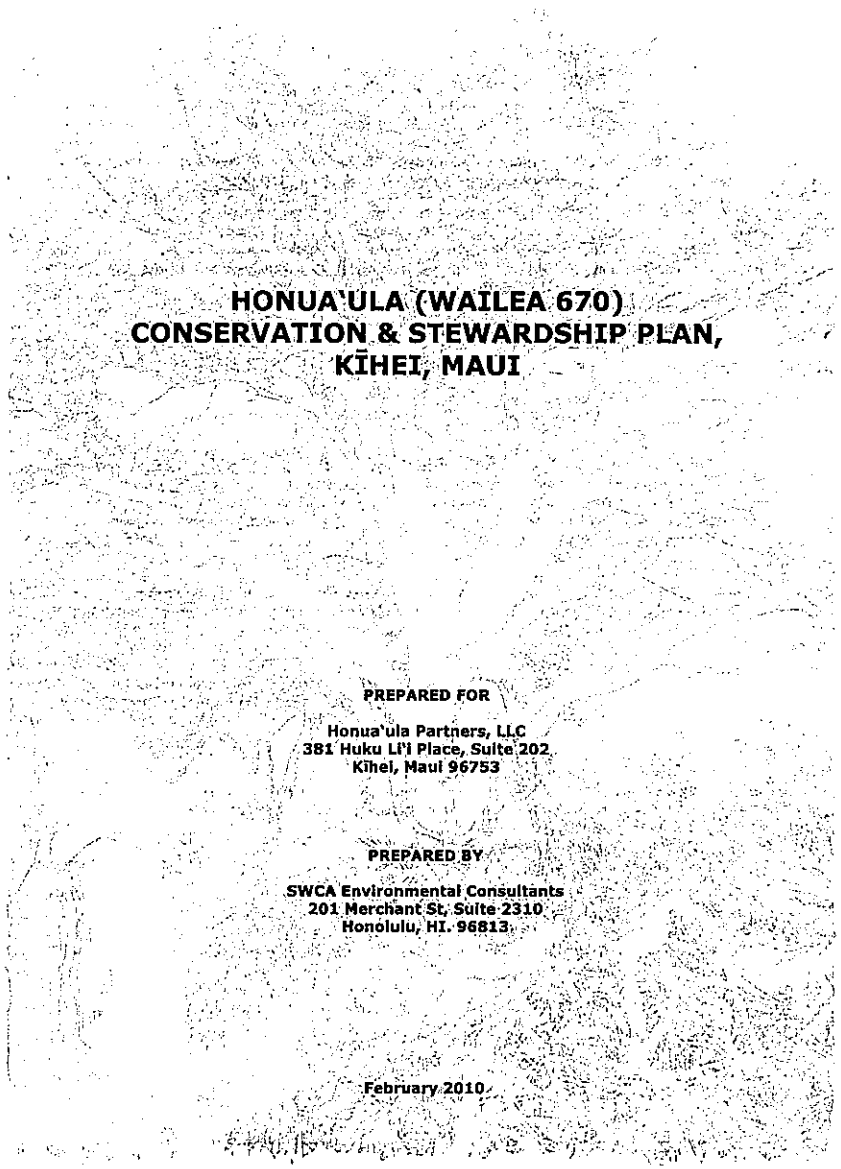
Appendix F

Conservation & Stewardship Plan



HONUA'ULA (WAILEA 670) CONSERVATION & STEWARDSHIP PLAN, KĪHEI, MAUI

PREPARED FOR

Honua'ula Partners, LLC
381 Huku Li'i Place, Suite 202
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1.0 INTRODUCTION AND BACKGROUND

1.1 Project Summary

Honua'ula is a master-planned residential community encompassing a rectangular area of 271 hectares (ha) or 670 acres (ac) east of, and adjacent to, the existing Wailea Resort in Kihei, Maui (hereinafter referred to as the 'Property'). The proposed community is composed of single and multi-family homes, supporting commercial uses, open space, an 18-hole golf course and club, and other recreational amenities. The Property is located on the lower slopes of Haleakalā and is bounded by the Maui Meadows subdivision to the north, the Makena golf course to the south, the Wailea golf course to the west, and the 'Ulupalakua Ranch to the east (Figure 1).

An Environmental Impact Statement (EIS) was first published for the Property (then known as Wailea 670) in 1988 (PBR Hawaii, Inc. 1988). Since 1988, ownership of the Property and the conceptual plan for the Property has changed several times. In January 2000, WCPT/GW Land Associates, LLC acquired the Property, and the new owner proposed a revised plan from what earlier landowners had proposed. In July 2007, the Property was acquired by Honua'ula Partners, LLC, an entity comprised primarily of the same members as WCPT/GW Land Associates. Honua'ula Partners did not change the revised master plan and continued to process the applications previously prepared and submitted by WCPT/GW Land Associates. An EIS for the current proposed project is currently being prepared for Honua'ula by PBR Hawaii, Inc. (2009) in accordance with Chapter 343, Hawaii Revised Statutes (HRS) and Title 11, Chapter 200, Hawaii Administrative Rules (HAR).

Recently, Altenberg (2007) drew attention to the southern portion of the Property which he claimed to be among the best examples of a remnant native lowland dry forest remaining on Maui. He suggested that Honua'ula "contains most of the 3rd largest contiguous area of *wiliwili* (*Erythrina sandwicensis*) habitat on Maui, approximately 110 acres in the southern 1/6 of the property" (Altenberg 2007). Altenberg recommended that an area of approximately 45 ha (110 ac) be preserved for its ecological significance.

To address concerns raised by Altenberg over the presence of native plants within the southern portion of the Property, SWCA Environmental Consultants (SWCA) was tasked to conduct a thorough quantitative botanical assessment within the Property (SWCA 2009a). A companion document addressing wildlife and plant-related wildlife issues was also prepared by SWCA (2009b). In collaboration with federal and state natural resource agency staffs, SWCA developed mitigation measures to help protect and conserve native plant and animal resources at Honua'ula (SWCA 2009a, 2009b). The specific mitigation measures developed by SWCA, in collaboration with USFWS and DLNR, for botanical and wildlife resources are listed in the natural resources reports prepared by SWCA (2009a, 2009b, respectively).

1.2 Project Approval and Natural Resource Conditions

The former owner of the Property obtained several land use entitlements, as outlined in the *Environmental Assessment / Environmental Impact Statement Preparation Notice* (PBR Hawaii, Inc. 2009). Project district zoning was approved for the entire Property in 1993, and approximately 170 ha (420 ac) was approved for golf course development and accessory uses. The following year, the State Land Use Commission issued a decision to reclassify the Property from an Agricultural District to an Urban District.

In June 2000, the current owner (now Honua'ula Partners, LLC) submitted applications to Maui County for a Change in Zoning and Project District Phase I Approval for the revised master plan (PBR Hawaii, Inc. 2009). After six years of project revisions by the present owner to accommodate community concerns, including issues with native plants in the southern portion of the Property, the Maui County Council approved Phase I conditional Project District Zoning for 271 ha allowing for residential, limited commercial, golf course, and open space zoning. With this approval, the Maui County Council passed Ordinance No. 3554 in March 2008, which promulgated 28 specific conditions in granting a Phase I project district zoning approval for Honua'ula. Ordinance No. 3554 included several conditions regarding the conservation of natural resources, including the creation of a conservation easement and stewardship plan. The following conditions are related to the purpose and scope of this plan:

Figure 1
Aerial Photograph

27. That Honua'ula Partners, LLC, its successors and permitted assigns, shall provide the report "Remnant Wiliwili Forest Habitat at Wailea 670, Maui, Hawaii by Lee Altenberg, Ph.D.", along with a preservation/mitigation plan, to the State Department of Land and Natural Resources, the United States Fish and Wildlife Service, and the United States Corps of Engineers for review and recommendations prior to Project District Phase II approval. The Maui Planning Commission shall consider adoption of the plan prior to Project District Phase II approval.

Such plan shall include a minimum preservation standard as follows: That Honua'ula Partners, LLC, its successors and permitted assigns, shall establish in perpetuity a Conservation Easement (the "Easement"), entitled "Native Plant Preservation Area", for the conservation of native Hawaiian plants and significant cultural sites in Kihei-Makena Project District 9 as shown on the attached map. The Easement shall comprise the portion of the property south of latitude 20°40'1 5.00"N, excluding any portions that the State Department of Land and Natural Resources, the United States Fish and Wildlife Service, and the United States Corps of Engineers find do not merit preservation, but shall not be less than 18 acres and shall not exceed 130 acres.

The scope of the Easement shall be set forth in an agreement between Honua'ula Partners, LLC and the County that shall include:

a. A commitment from Honua'ula Partners, LLC, its successors and permitted assigns, to protect and preserve the Easement for the protection of native Hawaiian plants and significant cultural sites worthy of preservation, restoration, and interpretation for public education and enrichment consistent with a Conservation Plan for the Easement developed by Honua'ula Partners, LLC and approved by the State Department of Land and Natural Resources, the United States Geological Survey, and the United States Fish and Wildlife Service; and with a Cultural Resource Preservation Plan, which includes the management and maintenance of the Easement, developed by Honua'ula Partners, LLC and approved by the State Department of Land and Natural Resources (collectively, the "Conservation/Preservation Plans").

b. That Honua'ula Partners, LLC, its successors and permitted assigns, shall agree to confine use of the Easement to activities consistent with the purpose and intent of the Easement.

c. That Honua'ula Partners, LLC, its successors and permitted assigns, shall be prohibited from development in the Easement other than erecting fences, enhancing trails, and constructing structures for the maintenance needed for the area, in accordance with the Conservation/Preservation Plans.

d. That title to the Easement shall be held by Honua'ula Partners, LLC, its successors and permitted assigns, or conveyed to a land trust that holds other conservation easements. Access to the Easement shall be permitted pursuant to an established schedule specified in the Conservation/Preservation Plans to organizations on Maui dedicated to the preservation of native plants, to help restore and perpetuate native species and to engage in needed research activities. These organizations may enter the Easement at reasonable times for cultural and educational purposes only.

e. Honua'ula Partners, LLC, its successors and permitted assigns, shall be allowed to receive all tax benefits allowable under tax laws applicable to the Easement at the time that said Easement is established in Kihei Makena Project District 9, which will be evidenced by the recordation of the Easement in the Bureau of Conveyances, State of Hawaii.

1.3 Purpose and Scope of this Plan

To help meet Maui County Phase I conditions, Honua'ula Partners, LLC, in cooperation with SWCA, developed this *Honua'ula Conservation and Stewardship Plan*. This plan incorporates findings, conclusions, and recommendations from previous botanical and wildlife surveys and biological assessments on the Property (Char and Linney 1988; Bruner 1988, 1993; Char 1993,

2004; Altenberg 2007; SWCA 2009a, 2009b). The *Honua'ula Conservation and Stewardship Plan* recommends proactive stewardship actions to manage the proposed Easement (hereinafter referred to as the 'Native Plant Preservation Area') and the related management and enhancement areas.

The overall goal of the *Honua'ula Conservation and Stewardship Plan* is to conserve elements of the *kiawe-wiliwili* shrubland and other portions of the Honua'ula Property, as much as possible, to protect native plants and animals within the Property. The secondary goals of this plan are to cooperate with researchers in furthering the science of native plant propagation, provide education and outreach opportunities, and enhance the natural beauty of the proposed Honua'ula project. This plan focuses specifically on management actions to preserve and conserve native plants within the Property. Management actions to address native animals on the Property will be addressed in a separate multi-species Habitat Conservation Plan (HCP) being prepared under Section 10(a)(1)(B) of the Endangered Species Act (ESA).

In accordance with the County of Maui Ordinance No. 3554, copies of all SWCA reports prepared for this project, including this *Honua'ula Conservation and Stewardship Plan* for the proposed Native Plant Preservation Area, along with the report by Altenberg (2007) have been submitted to the Department of Land and Natural Resources (DLNR), U.S. Fish and Wildlife Services (USFWS), U.S. Geological Survey (USGS), and U.S. Army Corps of Engineers for review and comment.

2.0 STATUS OF HAWAIIAN LOWLAND DRY FORESTS AND SHRUBLANDS

At one time, Rock (1913) suggested that lowland dry and mesic forests in Hawai'i had more native tree species than any other area in the state. In addition to supporting native flora and fauna, dry forests were a source of food, fiber, and medicine for native Hawaiians. Since then, however, the amount of true native dry forests has declined (Wagner, et al. 1999). Tropical dry forests are acknowledged as the rarest native plant community within the main Hawaiian Islands (Bruegmann 1996, Sakai et al. 2002, Pau et al. 2009) and the nation (Janzen 1988, Noss and Peters 1995, Janzen 2002). Bruegmann (1996) estimated that over 90 percent of Hawai'i's native dry forest habitats have been severely fragmented and degraded.

The decline of Hawaiian dry forests is the result of a variety of factors, which began prior to European contact. Zimmerman (1963), Kirsch (1982), Wagner et al. (1985), Stone (1985), Cuddihy and Stone (1990), Gagné and Cuddihy (1999), Athens et al. (2002), Ziegler (2002), and Burney and Flannery (2005) summarized the impacts to the Hawaiian landscape caused by activities of prehistoric Polynesians beginning about 1,600 years ago. By the time the first Europeans arrived in Hawai'i, the Hawaiians had modified "virtually all valley bottoms with permanent stream flow...into reticulate irrigation systems" (Handy and Handy 1972, Kirsch 1977, 1982). In 1789, Vancouver reported that literally half the Island of Hawai'i appeared to have been cleared for taro plantations. Kirch (1982) found archaeological evidence of significant human-induced soil erosion, siltation, and shoreline change by 1200 A.D.

Following centuries of lowland land clearing by native Hawaiians, other factors contributed to the loss of native Hawaiian dry forests. These include ungulate grazing; invasions and competition from alien plants; development of lowlands for agricultural, urban, and military uses; loss of native pollinators, seed predation by rodents, and loss of native birds that scarified and dispersed seeds (Williams 1990; Cabin et al. 2000a, 2000b; Medeiros et al. 1993; Chimera 2004b).

Non-native ungulates have specifically been identified as a major contributor to the decline of native ecosystems in Hawai'i, including dry forests and shrublands. Although domestic animals, including the Polynesian pig, were introduced into Hawai'i between 400 and 600 A.D., it is unlikely that they spread rapidly into neighboring ecosystems because the pigs at that time were highly domesticated and reliant upon humans (Stone 1989, Cuddihy and Stone 1990). But by the time comprehensive descriptions of the Hawaiian landscape appeared in western literature in the late 1700s, feral ungulates and non-native ornamental plants and trees had already begun to dramatically change the nature of Hawaiian watershed structure and function.

The ban or kapu placed upon killing introduced cattle permitted the unchecked growth of large herds, which along with introduced sheep beginning in 1793 decimated native lowland forests. Non-native axis deer (*Axis axis*) were introduced to Maui by legislative mandate in 1960 (Tomich

1986). Because they occupied mostly private lands, their populations on Maui were not censused regularly by state wildlife biologists. Ueoka (1982) noted the extension of their range into dryland forests in Kihei between 'Ulupalakua and Makena. Today, large herds of axis deer roam freely throughout the dryland forest of Honua'ula.

Ungulate impacts were accompanied by the intentional introduction of non-native plants, which were quick to dominate landscapes denuded by fire or clearing. Introduced trees were regarded as a means to protect denuded watersheds from erosion, and forestry agencies were established to address problems caused by overgrazing and deforestation at the turn of the 20th century.

3.0 PHYSICAL SETTING AND HISTORIC LAND USE OF HONUA'ULA

Honua'ula encompasses a rectangular area of 270 ha (670 ac) on the southeastern slope of Mt. Haleakalā, Paeahu Ahupua'a, Maui, between 90-245 m (295-804 ft) elevation (Figure 1). Located on the leeward side of the island, the climate is generally dry with an average annual rainfall ranging from 406 to 508 mm (16 to 20 inches) throughout the region (Maui County Data Book 2007). The terrain slopes gently at about 12% in an east to west direction across the Property.

Approximately 200 ha (495 ac) of land in the northern three-quarters of the Honua'ula Property is underlain by older lava flows of the Kula Volcanic Series (ranging from 13,000 to 950,000 years old). Weathering of lavas led to the formation of a thin layer of soil over the northern portion. About 70 ha (173 ac) of younger lava of the Hana Volcanic Series (between 5,000 and 13,000 years old) makes up the southern quarter of the Property. The southern lava flows have not undergone extensive weathering. This southern area is characterized by an extremely rough surface composed of broken 'a'ā lava blocks called clinker with little or no soil accumulation (PBR Hawaii, Inc. 1988). The soils and lavas covering the Property, and the drainage gulches that run across the land, strongly influence the nature of the vegetation that grows there.

The Palauea Cultural Preserve, located about 770 m (2,500 ft) west of the Honua'ula Property, represents the remains of a traditional fishing village which lies just above the shore within the same 'a'ā lava flow that underlies the southern portion of Honua'ula. Other archaeological remains found in the region include pre-contact religious temples (*heiau*), house foundations (*hale*), agricultural terraces and foot trails, cairns (*ahu*), and possibly water wells (http://www.anthropology.hawaii.edu/Projects/Palauea%20Cutural%20Preserve/index.html; Sinoto and Pantaleo 2006, Hana Pono LLC 2009). By the late 1800's, the area was used for cattle grazing.

During the Second World War, the military used lands in Kihei for training and maneuvers (P. Erdman, Ulupalakua Ranch, pers. comm.). Historic activities within and adjacent to the Property included a Navy Underwater Demolition Team (UDT) training base at Kamaole, an Army camp at Makena, and amphibious assault training exercises by the Marine Corps. Jeep roads were bulldozed inland and cross-country movement by armored vehicles and troops were conducted. Following 1945, the area was returned to open pasture. Periodic bulldozing of the highway easement connecting Kihei to 'Ulupalakua by the State of Hawai'i, grazing pressure from axis deer (*Axis axis*) and feral goats (*Capra hircus*), and unauthorized *kiawe* (*Prosopis pallida*) logging have caused further disturbance to the area.

4.0 VEGETATION AT HONUA'ULA

Gagné and Cuddihy (1999) noted that native dry forest communities occur on all of the main islands between 300 and 1,500 m (984-4,921 ft) elevation, especially on leeward aspects or in the rain shadows of mountains. Precipitation is between 500 and 2,000 mm (17-79 in) annually, and is usually concentrated between November and March. Gagne and Cuddihy (1999) noted that lowland dry forests usually "grade into lowland dry grasslands or shrub lands below 300 m elevation..." The semi-arid Honua'ula project area lies between 90 and 245 m (295-804 ft) elevation, and is estimated to receive about 300 mm (12 in) of precipitation annually. Hence, the southern portion of the Property may be described more accurately as a highly disturbed, remnant native coastal dry shrubland (sensu Gagne and Cuddihy 1999) in which *wiliwili* (*Erythrina sandwicensis*) has become a common inhabitant.

The recent US Geological Survey GAP Analysis Program (Figure 2) maps classified landcover within the Property as largely "XT: open kiawe forest and shrubland (alien grasses)", "Y: uncharacterized open-sparse vegetation", with small patches of "XG: alien grassland" and "XT: alien forest". Price et al. (2007) recently developed methods using bioclimatic data to map habitat quality and range for *wiliwili* (*Erythrina sandwicensis*) throughout the Hawaiian Islands. The area encompassed by the Property appears on these maps as 'medium' to 'low' habitat quality for *wiliwili* (*E. sandwicensis*). However, numerous areas in southeastern Maui located between Pu'u Ola'i and Kaupo outside the Property did appear as having 'high' habitat characteristics on the maps prepared by Price et al. (2007). Medeiros (USGS, pers. comm.) suggested that mature *wiliwili* (*E. sandwicensis*) may be found throughout southeastern Maui, often in abundance and greater densities than those encountered in the Property. Altenberg (2007) identified eight *wiliwili* (*E. sandwicensis*) forests in southeast Maui including Kanaio, Pu'u o Kali, Honua'ula / Wailea 670, Makena, La Perouse, Kaupo, Lualailua, and Waikapu.

4.1 Previous Surveys

Various botanical surveys have been conducted within the Property (Char and Linney 1988, Char 1993, Char 2004, Altenberg 2007, and SWCA 2009a). Similar to the vegetation categories described by Char and Linney (1988) during the first survey on the Property, SWCA (2009a) found three distinct vegetation types within the Property (see Figure 3). Each of these is described below. Figure 4 illustrates the percent of introduced and native plants reported from each of the three predominant vegetation types.

- *Kiawe*-Buffelgrass Grassland

About 75% of the northern portion of the project parcel is characterized by an extensive grassland comprised primarily of *kiawe* (*Prosopis pallida*) *and* buffelgrass (*Cenchrus ciliaris*). There is scattered evidence that trespassers may be logging *kiawe* (*P. pallida*) trees for charcoal in this area. Guinea grass (*Urochloa maxima*), natal redtop (*Rhynchelytrum repens*), and sour grass (*Digitaria insularis*) are also scattered throughout the northern portion of the Property. Other plants found here include the invasive *koa haole* (*Leucaena leucocephala*), lantana (*Lantana camara*), partridge pea (*Chamaecrista nictitans*) and cow pea (*Macroptilium lathyroides*).

The area has been disturbed throughout by numerous jeep trails and unrestricted grazing by axis deer. Some open areas that appeared to be heavily grazed were devoid of buffelgrass (*Cenchrus ciliaris*), but contained the native shrubs *'ilima* (*Sida fallax*) and hoary abutilon (*Abutilon incanum*), and the introduced golden crown beard (*Verbesina encelioides*).

- Gulch Vegetation

The vast expanse of *kiawe*-buffelgrass in the northern three quarters of the Property is bisected from east to west by several gulches that carry flood waters to the sea (Figure 3). These intermittent gulches vary in depth and are characterized by patches of exposed bedrock. The gulches are shaded by their steep walls providing relatively cool and moist conditions. Three species of ferns including maidenhair fern (*Adiantum capillus-veneris*), sword fern (*Nephrolepis multiflora*), and the endemic *'iwa'iwa* fern (*Doryopteris decipiens*) were found in the shaded rocky outcrops and crevices within the gulches. Native *Pili* grass (*Heteropogon contortus*) was found in more open and sunny locations. Other species found within the gulches include tree tobacco (*Nicotiana glauca*), *wiliwili* (*Erythrina sandwicensis*), lantana (*Lantana camara*), partridge pea (*Chamaecrista nictitans*), golden crownbeard (*Verbesina encelioides*), *'ilima* (*Sida fallax*), hoary abutilon (*Abutilon incanum*), *koa haole* (*Leucaena leucocephala*), indigo (*Indigofera suffruticosa*), *'uhaloa* (*Waltheria indica*) and lion's ear (*Leonotis nepetifolia*).

- Mixed *Kiawe-Wiliwili* Shrubland

Remnant mixed *kiawe-wiliwili* shrubland was limited to the southern 'a'ā lava flow in the southern quarter of Property (Figure 3). Scattered groves of large-stature *wiliwili* (*Erythrina sandwicensis*) and *kiawe* trees co-dominated the upper story. Native shrubs, such as *'ilima* (*Sida fallax*) and *maiapilo* (*Capparis sandwichiana*), and the native vine *'ānunu* (*Sicyos pachycarpus*), were represented in the understory.

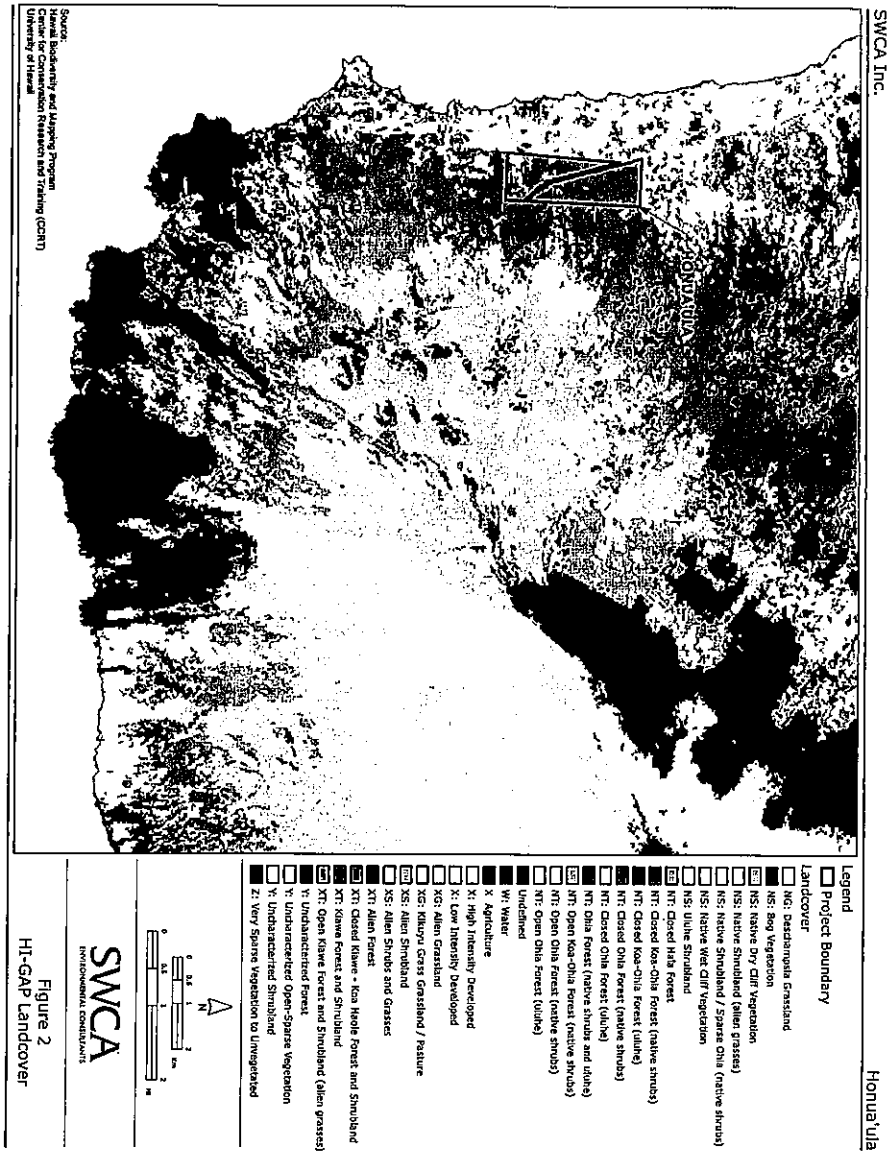

Figure 2
HI-GAP Landcover

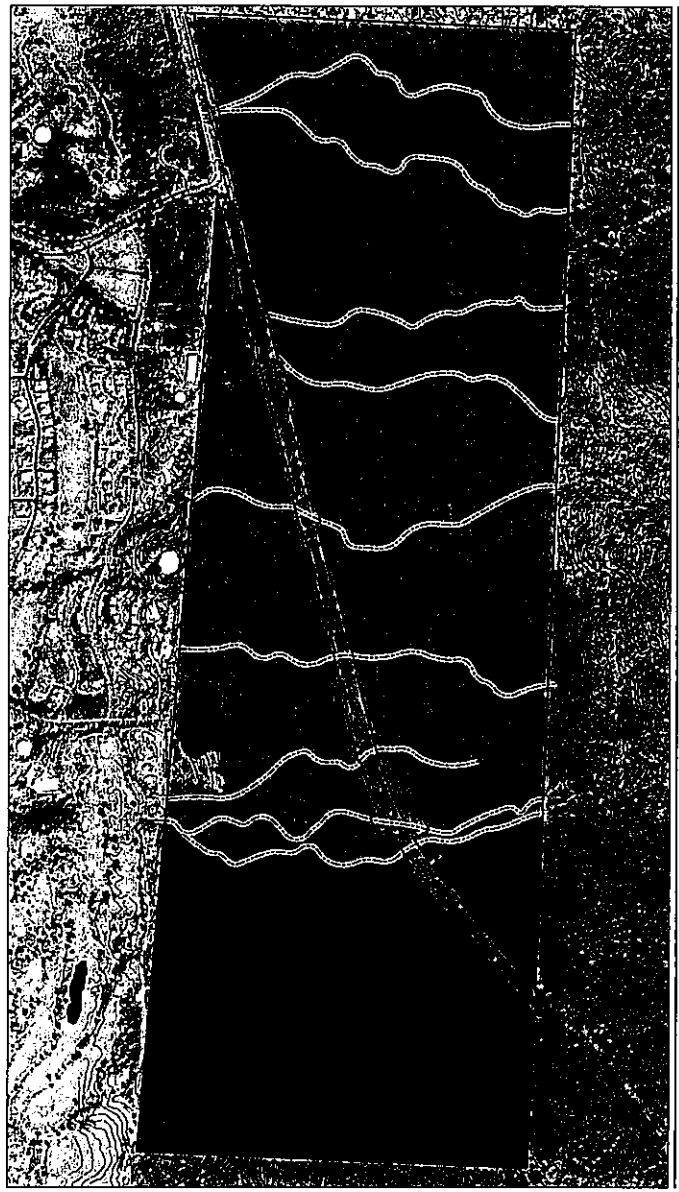

Figure 3
Vegetation Types

Introduced shrubs, introduced grasses, and introduced vines and herbaceous species dominated the ground vegetation. Lantana (*Lantana camara*), found throughout the mixed *kiawe-wiliwili* shrubland, showed signs of dieback. Although abundant, the guinea grass (*Urochloa maxima*) found on the site was grazed to stubble, probably by axis deer.

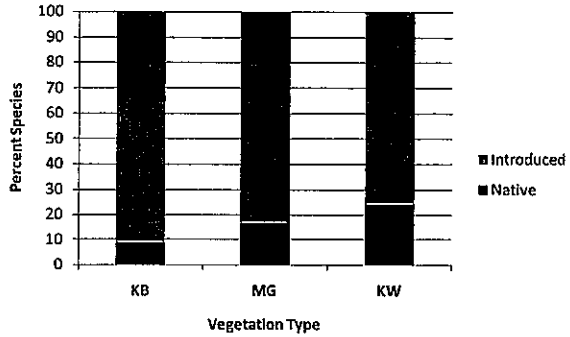

Figure 4. Percent of native and introduced plant species found in each of the three predominant vegetation types within the Property. *Data is pooled across all plant species (n= 146) observed by Char and Linney (1988), Altenberg (2007) and SWCA (this study). KB = Kiawe-buffelgrass grassland (n= 105, 9 natives and 96 introduced), MG = mixed gulch vegetation (n= 66, 11 natives and 55 introduced), KW = kiawe-wiliwili shrubland (n= 106, 26 natives and 80 introduced).*

In all, 146 plant species have been identified within the Property during these surveys. Of these species, 14 are endemic and 12 are indigenous to Hawai'i (Table 1). None are endemic to Maui. The remaining 120 plant species are introduced non-native species. Table 2 lists the occurrence of adult and seedling native plants identified within the Property by SWCA in 2008 (SWCA 2009a). Figure 5 illustrates the distribution of native plant species within the Property by count. A complete list of all plants found within the Property is provided in Appendix A.[1]

The 26 native species known to occur in the Property were arranged in order of their relative importance by the SWCA botanists (Table 1). Only the top eight endemic and indigenous plant species that are uncommon within the Property and elsewhere in the State were included in a GIS density analysis as a means of identifying suitable boundaries for a conservation easement within a portion of the Property based upon their greatest concentration.

Using the ArcView GIS Spatial Analyst extension, SWCA converted species count classes of the eight species to density (number of species/acre) classes. These resulting density maps allow comparison of native plants on the same spatial scale. However, density maps for these species varied greatly from 0-57 plants per acre for *wiliwili* (*Erythrina sandwicensis*) to 0-1 plant per acre for *'āwikiwiki* (*Canavalia pubescens*). Therefore, the maps were further standardized by reclassifying the densities for the species to a common scale where nine (9) represented the highest density for each species, and one (1) represented lowest.

[1] *Portulaca* sp. nov. was reported by Char and Linney (1988); however, it is not included in Appendix A because the species level was never determined and no known collections were made by Char and Linney (1988).

Table 1. Native plants reported from the Property arranged in order of their relative importance by project botanists. *Group 1 = endemic (E) and indigenous (I) plants uncommon within the Property as well as elsewhere in the State, and/or of significance to life stages of the endangered Blackburn sphinx moth (Manduca blackburni); Group 2 = relatively common endemic species throughout Hawai'i, Group 3 = relatively common native (indigenous) species throughout Hawai'i.*

Species	Status	Hawaiian Name	Family
GROUP 1			
Lipochaeta rockii	E	*nehe*	Asteraceae
Canavalia pubescens	E	*paunu*	Fabaceae
Erythrina sandwicensis	E	*wiliwili*	Fabaceae
Capparis sandwichiana	E	*maiapilo*	Capparaceae
Senna gaudichaudii	I	*kolomona*	Fabaceae
Sicyos hispidus	E	*'ānunu*	Cucurbitaceae
Sicyos pachycarpus	E	*'ānunu*	Cucurbitaceae
Chamaesyce celastroides var. *lorifolia**	E	*'akoko*	Euphorbiaceae
Argemone glauca	E	*pua kala*	Papaveraceae
GROUP 2			
Myoporum sandwicense	E	*naio*	Myoporaceae
Panicum torridum	E	*kakonakona*	Poaceae
Heteropogon contortus	E	*pili*	Poaceae
Ipomoea tuboides	E	*ipomea*	Convolvulaceae
Boerhavia herbstii	E	*alena*	Nyctaginaceae
Doryopteris decipiens	E	*'iwa'iwa*	Adiantaceae
Plumbago zeylanica	E	*'ilie'e*	Plumbaginaceae
GROUP 3			
Dodonaea viscosa	I	*'a'ali'i*	Sapindaceae
Sida fallax	I	*'ilima*	Malvaceae
Boerhavia spp.**	I	*alena*	Nyctaginaceae
Abutilon incanum	I	hoary abutilon	Malvaceae
Ipomoea indica	I	*koali awahia*	Convolvulaceae
Waltheria indica	I	*'uhaloa*	Sterculiaceae
Pellaea ternifolia	I	*pellaea*	Adiantaceae
Adiantum capillus-veneris	I	maidenhair fern	Pteridaceae
Solanum americanum	I	*popolo*	Solanaceae

** A single stunted akoko was found within the Property in 2006; however, the plant was found to be dead in the late summer of 2007, and was not found at all during the 2008 surveys. Therefore, it is not considered in further plant density analysis for the purpose of defining boundaries of the native plant preserve.*
*** Two indigenous species of Boerhavia (repens and acutifolia) were reported within the Property during the SWCA surveys. Char and Linney (1988) and Char (1993, 2004) also found B. repens within the Property.*

The reclassified density map was then overlaid with a percent weight assigned to each. Each species was assigned a different weight by the project botanists based on their relative botanical importance throughout the State and the Property (Table 3). The density map and the overlay analysis were developed using 100 m (328 ft) resolution to define specific and contiguous preservation areas that protect the greatest concentration of rare native plant species within the Property. Figure 6 illustrates the results of the weighted density analysis for the eight most important native plant species. The colors represent the weighted average of the densities of the eight species.

The Property was viewed by Char and Linney (1988) and Char (1993, 2004) as having unremarkable vegetation. Until SWCA (2006) and Altenberg (2007), there had been no recognition of the remnant mixed *kiawe-wiliwili* shrubland as an area worthy of special recognition. Similarly, there have been no previous efforts by any Federal, State, local government agency, or conservation Non-governmental organizations (NGOs) to acquire and protect any portion of the Property.

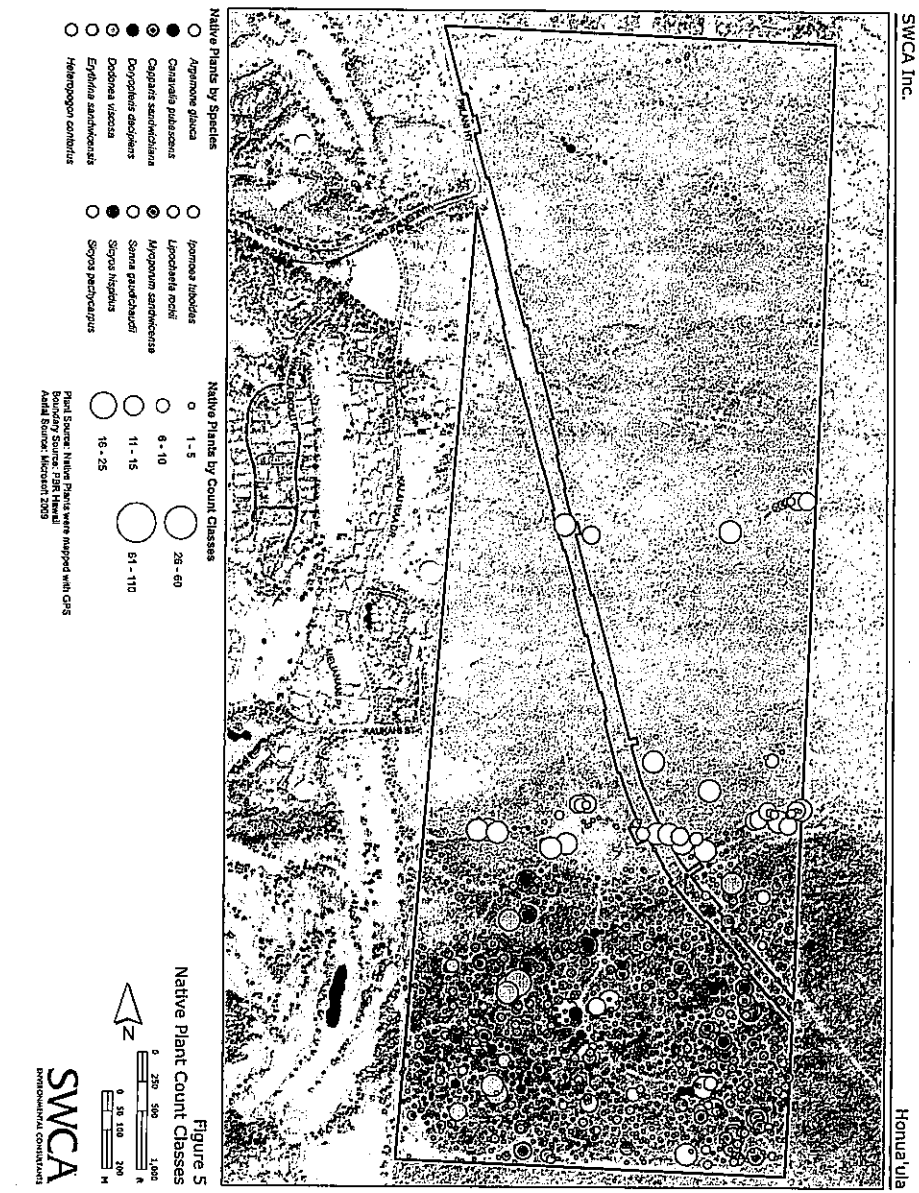

Figure 5

Table 2. A comparison of the number of native plants and seedlings observed within the entire Honua'ula Property and the remnant mixed kiawe-wiliwili shrubland in the southern portion of the Property. *Prop = entire Honua'ula Property, KW = kiawe-wiliwili shrubland.*

Species (Hawaiian name)	Number of Points		Number of Seedlings		Number of Adults		Total Numbers Observed	
	KW	Prop	KW	Prop	KW	Prop	KW	Prop
Argemone glauca (pua kala)	26	26	247	247	165	165	412	412
Canavalia pubescens ('āwikiwiki)	5	5	0	0	5	5	5	5
Capparis sandwichiana (maiapilo)	311	312	14	14	548	549	562	563
Dodonea viscosa ('a'ali'i)	7	7	0	0	16	16	16	16
Doryopteris decipiens ('iwa'iwa)	2	14	0	2	7	52	7	54
Erythrina sandwicensis (wiliwili)	546	569	334	341	2105	2137	2439	2476
Heteropogon contortus (pili)	0	66	0	384	0	1109	0	1493
Ipomoea tuboides (ipomea)	5	5	0	0	5	5	5	5
Lipochaeta rockii (nehe)	24	24	56	56	45	45	101	101
Myoporum sandwicense (naio)	17	17	0	0	21	21	21	21
Senna gaudichaudii (kolomona)	28	32	1	5	36	38	37	43
Sicyos hispidus ('ānunu)	48	49	5	5	107	108	112	113
Sicyos pachycarpus ('ānunu)	101	102	313	313	289	290	602	603

Table 3. Percent weight assigned for the eight species selected for density analysis; *based on their relative botanical importance throughout the State and the Honua'ula Property.*

Species	Common Name	Percent Weight
Lipochaeta rockii (E)	*nehe*	16
Canavalia pubescens (E)	*'āwikiwiki*	15
Erythrina sandwicensis (E)	*wiliwili*	14
Capparis sandwichiana (E)	*maiapilo*	13
Senna gaudichaudii (I)	*kolomona*	12
Sicyos hispidus (E)	*'ānunu*	11
Sicyos pachycarpus (E)	*'ānunu*	10
Argemone glauca (E)	*pua kala*	9

The remnant native vegetation in the remnant mixed *kiawe-wiliwili* shrubland represents a highly degraded lowland dry shrubland in which *wiliwili* trees (*E. sandwicensis*) are a natural component. High density *wiliwili* (*E. sandwicensis*) stands occur in other locations throughout the region. Altenberg (2007) identified eight areas in southeast Maui, including the Property, where *wiliwili* (*E. sandwicensis*) groves are found. SWCA also found dense *wiliwili* (*E. sandwicensis*) groves east of Pu'u Olai (2009a). Far from being pristine, this dry shrubland has been degraded by human activities including unrestricted grazing by ungulates, cattle grazing, invasive plant species, road works, *kiawe* (*P. pallida*) logging, and military activities.

4.2 Endangered, Threatened and Candidate Endangered Plants

No Federal or State of Hawai'i listed threatened, or endangered plant species were found in the Property. Honua'ula is not located within or immediately adjacent to any designated critical habitat or recovery management units designated by the USFWS. All the native plant species described from the Property are known to occur elsewhere on Maui and most also occur throughout the main Hawaiian Islands.

Weighted Average
- 5 - Highest Weighted Average
- 4
- 3
- 2
- 1 - Lowest Weighted Average

Figure 6
Visual Representation of Weighted Density Analysis of the Eight Most Important Plant Species within the Project Area

Nehe (*Lipochaeta rockii*) occurs in scattered locations on Maui, but is primarily known from Moloka'i and Kaho'olawe where it is scattered to common in coastal sites to dry forests, and along the margins of lava flows (Wagner et al. 1999). The *nehe* plants (*L. rockii*) reported from the Property have a distinct leaf shape that appears to be limited to the Property (A.C. Medeiros, USGS, pers. comm.); the leaves are less dissected compared to specimens at other Maui locations. However, the current Manual of Flowering Plants of Hawaii (Wagner et al. 1999) did not find sufficient scientific evidence to recognize it as a distinct variety or subspecies. Herbst (Bishop Museum, pers. comm.) suggested that it might easily hybridize with other plants of the same species. This species, including individuals with a distinct leaf shape, is also not given statutory protection by State or Federal laws.

One candidate endangered species, *'āwikiwiki* (*Canavalia pubescens*), has been identified in the project area. Over a period of time, Altenberg (2007) collected roughly 15 GPS points for *'āwikiwiki* (*C. pubescens*) within the *kiawe-wiliwili* shrubland during his hikes across the Honua'ula parcel. It is unknown how many of his GPS points represent duplicate occurrences of the same plant. The U.S. Fish and Wildlife Service (2009) reported "a few individuals at Palauea-Keahou" [including the Property] based upon information received from Altenburg (2007) and Hank Oppenheimer (Plant Extinction Prevention Program, pers. comm.). During the SWCA botanical survey of Honua'ula in 2008 (SWCA 2009a), the project botanists found only five (5) individual *'āwikiwiki* (*C. pubescens*) plants on the Property. All *'āwikiwiki* (*C. pubescens*) were flowering and fruiting at the time of the survey; however, no seedlings were detected. The plants appeared to be healthy with no signs of damage or disease.

Canavalia pubescens Hook. & Arnott was described by Wagner et al. (1999) as "...uncommon in open dry sites such as lava fields, kiawe thickets, and dry forest, 15-540m, on Ni'ihau, Kaua'i (Nāpali Coast), Lāna'i, and leeward East Maui." Extant populations of *'āwikiwiki* (*C. pubescens*) on Maui are listed in Table 4. Both historical and current populations of the species on Maui are illustrated in Figure 7.

Table 4. Extant populations of Canavalia pubescens on Maui.

Site Name	No. of Individuals	Reference/Source
Honua'ula (Palauea-Keauhou)	5	SWCA (2009a).
Pu'u O Kali Forest Reserve	100+	A. Medeiros, pers. comm.
'Ahihi-Kina'u Natural Area Reserve	16-21	J. McDonald, pers. comm.
Papaka Kai (La Perouse)	6	USFWS (2008a).
Southeast Pohakea	1	USFWS (2008a).

In 1997, the species was added as a candidate species by the U.S. Fish and Wildlife Service (USFWS). The most recent USFWS (2009) information on the species includes the following:

> "Habitat/Life History
> *Canavalia pubescens* is found on dry, open lava fields and in dryland forest. On Kauai, *C. pubescens* was found in open, moist forest and in dry scrub forest at elevations between 180 to 2,900 feet (ft) (55 to 884 meters (m)). On Niihau, this species was last seen growing on an exposed basalt ledge at 300 ft (91 m) in elevation. On Lanai, *C. pubescens* was observed growing among sun-scorched lava rocks along a coastal trail at 50 ft (15 m) elevation with *Cordia subcordata* (kou) (H. Oppenheimer, PEP Program, pers. comm. 2007). On Maui, *C. pubescens* is found on recent lava flows in *Erythrina* (wiliwili) lowland dryland forest and shrubland with the following native species: *Capparis sandwichiana* (maiapilo), *Chamaesyce celastroides* var. *lorifolia* (akoko), *Dodonaea viscosa* (aalii), *Ipomoea* spp. (no common name), *Morinda* spp. (noni), *Sida fallax* (ilima), *Rauvolfia sandwicensis* (hao), and *Waltheria indica* (uhaloa); at elevations between 80 to 400 ft (24 to 122 m) (Wagner and Herbst 1999, p. 654; Hawaii Biodiversity and Mapping Program (HBMP) 2008)."

> "Historical Range
> Historically, *Canavalia pubescens* was wide ranging in the coastal dryland forest and shrublands of southeastern Maui, Lanai, northwestern Kauai, and Niihau (HBMP 2008). It was historically recorded from one population on Niihau at Haao Valley; from six populations ranging from Awaawapuhi to Wainiha on the northwest coast of Kauai; from six populations ranging from Keokea to Wailaulau-Pahihi on Maui; and from four populations on Lanai, from Ka'ena Point to Huawai Bay (HBMP 2008)."
>
> "Current Range/Distribution
> Currently, *Canavalia pubescens* is found on the island of Maui (HBMP 2008; H. Oppenheimer, Plant Extinction Prevention Program, pers. comm. 2006; F. Starr, U.S. Geological Survey, Biological Resources Discipline (USGS-BRD), pers. comm. 2006). No plants were observed at the last known location of this species on Lanai in 2007; however, it could possibly be found there again (H. Oppenheimer, pers. comm. 2007). There were a few individuals at Palauea-Keahou, but this area is currently undergoing development (Altenburg 2007, pp. 12-13; H. Oppenheimer, pers. comm. 2007)."
>
> "Population Estimates/Status
> Five populations are known on Maui: Keokea and Puu o Kali with "hundreds" observed; southwest Kalua o Lapa with two individuals; Papaka Kai with six individuals; Ahihi-Kinau with a few individuals; and southeast Pohakea, with at least one individual (HBMP 2008; F. Starr, pers. comm. 2006; H. Oppenheimer, pers. comms. 2006, 2007). These populations total a little over 200 individuals, with the majority ("hundreds") in one population (Puu o Kali)."

Altenberg (2007), F. Starr (pers. comm.), and H. Oppenheimer (pers. comm.) apparently presumed that the remaining *'āwikiwiki* (*C. pubescens*) at Palauea-Keahou [Honua'ula] have "... likely been destroyed by development" (as cited in USFWS 2008a and 2009). Contrary to this pessimistic outlook, all five individuals on the Honua'ula Property continue to thrive. No construction or other development related activity other than recent fence building to keep cattle from the *kiawe-wiliwili* shrubland has been conducted in that area. Honua'ula Partners, LLC is committed to the Maui County Council conditions to insure that all five *'āwikiwiki* (*C. pubescens*) plants within the Property are protected and managed to help ensure their conservation.

The Species Assessment and Listing Priority Assignment Form (USFWS 2009) notes that the USFWS has "promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed" and determined that the species "does not appear to be appropriate for emergency listing at this time because the immediacy of the threats is not so great as to imperil a significant proportion of the taxon within the time frame of the routine listing process."

The USFWS (2009) states that the primary threat to remaining *'āwikiwiki* (*C. pubescens*) on Maui are grazing by feral goats (*Capra hircus*) and axis deer (*Axis axis*). Feral ungulates are known to graze on native plants, degrade and destroy habitat, disrupt topsoil leading to erosion, and facilitate the establishment and spread of non-native plants. Land development is also listed as a threat to certain populations of *'āwikiwiki* (*C. pubescens*). The USFWS determined that *'āwikiwiki* (*C. pubescens*) is also highly threatened by competition and habitat degradation from non-native plant species, and wildfires (USFWS 2008a).

Non-native plant species that are reported to be threats to *'āwikiwiki* (*C. pubescens*) by USFWS (2008a) include: *kiawe*, *koa haole*, natal redtop, and buffelgrass at Keokea; buffelgrass and *kiawe* at Pu'u O Kali and Palauea-Keauhou; natal redtop and *koa haole* at Papaka Kai; and *koa haole* and air plant (*Kalanchoe pinnata*) at southwest Kalua o Lapa population in the Ahihi-Kinau NAR (Altenberg 2007; HBMP 2008; F. Starr, pers. comm. 2006).

A single *Chamaesyce celastroides* var. *lorifolia* was observed within the *kiawe-wiliwili* (*Prosopis pallida – Erythrina sandwicensis*) shrubland by Altenberg (2007) and SWCA (2006). Only about four feet in height, this plant appeared to be stunted and subject to intense grazing pressure. Someone also had attempted to wrap protective material around its blossoms and/or seeds. This tree had died by the SWCA March 2008 survey.

Figure 7
Canavalia pubescens Locations in South Maui

5.0 OTHER HAWAIIAN DRY FOREST AND SHRUBLAND RESTORATION EFFORTS

Numerous dry forest restoration efforts have been initiated throughout the State to save these degraded ecosystems. Several small-scale projects have been successful in restoring dry forest fragments by excluding ungulates, planting seedlings, and reducing grass competition via grass removal (Cabin et al. 2002a, Brooks et al. 2009). However, these efforts have proven that restoring Hawai'i's dry forests, even at a small-scale, can be challenging and expensive (Leonard Bisel Associates, LLC and Geometrician Associates 2008). Private developments and State and Federal protected areas in Hawai'i where active management activities are underway to protect native dry forest ecosystems and rare native plants are listed in Table 5. Figure 8 illustrates protected and managed natural areas in south Maui in relation to the location of Honua'ula. A more detailed description of existing dry forest restoration efforts, especially those on Maui, is provided in the following paragraphs.

5.1 Dry Forest and Shrubland Restoration Efforts

5.1.1 Auwahi Forest Reserve, Maui

On November 29, 2009, the Maui Coastal Land Trust entered into a historic land preservation agreement with the Erdman Family of Ulupalakua Ranch ensuring over 11,000 acres along the leeward slopes of Haleakala will continue as a working ranch and wildlife habitat. Although the purpose of this perpetual easement is to assure the roughly 6,000 acres of land are always protected for agricultural uses, corollary benefits include the permanent protection of one of Maui's most iconic views and the entire `Auwahi ahupua`a.

`Auwahi is a 5,328 rectangular parcel running lengthwise from the ocean shore up the mountain to 6,000 ft. elevation. The mauka portion of this ahupua`a is home to the Auwahi Habitat Restoration Project, and is part of the Leeward Haleakala Watershed Restoration Partnership. The Auwahi Forest Reserve lies within this area and includes a remnant native dry forest on the south slope of East Maui at 900-1,200 m (3,937 ft) elevation (Medeiros 2006). The forest at Auwahi, with a very high diversity of native tree species, is generally considered the floristically richest dryland forest area in the State of Hawai'i (Medeiros, personal communication). A 4 ha (10 ac) site has been undergoing intensive restoration efforts since 1997 under a partnership between landowners, government agencies and scientists. Auwahi has a rich plant diversity including 50 native tree species, at least five of which are endangered (Medeiros 2006).

5.1.2 Kanaio Natural Area Reserve, Maui

Established in 1990, the Kanaio Natural Area Reserve located to the south of the project area encompasses 354 ha (876 ac), portions of which include *wiliwili*. The reserve is situated between 335 to 850 m (1100 to 2780 ft) elevation on leeward East Maui. The substratum at Kanaio is similar to the southern portion of Honua'ula and consists of broken 'a'ā lavas estimated to be less than 10,000 years old (Medeiros et al. 1993). The reserve contains representatives of three native vegetation types: *'a'ali'i* (*Dodonea*) lowland shrublands, *lama* (*Diospyros*) forest, and *wiliwili* (*Erythrina*) forest.

Nearly 38% of the vegetation in Kanaio is native with about 14% indigenous and 24% endemic. Twenty-two species of Hawaiian dry land forest trees are found in Kanaio, over 35% of the total number of native species in the area (Medeiros et al. 1993). Primary threats to the native dry forest community at Kanaio include the activities of feral goats, invasion of weed species, wildland fires, and the small population sizes of rare native plants. Management activities at Kanaio have focused on exclusion of feral ungulates, alien plant control, and propagation of native species.

5.1.3 Pu'u O Kali Forest Reserve, Maui

Pu'u O Kali Forest Reserve is a remnant *wiliwili* forest on the slopes of east Maui above Kihei. The Pu'u-o-kali lava flows support some of the most diverse and intact lowland dryland forest ecosystems remaining in the Hawaiian Islands and comprise, by far, the best remnant of lowland dryland forest vegetation on Maui (Medeiros, personal communication). As Monson (2005) quoted A.C. Medeiros, "*Pu'u-O-Kali* is the only place on this whole side that looks like it did in ancient

times... It's the only place where a Hawaiian from long ago would look around and say, 'Oh, I know where I am.' They wouldn't recognize the rest of South Maui."

5.1.4 'Ahihi-Kina'u Natural Area Reserve, Maui

The 'Ahihi-Kina'u Natural Area Reserve is located on the southwest corner of the Island of Maui and was the first established in 1973. Its 501 ha (1,238 ac) contain extensive nearshore coral reef communities, rare and fragile anchialine ponds, and lava fields from the last eruption of Haleakala 200-500 years ago. Native plant communities include *naio, wiliwili,* and *ma'o* (*Gossypium tomentosum*) in kipukas.

Table 5. Protected and managed dry forests and shrublands in Hawai'i.

Project/Protected Area	Island	Total Preserve Size	# of Native Plants	Owner/ Manager
'Ahihi-Kina'u Natural Area Reserve	Maui	501 ha (1,238 ac)	21 taxa, 3 rare	NARS-DLNR
Auwahi Ahupua`a and Forest Reserve (Pu'u Outi)	Maui	2,120 ha (5,238 ac)	50 taxa, 5 rare	Ulupalakua Ranch/ Maui Coastal Land Trust/Auwahi Restoration Group
Kanaio Natural Area Reserve	Maui	354 ha (876 ac)	66 taxa, 14 rare	NARS-DLNR; Ulupalakua Ranch
Pu'u O Kali Forest Reserve	Maui	96 ha (236 ac)	Unavailable	Dept. of Hawaiian Homelands/ The Maui Restoration Group
Ku'ia Natural Area Reserve	Kaua'i	662 ha (1,636 ac)	160 taxa, 54 rare	NARS-DLNR
Halona Exclosure	O'ahu	1.2 ha (3 ac)	1 rare	U.S. Navy
Kaluakauila Management Unit	O'ahu	42 ha (104 ac)	Unavailable	State of Hawai'i and U.S. Army
Mokulela Forest Reserve	O'ahu	1,352.6 ha (3,342.4 ac)	Unavailable	DOFAW-DLNR
Pahole Natural Area Reserve	O'ahu	266 ha (658 ac)	168 taxa, 18 rare	NARS-DLNR
Kānepu'u Preserve	Lāna'i	239 ha (590 ac)	48 taxa, 11 rare	The Nature Conservancy
Ka'upulehu Preserve	Hawai'i	27.3 ha (67.5 ac)	45 taxa, 22 rare	Kamehameha Schools/ North Kona Dry Forest Working Group
Kipahoehoe Natural Area Reserve	Hawai'i	2,259 ha (5,583 ac)	117 taxa, 4 rare	NARS-DLNR
La'i'ōpua Preserves	Hawai'i	16.8 ha (41.6 ac)	21 taxa, 5 taxa	DHHL
Manuka Natural Area Reserve	Hawai'i	10,340 ha (25,550 ac)	187 taxa, 10 rare	NARS-DLNR
Pālamanui Forest Reserve	Hawai'i	22 ha (55 ac)	27 taxa, 5 rare	Pālamanui, LLC
Pu'u Wa'awa'a Forest Reserve	Hawai'i	15,338 ha (37,901 ac)	184 taxa, 40 rare	DOFAW-DLNR
Waikoloa Dry Forest Recovery Project	Hawai'i	111 ha (275 ac)	2 taxa, 1 rare	Waikoloa Village Chapter of the Outdoor Circle

The native communities were described as the 'A'ali'i Lowland Dry Shrubland, the Mixed Coastal Shrubland/Herbland composed of Coastal Dry Grassland and Naupaka Coastal Dry Shrubland, the 'Akoko Coastal Dry Shrubland and the Low Salinity Anchialine Pool. The 'A'ali'i Lowland Dry Shrubland community is not considered rare in Hawai'i, though some examples are known to contain rare plants.

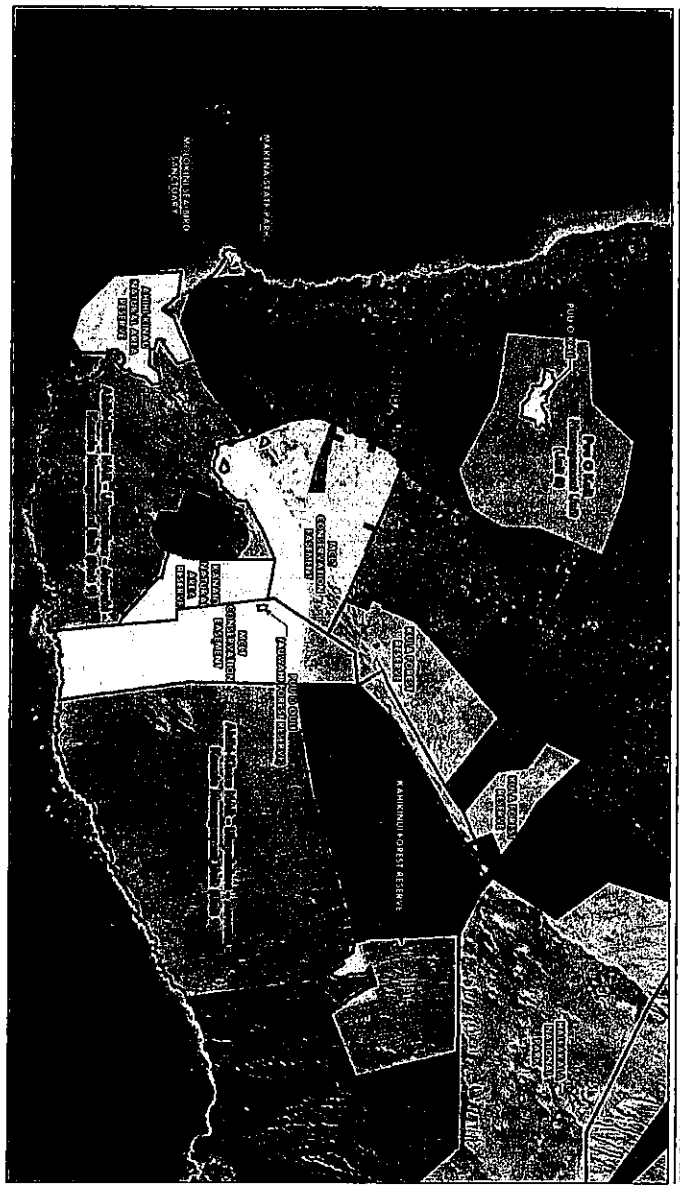

Figure 8
Vicinity Conservation Efforts

Native components found in this community include *'ilima, 'uhaloa, nalo, naupaka* (*Scaevola sericea*); *alena* (*Boerhavia repens*), and *koali 'awa* (*Ipomoea indica*). The NARS also contains a single site of the 'Akoko Coastal Dry Shrubland community at the western edge of the Kanaio ahupua'a. This extremely rare coastal shrubland dominated by *'akoko* (*Chamaesyce celastroides*). Like all other dry forest and shrublands in Hawai'i, this area is severely imperiled by the encroachment of weeds and feral ungulates.

5.1.5 Ka'upulehu Preserve, Hawai'i

In their research studies conducted at Ka'upulehu dry forest on Hawai'i Island, Cabin et al. (2000a) found that excluding ungulates with fencing is effective in helping the recruitment of some native tree species. However, fencing alone was insufficient to restore native dry forests. In another study at Ka'upulehu, Cabin et al. (2002a) experimentally manipulated micro-site conditions (canopy vs. no canopy), water (ambient vs. supplemental), and weeding (removal vs. non-removal).

They also added seeds of six native species in 64 1m² plots to investigate the regeneration of native dry forest species. The authors suggest that it is possible to restore degraded dry forests in Hawai'i by manipulating the ecological conditions particularly for the fast growing understory species which then create micro-sites more favorable for the establishment of native trees.

Cabin et al. (2002b) investigated how light availability (full vs. 50% shade), alien grass control (bulldoze, herbicide, plastic mulch and trim treatments), and out-planting vs. direct seeding affected the establishment of native plants and suppression of invasive grasses. Their results highlight the fact that restoration can be site specific and hence it is important to examine species and treatment specific responses to these species before attempting large scale conservation efforts. They also suggest that relatively simple techniques can be used to simultaneously suppress invasive grasses and establish populations of vigorous native understory species even at larger scales. Over the term of his studies at Ka'upulehu, Cabin found that 16 non-native plants invaded the preserve, suggesting that management efforts to control non-native grasses and rodent seed predators facilitated invasion of non-native species. This further demonstrates how preserving native vegetation within the Native Plant Preservation Area and other areas designated for native plant protection at Honua'ula will require active management to control non-native species and reintroduce key native species.

5.1.6 Pālamanui Forest Reserve, Hawai'i

A relatively pristine remnant native dry forest occurs at Pālamanui, a 293 ha (725 ac) mixed use residential and commercial development in Kona, Hawai'i. Sixty two plant species have been described from the native forest there, of which 27 are native and 35 are introduced (Hart 2003). Roughly seven percent of the total Pālamanui development parcel consists of a *Diospyros-Psydrax-Santalum* dry forest that has "apparently never received any major disturbance" (Hart 2003, Group 70 International 2004). Three federally listed endangered plant species are found at Palamanui: *uhiuhi* (*Caesalpinia kavalensis*), *'aiea* (*Nothocestrum breviflorum*), and *halapepe* (*Pleomele hawaiiensis*). Several large *'akoko* (*Chamaesyce multiformis*), many of which are larger than have ever been seen before, have been described from Pālamanui (Group 70 International 2004). Protection of at least 22 ha (55 ac) of the dry forest remnant at Pālamanui is an integral part of the overall development proposal. The proposed preserve management plan for Pālamanui (Hart 2003; J. Price, UH Hilo, pers. comm.) are directly relevant to management of the proposed Native Plant Preservation Area at Honua'ula and have been incorporated into our recommendations.

5.1.7 La'i'ōpua Preserves, Hawai'i

Another plant mitigation and preserve restoration plan has been developed for construction of The Villages at La'i'ōpua in Kealakehe, North Kona on the Island of Hawai'i for the Department of Hawaiian Home Lands (Leonard Bisel Associates, LLC and Geometrician Associates 2008). Originally conceived in 1999, the plan addresses the protection of two listed endangered plants, *aupaka* (*Isodendrion pyrifolium*) and *uhiuhi* (*Caesalpinia kavalensis*), as well as 19 associated endemic and indigenous plants. Fifty-five species of introduced plant species have been recorded within or near the proposed preserves at La'i'ōpua. Four preserves are planned for La'i'ōpua, the

largest of which is 10.8 ha (26.6 ac) in size. The other preserves are 4.5 and 1.6 ha (11 and 4 ac) in size, with additional 'mini-preserves' proposed to protect individual trees. As with the proposed Native Plant Preservation Area at Honua'ula, the La'i'ōpua preserves also incorporate archaeological features, and include specific conservation principals, management objectives, and physical plans.

5.1.8 Kānepu'u Preserve, Lāna'i

The Kānepu'u Preserve was established in 1989 to protect and enhance the *olopua/lama* (*Nestegis/Diospyros*) dryland forest. The preserve is comprised of seven disjunct units totaling 239 ha (590 ac). Six federally listed plant taxa have been reported in the Kānepu'u Preserve, although only four of those taxa are currently known to occur in the preserve. The primary goal of the preserve is to maintain and enhance native ecosystems and protect the habitat of rare plants.

The Kānepu'u Preserve is managed by the Nature Conservancy of Hawai'i (TNCH). Additional funding is provided through the State of Hawai'i's Natural Area Partnership Program (NAPP), which provides matching funds for the management of qualified private lands that have been permanently dedicated to conservation (TNCH 2010). Due to budgetary constraints, TNCH has scaled-back on management efforts focusing on protecting fencing, ungulate control, weed control, habitat restoration, and firebreak maintenance. TNCH is actively seeking other entities to assist us with management of the preserve and believes that a community-based organization will provide the best solution for long-term management of the preserve; however, currently no community group has demonstrated the financial, administrative, and management capacity to manage (TNCH 2010).

5.2 Lessons Learned

Each of these preserves have in common with Honua'ula the same major threats to dry forest ecosystems in Hawai'i, including the detrimental activities of feral goats, deer, and pigs; wildfires; and the proliferation of weedy species. Like Honua'ula, a growing number of remnant dry forests and shrublands lie adjacent to or within areas proposed for development. The aforementioned projects, as well as other dry forest restoration research (Brooks et al. 2009), has shown that multiple techniques are critical for effective restoration in dry forests. For example, fencing alone is insufficient to restore native dry forests (Cabin et al. 2000a). A combination of techniques may include fencing, herbicide application, manual and mechanical weeding, native species outplanting, seedling shading, broadcast seeding, and supplemental watering.

Other research has stressed the importance of a long-term approach to restoration in Hawaiian dry forests (Thaxton et al. in press). The studies being conducted at these sites, and the studies of Allen (2000), Blackmore and Vitousek (2000), Cabin et al. (2000a, 2000b, 2001); Chang (2000), Chimera (2004), Cordell et al. (2001, 2002); D'Antonio et al. (1998), Henderson et al. (2001), Litton et al. (2004), Merlin and Juvik (1992), Sandquist et al. (2004), Stratton (1998), Tunison (1992) and others give hope that even small restoration efforts consisting of a few hectares can help provide habitat for rare native dry forest species and can subsequently serve as urgently-needed sources of propagules.

This hope is reinforced by the numerous sources of information on successful propagation of rare native Hawaiian plants specifically for landscaping (e.g., TNC 1997, Tamimi 1999, Friday 2000, Wong 2003, Bornhorst and Rauch 2003, Lilleeng-Rosenberger and Chapin 2005, CTAHR 2006). In fact, even mini-preserves consisting of individual trees are being deemed as appropriate and feasible by USFWS and DLNR when managed in combination with adjacent preserve areas, such as at La'i'ōpua on Hawai'i Island.

Community outreach and public support have proven to be a critical factor in the success of dry forest and shrubland restoration efforts in Hawai'i. Due to shortfalls in funding, volunteers are important for these projects. It is important to note that although general lessons can be learned from dry forest restoration project throughout the state, each restoration effort (including Honua'ula) will have site specific issues. As noted by the results of Cabin et al. (2002b), it is important to examine site-specific species and treatment responses. These site-specific issues will only arise once active management begins. Adaptive management can subsequently be initiated.

6.0 DESCRIPTION OF THE PROPOSED HONUA'ULA PRESERVES AND RELATED MITIGATION

Altogether, 57.8 ha (143 ac) are proposed for the preservation, conservation, propagation, and management of native plant species at Honua'ula (Figure 9). Included in this area is an 8.9 ha (22 ac) Native Plant Preservation Area that will be dedicated in perpetuity as a conservation easement for the preservation of the highest density of native dry shrubland plants in the southern portion of the Property. Existing native plants within the Native Plant Preservation Area and the additional 9.3 ha (23 ac) Native Plant Conservation Areas within the *klawe-wiliwili* shrubland will remain ungraded and protected. In addition to this, 11.3 ha (28 ac) of natural gulch vegetation, and 21.4 ha (53 ac) of existing or enhanced natural landscape will be dedicated for native plants. Table 6 identifies the elements unique to each conservation sub-area. The boundaries of the Native Plant Preservation Area encompass the highest density of uncommon native and indigenous plants found at Honua'ula by SWCA botanists (SWCA 2009a).

The Native Plant Preservation Area and other Native Plant Areas will encompass several archaeological complexes, historic walls, trail systems, and drainage gulches. The trail systems will be enhanced to promote access for management activities, education and outreach, and traditional and customary native Hawaiian practices. An additional 6.9 ha (17 ha) of land will be dedicated as 'outplanting areas' for landscaping with native dry shrubland species characteristic of the project area.

Table 6. The proposed native plant areas at Honua'ula. The approximate geographical extent of each area is illustrated in Figure 9.

Preservation and Conservation Designation	Approximate Area	Management Objective
Native Plant Preservation Area (The Easement)	8.9 ha (22 ac)	Easement protected in perpetuity and managed exclusively for preservation of the existing *klawe-wiliwili* shrubland association
Native Plant Conservation Areas	9.3 ha (23 ac)	Ungraded conservation areas in which existing native plants are to be protected and managed as natural areas
Naturalized Landscape (Existing and Enhanced)	21.4 ha (53 ac)	Areas for conservation of existing native vegetation
Natural Gulches	11.3 ha (28 ac)	Natural drainage gulches will be left undisturbed and existing native vegetation will remain intact
Outplanting Areas for Native Plants	6.9 ha (17 ac)	Areas dedicated to the propagation of native plants
TOTAL AREA	**57.8 ha (143 ac)**	**Areas set aside for native plants**

6.1 Native Plant Preservation Area

The proposed Native Plant Preservation Area (i.e. the Easement) at Honua'ula will consist of a conservation easement 8.9 ha (22 ac) in area located in the central southern portion of the property. The Native Plant Preservation Area encompasses the highest densities of the rarest elements of the native vegetation within the project parcel (SWCA 2009a), and complies with the 7.3-52.6 ha (18-130 ac) directive imposed by the Maui County Council. The scope of the Native Plant Preservation Area will be set forth in an agreement between Honua'ula Partners, LLC and the County that shall include: 1) a commitment from Honua'ula Partners, LLC, its successors and permitted assigns, to protect and preserve the Native Plant Preservation Area for the protection of native Hawaiian plants; 2) use of the Native Plant Preservation Area will

be confined to activities consistent with the purpose and intent of the Native Plant Preservation Area; and 3) no development other than fences, trails, and structures for the maintenance needed will be allowed within the Native Plant Preservation Area.

Title to the Native Plant Preservation Area will be held by Honua'ula Partners, LLC, its successors and permitted assigns, or conveyed to a land trust that holds other conservation easements. Access to the area will be permitted pursuant to an established schedule specified in the Conservation / Preservation Plans to organizations on Maui dedicated to the preservation of native plants, to help restore and perpetuate native species and to engage in needed research. These organizations[2] may enter the Native Plant Preservation Area at reasonable times for cultural and educational purposes only. Native plant species that occur in the preservation area and the estimated number of individuals of each species are listed in Table 7.[3] The goals and management objectives for the Native Plant Preservation Area are found in Section 7 of this document.

Table 7. The number of existing native plants that will be protected in all conservation areas at Honua'ula (2009a). This does not include the number of native plants that can be propagated within the Property.

Species (Hawaiian Name)	Total Number of Individuals Protected (Seedlings + Adults)
GROUP 1	
Argemone glauca (pua kala)	211
Canavalia pubescens ('āwikiwiki)	5
Capparis sandwichiana (maiapilo)	179
Erythrina sandwicensis (wiliwili)	874
Lipochaeta rockii (nehe)	36
Plumbago zeylanica	163
Senna gaudichaudii (kolomona)	12
Sicyos hispidus ('ānunu)	51
Sicyos pachycarpus ('ānunu)	393
GROUP 2	
Doryopteris decipiens ('iwa'iwa)	27
Myoporum sandwicense (naio)	7
GROUP 3	
Boerhavia sp. (alena)	18
Dodonaea viscosa ('a'ali'i)	3
Heteropterus contortus (pili grass)	686
Ipomoea tuboides	1

Regardless of the areal extent of a Native Plant Preservation Area, there is no guarantee that the best possible conservation efforts and best management practices will perpetually protect all plant species in the same numbers currently found within the Property. However, SWCA believes that the immediate management concerns for the Native Plant Preservation Area include: 1) elimination of browsing, grazing, and trampling pressure on native plants by feral ungulates, 2) removal of noxious invasive plant and animal species, and 3) protection against wildland fires.

[2] Organizations wishing access to the easement should apply with the Preserve Natural Resource Manager.
[3] The actual number of individuals of each species within the Native Plant Preservation Area will be determined when the preserve is delineated. Therefore, these numbers may change due to minor design changes or seasonal changes in the plant populations.

6.2 Native Plant Conservation Areas

Native Plant Conservation Areas will be located throughout the Property adjacent to both the golf course and the Native Plant Preservation Area, and will include existing drainage gulches. These areas will not be graded or disturbed so that existing native vegetation can be conserved and integrated as native species landscaping. This will help ensure the long-term genetic viability and survival of the native dry shrubland species and enhance long-term population growth (Groom 2001, Maschinski 2006). The Native Plant Preservation Area and Native Plant Conservation Areas are intended to serve as the seed source for plant propagation efforts on the property. The boundaries are illustrated in Figure 9. Native plants that occur in the conservation areas and the estimated number of individuals of each species are listed in Table 8.

When considered together with the other conservation measures identified for plants and wildlife (SWCA 2009a, 2009B), the Native Plant Preservation Area, the Native Plant Conservation Areas, and the other Native Plant Areas will make an important and valuable contribution to the long-term viability of remnant mixed *kiawe-wiliwili* shrubland associations in southeastern Maui.

7.0 MANAGEMENT OBJECTIVES

The following management objectives were designed to achieve the goals mentioned above.

Management Objective 1: Delineate the Boundaries of the Honua'ula Native Plant Preservation Area and Native Plant Conservation Areas.

Prior to construction, the boundaries of the Native Plant Preservation Area and Native Plant Conservation Areas adjacent to the Native Plant Preservation Area will be delineated with orange plastic construction fencing. This barrier will minimize trampling and damage to native plants during construction activities. Eventually, this fencing will be replaced with stone walls using material from the site to delineate the Native Plant Preservation Area and Native Plant Conservation Areas. In addition, a briefing will be conducted with construction personnel prior to construction activities to emphasize the importance of not entering the fenced areas.

Management Objective 2: Fund and Hire a Natural Resources Manager.

A Natural Resources Manager will be required to properly implement the goals and objectives of the *Honua'ula Conservation and Stewardship Plan* which includes the Animal Management Plan. The Natural Resources Manager will be responsible for implementing the management objectives described in this plan, including but not limited to, conducting public outreach, supporting plant propagation efforts and scientific research, and controlling and eradicating invasive plant species. The Natural Resources Manager will also need to work cooperatively with government and non-governmental conservation agencies including the Maui Invasive Species Council (MISC), Leeward Haleakala Watershed Alliance, DLNR, and other organizations.

The qualifications for the Natural Resources Manager shall include: a) Education: Bachelor's degree from an accredited four (4) year college or university in biological sciences or related field (e.g. Botany, Environmental Sciences, Planning); b) Experience: At least two (2) years of experience dealing with natural resources in Hawai'i; experience should include the organization and supervision of public service groups and the execution of education and outreach programs; c) Knowledge, Skills, and Abilities: Working knowledge of Hawaiian biota and threats from non-native invasive species, including the ability to identify native Hawaiian plants and non-native invasive plants; ability to read maps and aerial photographs; knowledge of herbicide use and weed control techniques; and d) Physical Demands: Ability to lift and carry at least 50 pounds, and work in hot and relatively dry climates.

Management Objective 3: Eliminate Browsing, Grazing, and Trampling By Feral Ungulates.

The entire perimeter of the project parcel has already been fenced to exclude feral ungulates from the *kiawe-wiliwili* shrubland. In accordance with DLNR stipulations, this will be replaced with an ungulate proof fence to exclude non-native deer, goats, and cattle from damaging native plants. The fence will be made of rust resistant, galvanized steel materials and will be

approximately 8 feet height with a mesh size of no more than 6 inches. Ungulates trapped within fenced area shall be removed from the project area in a humane manner to allow regeneration of native plants.

Management Objective 4: Remove and Manage Noxious Invasive Plants.

Honua'ula Partners, LLC will implement a program to control and eradicate invasive grasses, weeds, and other non-native plants from the Native Plant Preservation Area and Native Plant Conservation Areas *with the exception of* the non-native tree tobacco (*Nicotiana glauca*), which is a recognized host plant for the endangered Blackburn's sphinx moth. Potential weed control techniques include manual, mechanical, and chemical measures, or a combination of these techniques. Specific species to be targeted include lantana, *koa haole*, guinea grass, and allen fire-prone grasses.

In addition, the Nature Resources Manager will establish a protocol to avoiding the introduction of new invasive plants or spread of existing plants. This protocol may include inspecting plants for outplanting, and making sure clothes and tool are free of weed propagules. The Natural Resources Manager will also collaborate with the landscape designers for the golf course and the residential areas to ensure that the ornamental plants being used for landscaping are not likely to become invasive within the Native Plant Preservation Area or Native Plant Conservation Areas.

Management Objective 5: Protect and Augment All Native Plants Within the Native Plant Preservation Area.

In addition to building features or physical barriers (stone walls, fences, etc) to protect the Native Plant Preservation Area from further disturbance, Honua'ula Partners, LLC will augment existing native populations by seeding, outplanting nursery grown native plants, or transplanting native plants from un-protected areas in the project area.

The Natural Resources Manager will implement a program to translocate scattered rare native plants occurring outside of the Native Plant Preservation Area and Native Plant Conservation Areas (e.g. *nehe*) to appropriate areas within the boundaries of the Native Plant Preservation Area or other Native Plant Areas. The Natural Resources Manager will be responsible for improving habitat conditions, as needed, to augment the health of rare plants in the Native Plant Preservation Area, Native Plant Conservation Areas, and other Native Plant Areas. This may include the use of supplemental shade, watering, mulching, or fertilizer, as deemed appropriate by the Natural Resources Manager.

Furthermore, at the discretion of the Natural Resources Manager, propagated native dry forest plants will be out-planted into the Native Plant Preservation Area and Native Plant Conservation Areas, as appropriate. Because the primary focus of the Native Plant Preservation Area is restoration, not gardening, supplemental shade, watering, mulching, or fertilizer will be primarily limited to the establishment period.

Management Objective 6: Create a Plant Propagation Effort.

The Natural Resources Manager will work with native plant propagators in the community to help facilitate a native plant propagation program. Selective seeds and cuttings will be collected from native plants found within *Honua'ula* to be stored outside the natural environment (i.e. seed banks), and for use in plantings in the project area, as well as at protected areas such as Pu'u O Kali. The success of this effort depends largely on the availability of *fresh*, *viable* seeds. Proper techniques for cleaning and preparing seeds will be followed to induce dormancy for storage (TNC 1997). The services of native Hawaiian plant experts and nurseries such as Anna Palomino of Ho'olawa Farms and Matt Schirman of Hui Ku Maoli Ola will also be sought to assist with seed banking and propagation efforts. This may require the installation of temporary irrigation systems to facilitate initial propagation efforts.

A multi-species Habitat Conservation Plan (HCP), to include the candidate endangered *'awikiwiki* will be prepared under Section 10(a)(1)(B) of the Endangered Species Act and in collaboration with DLNR and USFWS.

Management Objective 7: Attempt Propagation and Outplanting of Native Host Plants for the Blackburn Sphinx Moth.

Despite its importance to the endangered Blackburn's sphinx moth, the non-native tree tobacco is not an ideal species to maintain within the Native Plant Preservation Area. The Hawaii Weed Risk Assessment gave it a score of 15 indicating that it is a high risk invasive species, primarily due to its prolific seed production, environmental versatility, and toxicity to humans and cattle (http://www.botany.hawaii.edu/faculty/daehler/WRA/full_table.asp).

Because the intent of the Native Plant Preservation Area is to protect valuable native plant species, consideration is being given to propagating native *'aiea* (*Nothocestrum latifolium*) in this area to replace the non-native tree tobacco. The ultimate outcome of this effort is unknown because the project area is lower in elevation than the average distribution reported for the species by Wagner et al. (1999) (Palomino, personal communication). According to Palomino (personal communication) *N. latifolium* has been successfully grown at the Ho'olawa Farms nursery (60 m or 200 ft elevation) until it is about 8 inches in height. However, at this point it is out-planted to higher elevation sites. The lowest elevation at which Palomino (personal communication) is aware that adult *'aiea* thrive is near 457 m (1,500 ft) at Kanaio, so this may not be a valid option for the low elevation Native Plant Preservation Area at Honua'ula.

If *'aiea* becomes established within the Native Plant Preservation Area and is used by the Blackburn sphinx moth, then non-native tobacco trees will be removed. Removal of non-native tree tobacco will only occur in the season when Blackburn sphinx moths are underground. Precautions will be taken to ensure pupae are not harmed (Duvall, personal communication). Expanding existing wild populations of the host plant *'aiea* is a recovery objective of the *Recovery Plan for Blackburn's Sphinx Moth* (2005). The multi-species Habitat Conservation Plan (HCP) discussed in the previous paragraph will also contain the requirements of the endangered Blackburn's sphinx moth and develop long-term management and protection programs aimed at minimizing incidental take and enhancing recovery of the species.

Management Objective 8: Protect Native Plants and Animals Against Wildland Fires.

Honua'ula Partners, LLC will implement a fire control program to help protect the Native Plant Areas to help insure the success of plant propagation and conservation efforts. This program will include the creation of a fire break immediately outside of the perimeter of the Native Plant Preservation Area at least 6 m (20 ft) wide. The proposed golf course which will abut a portion of the Native Plant Preservation Area and Native Plant Conservation Areas will also act as a fire break to protect native plants. In addition, non-native grasses which augment fuel biomass, will be controlled from inside of the area. It will be the responsibility of the Natural Resources Manager to develop and finalize the fire control plan in coordination with resource agencies and fire department officials.

Management Objective 9: Remove and Manage Non-Native Seed Predators.

The Natural Resources Manager will design and implement a predator control program for rats, mice, and other predators within the Native Plant Preservation Area and Native Plant Conservation Areas that prey on native plant seeds and seedlings. This program may include the use of bait stations containing diphacinone or other rodenticides, as well as traps. The program will be developed through coordination with U.S. Department of Agriculture (USDA) Animal Damage Control and DLNR staff. State Department of Health (DOH) best management practices will be implemented.

Management Objective 10: Develop and Implement a Scientific Monitoring Program.

The Natural Resources Manager shall work with the USFWS, DLNR, and others as appropriate to conduct a detailed scientific inventory and monitoring program. The purpose of the monitoring will be to establish an accurate baseline to evaluate the efficacy of management activities, determine if the goals of this plan are being achieved, and identify impending threats to the Native Plant Preservation Area. This program will monitor annual survival rates, natural reproduction, sign of herbivory, abundance of invasive species, and accurately mapping native species, as appropriate.

Management Objective 11: Utilize Appropriate Native Plant Landscaping in Areas Outside the Native Plant Preservation Area and the Native Plant Conservation Areas.

Honua'ula Partners, LLC will landscape common areas with native plant species to the maximum extent practicable. Preference will be given to xeric species (i.e. plants that require minimal irrigation and are tolerant of dry conditions); however, all plants native to the geographic area should be considered as potential species for use in landscaping. Honua'ula Partners, LLC will also conserve as many of the *wiliwili* trees as possible outside the Native Plant Preservation Area and the Native Plant Conservation Areas to be managed as landscaping. This management objective is fully consistent with the spirit of Maui County Council Resolution 00-24: Recognizing the Threat of Invasive Alien Plant Species to the Ecosystems, Native Forests and High Quality Watersheds.

Management Objective 12: Manage the Native Plant Preservation Area With the Cooperation of Stakeholders.

Honua'ula Partners, LLC will attempt to involve a wide range of stakeholders in the management of the Native Plant Preservation Area. The Natural Resources Manager will work with the University of Hawai'i, Maui Invasive Species Council, Leeward Haleakala Watershed Alliance, State DLNR, and others, as appropriate, to conduct detailed scientific inventories and monitoring programs to develop an accurate baseline and ongoing monitoring to evaluate the efficacy of management activities and identify imminent threats to the Native Plant Preserve Area. Honua'ula Partners, LLC will make an effort to continually disseminate useful information to all stakeholders.

Management Objective 13: Develop a Public Education and Outreach Program.

Honua'ula Partners, LLC will implement an education and outreach program open to the local community and the general public at large. This program will be coordinated by the Natural Resources Manager and would involve sponsoring service trips to assist with management activities, field trips for island students, and developing interpretive signage to encourage public cooperation and discourage trespassing through the Native Plant Preservation Area and other Native Plant Areas.

Management Objective 14: Incorporate Adaptive Management Principals.

To accommodate for uncertainty inherit in natural systems, Honua'ula Partners, LLC will adopt an active adaptive management approach. In this approach, information that is gathered during the monitoring program will influence and improve future management practices. According to USFWS policy [see 65 Fed. Reg. 35242 (June 1, 2000)], adaptive management is defined as a formal, structured approach to dealing with uncertainty in natural resources management, using the experience of management and the results of research as an on-going feedback loop for continuous improvement. Adaptive approaches to management recognize that the answers to all management questions are not known and that the information necessary to formulate answers is often unavailable. Adaptive management also includes, by definition, a commitment to change management practices when determined appropriate.

8.0 FUNDING

In accordance with the County of Maui Phase I Conditions, title to the Native Plant Preservation Area will be held by Honua'ula Partners, LLC, its successors and permitted assigns, or be conveyed to a land trust that holds other conservation easements. Honua'ula Partners, LLC shall receive all tax benefits allowable under tax laws applicable the easement (Native Plant Preservation Area) at the time the easement is established. Honua'ula Partners, LLC, its successors and permitted assigns will also apply for additional programmatic funding from existing programs managed by the USFWS and DLNR to share in the conservation of natural resources. These include, but may not be limited to, the Forest Stewardship Program, Forest Land Enhancement Program, Landowner Incentive Program, and Natural Area Partnership Program of the Hawaii DLNR; and the Conservation Partnership Program and Habitat Conservation Planning Assistance programs of the USFWS.

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Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Aspleniaceae						
Nephrolepis multiflora (Roxb.) F.M. Jarrett ex. C.V. Morton	sword fern	X	C	*		*
MONOCOTS						
Agavaceae						
Furcraea foetida (L.) Haw.	*malina*	X	S			*
Cannaceae						
Canna indica L.	indian shot	X	C	*		
Commelineaceae						
Commelina benghalensis L.	hairy *honohono*	X	C, S	*	*	*
Commelina diffusa N.L. Burm.	blue day flower	X	C	*	*	
Liliaceae						
Crinum sp.	crinum	X	C	*		
Yucca sp.	yucca	X	C	*		
Poaceae						
Bothriochloa pertusa (L.) A. Camus	hurricane grass	X	C	*	*	
Brachiara subqudripa (Trin.) A.S. Hitchc	brachiara	X	C	*		
Cenchrus ciliaris L.	buffelgrass	X	C, S			*
Cenchrus echinatus L.	sandbur	X	C	*		

APPENDIX A

CHECKLIST OF PLANTS REPORTED FROM HONUA'ULA

Checklist includes plants reported from Honua'ula by Char and Linney (1988), Char (1993, 2004), Altenberg (2007), and SWCA (this study). Plant names appear alphabetically by family and then by species into each of three groups: Ferns and Fern Allies (Pteridophytes), Monocots, and Dicots. The taxonomy and nomenclature of the flowering plants are based on Wagner et al. (1999), Wagner and Herbst (1999), and Staples and Herbst (2005). Recent name changes are those recorded in the Hawaii Biological Survey series (Evenhuis and Eldredge, eds, 1999-2002). The list includes scientific name with author citation, common English and/or Hawaiian name(s), biogeographic status, and location within the three dominant vegetation types at Honua'ula.

KEY to biographic status:
E = endemic (occurring only in the Hawaiian Islands);
I = indigenous (native to the Hawaiian Islands and elsewhere);
X = introduced or alien (all those plants brought to the Hawaiian Islands after 1778).

KEY to vegetation types:
KB = *kiawe*-buffelgrass grassland;
MG = mixed gulch-vegetation;
KW = mixed *kiawe-wiliwili* shrubland.

KEY to surveys:
C = Char and Linney (1988), Char (1993), Char (2004);
A = Altenberg (2007);
S = SWCA (2008 - this study).

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
PTERIDOPHYTES						
Adiantaceae						
Adiantum capillus-veneris L.	maiden-hair fern	I	C		*	
Doryopteris decipiens (Hook.) J. Sm.	*'iwa'iwa*	E	C, A, S	*	*	*
Pellaea ternifolia (Cav.) Link	*pellaea*	I	C		*	*

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Zoysia sp.	zoysia	X	C	*		
DICOTS						
Amaranthaceae						
Amaranthus spinosus L.	spiny amaranth	X	C, S	*	*	*
Asclepiadaceae						
Asclepias physocarpa (E.Mey.) Schltr.	balloon plant	X	C, S	*		*
Stapelia gigantea (N.E. Brown)	zulu giant	X	S			*
Asteraceae						
Ageratum conyzoides L.	*maile hohono*	X	C, S	*	*	*
Bidens cynaplifolia Kunth	beggar tick	X	C, S	*	*	*
Bidens pilosa L.	Spanish needle	X	C, S	*	*	*
Calyptocarpus vialis Less.	straggler daisy	X	C, S			*
Centaura melitensis L.	star thistle	X	S			*
Cirsium vulgare (Savi) Ten.	bull thistle	X	S			*
Conyza bonariensis (L.) Cronq.	hairy horseweed	X	C	*		
Conyza canadensis (L.) Cronq.	horseweed	X	C, S	*		*
Crassocephalum crepidioides (Benth.) S.Moore		X	C, S	*	*	*
Emilia fosbergii Nicolson	red *pualele*	X	C	*		*

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Chloris barbata (L.) Sw.	swollen finger grass	X	C, S	*	*	*
Chloris radiata (L.) Sw.	plush finger grass	X	C	*	*	*
Cynodon dactylon (L.) Pers	*manienie*	X	C, S	*		*
Digitaria ciliaris (Retz.) Koeler	Henry's crab grass	X	C	*		
Digitaria insularis (L.) Mez ex Ekman	sour grass	X	C, S	*	*	*
Digitaria radicosa (Presl.) Miq.	digitaria	X	C	*		
Digitaria sp.	crab grass	X	C	*		
Eleusine indica (L.) Gaertn.	goose grass	X	C	*	*	*
Eragrostis cilianensis (All.) Vign. ex Janchen	stink grass	X	C	*	*	
Eragrostis tenella (L.) Beauv. ex R. & S.	love grass	X	C	*		
Eragrostis sp.	eragrostis	X	C	*		
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.	*pili* grass	E	C, A, S	*	*	*
Panicum maximum L.	guinea grass	X	C, S	*	*	*
Panicum torridum Gaud.	*kakonakona*	E	C			*
Rhynchelytrum repens (Willd.) Hubb.	natal red top	X	C, S			*
Setaria verticillata (L.) P. Beauv.	*mau'u pilipili*	X	C	*	*	*
Tragus berteronianus J.A. Schultes	goat grass	X	C	*	*	*
Urochloa subquadripara (Trin.) R. Webster	signal grass	X	C	*		

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Cactaceae						
Opuntia ficus-indica (L.) Mill.	*panini*	X	C, S	*	*	*
Pilocereus royenii (L.) Byles & Rowley	Royen's tree cactus	X	S			*
Capparaceae						
Capparis sandwichiana DC.	*maiapilo*	E	C, A, S			*
Cleome gynandra L.	spider flower	X	C	*		*
Caryophyllaceae						
Polycarpon tetraphyllum (L.) L.		X	C	*	*	
Chenopodiaceae						
Chenopodium carinatum R.Br.		X	C, S	*	*	*
Chenopodium murale L.	*aheahea*	X	C, S	*	*	*
Convolvulaceae						
Dichondria repens J. R. & G. Forst.		X	C	*		
Ipomoea indica (J. Burm.) Merr.	*koali awahia*	I	C, A, S	*	*	*
Ipomoea obscura (L.) Ker Gawl.	yellow bindweed	X	C, S	*		
Ipomoea tuboides (Degener & Ooststr.)	Hawaiian moon flower	E	C, A, S			*
Merremia aegyptia (L.) Urb.		X	C, S	*	*	*

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Galinsoga parviflora Cav.		X	C	*	*	
Gnaphalium cf. japonicum Thunb.	cudweed	X	C	*	*	
Hypochoeris sp. L.	cat's ear	X	C	*	*	*
Lactuca serriola L.	prickly lettuce	X	C, S			*
Lipochaeta rockii Sherff	*nehe*	E	C, A, S			*
Parthenium hysterophorus L.	false ragweed	X	S			*
Sigesbeckia orientalis L.		X	C	*	*	
Sonchus asper (L.) J. Hill	spiny snowthistle	X	C	*	*	*
Sonchus oleraceus L.	*pualele*	X	C, S	*	*	*
Sphagneticola trilobata (L.) Pruski	wedelia	X	S			*
Synedrella nodiflora (L.) Gaertn.	node weed	X	C	*	*	*
Tridax procumbens L.	coat buttons	X	C, S	*	*	*
Verbesina encelioides (Cav.) Benth. & Hook	golden crown beard	X	C, S	*	*	*
Xanthium strumarium L. var. *canadense* (Miller)	cocklebur	X	C	*	*	*
Zinnia peruviana (L.) L.	wild zinnia	X	C, S	*	*	*
Brassicaceae						
Cornopus didymus (L.) Sm.	wart cress	X	C	*		

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Chamaecrista nictitans (L.) Moench	partridge pea	X	C, S	*		*
Crotalaria incana L.	fuzzy rattlepod	X	C	*		
Crotalaria pallida Alton	smooth rattlepod	X	C	*		
Desmanthus virgatus (L.) Willd.	virgate mimosa	X	C, S	*		*
Desmodium tortuosum (Sw.) DC.	beggar weed	X	C			*
Erythrina sandwicensis O.Deg.	*wiliwili*	E	C, A, S	*	*	*
Indigofera suffritocosa Mill.	*iniko*	X	C, S	*		*
Leucaena leucocephala (Lam.) de Wit	*koa haole*	X	C, S	*	*	*
Macroptilium lathyroides (L.) Urb.	wild bean	X	C, S	*		*
Prosopis pallida (Humb. & Bonpl. Ex Willd.) Kunth	*kiawe*	X	C, S	*	*	*
Samanea saman (Jacq.) Merr	monkey pod	X	C	*		
Senna alata (L.) Roxb	candle bush	X	C	*		
Senna gaudichaudii (Hook. & Arn.) H.S.Irwin & Barneby	*kolomona*	I	C, A, S		*	*
Senna occidentalis (L.) Link	coffee senna	X	C			*
Lamiaceae						
Ocimum basilicum L.	sweet basil	X	C, S	*		*
Ocimum gratissimum L.	basil	X	C, S	*	*	*
Leonotis nepetifolia (L.) R. Br.	lion's ear	X	S			*

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Cucurbitaceae						
Cucumis dipsaceus (Ehrenb. ex Spach	wild cucumber	X	C, S	*		*
Momordica charantia L.	bitter melon	X	C, S	*	*	*
Sicyos hispidus Hillebr.	*'anunu*	E	C, A, S			*
Sicyos pachycarpus Hook. & Arnott	*'anunu*	E	A, S			*
Euphorbiaceae						
Chamaesyce celastroides var. lorifolia (A. Gray) Degener & I. Degener	*'akoko*	E	A			*
Chamaesyce hirta (L.) Millsp.	hairy spurge	X	C, S	*	*	*
Chamaesyce hypercifolia (L.) Millsp.	graceful spurge	X	C	*		
Euphorbia heterophylla L.	*kaliko*	X	C, S	*	*	*
Phyllanthus tenellus Roxb.		X	C, S	*		
Ricinus communis L.	castor bean	X	C, S	*	*	*
Fabaceae						
Acacia farnesiana (L.) Willd.	klu	X	C, S		*	*
Bauhinia blakeana Dunn	orchid tree	X	C	*		
Calopogonium mucunoides Desv.		X	C			*
Canavalia pubescens Hook. & Arnott	*'āwikiwiki*	E	C, A, S			*
Cassia fistula L.	golden shower	X	C	*		

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Nyctaginaceae						
Boerhavia coccinea Mill.		X	C	*		
Boerhavia acutifolia (Choisy) J.W.Moore	*alena*	I	S			*
Boerhavia herbstii Fosb.	*alena*	E	A			*
Boerhavia repens L.	*alena*	I	C, S			*
Mirabilis jalapa L.	four-o' clock	X	C			*
Oxalidaceae						
Oxalis corniculata L.	wood sorrel	X	C, S	*	*	
Papavaraceae						
Argemone glauca (Nutt. Ex Prain (Pope)	*pua kala*	E	A, S			*
Argemone mexicana L.	prickly poppy	X	C, S			*
Bocconia frutescens L.		X	S			*
Eschscholzia californica Cham.	California poppy	X	S			*
Passifloraceae						
Passiflora foetida L.	love-in-a-mist	X	C	*		*
Passiflora subpeltata Ort.	passion flower	X	C, S			*
Plumbaginaceae						
Plumbago zeylanica L.	*'ilie'e*	I	C, A, S	*	*	*

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Stachys arvensis L.	stagger weed	X	C	*	*	*
Malvaceae						
Abutilon grandifolium (Willd.) Sweet	*ma'o*	X	C, S	*	*	*
Abutilon incanum (Link.) Sweet	hoary abutilon	I	C, A, S	*	*	*
Malva parviflora L.	cheese weed	X	C, S	*	*	*
Malvastrum coromandelianum (L.) Garcke	false mallow	X	C	*	*	*
Sida fallax Walp.	*'ilima*	I	C, A, S	*	*	*
Sida rhombifolia L.		X	C	*		
Meliaceae						
Melia azedarach L.	Chinaberry	X	S			*
Moraceae						
Ficus elastica Roxb.ex Hornem	rubber tree	X	C	*		
Ficus microcarpa L. f.	Chinese banyan	X	C, S	*	*	
Myoporaceae						
Myoporum sandwicensis A. Gray	*naio*	E	C, A, S			*
Myrtaceae						
Psidium guajava L.	guava	X	C	*		

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Sterculiaceae						
Waltheria indica L.	*'uhaloa*	I	C, A, S	*	*	*
Tiliaceae						
Triumfetta semitriloba Jacq.	Sacramento bur	X	C, S			*
Verbenaceae						
Lantana camara L.	Sacramento bur	X	C, A, S	*	*	*

Scientific Name	Common Name	Status	Source Survey	Vegetation Type		
				KB	MG	KW
Polygonaceae						
Antigonon leptopus H. & A.	coral vine	X	C	*		
Portulacaceae						
Portulaca oleracea L.	pigweed	X	C, S	*	*	*
Portulaca pilosa L.	*'akulikuli*	X	C, S	*	*	*
Primulaceae						
Anagallis viscosa L.	scarlet pimpernel	X	C	*	*	*
Sapindaceae						
Dodonaea viscosa Jacq.	*'a'ali'i*	I	C, A, S			*
Solanaceae						
Capsicum annum L.	chili pepper	X	C, S	*		
Datura stramonium L.	jimson weed	X	C	*	*	*
Lycopersicon pimpinellifolium (Jusl.)	currant tomato	X	C, S	*	*	*
Nicandra physalodes (L.) Gaertn.	apple of Peru	X	C	*	*	*
Nicotiana glauca R.C. Graham	tree tobacco	X	C, S	*	*	*
Solanum americanum Mill.	*popolo*	I	C, S	*	*	*
Solanum seaforthianum Andrews		X	S			*

APPENDIX B

ANIMAL MANAGEMENT PLAN FOR HONUA'ULA

1.0 BACKGROUND

Located some 3,100 mi (5,000 km) southwest of the nearest continental landmass, the Hawaiian Islands are among the most isolated and youngest islands in the world. The former high islands in the extreme northwestern portion of the archipelago (now seamounts) are perhaps 60-90 million years old, Kaua'i is roughly 5.5 million years old, and volcanism is still building the Island of Hawai'i today (Juvik and Juvik 1998). All of Hawai'i's native biota originated from sources outside the archipelago (Ziegler 2002). Representatives of various taxonomic groups arrived infrequently from diverse regions throughout the Pacific Rim. As a result, the biota is considered disharmonic, that is, it lacks many groups of organisms represented on continental landmasses. Many of the founding populations radiated and diversified over a broad range of ecological niches in a relatively short period of time (Gagne and Christiansen 1985). The uniqueness of the endemic island biota contributed to its vulnerability, particularly to significant habitat disturbances and the impacts of invasive species (Cuddihy and Stone 1990, Clements and Daehler 2007).

Invasive species are non-native species that have an economic and/or environmentally adverse affect on the ecosystems they invade (Pattison et al. 1998). More than 50,000 species of plants, animals, and microbes have been introduced into the United States and some $120 billion in damages and control costs associated with invasive species are incurred yearly (Pimentel 2007). Further, invasive species are responsible for more native species extinctions than any other threat (Pimentel 2007). Inhabited islands are frequently at greatest risk of exposure to invasive species because of the volume of commodities imported and high level of tourist visitation for those seeking the ideal island-getaway (Van Driesche and Van Driesche 2004). Once established, invasive species are costly and difficult (often impossible) to remove. Establishment frequently incurs enormous expense to human enterprises, biodiversity, and ecosystem health (Schofield 1989, Myers et al. 2000). Introductions to islands not adapted to their presence can disturb the predator/prey balance because native plants and animals usually lack suitable defense mechanisms, escalating their vulnerability to predation (Dickman 1996, Fritts and Rodda 1998). Invasive species can also be vectors for pathogens and disease to humans and other wildlife (Geering et al. 1995, Dickman 1996).

The Hawaiian Islands are a notable example of invasion potential and success with the introduction of a large number of non-native flora and fauna over the past century. There are almost 3,000 established, invasive flora and fauna species in the Hawaiian Islands (Vitousek et al. 1997). Maui, situated in the middle of the island chain is certainly not immune to invasive species where they pose serious threats to the island (e.g., Miconia (*Miconia calvescens*), fountain grass (*Pennisetum setaceum*), pampas grass (*Cortaderia jubata*), ivy gourd (*Coccinia grandis*), coqui frog (*Eleutherodactylus coqui*), and veiled chameleon (*Chamaeleo calyptratus*) (MISC 2009).

Domestic goats (*Capra hircus*), were deposited in the Hawaiian Islands by British captains Cook and Vancouver, and were well know in Hawai'i by 1973. By 1910, they were recognized as a serious threat to native vegetation and land cover (Tomich 1986). Axis deer (*Axis axis*) were first released in Hawai'i on Moloka'i Island in January 1868, but were not introduced to Maui until 1959. The release point was located on Pu'u O Kali near 457 m (1500 ft) elevation (Tomich 1986). By 1968, the Maui population was estimated to be 85-90 animals (Kramer 1971). By 1995, the population on the 'Ulupalakua Ranch alone was >500 (Waring 1996). The highest numbers occur nearest the original release site and extend southward around the leeward side of the island. Year-round hunting is now permitted. Small and easily domesticated Polynesian pigs (*Sus scrofa*) were already common throughout Kaua'i in 1778 (Cook 1785). Tomich (1986) suggests that the Polynesian pigs were gradually replaced by stocks of European origins which are considerably larger in size. The first cattle (*Bos taurus*) were released on Hawai'i Island in 1793 by the English navigator George Vancouver.

These four introduced ungulates are among the leading causes for the decline of Hawai'i's natural ecosystems (Reeser and Harry 2005). Their grazing, browsing, wallowing, and rooting result in land erosion; stream and reef siltation; loss of native, threatened, and endangered plant and animal species; and degradation of native species' habitat (Nowak 1999, Reeser and Harry 2005). They can also be vectors for invasive plants (Stone et al. 1992); and their rooting behavior creates shallow basins which, when flooded, provide habitat for mosquitoes (Atkinson et al. 2005). The damage to Hawai'i's unique ecosystems after the arrival of Western man in 1778, led Zimmerman (1970) to his prescient conclusion that Hawai'i's "...mountains are being washed back into the sea whence they came."

There have been no formal studies of the ungulate populations within the Honua'ula area; however, the Division of Forestry and Wildlife (DOFAW) stated that "herds of Axis deer in numbers upward of 100" were found in the vicinity of Wailea 670 (DOFAW 2000).

2.0 PURPOSE OF THE PLAN

This Animal Management Plan (AMP) outlines the options for managing unwanted non-native deer, goats, cattle, and pigs at Honua'ula. The plan focuses on the proposed Native Plant Preservation Area, as proposed to meet the requirements of the Project District Phase 2 Master Plan, December 1, 2009. This area was identified as the priority for ungulate management because it contains within its boundaries the highest priority native plant species documented during extensive botanical surveys (SWCA 2009a). The AMP is also being developed in response to recommendations by the Division of Forestry and Wildlife (DOFAW), Hawaii Department of Land and Natural Resources (DLNR) dated August 3, 2000 and March 31, 2009 for fencing to preclude ungulates from entering the Property (Appendix C) and creating a nuisance to golf courses, residents, and native vegetation.

The intent of this Animal Management Plan is to protect the native plants within the Native Plant Preservation Area by addressing the primary threats to their survival and reproduction, and to reduce the nuisance created by non-native ungulates that stray onto golf courses, private lawns, and commercial spaces, and public parks. The AMP consists of four basic actions: fencing; removal of ungulates from the Native Plant Preservation Area, the Native Plant Conservation Areas, and the areas to be developed; long-term fence maintenance; and occasional removal of ungulates that stray within the Property.

3.0 METHODS OF ANIMAL MANAGEMENT

Fences are constructed as physical barriers to impede ingress and/or egress in an area (Reeser and Harry 2005). Most ungulate fences are designed to inhibit entry to an area, but in some instances the aim is to contain them for easier lethal removal. Tipton (1977) and Katahira et al. (1993) demonstrated that to cause a decline in the number of pigs within an unfenced area with typical ingress rates requires removal of over 70 percent of its population per year.

The most cost effective method of mitigating ungulate impacts at Honua'ula is to fence the northern, eastern, and southern boundaries of the 670 acre property with 7 ft-high deer fences; fence the Native Plant Preservation Area with hog wire, remove the ungulates from all areas, and then carry out restoration activities (i.e. propagation of native plants and removing other harmful alien plants and animals). The hog wire fence around the Native Plant Conservation Area may ultimately be replaced by a tradition lava rock wall. This approach is consistent with the recommendations of DOFAW (2000).

3.1 Fencing

Fencing has been tested as a control measure for feral ungulates, and has proven effective in a variety of locations, including Hawai'i Volcanoes and Haleakala National Parks (Stone 1985, Stone et al. 1992, Jacobi 1979, Katahira et al. 1993). A feral pig eradication program at Hawai'i Volcanoes National Park used containment to enclose nine management areas (total 30 mi^2 (78 km^2)) and successfully eradicated pigs in each (Katahira et al. 1993). In the same park, feral pigs were eradicated from fenced regions 0.4 - 7.3 mi^2 (1 - 19 km^2) in size by professional animal removal crews and snaring (Stone and Anderson 1988). Once boundary and barrier fencing was erected, organized control carried out by volunteers and paid personnel successfully removed 15,000 feral goats from a 100 mi^2 (260 km^2) area between 1970 and 1986 (Stone and Anderson 1988).

A properly constructed fence is humane and highly effective when appropriately maintained. However, no fence can ever be considered completely ungulate-proof. Given the right stimulus, some deer can jAMP an eight-foot fence and pigs can dig under a barrier (Z. Lopez, U.S. Air Force, personal communication). Additionally, not all targeted species can be contained or excluded by a standard or species-specific fence design. Some deer require 10-ft high (3 m) fences, but most are deterred by six to eight-ft (1.8 – 2.4 m) barriers (Barnes 1993, Anderson 1999). Pig fences are at least three-ft (0.9 m) high and require a guard such as barbed wire or an apron net to prevent forcing their way under the barrier (Long and Robley 2004). A woven-wire (hog wire) fence design (2.7 to 3.9 ft (0.8 – 1.2 m)) high, secured close to the ground with barbed wire extending out from the fence at ground level) has been successfully utilized for feral pig control (Stone and Anderson 1988).

In Hawai'i, four-ft (1.2 m) high hog wire has frequently been used for control of feral goats (HIDOFAW 2007). Fencing specifications suggested by Sailer (2006) for feral goats, feral pigs, and deer in Hawaii are outlined in Table 1. The type and condition of fencing material can impact susceptibility of animals to injury. Mesh size can dictate whether a horned animal is more or less likely to become trapped in the fence (Long and Robley, 2004). A damaged fence can not only allow access by species across the barrier, but provide a surface in which individuals can become snagged, caught, or injured. Double fences and plastic mesh can also be used but these may be impractical for Kaua'i's climatic conditions. Although electric fences are widely used in the mainland U.S. and Australia (Littauer 1997) they may not be practical at Honua'ula.

Table 1. Suggested standard fencing specifications for feral goats, feral pigs, and deer in Hawai'i. Adapted from Sailer (2006).

Target species	Minimum fence Height (in)	Graduated meshing	Fence skirting recommended	Electric top wire recommended
Goat	48" (1.2 m) (52" better) Slinky fence useful	Yes (no gaps at ground)	Yes 24"-36" (60-90 cm) as needed	No*
Deer	78" (2 m) (84" better) Slinky fence w/ barbed wire top useful	Yes	Yes	No*
Pig	42" (1.1 m) (48" better) Slinky fence useful	Yes (no gaps at ground)	Yes 24"-36" (60-90 cm) as needed in soft soils	No*

* Maintaining an uninterrupted power supply in remote, wet, stormy, and corrosive conditions decreases fence integrity and increases labor costs to maintain (E. Campbell, U.S. Fish and Wildlife Service, personal communication).

In addition to being effective over a long time period, fences can be cost-effective only if maintained. After the initial population "knockdown", they preclude the need for continuous, labor-intensive control inside a protected area. The lifespan of a fence can be considerably reduced by exposure to salt spray, high rain volume, and hurricanes. Although fencing can be costly and intrusive, most natural resource managers agree that it is necessary for effective feral ungulate control. Corrosion, storms, falling trees, and vandalism can affect the integrity of a fence, and lead to further disintegration. Once a fence is breached, considerable effort is needed to locate animals and restore barrier effectiveness. Ungulate fencing appears to be a viable option for ungulate control at Honua'ula.

In Hawai'i, ungulate fences may last less than five years where they are exposed to sulfur plumes and/or corrosive salt spray, or more than 20 years in open, high elevation slopes (DOFAW 2007). Without protection from ungulates, the abundance of native plants will continue to decline within the Property; while ungulate exclusion will lead to visible native species recovery, provided that competing invasive plants can be controlled or eradicated. At the Kanaio dry forest area on Maui native species have shown signs of recovery in as little as two years after ungulate exclusion (Jokiel and Dumaran 2002).

As of January 2007, the cost of typical ungulate fencing in Hawai'i ranged from $31-$87 per meter ($50,000-$140,000/mile) (DOFAW, 2007). However, prices obtained in 2009 from conservation practitioners for deer fences were higher at $111 per meter ($178,500/mile) (Fern Duvall, pers. comm.). Labor estimates from DOFAW (Fern Duvall, pers. comm.) and West Maui Mountain Watershed Partnership (Chris Brosius, West Maui Mountain Watershed Partnership, pers. comm.) ranged from $42-$84 per meter ($67,590-$135,180/mile), and materials range from $15-$20 per meter ($24,135-$32,180/mile) for goat and pig fencing, and $25-$34 per meter ($40,225-$54,706/mile) for deer fencing. For our purposes, we used $110 per meter ($176,990/mile) for deer fencing and $92 per meter ($148,028/mile) for goat and pig fencing, which includes materials and labor. We erred toward the conservative end of current price estimates, but material prices have been going up every few months so prices are approximate (Chris Brosius, West Maui Mountain Watershed Partnership, pers. comm.; Greg Czar, Feral Animal Removal Experts LLC, pers. comm.). Predator proof fences are also available that can exclude ungulates, cats, mongoose, rats, and mice, but costs may exceed $200 per meter ($321,800/mile). Final costs for fences will depend on specific decisions about materials, and construction methods.

3.2 Animal Removal

Once fences have been constructed it will be necessary to remove feral ungulates from the Property as quickly as possible. Various methods for the removal of feral ungulates have been employed in Hawaii and elsewhere on Pacific islands to protect native ecosystems and control soil loss (DOFAW 2007, SWCA 2009b). These include trapping, population control, population control with dogs or helicopters, driving, aerial control, snares, the use of radio collars (Judas method), and others. A general discussion of the pros and cons of each of these methods is presented in the following paragraphs.

3.2.1 Live Trapping

Live trapping using cage, box or corral traps allows animals to be taken alive. This provides the option of releasing captured individuals elsewhere, giving them away or humanely dispatching them at close range if necessary. Traps used in combination with other methods are useful tools, but as a sole method of control, they have limited success. Trapping has primarily been used for pig control but deer and goats may also be trapped.

By baiting the area around and inside the trap, capture success is greatly increased. If baited trapping can be timed to coincide with low food availability, take can be further increased (Barrett and Birmingham 1994). Pre-baiting allows individuals to freely wander into the traps to forage without getting caught. In Hawai'i, if traps were set during peak breeding seasons, the probability of catching family groups or roaming solitary males was increased (Katahira et al. 1993).

Corral traps work well if the target species congregate in an area. Corral traps need to provide adequate cover, food and water because they are usually deployed for extended time periods. By placing one or two decoy animals in the corral, others are attracted (Barrett and Birmingham 1994). Since corral traps are designed to attract as many individuals as possible and are set in one location for greater periods of time than other traps, the high localization of animals can cause damage to the environment in which the corral traps are set.

Trapping is particularly useful in areas where other methods are considered unsafe or unfeasible. These include urban and residential areas, where discharge of firearms is illegal or unsafe; or where the use of dogs conflicts with other land uses (Debernardi et al. 1995). Because traps are live capture, the animal is usually unharmed by the capture process and non-target animals caught can be released unharmed. If animals are to be being captured for relocation or fitting of radio transmitters, live trapping is necessary.

There are some disadvantages to live trapping. Traps can be logistically challenging and labor intensive to deploy. Even small ungulate traps can be heavy and cumbersome, requiring two or more people as well as trucks to deploy and maneuver. Traps must be checked regularly, cleared and refurbished with bait regularly. As with any trapped animal, there are safety concerns for those checking and releasing individuals. Trapping can be less cost effective than other methods because of higher labor and materials costs. For example, a box trap typically costs around $400.

Some estimates put the cost of trapping at approximately $54.00 per trap check including cost of labor, bait and trap (based on a trap lifespan of one year).

Different regions and species will require different baits. The process of discovering the optimum bait type and conditioning animals to take the bait in the presence of traps can be frustrating and time consuming. They can be less effective when food is plentiful (bait is less attractive). Animals may also escape from even well-built traps if frightened. Finally, there will always be a residual population that will be reluctant to enter traps; therefore, traps alone will not result in a zero population if total eradication is required.

3.2.2 Population Control

Animal population control through the use of firearms or archery to remove wildlife has been employed extensively as an ungulate management tool worldwide. Most animal control programs aim to significantly decrease or totally remove a species from specific areas. Typically animal control measures are carried out using shotguns (with slugs, particularly in small areas bounded by urbanization) and rifles. In sensitive habitats or close to infrastructure and human habitation where use of longer range weapons is undesirable (Kuser and Applegate 1985, Curtis et al. 1995), archery (bows and cross bows) can be utilized. Most often, such control measures are carried out at night using spotlights to detect ungulates. Spotlights have the added advantage of pinpointing individuals at a distance using eye shine (D'Angelo et al. 2007). In addition, the visual system of some species, such as deer, is typically overwhelmed by abrupt increases in light from spotlights and vehicle headlights, rendering the individual motionless and therefore an easy target (D'Angelo et al. 2007).

Public hunting can reduce ungulate populations, but spatial variation in hunting pressure can greatly affect the efficacy of a hunting program (Wright 2003). There is a perception by recreational and some volunteer hunters that aggressively reducing the number of ungulates will impact their ability to successfully hunt these species. Also as game density decreases and hunter effort increases, hunters will more often move to more productive hunting grounds. Coupled with a propensity for some people to 'trophy hunt' (i.e. selectively kill more desirable individuals in a population such as sizable males with large tusks or antlers), the ability to significantly decrease a species' population is even more problematic.

Public, wildlife and hunting safety are non-trivial issues. CASH (2009) reported almost 200 hunting accidents in the U.S. during 2008 and almost 150 in 2007. Hunting accidents occur in the Hawaiian Islands. In August 2001, a man was killed by his son's misfired arrow while hunting wild sheep on the Big Island of Hawai'i (Blakeman 2001). On the island of Moloka'i, a man was shot and killed with a rifle while hunting deer in November 2005 (Honolulu Advertiser Staff 2005). The restriction of access for hunting on private land can lead to increased safety risks. If the whereabouts of poachers is unknown, and if poachers engage in unsafe actions to evade detection and apprehension, hunters not only risk their own lives, but the lives of others. There is always a possibility that military personnel or authorized contractors could be injured or killed by poachers.

Programmatic costs of animal population control can be reduced considerably by decreasing the initial population of the target species rapidly, employing salaried rather than contracted personnel and utilizing other methods in concert with animal control. A professional control program can be costly. Rough estimates of population control of the three species of ungulates is about $121 to $202 per ac ($300 - $500 per ha) (C. Kessler, USFWS, personal communication). Ungulate control on the 605 ac (245 ha) Makaha Ridge facility may cost between $73,204 and $122,210. While this cost does not seem prohibitive, it does not include control of ungulates on the steep sea cliffs and gulches. Since these areas are extremely rough and generally inaccessible by foot, more expensive alternatives would have to be used. Further, due to the proximity of residential and resort areas to Honua'ula, the use of high velocity / long range firearms is not recommended.

3.2.3 Population Control With Dogs

The use of tracking dogs is a cost-effective method to locate ungulates present in steep terrain and dense vegetation. Dogs were used to locate small numbers of goats in remote areas of Hawai'i Volcanoes and Channel Islands National Parks (National Park Service 2004).

Pig population control with dogs proved the most successful option in Volcanoes National Park; after the first six months of control 150 of the estimated 175 pigs taken were taken by shooters with dogs (Katahira et al. 1993). Following aerial control on Sarigan Island, dogs were brought in to locate and chase feral pigs to natural barriers where shooters could eliminate them (Kessler 2002). Dogs were also helpful with eradication efforts on Santa Catalina Island, California (Schuyler et al. 2002) and Santiago Island, Galapagos (Cruz et al. 2005) by locating residue populations that evaded escape by shooters alone.

The safety of the dog and non-target species must be considered. Other considerations such as adequate rest time for the dogs, weather conditions for successful tracking and the use of dogs after dark need to be addressed. It is difficult to determine the cost of using dogs in an ungulate control program because dogs are often accompanied by a professional control team whose cost can vary. In addition, dogs are often brought in to find the remaining animals and thus are utilized primarily in low-density scenarios. Most managers agree that finding the last remaining proportion of a population takes as much effort as it took to get to that point, because capture success declines considerably as animal density becomes low. Dogs on Sarigan were able to locate and corral on average two to four animals per day before the dogs were too fatigued to be effective Kessler (2002).

The recent methods employed by The Nature Conservancy of Hawaii and reported by Allen (2009) are valuable to reference here. This project aimed to reduce non-native ungulate populations within specific management units on Maui and Moloka'i. Each site was divided into a series of "day-size control areas" and culled in a sequence that systematically worked to push any escaping ungulates ahead of the control team rather than into areas just covered. The control team utilized a systematic, dog and helicopter-assisted ground technique to sweep through the specific management units to remove feral ungulates. A team of 4 shooters, each with an experienced dog, moved across the landscape in a line, with each shooter no more than 330 to 500 ft (100 -150 m) apart. The shooters remained in constant communication with each other by FM handheld radios on a simplex frequency.

Short range bailer dogs (dogs that corner subjects rather than grab and hold them) were used; each trained to target feral pigs, and to stay approximately in a 500 – 650 ft (150-200 m) radius around the shooter. When target animals were found, dogs not immediately involved in bailing the target were trained to not join in, and instead maintained the integrity of the line to catch pigs that tried to escape through the line of shooters. Bailed target animals were then humanely dispatched by the nearest shooter and either shared with the community, safety permitting, or left in the field at pre-approved and appropriate locations remote from trails, drainages, and water supplies. A principal limitation of ground control with dogs at Honua'ula is the jagged, clinkery lava within the southern remnant mixed *kiawe-wiliwili* shrubland, and the steep gullies that cross the property.

3.2.4 Driving

DOFAW (2007), Henzell (1984) and Katahira and Stone (1982) found that driving ungulates from newly fenced areas just before the last section of fence is installed can be effective at removing animals. Animals can be driven or herded into open areas for aerial or ground control by shooters on horseback or on foot, or with motorcycles, or together with dogs. Helicopters may also be used more effectively to herd animals in rough terrain (Parkes, et al. 1996). Once driven into holding pens, animals can be dispatched by ground crews, given to interested individuals, or translocated to appropriate areas away from the site of their capture (DOFAW 2007). DOFAW (2007) reported the removal of 100 mouflon hybrid sheep out of a 5,000 acre exclosure area on the Island of Hawai'i in 45 minutes time with a helicopter. Similar success with driving was reported in Australia by Parkes, et al. (1996) and Henzell (1984).

3.2.5 Aerial Control

Aerial control has been effective at reducing ungulate populations, particularly in remote or inaccessible areas. On Sarigan, aerial control was successfully used as the initial step in a pig and goat eradication program (Kessler 2002). Nearly 80 percent of the 5,036 pigs dispatched from Santa Cruz Island were achieved from a helicopter over a 15 month period at a cost of approximately $3.9 million (Morrison 2007).

Helicopters were also used on Santa Catalina Island in conjunction with baiting to eradicate pigs (Schuyler et al. 2002). Foraging pigs investigating bait stations after dark were shot from the air. The eradication program was estimated at approximately $3.2 million over a 15-year period (Morrison 2007). Allen (2009) reported over 200 hours of helicopter time flown over a period of one year, combined with ground hunting with dogs, resulted in 819 ungulate dispatched in a combined area of 17,423 ac (7050 ha) on Maui and Moloka'i.

Aerial control has the advantage of not leaving human scent that animals can cue into, or requiring disturbance or destruction for roads or tracks. Like all control methods, aerial control has its own limitations. The method can be expensive depending on flight time. Since the shooter is some distance away from the target and the noise of an aircraft can spook the target, there is a higher risk of non-fatal strike than shooting from the ground (Kessler 2002).

Further, the effectiveness of aerial control in areas covered by thick canopy is reduced because the target animal can disappear from sight under the canopy (Kessler 2002). Aerial control may be useful for decreasing ungulates utilizing the steep gulches within the Honua'ula Property. Careful a priori planning with FAA, FWS, and DLNR personnel would be required to account for local airspace restrictions and safety for area residents and tourist helicopter flights in adjacent airspace. Aerial control is the most cost effective single method of ungulate control after corrals (Allen 2009, Cruz et al. 2009).

3.2.6 Snares

The use of snares has been successful in the removal of ungulates. They are particularly effective in catching pigs, and are often most effective in ingress areas at the edges of fencing or natural barriers. For example, adult and juvenile feral pigs were removed from a remote area of Hawai'i by snares (Anderson and Stone 1993). Snares set between 2 - 8 in (5 – 20 cm) from ground level caught 228 pigs in almost four years. Total eradication of pigs in Haleakala National Park was achieved via a variety of methods including snaring (Van Driesche and Van Driesche 2004). On Sarigan, a locally fashioned snare had limited success but was a low cost method of capturing pigs (Kessler 2002).

Although the actual cost of snares is low ($12 - $20 per snare) the cost of maintenance and monitoring time needs to be considered. Anywhere from 20 to 200 snares can be set and monitored in a day by a single person, but number and placement is dependent on personnel, travel time, suitable placement sites, terrain and setting time. Furbishing a snare with a radio transmitter can increase the cost of snaring considerably (Halstead et al. 1996). Snares can usually be set in a relatively short time and do not require constant monitoring. They can be more effective than hunting to catch residual populations in heavily vegetated, rugged terrain.

Snares are often used in Hawai'i to capture wary individual pigs that have evaded other methods (Katahira et al. 1993, Littauer 1997, Buddenhagen et al. 2006) and are particularly useful in fenced areas. However, "reading" pig sign, and understanding home ranges and dispersal paths is an important factor in determining the placement of snares, particularly if the goal is to catch specific individuals (Anderson and Stone 1993). Time invested for snaring compares well with hunting, e.g. 9-60 hrs/pig versus 7-43 hrs/pig (Anderson and Stone 1993), or 27 hrs/pig (Buddenhagen et al. 2006). The latter two programs, however, were snaring "to extinction" within fenced areas. Initial "knockdown" of a population will be less time consuming and expensive.

Snares are effective but have some disadvantages. They have been criticized as inhumane if they are not checked frequently. Further, there is a heightened risk of death or injury if snares are set on sloping ground that could cause the animal to slip or lose its footing. Alarms or telemetry devices have been used to alert personnel when a snare has been tripped, leading to a quicker reaction time and less chance for injury (Marks 1996).

However, reducing response times may be logistically impractical in isolated areas and cost can be prohibitive. Conversely, the effectiveness of snares can be greatly reduced by frequent checks because of the human scent left behind (Hawai'i Conservation Alliance 2005a). Non-target animals are also susceptible to snares since they are not species specific. Goats, deer, and dogs are the only possible non-target species present at Makaha Ridge.

3.2.7 Other Tools for Control

Because some species of ungulate are highly social animals, an individual equipped with a radio transmitter can lead personnel to locations where the species congregate (Taylor and Katahira 1988, White and Garrott 1990). This technique, called the "Judas" method, was developed by Taylor and Katahira (1988) to find the last remaining goats in Hawai'i Volcanoes National Park. The technique entails the capture of a target animal such as a goat, fitting it with a telemetry collar, and releasing it. Being a gregarious animal, the goat will rejoin its herd, allowing personnel to locate and kill the herd. Usually the Judas animal is left unharmed to escape and find a new herd (Kessler 2002). "Mata Hari" goats (sterilized females induced into long term estrus) have been used in a similar way (Cruz et al. 2007). The Judas method is particularly useful for locating animals on steep slopes and dense underbrush. The method may therefore be a valuable tool for goat (and possibly pig) control at Honua'ula. Prior to fitting the radio transmitter, the animal must be captured and restrained. Capture is often achieved with traps and occasionally darting with a sedative.

The use of bounties to affect animal management and control has generally been found to be ineffective (Latham 1960, Hassall & Associates P/L. 1998, Buddenhagen, personal communication; DOFAW 2007). Many problems defined by Choquenot et al. (1996) include individuals bringing false evidence of kills, deliberate release of breeding animals, and purposefully leaving behind some animals to provide future income. Use of this method at Honua'ula is not recommended.

3.3 Related Management Actions

3.3.1 Disposition and Use of By-Products

Where possible, biological data should be collected on all captured and dispatched animals to obtain valuable demographic information on each target species. Following the successful approach detailed by Allen (2009), animals corralled at Honua'ula should be humanely dispatched by the nearest shooter and either shared with the community, safety permitting, or removed and buried offsite. According to U.S. Department of Agriculture, Food Safety Inspection Service, non-native deer are the only one of the species not covered by mandatory inspection and therefore their meat can be donated if deemed acceptable by local governing officials. Other State restrictions may apply.

3.3.2 Community Outreach and Education

Recreational hunting is an important part of life for many people on Maui, and eradication of goats, deer or pigs may still be misunderstood to many who don't see the threat to the land caused by these animals. Knowledge regarding invasive species and the harm they can cause are relatively low among the general public (Conover 2002). Therefore, it is important that Honua'ula Partners LLC develop a Public Relations Plan for the population management of ungulates on on the Property. The focus of the ungulate control program at Honua'ula should clearly be the restoration of native vegetation and prevention of soil loss which degrades adjacent marine habitats and coastal water quality.

Pro-active outreach can involve making the problem known, informal "talk story" sessions with stakeholders that may be concerned, involving the community in understanding the problem and helping to formulate solutions. Supporters are normally silent, and these stakeholders need to be encouraged to share their views. The plan will be to inform the public why ungulate control is needed, what is currently being done to control ungulate populations, and what is the long-term goal for control on the Property.

There are two primary goals of the public affairs plan: 1) understand the problem; 2) respond to questions and concerns about efforts to address damages to natural resources and facilities caused by feral ungulates, and managing ungulates to protect natural resources; 3) convey key points such as strategies and fundamental components for control as well as cooperating local and federal government agencies; and 4) support the proposed control. Public awareness regarding the ungulate reduction program would be promoted whenever possible. Honua'ula LLC and their Natural Resources Manager would work with community leaders in an effort to maintain communication avenues and resolve any issues should they arise.

Technique	Advantages	Disadvantages
Lethal baits	• Very effective • Cost effective • Modest labor requirements • Can be aerially distributed in remote areas	• Not acceptable for use in Kaua'i • Public relations issues may ensue
Non-toxic Baits	• Can be species specific • Complements other methods such as trapping • May catch animals that avoid other methods • Cost effective • Can rapidly reduce the number of animals • Can take advantage of nocturnal feeding habits	• If used with hunting, wait time can be consuming • Bait may provide a food source for other pest species (e.g., rats) • Some seed bait may germinate and establish • May attract non-target animals
Fencing	• Highly effective at blocking animals • Precludes need for continuous, labor-intensive control • Deters illegal trespass • Cost-effective if maintained • Can create a barrier against which to hunt • May be fitted with one-way gates to allow animals to exit	• Must be used in combination with other methods • Disruption of movement patterns may increase damage to adjacent areas and have negative effects on non-target animals • Expensive to build and maintain • Kaua'i conditions may decrease the longevity of fences • Can be damaged by hurricanes • Can be breached by poachers, particularly in remote areas
Driving	• Highly effective to rapidly move large numbers of animals • Non-lethal when conducted properly • Allows relocation of animals to other areas	• Labor intensive and potentially costly • Heavy vegetation or steep slopes may hamper effectiveness • Limited viability at low population densities • Not effective on some species • May exhaust animals if done improperly or if area is too large
Fertility Control	• Non-lethal • Could be effective if one-time treatment were permanent • May be improved for future application	• Temporary solution • Requires repeated administration • Labor intensive and hence costly • No large-scale oral deliverable methods are available
Radio-telemetry (Judas animal)	• Effective for goats • May potentially be used for pigs • Effective at finding evasive herds • Aerial telemetry can be used to locate herds in remote areas • Can be used in conjunction with live trapping	• Cannot be used for deer • Animal must be captured and restrained using a sedative • Telemetry equipment is costly • Transmitter collars can cause irritation and injury to the animal

Table 2. A summary list of techniques for animal control considered along with their advantages and disadvantages (after DOFAW 2007).

Technique	Advantages	Disadvantages
Ground control	• Capable of removing enough to be effective • Cost per animal relatively low • Effective in accessible areas • Can be undertaken by professional and amateur shooters • Only target animals are taken • Results are immediate • Rapid removal of many animals	• Less effective along steep, rugged and inaccessible terrain • Safety issues
Aerial control	• Effective along steep, rugged and inaccessible terrain • Does not leave human scent • Only target animals are taken • Results are immediate • Rapid removal of many animals	• Undertaken by professionals only • Canopy cover limits effectiveness • High risk • Helicopter time is expensive • Weather conditions affect scheduling
Control with dogs	• Capable of removing enough to be effective • Cost effective • Intensity and duration dictated by the control program • Effective for animals that have evaded other methods • Dogs increase efficiency of shooters	• Well trained dogs are expensive and may be hard to obtain • Dogs may be injured or killed by target animals or firearms • Should only be utilized by professionals • Inadequately trained dogs may take non-target animals • Some concerns regarding humaneness of method • Animal take per day is low compared with some other methods • In unfenced areas, may drive animals into sensitive natural areas
Live trapping (including corrals)	• Multiple animals can be taken at once • May catch animals that avoid to other methods • Non target animals captured can be released unharmed • Allows potential to radio-collar animals for Judas method	• Requires road or helicopter access • Traps are heavy and require multiple personnel to operate • Less effective when food is plentiful (bait is less attractive) • Time needed to find attractive bait or condition animals to take bait • Non- targets may become trapped • Trap shyness may preclude some individuals from capture • Must be checked regularly to reset and add bait • Some concerns regarding humaneness of method
Snares	• Effective for pigs • Relatively inexpensive • Presence of personnel not required • May catch animals that avoid other methods • Effective at low densities • Can catch animals that breach a fence	• Low public acceptance • Potential harm to animal if snared too long • Non-target animals may become snared • Snares must be removed before hunting with dogs can be used • May be less humane than other methods

3.3.3 Ecological Research and Monitoring

Successful long term control of ungulate numbers requires continuous review and refinement of management practices (Gogan et al. 2001). An "adaptive management" strategy or monitoring and assessment of key ecosystem components would be a necessary component of a sustained reduction program for deer, pig, and goats. Pre-reduction surveys for baseline data of ungulate damage should be conducted. This includes damage to vegetation as well as direct (observations) and indirect (e.g., scats, hoof prints and active wallows) evidence of ungulate presence.

Post-reduction surveys of affected areas should be conducted in order to measure reduction in damage due to the control of these ungulates. Tools such as bait stations, and scat and track analysis would allow field personnel to estimate relative population activity at key time periods prior to and following control treatments. Long-term impacts to vegetation would also be monitored. A summary of the pros and cons of each of the ungulate control methods discussed above appears in Table 2.

4.0 ALTERNATIVE STRATEGIES FOR UNGULATE MANAGEMENT AT HONUA'ULA

Alternative strategies are reviewed to accomplish two objectives: 1) protection of the entire Property from incursion by deer, pigs, goats, and cattle; and 2) protection of the Native Plant Preservation Area and Native Plant Conservation Areas.

4.1 Ungulate Management across the Entire 670 Acre Property

One of the conditions promulgated by the Maui County Council and DOFAW was to put in place a perimeter fence around the Property to restrict animal incursions, and protect not only native plants but also golf course features, private residences, public parks, and commercial establishments. Health risks to residents are probably not high, but ungulates could create health and traffic hazards. Ungulates are carriers of several diseases, including Leptospirosis, which is caused by a spirochete bacterium. Leptospirosis infection rates in Hawai'i are higher than anywhere else in the United States (Katz et al. 2002). Cows, pigs, goats, and deer are known vectors of the disease (Katz et al. 2002). Deer-vehicle collisions are unlikely in Hawai'i and have been given a 1 in 9,931 chance in any given year (State Farm 2009), but pig-vehicle encounters are not so uncommon (Robert Preston, Hawaii Department of Transportation, pers. comm.). However, pig densities in dry rocky areas like Honua'ula are not likely to be as high as wet forest areas (Chris Buddenhagen, SWCA, pers. comm.).

DOFAW (1988) recommended fencing the entire Property to preclude ungulates from entering developed areas. A resident of the Maui Meadows development immediately to the north of Honua'ula said he's never seen deer or other ungulates in the residential area and other residents do not view them as a problem (Greg Spencer, First Wind, pers. comm.). However, this statement is refuted by staff of the State Division of Forestry and Wildlife (DOFAW) in a letter dated August 3, 2000 (Appendix C). Golf course areas in Maui sometimes experience problems with pigs and deer. Due to their rooting activity, pigs are the most damaging ungulate for landscaped areas. Hunters are contracted from time to time to control ungulate impacts to the Makena resort's golf courses (Greg Czar, Feral Animal Removal Experts LLC, pers. comm.). Existing fences at Honua'ula do protect the area from some cattle, but other ungulates may need to be managed to meet requirements (see below).

Much of the perimeter of the Property is already fenced with a mix of four strand barbed wire and hog wire with a barbed top wire. Yet none of the existing fences have the base skirting required to keep pigs out. Fence and gate integrity is variable throughout the perimeter, with significant portions in poor repair. Along the upper property boundary, adjacent to 'Ulupalakua Ranch, fencing is of a reasonable standard; however, this area of the fence probably only excludes cattle due to the height and lack of skirting. The four strand barbed wire fences along part of the southern boundary would do little to keep out pigs, goats, or deer.

Fences in the lower perimeter (western side of the property) are mainly designed to keep animals from entering developments below the property. This area has a number of access gates that are designed to exclude vehicular access, but would not prevent animal ingress. Some existing fencing will need replacing or upgrading.

SWCA recommends that Honua'ula Partners LLC upgrade fences along the northern, eastern, and southern boundary of the Property to ensure that they are effective against deer, pigs, goats, and cattle (Table 3, Figure 1). Over the long term, fencing should not be necessary along the lower (western) part of the property because it abuts resorts, residences, and golf courses. Existing and proposed access roads along the boundary with Wailea Resort would reduce fence effectiveness. This partial perimeter fencing option means that areas at a high risk of ungulate ingress are dealt with, but occasional ingress would still be possible along the lower boundaries or via roads.

Feral Animal Removal Experts LLC recommends an eight (8) foot (2.4 m) deer fence with a ground skirt all the way around it (Table 1). The corners should be two and seven eighths (2 7/8) inch (7.3 cm) or larger galvanized pipe. Pipe, or galvanized ten (10) foot (3 m) t-pins, or a combination of both, can be used for in-line posts. One pipe for every ten (10) or twelve (12) pins is the best ratio. It is important to use American made t-pins and wire as they are stronger and last three times as long. It is possible to build this type of fence in any terrain and soil type. Pipes should be pounded in a minimum of 0.9 m (3 ft) in soil or 46 cm (18 in) when drilled in solid rock. Occasional pedestrian gates will be required to access the enclosure.

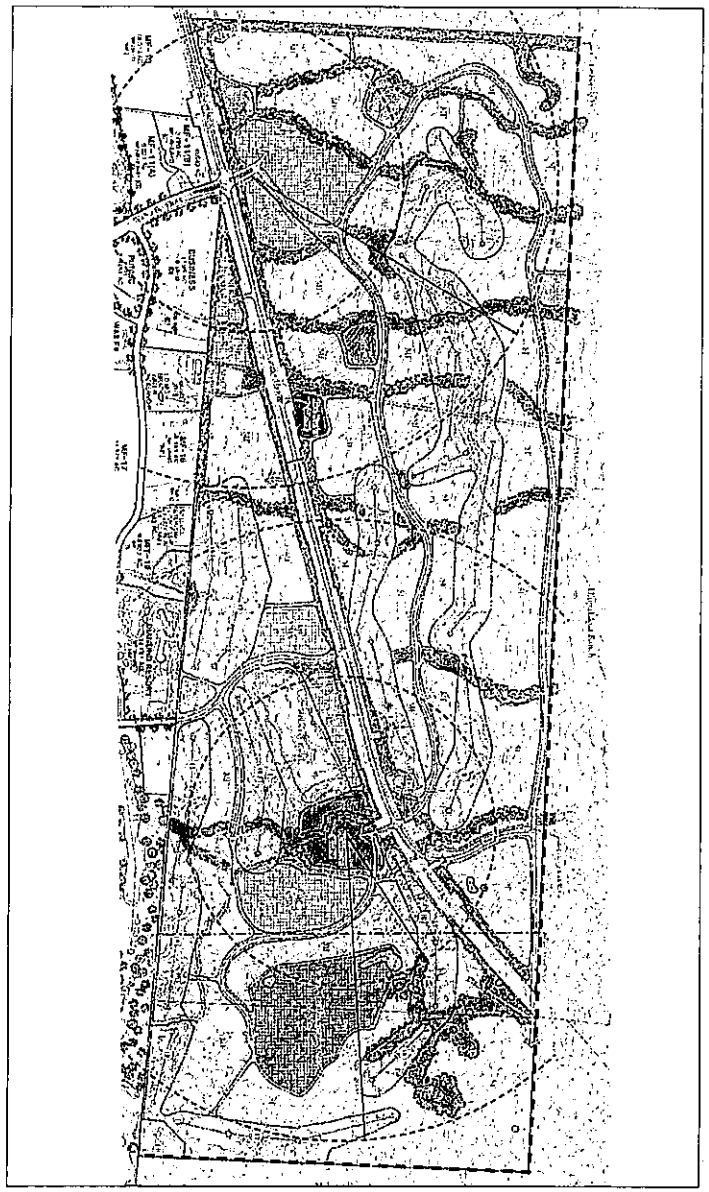
Access is relatively easy at the site, but the lava substrate would require special equipment to put in fence posts. One option is to use a geological core sampling bit on a 2-cycle (chainsaw) motor drive. This works as a "hole saw" and pins can be placed in the hole, but one challenge is that the drill bit needs irrigating with water during drilling. It is best to bulldoze the line as it will improve fence integrity, reduce construction time, and facilitate future maintenance. Care will be needed to ensure that significant cultural sites and native plants are not damaged by bulldozing. The cost of a D-9 bulldozer and operator on Maui is approximately $350 per hour.

Another consideration relates to the aesthetics of the fence, different options may be desirable depending on the visibility of the fence from residential areas. Each gate added for access could cost anywhere from $300 to $3,000 depending on the type of gate. Final costs will need to be determined by a fencing contractor. It is recommended that a single contractor be hired for both fencing and ungulate removal (Greg Czar, Feral Animal Removal Experts LLC, pers. comm.). Where necessary at road crossing, two cattle guards can be placed in succession, approximately 12-16 feet (3.7-4.9 m) wide, to deter all ungulates. Guards are normally only 6-8 feet (1.8-2.4 m) wide for cattle (Anon 2009). Material costs for guards are likely to exceed $5,000. Installation costs vary.

Table 3. Estimated costs for ungulate fencing the Honua'ula Property

Fencing Options	Estimated Fence Length	Estimated Cost (All ungulates)	Estimated Cost (goat-pig-cattle)	Acres Protected
Eastern and Southern Perimeter	3953 (2.46 miles)	$434,830	$363,676	~670
Cost per unit		**$110/meter (~$177,050/mile)**	**$92/meter (~$148,060/mile)**	

After fencing is completed, ungulates will need to be removed from the Property. With the Honua'ula site being so close to residential areas, the option to use shooters may cause concerns in the community. Some people may have permission to hunt on the Property so professional animal removal teams could conceivably shoot animals. However, the best option would be to drive any ungulates out of the area (through a gate) using skirmish lines with people spaced every 33-164 feet (10-50 meters) (Greg Czar, Feral Animal Removal Experts LLC, pers. comm.). Animals would be driven out of the preserve for humane dispatch, capture, or release. Costs for professional animal removal services could be anywhere between $250 and $600 per acre ($618 and $1,483 per hectare) (Greg Czar, Feral Animal Removal Experts LLC, pers. comm.). After animals are removed, the fence would be sealed off and the positive effects of animal removal on the vegetation should become evident over the next 6-24 months.



Legend

Proposed Perimeter Fence

Sources:
Topography - PBR
Land Ownership - TMK
Cultural Sites - Aki Sinoto

Feet

Honua'ula

Figure 1 - Fencing Plan for a Perimeter Fence

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4.2 Ungulate Management to Protect the Native Plant Preservation Area

The Native Plant Preservation Area must have permanent protection and long-term intensive management to protect its native resources from external threats. To adequately meet this requirement, it should be protected as early in the development of the Property as possible. To estimate costs, two fencing options were mapped in the field by SWCA on December 1, 2009 (Figure 2). SWCA used a Trimble GeoXT Mapping Grade Global Positioning System (GPS) unit with ArcPad8 software to obtain an accurate estimate of the proposed perimeter fence path and length.

One fencing option follows the preserve boundary as proposed in the Project District Phase 2 Master Plan, December 1, 2009, and the other makes adjustments to follow certain landscape features (contours, gullies, and ridges). It includes native species, especially stands of *wiliwili* (*Erythrina sandwicensis*) trees adjacent to the proposed preserve (Figure 2). Following landscape features in this way will make fence construction simpler in some cases, and would often act to make the fence less visible from developed areas. The difference between the two scenarios amounts to a difference of 0.8 ac (0.3 ha) and the inclusive scenario would add approximately 40 more *wiliwili* (*Erythrina sandwicensis*) trees to the preserve (Figure 3), depending on the final fence placement (Table 4).

Table 4. Approximate cost of installing fences around the proposed Native Plant Preservation Area. *Two fence paths are presented based on the preserve area proposed in the Master Plan, and a modified inclusive version that seeks to protect native plants that were just outside the proposed preserve boundary.*

Fencing Option	Estimated Fence Length	Estimated Cost (All ungulates)	Estimated Cost (goat-pig-cattle)	Acres Protected
Current Plant Preservation Area in Master Plan	1,229 meter (0.7636 mile)	$135,190	$113,068	22.3
Inclusive Plant Preservation Area Option	1,315 meter (0.8171 mile)	$144,650	$120,980	23.1
Cost / Unit		**$110/meter (~$177,050/mile)**	**$92/meter (~$148,060/mile)**	

After fencing is completed, ungulates will need to be removed from the preserve using the same methods employed to remove ungulates from the larger Property.

4.3 The Do Nothing Alternative

The last option is to do nothing. Existing fences are probably adequate to protect the area from cattle ingress, although fence repair may be needed from time to time. However, deer, pigs, and goats would likely continue to enter the Property through the existing unskirted, permeable fences. This would increase the level and cost of control required to herd and remove ungulates that threaten invade the Native Plant Preservation Area, Native Plant Conservation Areas, golf course, or developed urban areas. It may also lead to damage or loss of native plant resources unless the ungulates are found and controlled soon after they invade the Property.

Construction activities would probably cause many animals to leave the property; thus, no special effort is likely needed to remove animals unless new fences are put up early during project implementation. Individual animals could be removed humanely as they are found. At some point a concerted effort to remove animals from the property using skirmish lines may be warranted, especially after perimeter fencing is put in place. Costs for professional animal removal services could be anywhere between $250 and $600 per acre ($618 and $1,483 per hectare) (Greg Czar, Feral Animal Removal Experts LLC, pers. comm.).

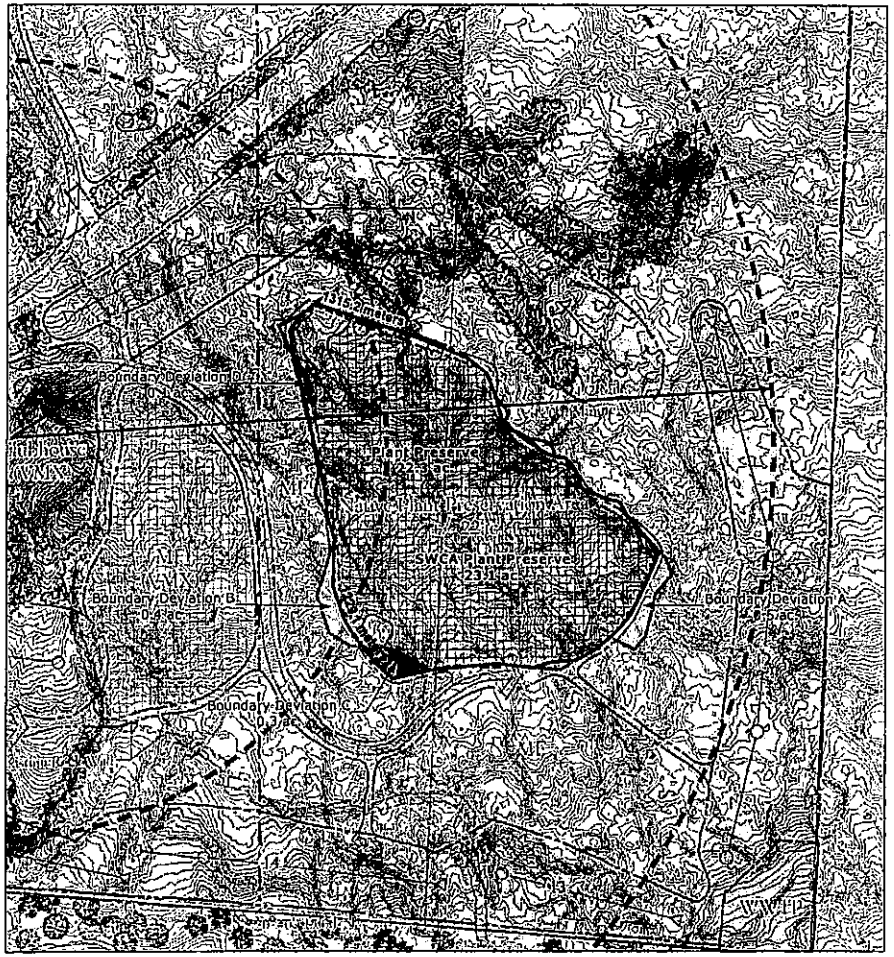

Figure 2
Fencing Plan Options Native Plant Preserve
Honua'ula

Figure 3. A wiliwili (Erythrina sandwichensis) tree slated for protection within the proposed Native Plant Preservation Area.

5.0 SUMMARY OF RECOMMENDATIONS

SWCA recommends the implementation of the following measures to preserve elements of the Native Plant Preservation Area and Native Plant Conservation Areas at Honua'ula and mitigate damage to native plants caused by feral ungulates.

- Upgrade the perimeter fence to pig-goat-cattle fencing around the eastern and southern boundaries of the Honua'ula Property to eliminate most ingress by deer, pigs, goats, and cattle or all ungulates except deer.
  - Estimated cost: ~$434,830 (including deer)
  - Estimated cost: ~$363,676 (pigs, goats and cattle)
- Fence the proposed Native Plant Preservation Area with fencing to keep out deer and other ungulates.
  - Estimated cost: ~$120,980.
- Remove ungulates from Native Plant Preservation Area with professional teams.
  - Estimated cost: ~$5,500-$13,200.
- Remove ungulates from the over the remaining property with professional teams.
  - Estimated cost: ~$167,500 - $402,000

In addition, the ungulate control program should also include elements of an outreach program to share information about impacts with cooperators and the community through formal and informal outreach channels. Monitoring of management actions (i.e. control and native plant restoration efforts) will demonstrate management effectiveness, and allow for management methods for animal population control to be adjusted. Changes in ungulate populations and the outcomes will be measured against baseline information and allow successes to be celebrated and any potential problems to be addressed. Monitoring information is used to inform outreach, management and restoration efforts into the future.

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