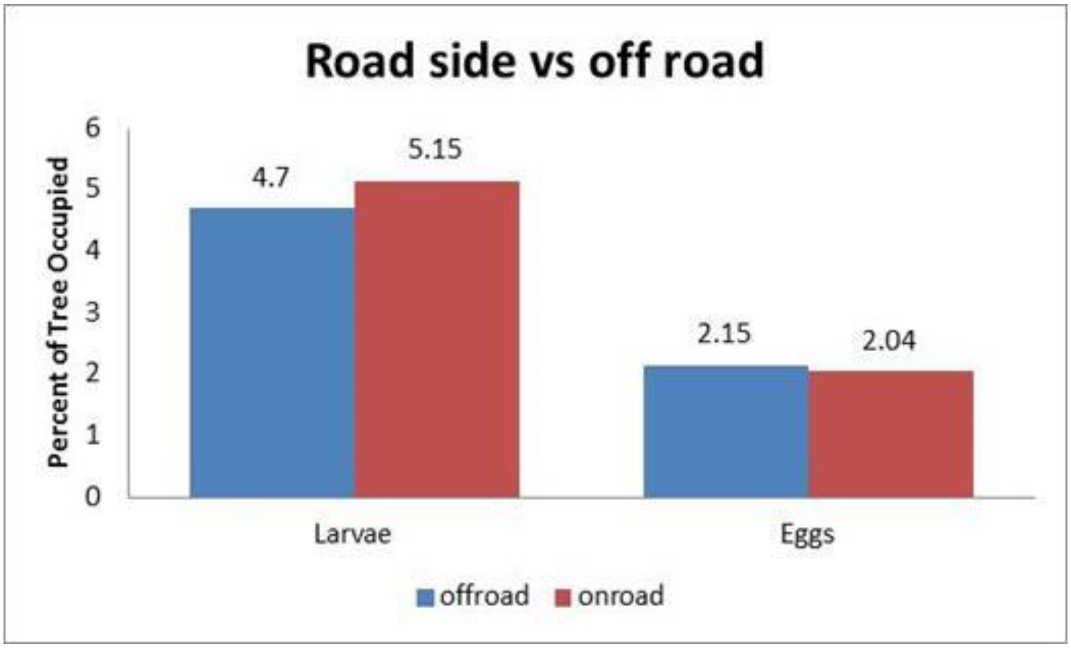

Figure D-6. A comparison of the number of eggs and larvae present on tree tobacco that were located on road transects (red bars) or on perpendicular off-road transects (blue bars).

***Manduca blackburni* larval density/distribution on ‘Aiea:** To date, 17 ‘Aiea trees have been surveyed for *M. blackburni* use. Feeding damage was noted on all individuals surveyed. Larvae and eggs were documented on two individuals, one located makai of the highway in the Uhiuhi/Wiliwili exclosure and the other in the proposed Henahena exclosure. There have been observations from DOFAW staff of larvae on ‘Aiea on two other instances in recent years, one on a wild individual and the other on an outplant on the Pu‘u Wa‘awa‘a cinder cone.

***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 ‘Ōhi‘a 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 *N. glauca* and ‘Aiea present, 2) a predominantly native forest with ‘Aiea present, and 3) a highly disturbed area dominated by *N. glauca*. Light trapping was conducted on the Pu‘u Wa‘awa ‘a cinder cone, in native outplanted habitat with ‘Aiea present in February 2011. Light traps were deployed on 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.

Take Estimate

In order to estimate take of Blackburn's sphinx moth, we decided to use 2012 data because we had the largest number of surveyed transects that year (139 total) and we surveyed during both winter and summer months, thus capturing both a high and low *M. blackburni* abundance. We are requesting take of Blackburn's sphinx moth based on following a schedule that allows DOFAW to clear the roads and fuel-breaks every two months, 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). Because of this variability we divided the years into two season, winter and summer, and used the data collected in summer and winter of 2012 to estimate take year round with three winter clearings and three summer clearings.

Winter Take Estimate

A total of 73 Blackburn's sphinx moth detections (larvae and un-hatched eggs) were found on 2323 tree tobacco plants across 93 transects during the winter 2012 surveys. Using these data, we calculated: 73 BSM/2323 trees = 0.03142 BSM/tree. We surveyed 93 transects with a total of 2323 trees: 2323/93 = 24.98 individual tree tobacco plants per transect. Given a density of 0.03142 BSM per tree, we then get a density of 0.7849 BSM per transect (0.03142 x 24.98 trees per transect). One transect has an area of 75 m^2 (25 m x 3 m). Therefore overall BSM density for the winter is 0.7849/75 m^2 = 0.0105 BSM/m^2. Based on the Occupied Area calculated above from above (156,144.467 m^2), estimated take for one winter clearing period rounds up to 1640 Blackburn's Sphinx moth individuals (larvae plus un-hatched eggs).

Summer Take Estimate

A total of 4 Blackburn's sphinx moth detections (larvae and un-hatched eggs) were found on 1329 tree tobacco plants across 49 transects during the winter 2012 survey. Using these data, we calculated: 4 BSM/1329 trees = 0.003 BSM per tree. We surveyed 49 transects with a total of 1329 trees: 1329 trees/49 transects = 27.122 individual tree tobacco plants per transect. Given a density of 0.003 BSM per tree, we then get a density of 0.0814 BSM per transect (0.003 x 27.122 trees per transect). One transect has an area of 75 m^2 (25 m x 3 m). Therefore overall BSM density for the summer is 0.0814/75 m^2 = 0.001 BSM/m^2. Based on the Occupied Area calculated above from above (156,144.467 m^2), take for one summer clearing period rounds up to 157 Blackburn's Sphinx moth individuals (0.001 x 156,144.467 = 156.144 larvae plus un-hatched eggs).

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

We estimated the location and distribution of tree tobacco in the Plan Area based on a helicopter survey conducted in January 2015 (see Figure 5.8). 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 approximately 6462 acres of the Project Area (outside of roads) contain tree tobacco. The winter 2012 off-road BSM survey data was then used to estimate BSM density (24 BSM/acre) across the entire area colonized by tree tobacco (24 x 6462 = 155,088 BSM). Based on this calculation, the population estimate for Blackburn's sphinx moth larvae and un-hatched eggs outside of roads is 155,088

BSM. We then added the winter 2012 on-road population estimate (1640 BSM) for a total winter Blackburn's sphinx moth population estimate of 156,728 individuals (larvae plus un-hatched eggs).

Total annual take estimate

If we assume we will clear all tree tobacco plants 6 times a year, three times during summer or dry months and three times during winter or rainy months, the overall annual take estimate is 5,391 individual BSM (1,640 x 3 = 4,920 +_157 x 3 (471) = 5,391) un-hatched eggs and larvae) which is 3.44 % of the estimated Blackburn's sphinx moth population in the Plan Area (5,391/156,728) x 100 = 3.44%).

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 to 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 in immediate delivery is not possible.
Dry dehiscent: Only available before it disperses. Try to harvest just before dehiscing.

Dry Indehiscent: Dependent upon when and how dispersed. For example, wind dispersed, by animals or insects, etc.
Fleshy fruits: Need to know if recalcitrant (desiccation intolerant) or orthodox (desiccation tolerant).

Recalcitrant Seed
Recalcitrant seeds cannot withstand any drying, have some seed coats adapted to prevent excessive water loss while others have no such adaptation and are prone to rapid water loss post harvest. In fleshy fruits, high seed moisture can be maintained by keeping the fruit intact. Their individual seeds can be stored in impermeable plastic bags, but must be aerated by opening the bag intermittently to compensate for the restrictive gas exchange environment. Insulate against heat and temperature extremes. Try to maintain a temperature as close to ambient as possible. In mature fruit, indicate if picked off the ground or parent plant. Try not to collect from the ground if possible, unless it is known that they have recently fallen.

Orthodox Seed
In general, the desiccation tolerance of orthodox seed varies throughout its development. They tend to be intolerant of drying during early development and become more tolerant as the seeds mature. If the fruits are immature, leave the seed within the fruit. Treat in the same manner as recalcitrant seeds. Mature seeds from dry indehiscent or dehiscent fruits can be kept in permeable containers such as paper or cloth bags.

Collecting and Handling of Vegetative Propagules
Successful propagation of vegetative propagules are dependent upon many different factors such as the vigor of the parent, the collection date and even the environmental conditions at the time of collection. Correct handling of vegetative material is also important.
1. Vegetative materials deteriorate quickly post harvest and quick transfer from field to the propagative facility is imperative to ensure maximum viability.
2. Additional care must be taken during transport since they are easily damaged.
3. Place under cool conditions, such as a cooler with ice packs, as soon as possible after collecting and during transport to the propagation facility.
4. Try to collect samples that are insect and disease free.
5. Minimize damage during harvesting and transport.
6. In the case of vegetative cuttings, cut ends can be wrapped in damp towels or newspaper.

Vegetative Cuttings (Herbaceous)
The shoots harvested should be from the last mature flush of the plant. Cuttings should be long enough to allow for trimming and possible division.
If the plant species is known to be hard to propagate, small rooted plant suckers with some of the soil surrounding the roots could be taken if possible. Whole plants should not be removed at any time.

Vegetative Cuttings (Woody)
Propagation of mature trees is more difficult in general than their juvenile counterparts; but in many cases, juvenile forms are not available for collection. Whenever possible, the best material for propagation is the juvenile form. If only mature forms are available, material from their juvenile gradients may have a better chance of success.

Roots and Tubers
Timing of collection is important. The collection of immature or sprouting storage organs can result in significant losses in viability. In the case of plants that possess a dormant stage, a two-visit strategy may be required. One to identify individual clones and mark their location and another to collect the tubers or rhizomes once the top of the plant has died.

Fern Fronds
Fern fronds should be kept in plastic bags and not allowed to dry out during transport. If immediate delivery to the laboratory is difficult, place frond between 2 sheets of paper and allow to air dry flat within a plastic bag propped open. Spores will fall off frond as it dries. Seal the bag shut when completely dry and maintain a flat position to keep the spores on the paper surface.

Flowering Shoots
Some flowering shoots contain vegetative buds that do not develop but remain dormant. Sometimes the dormancy can be broken to produce juvenile vegetative shoots. Also, the immature flowers of a few tree species have been known to form adventitious shoots.

Root Cuttings
When lateral shoots are not available, such as in palms and other monocots, it is sometimes possible to produce vegetative shoots from root cuttings. Roots are often considered to be more juvenile in age than most of the tree. A juvenile gradient exists for roots, with the most juvenile material being closest to the trunk. Sprouts arising naturally from the roots of trees generally are juvenile in form. Store root cuttings in a moist sterile medium, such as peat moss.

Decontamination of Collecting Tools
Many of the Hawaiian endemic species have limited or non-existing *ex situ* collections, which necessitates the need for active *in situ* collecting. It is imperative that precautions be taken to keep the natural populations as disease free as possible. This is not only to maintain clean propagative stock material during collections, but also to ensure the integrity and overall health of the existing population and the surrounding flora. While absolute elimination of all pathogens is impractical and impossible, procedures should be directed toward preventing the introduction of serious foreign pathogens. The risk of disease transmission of viral, fungal, or bacterial origin is a realistic possibility through the cutting implements used in collection of plant samples. Whenever possible, plant cuttings should be made with a new, unused blade. This can be accomplished by using an implement such as a box knife fitted with a disposable razor blade. The used blade can be changed before cutting the next sample. Dr. Stephen Ferreira at UH Plant Pathology has also suggested that any cutting of plant propagules performed post collection should be done with disinfected tools. This is to prevent any disease contamination of the propagules before it goes to the propagation facility.

Decontaminate tools:
Make a 5 % to 10% solution of household bleach (such as Clorox manufactured by The Clorox Co.) and soak tools. Let sit for 2-3 minutes then rinse well with water. Always use a fresh batch of bleach solution.

APPENDIX F: TAXONOMIC CHANGES

A number of taxonomic changes have taken place during the development of this HCP. We have compiled a list of taxonimically accepted names for species that we are aware of and left the commonly used names in the document for ease of understanding and use.

Table F-1. Taxonomic changes.

Scientific name used within the HCP	New Scientific name as of March 2014
Caesalpinia kavaiensis	*Mezoneuron kavaiense*
Chamaesyce olowaluana	*Euphorbia olowaluana*
Pleomele hawaiiensis	*Chrysodracon hawaiiensis*
Reynoldsia sandwicensis	*Polyscias sandwicensis*

APPENDIX G: Funding Matrix

SEE ATTACHED EXCEL FILE