

**Pu‘u Maka‘ala Natural Area Reserve (NAR)  
Management Plan**



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## EXECUTIVE SUMMARY

Pu‘u Maka‘ala Natural Area Reserve (NAR or Reserve) is situated on lands within the upper portions of Waiākea ahupua‘a of the South Hilo District and the kalana (sub-district) of ‘Ōla‘a within the District of Puna. It was formally established in 1981 by Governor’s Executive Order 3102 from lands withdrawn from the ‘Ōla‘a and Waiākea Forest Reserves (FR). The original 12,106 acre (ac) (4,899 hectare (ha)) Reserve was created to protect native wet forest. In November 2010, an additional 6,600 acres (2,671 ha) of the former Kūlani Correctional Facility property was added to the NAR, bringing the total acreage of the NAR to 18,706 acres (7,570 ha). This addition protects additional forest and native species as well as links important conservation areas including the ‘Ōla‘a Tract of Hawai‘i Volcanoes National Park (HAVO) and the upper elevation native forests of Kīlauea, Keauhou, and Upper Waiākea. These forests comprise an important water resource for the lower Puna and Hilo regions of Hawai‘i island, and provide exceptional habitat for a wide diversity of native plant and animal species.

The primary threats to biodiversity and watershed integrity at Pu‘u Maka‘ala NAR are feral ungulates (wild, hoofed animals such as pigs, sheep, goats and cattle), especially feral pigs (*Sus scrofa*) and non-native, invasive weeds. This management plan updates the 1989 Management Plan for Pu‘u Maka‘ala NAR to reflect management accomplishments and current management needs of this reserve, including proposed management for the Kūlani addition.

Governor Abercrombie’s *A New Day in Hawai‘i* plan calls for the stewardship of the natural resources that our survival, economy, and quality of life depend on. Priority actions of this Department of Land and Natural Resources (DLNR) initiative include managing invasive species, increasing Hawaii’s ability to withstand impacts from climate change, and restoring capabilities of the DLNR by finding additional sources of funding. The New Day Status Report also tasks the DLNR to ensure mauka watersheds are fully functioning so fresh water resources can be utilized and enjoyed by the people of Hawai‘i in perpetuity. *The Rain Follows the Forest* is the Department’s plan to implement these central goals of the Abercrombie administration. *The Rain Follows the Forest* identifies priority watersheds, including Pu‘u Maka‘ala NAR, and outlines on-the-ground actions and projects required to protect and sustain Hawaii’s critical water sources.

The Pu‘u Maka‘ala Management Plan is aligned with the priorities and actions identified in *The Rain follows the Forest*. The overall management goal is to protect, maintain, and enhance Pu‘u Maka‘ala’s unique natural, cultural, and geological resources. Management programs have been developed to support this overall goal and include the following:

1. Ungulate Management
2. Weed Management
3. Habitat Protection and Rare Species Restoration
4. Monitoring
5. Public Access, Outreach and Education
6. Fire Prevention and Response
7. Enforcement
8. Partnership Collaboration

## 9. Infrastructure and Other Actions

The 2012 Management Plan for Pu‘u Maka‘ala outlines the planned management activities in Pu‘u Maka‘ala over the next fifteen years, along with an estimated budget for full implementation.

### **INTRODUCTION**

The Natural Area Reserves System (NARS) was created in 1971 by the Hawai‘i State Legislature to “preserve in perpetuity specific land and water areas which support communities, as relatively unmodified as possible, of the natural flora and fauna, as well as geological sites, of Hawai‘i (HRS § 195-1).” The legislature further found that these unique natural assets should be protected and preserved, both for the enjoyment of future generations and to provide baselines against which changes to Hawaii’s environment can be measured. The NARS is administered by the Hawai‘i Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW). NARS Commission members act in an advisory capacity for the Board of Land and Natural Resources, which sets policies for the Department. Hawai‘i Administrative Rules 13-209 relate to the management of the Natural Area Reserves System.

The NARS is based on the concept of protecting ecosystems – not merely single species. Because the natural resources of Hawai‘i are under constant threat from invasive species, human encroachment, feral ungulates, climate change, and other threats, the NARS seeks to protect the best remaining examples of the State’s unique ecosystems. In addition to setting aside these areas as reserves, the NARS program strives to actively manage these reserves in order to preserve the unique characteristics that make these areas an integral part of the natural heritage of Hawai‘i. Reflecting this, the mission of the NARS program is: “The NARS exists to ensure the highest level of stewardship for Hawaii’s natural resources through acquisition, active management, and other strategies.”

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

Pu‘u Maka‘ala NAR was established in 1981 with the issuance of Executive Order 3102, and it was created to protect unique wet native forest that provides habitat for native plants, invertebrates, and birds. The addition of 6,600 acres (2,671 ha) of the Kūlani property was completed in November 2010 with the issuance of a Governor’s Executive Order 4338. This portion of the Reserve contains additional native habitats and species, including mesic forest ecosystems and high elevation habitat that contains existing populations of three critically endangered forest birds. Long-term management of the forested watershed of Pu‘u Maka‘ala

NAR provides multiple benefits to the state including protection of the island's water resources and undeveloped open space. The natural communities within the Reserve provide habitat for a diverse range of native plants and animals, from rare birds to endemic invertebrates, preserving Hawai'i's biodiversity.

The NARS website located at <http://hawaii.gov/dlnr/dofaw/nars> provides general information on NARS programs and policies as well as information on NARS management across the state.

## **PU'U MAKA'ALA NAR: BIOPHYSICAL RESOURCES**

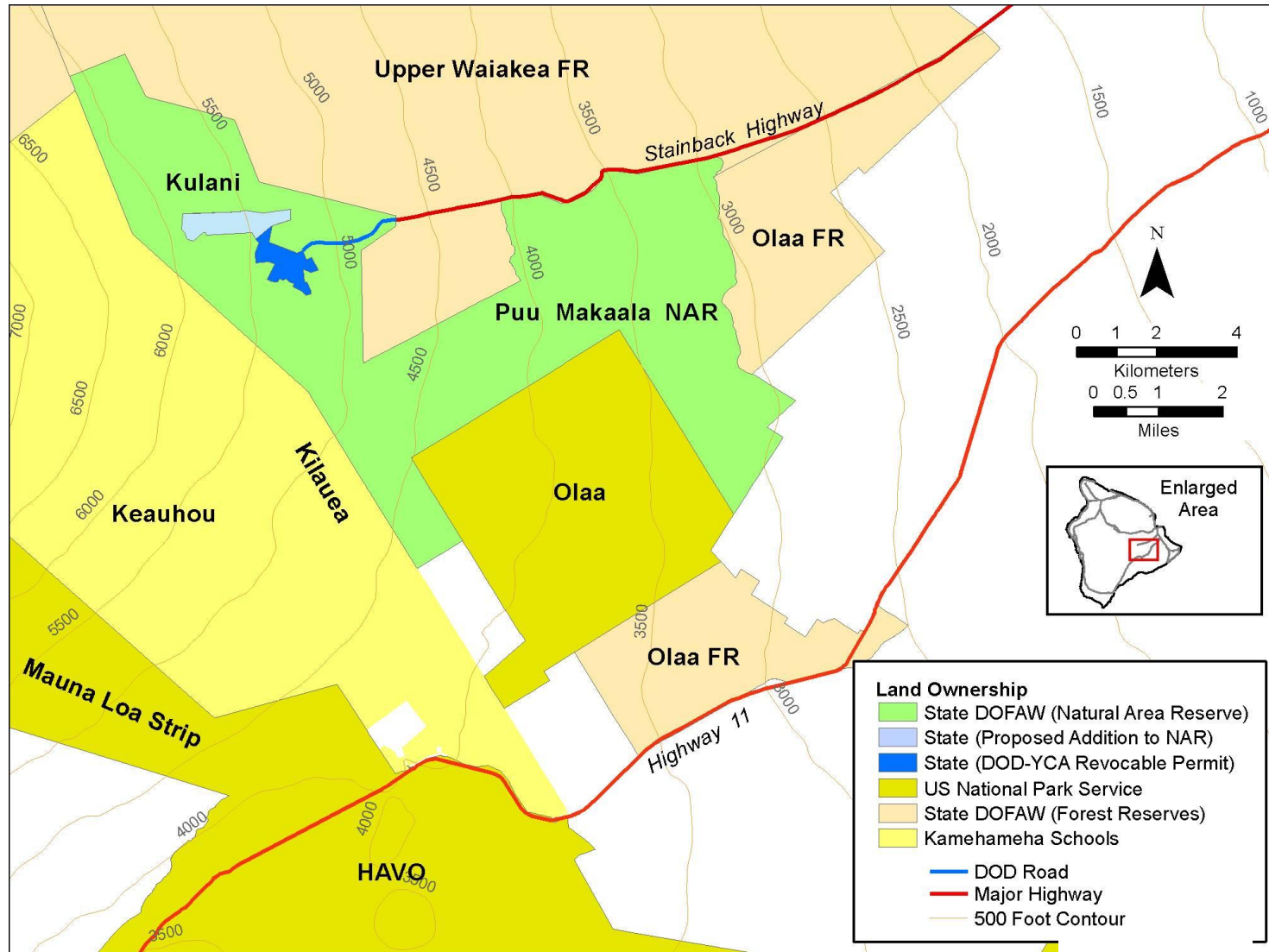
### ***Location***

Pu'u Maka'ala NAR occupies 18,706 acres (7,570 ha) in the Puna and South Hilo districts on the island of Hawai'i (Figure 1). The NAR includes the following TMKs: 1-8-12:03, 1-9-01:1, 2-4-8:19, 2-4-8:21, 2-4-8:25 (portion), and 2-4-008:09 (portion).

Landmarks include Kūlani Cone, Pu'u Kipu and Pu'u Maka'ala. The Reserve is bordered by the Upper Waiākea FR on the north and east, the 'Ōla'a FR on the east, the 'Ōla'a Tract of HAVO to the south, and private property to the west (Kamehameha Schools), southwest and southeast (numerous agricultural parcels). The former Kūlani Correctional Facility is being used by the state Department of Defense Youth Challenge Academy (DOD-YCA) under a revocable permit from DLNR. DOD-YCA controls access into the developed portions of the facility from the end of Stainback Highway.

Access to the NAR is from Volcano (via Wright Road and Amaumau Rd) and along Stainback Highway (Figure 11).

Figure 1. Pu‘u Maka‘ala NAR



### *Topography, Climate, Geology, and Soils*

Pu‘u Maka‘ala NAR is located on the eastern, windward slopes of Mauna Loa. Elevations within the NAR range from 2,800 - 6,229 feet (ft) (853 – 1,899 meters (m)).

The average annual rainfall is approximately 79 - 157 inches (2,000 – 4,000 millimeters) and the Reserve receives the prevailing northeast trade winds for much of the year. Condensation from ground-level clouds (fog drip) contributes additional moisture at higher elevations. The moist side of an ecotone (a transition to drier conditions) runs along the western edge of the NAR. Only the uppermost areas are subject to some seasonal nighttime freezing.

The NAR contains a variety of different ages and types of lava flows from Mauna Loa’s northeast rift zone, which contributes to the diversity of soils and vegetation within the Reserve. U.S. Geological Survey (USGS) has mapped seven different age lava substrates in the Reserve (Figure 2). Flow substrate ages range from recent flows (1942) in the northwest corner of Kūlani to flows older than 10,000 years. There are several prominent cinder cones in the Reserve, including Kūlani Cone and Na Lua Mahoe. This area is classified by USGS as within Volcanic Hazard Zones 2 and 3. The Kūlani portion of the NAR is within Zone 2, which includes areas on the northeast rift zone. Since Mauna Loa’s rift zones form prominent ridges, all the areas in Zone 2 are downslope of potential eruption sites. About 20 percent of this area has been covered by lava in historical time, 5 percent since 1950. Other portions of the NAR are within Zone 3, a designation for areas gradationally less hazardous than those in Zone 2 due to greater distance from recently active vents or because the topography makes it less likely that lava flows will cover the area.

Soils in the Reserve were formed in and on various aged volcanic substrates including cinder, ash, pāhoehoe and ‘a‘ā, and the age and type of lava substrate greatly influences soil type (Figure 3). Natural Resources Conservation Services (NRCS) draft soils classification for the area includes twenty-five different soil types. Soils that cover the greatest extent of the NAR include the Ekeuiki-Pekailio complex (3-10% slopes), which consists of deep soils that formed in volcanic ash deposited over ‘a‘ā. Lower elevations of the NAR contain Hao medial loam (3-10 % slopes), which consists of deep and very deep, moderately well drained soils that formed in volcanic ash. The Reserve also contains large areas of Kiloa extremely cobbly highly decomposed plant material (3 – 10% slopes) which consists of thin, well drained soils that formed in organic material and ash overlying ‘a‘ā lava and Keei very cobbly slightly decomposed plant material (3 - 10% slopes) which is similar to Kiloa but formed over pāhoehoe. Other major soil types in the Reserve include deep, well drained soils formed in volcanic ash deposited over cinders (Kūlani hydrous mucky loam) and in material weathered from or formed in volcanic ash (Piuhonua hydrous silty clay loam and Puaulu hydrous silt loam).



Figure 2. Pu‘u Maka‘ala NAR Geology (Substrate Age)

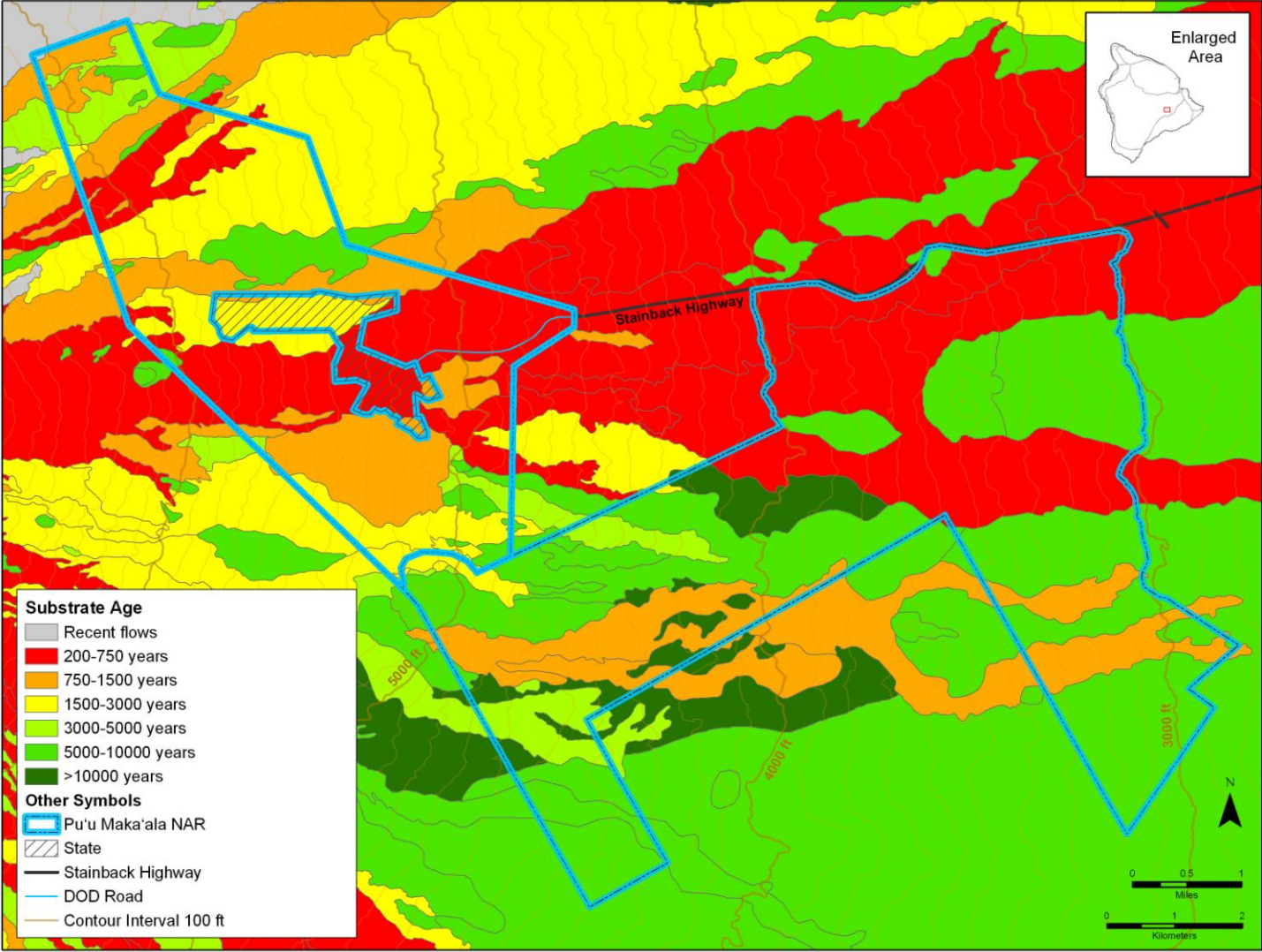
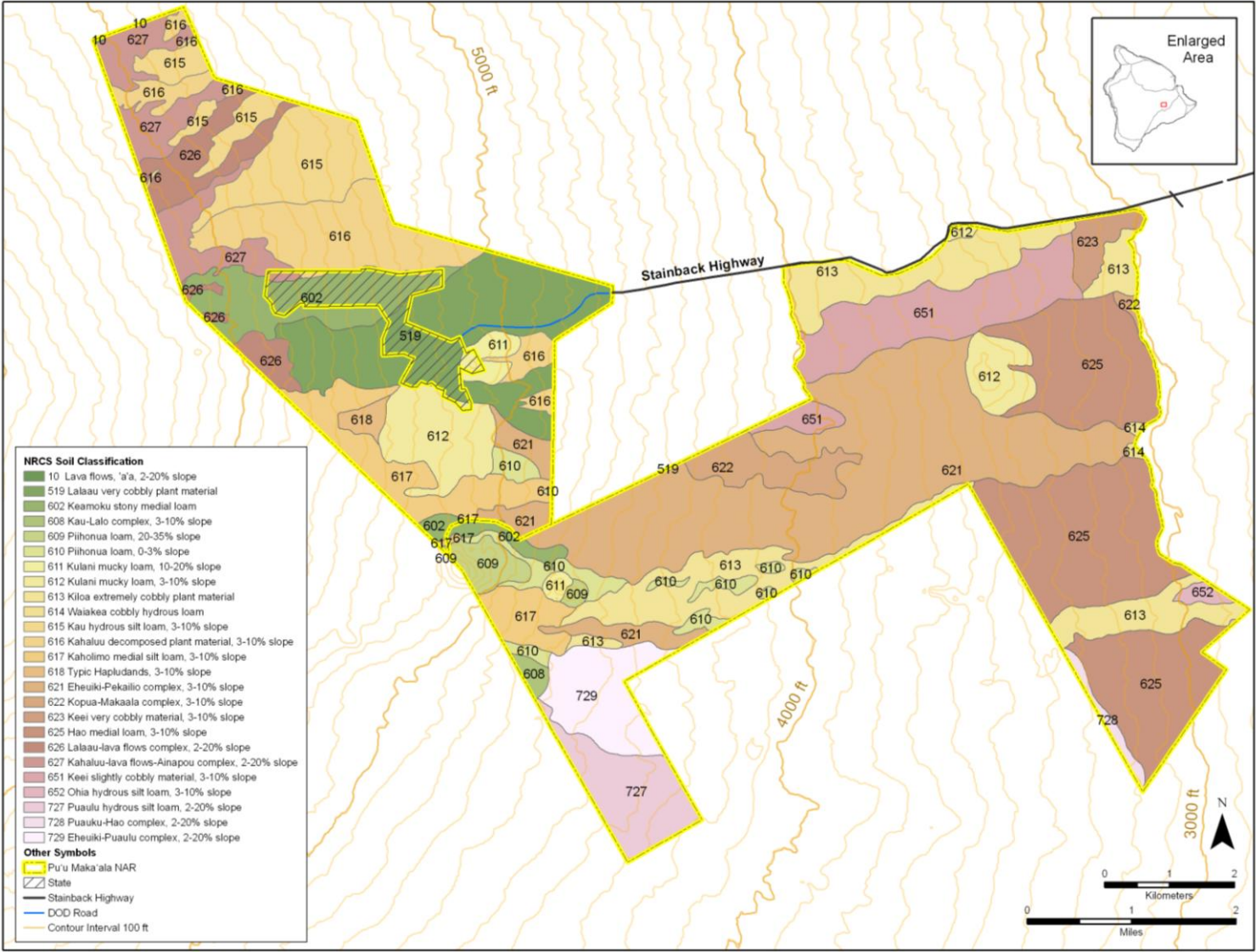


Figure 3. Pu'u Maka'ala Soils



## *Ecosystems and Species*

### Vegetation

Regionally, Pu‘u Maka‘ala NAR is an important conservation parcel and includes some of the best wet and mesic native forest on the island of Hawai‘i. It provides a link between the lower elevation ‘Ōla‘a Tract of Hawai‘i Volcanoes National Park and the higher elevation forests of Kīlauea, Keauhou and Upper Waiākea, thus protecting the transition between ‘ōhi‘a (*Metrosideros polymorpha*) and koa (*Acacia koa*) forest types. These forests contain a full mosaic of different-aged ‘ōhi‘a stands. While much of the forest is predominately ‘ōhi‘a canopy, characteristics of the forest (e.g. density of ‘ōhi‘a, composition of subcanopy and understory) change due to lava substrate type (ash, pāhoehoe, ‘a‘ā and cinder), lava flow age and elevation/rainfall.

Pu‘u Maka‘ala NAR contains three general vegetation zones: lowland wet, montane wet and montane mesic. The lowland wet vegetation zone includes areas in the NAR below 3,281 ft (1,000 m). This zone transitions into the montane wet forest zone at higher elevations and contains similar species. In the Kūlani portions of the NAR, the general trend is from montane wet forest in the east to mesic habitats at the upper elevation, western portions (Figure 4). Appendix A contains a list of plant species currently known from the NAR.

‘Ōhi‘a Lowland Wet Forest is present in the lower elevation, eastern side of the NAR (Figure 4). This forest type contains ‘ōhi‘a canopy with hāpu‘u (*Cibotium spp.*) and other native trees and shrubs similar to those in the ‘Ōhi‘a/Hāpu‘u Montane Wet Forest described below. Non-native weeds, particularly strawberry guava (*Psidium cattleianum*) are a major component of the lowland wet forests in the NAR. Along the NAR’s boundary, approximately 360 ac (146 ha) of tropical ash (*Fraxinus udei*) plantations constitute the Reserve’s only non-native dominated community. Within the scattered ash trees are elements of the surrounding ‘ōhi‘a/hāpu‘u forest, as well as a variety of non-native species. The tropical ash is spreading into the surrounding native-dominated forest and control of this species is addressed in the weed management program section of this plan.

The montane wet zone contains three native plant communities: ‘Ōhi‘a/Hāpu‘u Montane Wet Forest; Koa/‘Ōh‘ia Montane Wet Forest; and *Carex alligata* Montane Wet Grassland (Figure 4).

‘Ōhi‘a/Hāpu‘u Montane Wet Forest occupies the majority of the Reserve. A variety of substrate types result in a mosaic of different-age stands of ‘ōhi‘a/hāpu‘u forest. The closed ‘ōhi‘a canopies can exceed 75 ft (23 m) in height. Other sections of the ‘ōhi‘a/hāpu‘u forest are in various stages of dieback. These range from a few senescent trees to sections where all trees are dead and fallen, with a few snags standing over a 15 to 30 ft (4.5 to 9 m) canopy dominated by hāpu‘u and native trees. The hāpu‘u layer is dominated by *Cibotium glaucum* (hāpu‘u pulu), but hāpu‘u ‘i‘i (*C. menziesii*) and meu (*C. chamissoi*) can be locally abundant. Native trees include ‘ōlapa (*Cheirodendron trigynum*), kāwa‘u (*Ilex anomala*), pilo (*Coprosma spp.*), kōlea (*Myrsine lessertiana*), smaller stature ‘ōhi‘a, and occasionally naio (*Myoporum sandwicense*), manono (*Hedyotis spp.*), and loulou (*Pritchardia beccariana*). Vegetation under the hāpu‘u layer includes

a mix of native ferns such as *Pneumatopteris sandwichensis*, hō‘i‘o (*Diplazium sandwichianum*), ‘ama‘u (*Sadleria* spp.), *Dryopteris* spp., and uluhe (*Dicranopteris linearis*), native shrubs like kanawao (*Broussaisia arguta*), ‘ōhā wai (*Clermontia* spp.), ha‘iwale (*Cyrtandra* spp.), hāhā (*Cyanea* spp.), maile (*Alyxia oliviformis*), ālani (*Melicope* spp.), and ‘ōhelo (*Vaccinium* spp.), and herbs such as pa‘iniu (*Astelia menziesiana*) and ‘ala‘ala wai nui (*Peperomia* spp.). Sedges such as *Carex alligata* and *Uncinia uncinata* are also present.

Koa/‘Ōhi‘a Montane Wet Forest occupies a small portion of the northwestern edge of the Reserve on cinder and ash substrate in the Kūlani Cone area. Scattered individual koa trees, from 60 to 120 ft (18 to 36.5 m) in height, emerge from a layer of 30 to 90 ft (9 to 27 m) tall ‘ōhi‘a. Under the canopy is an association of native trees that include kōlea, kāwa‘u, ‘ōlapa, pilo, and young ‘ōhia. While the ‘ōhi‘a/hāpu‘u and koa/‘ōhi‘a wet forests share many of the same species, the ‘ōhi‘a/hāpu‘u wet forest contains a higher overall diversity due its larger area and expanded elevational range.

*Carex alligata* Montane Wet Grassland is scattered in small distinct patches throughout the Reserve, occupying low lying water-saturated areas such as cinder cone pits or depressions in the forest. These grasslands may consist entirely of *Carex* but may also include scattered shrubs of ‘ōhi‘a and patches of wawae’iole (*Lycopodium*). The largest examples in the NAR occupy cinder cone craters on Kūlani Cone and Na Lua Mahoe.

Montane mesic plant communities are found in the Kūlani portion of the NAR.

Koa/‘Ōhi‘a Montane Mesic Forest - Portions of Kūlani contain tall stature koa/‘ōhi‘a forest with other native trees and a hāpu‘u, native shrubs and ground fern understory. This forest type differs from the wet koa/‘ōhi‘a in that wet forest tends to have higher densities of hāpu‘u than mesic areas, which have more native trees and shrubs in the understory. Unless disturbed, both forest types have a diverse ground cover dominated by ferns.

‘Ōhi‘a Montane Mesic Forest - Portions of Kūlani contain plant communities composed primarily of open to closed canopy /‘ōhi‘a and an understory of native trees, shrubs, ferns and grasses without the prominent hāpu‘u component. This community can be found on intermediate aged lava flows as well as on young lava flows in association with other pioneer vegetation.

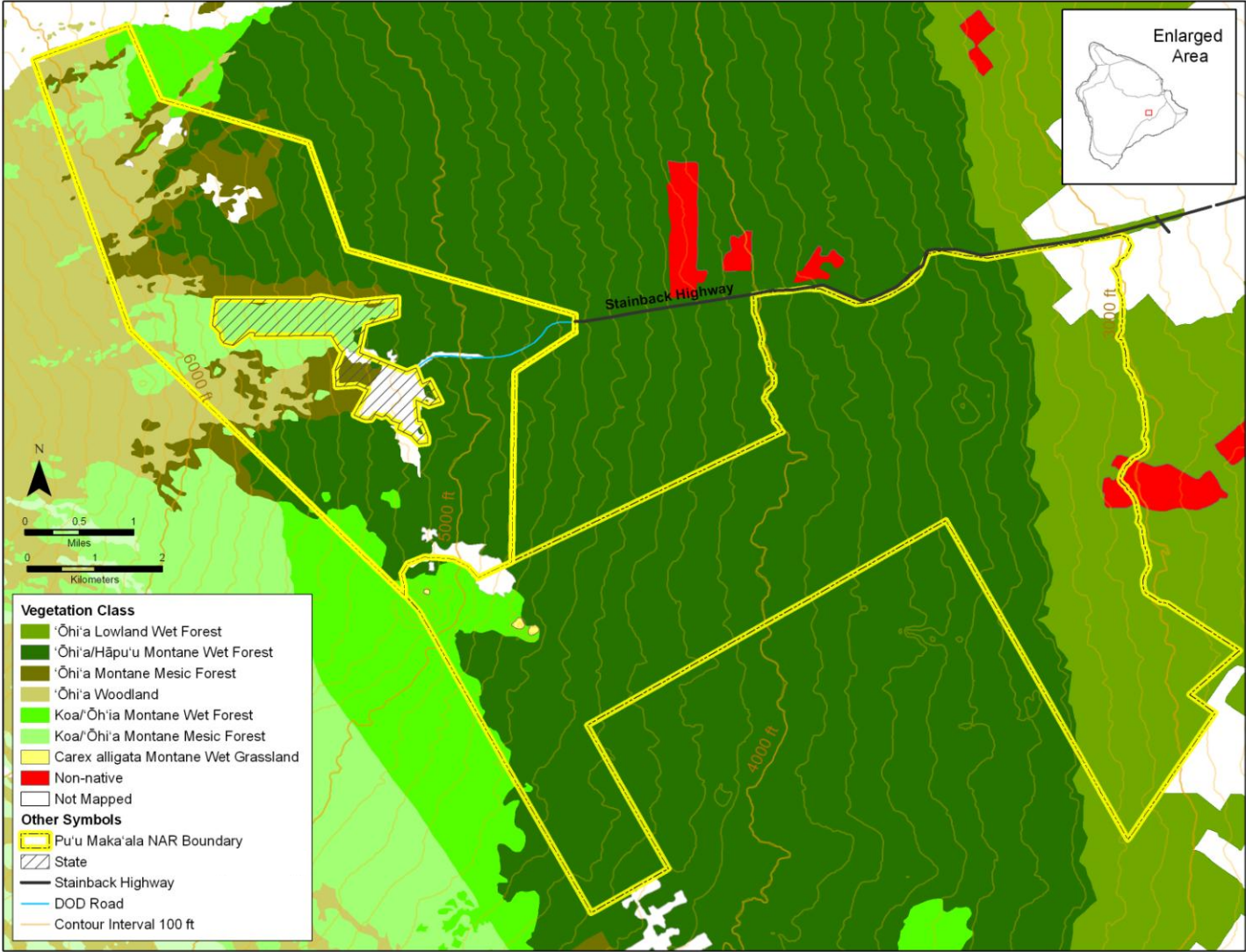
‘Ōhi‘a Woodland - This plant community consists of open canopy ‘ōhi‘a with mixed native trees and a native shrub and native grass (*Deschampsia nubigena*) understory. This community is found on young to intermediate aged lava flows in the higher elevation, drier parts of Kūlani. Some areas within this community have depressions in the lava flow surface that collect water and have formed perennial wetlands containing native grasses and sedges.

A diversity of native plants is found within the natural communities of Pu‘u Maka‘ala, including over 160 plant and fern species endemic to Hawai‘i (Appendix A contains a list of native and introduced plant species currently known from the NAR, including endemic species). Fifteen species of federally listed endangered plants occur in or near Pu‘u Maka‘ala NAR, and Pu‘u Maka‘ala contains federally designated critical habitat for seven endangered plants: *Argyroxiphum kauense*, *Clermontia lindseyana*, *Cyanea shipmanii*, *Sicyos alba*, *Cyrtandra*

*giffardii*, *Cyanea stictophylla*, and *Phyllostegia velutina*. Pu‘u Maka‘ala provides habitat for another twenty plant species that are Candidates for listing or considered Species of Concern (SOC) (Table 1).

Numerous other plant species historically and/or currently found in or near the NAR have no official status but are considered rare by NAR staff, other land managers and/or scientists. These species include: *Dubautia* sp. (unknown species), *Embilia pacifica* (kilioe), *Nothoctrum longifolium* (‘aiea), *Phyllostegia vestita*, *Phytolacca sandwicensis*, *Plantago pachyphylla*, *Platydesma spathulata*, *Stenogyne scrophularioides* (mā‘ohi‘ohi), *Tetraplasandra kavaiensis* (‘ohe ‘ohe), *Tetraplasandra oahuensis* (‘ohe mauka) and *Urera glabra* (ōpuhe).

Figure 4. Pu‘u Maka‘ala NAR Vegetation



**Table 1. Endangered and rare plant species historically and/or currently found in or near Pu‘u Maka‘ala NAR.**

<b>Taxon</b>	<b>Common name</b>	<b>Status*</b>	<b>NAR Critical Habitat</b>	<b>Location**</b>
<i>Adenophorus periens</i>	palai la‘aū	E		‘Ōla‘a Tract
<i>Anoectochilus sandwicensis</i>	jewel orchid	SOC		‘Ōla‘a Tract
<i>Argyroxiphum kauense</i>	Mauna Loa silversword	E	Yes	Pu‘u Maka‘ala (Kūlani)
<i>Asplenium schizophyllum</i>		SOC		Pu‘u Maka‘ala
<i>Asplenium peruvianum</i> var. <i>insulare</i>		E		Kīlauea, Pu‘u Maka‘ala
<i>Clermontia lindseyana</i>	‘oha wai	E	Yes	Pu‘u Maka‘ala (Kūlani), Kīlauea
<i>Clermontia peleana</i>	‘oha wai	E		‘Ōla‘a FR, Pu‘u Maka‘ala
<i>Cyanea coplandii</i>	hāhā	E (X)		660-1,600 m wet forest
<i>Cyanea giffardii</i>	hāhā	SOC(X)		725-800 m wet forest
<i>Cyanea platyphylla</i>	‘akū‘akū	E		Pu‘u Maka‘ala
<i>Cyanea shipmanii</i>	hāhā	E	Yes	Pu‘u Maka‘ala (Kūlani), Kīlauea
<i>Cyanea stictophylla</i>	hāhā	E	Yes	Pu‘u Maka‘ala (Kūlani), Kīlauea, Pu‘u Maka‘ala
<i>Cyanea tritomantha</i>	‘akū	C		Pu‘u Maka‘ala
<i>Cyrtandra giffardii</i>	ha‘iwale	E	Yes	Pu‘u Maka‘ala
<i>Cyrtandra tintinnabula</i>	ha‘iwale	E		‘Ōla‘a Tract
<i>Eurya sandwicensis</i>	ānini	SOC		Pu‘u Maka‘ala
<i>Fragaria chiloensis</i> ssp. <i>sandwicensis</i>	‘ōhelo papa	SOC		Keauhou
<i>Gardenia remyi</i>	nānū	C		Upper Waiakea FR
<i>Joinvillea ascendens</i> ssp. <i>ascendens</i>	‘ohe	C		Pu‘u Maka‘ala
<i>Liparis hawaiiensis</i>	‘awapuhiakanaloa	SOC		‘Ōla‘a Tract
<i>Pittosporum hawaiiense</i>	hō ‘awa	SOC		Pu‘u Maka‘ala (Kūlani)
<i>Phyllostegia ambigua</i>		SOC		Pu‘u Maka‘ala
<i>Phyllostegis floribunda</i>		C		Pu‘u Maka‘ala, ‘Ōla‘a Tract Upper Waiakea FR

<b>Taxon</b>	<b>Common name</b>	<b>Status*</b>	<b>NAR Critical Habitat</b>	<b>Location**</b>
<i>Phyllostegia macrophylla</i>		SOC		Pu'u Maka'ala, Kīlauea
<i>Phyllostegia racemosa</i>	kīponapona	E		Keauhou
<i>Phyllostegia velutina</i>		E	Yes	Pu'u Maka'ala
<i>Pritchardia beccariana</i>	loulu	SOC		Pu'u Maka'ala
<i>Rubus macraei</i>	'ākala	SOC		Pu'u Maka'ala (Kūlani), Keauhou
<i>Schieda diffusa</i>		SOC		'Ōla'a Tract
<i>Sicyos alba</i>	'ānunu	E	Yes	Pu'u Maka'ala
<i>Sisyrinchium acre</i>	mau'u lā'ili	SOC		Pu'u Maka'ala (Kūlani)
<i>Stenogyne macrantha</i>	mā'ohi'ohi	SOC		Pu'u Maka'ala
<i>Trematolobelia grandifolia</i>	koli'i	SOC		Pu'u Maka'ala
<i>Vicia menziesii</i>	Hawaiian vetch	E		Kīlauea, Keauhou
<i>Zanthoxylum kauaense</i>	a'e, mānele, hea'e	SOC		Upper Waiakea and 'Ōla'a FR
* E = endangered; T = threatened; C = candidate for listing; SOC = species of concern; (X) = possibly extinct				
** Species with populations historically/currently known from Pu'u Maka'ala NAR or nearby locations are noted.				



## Wildlife

The project area provides habitat for seven honeycreepers (Subfamily Drepanidinae) endemic to the Hawaiian Islands. These include four endangered species: Hawai‘i creeper (*Oreomystis mana*), Hawai‘i ‘ākepa (*Loxops coccineus*), ‘akiapōlā‘au (*Hemignathus munroi*) and ‘ō‘ū (*Psittirostra psittacea*), a species which has not been sighted in the area since the mid-1980’s and may be extinct. The non-endangered honeycreepers found in the project area include: ‘apapane (*Himatione sanguinea*), Hawai‘i ‘amakihi (*Hemignathus virens*), and ‘i‘iwi (*Vestiaria coccinea*). Other native forest birds reported from the project area include, ‘elepaio (*Chasiempis sandwichensis*), and ‘ōma‘o or Hawaiian thrush (*Myadestes obscurus*). Native forest birds are primarily found in the upper elevations of the NAR (above 4,000 ft (1,219 m)) elevation where lower numbers of mosquitoes reduce the incidence of diseases such as avian malaria and pox.

The Kūlani portion of the NAR is identified as a recovery area for Hawai‘i creeper, Hawai‘i ‘ākepa, and ‘akiapōlā‘au in the U.S. Fish and Wildlife Service (FWS) forest bird recovery plan and in the State Comprehensive Wildlife Strategy. Recovery areas are habitat that will allow for the long-term survival and recovery of endangered Hawaiian forest birds. The Kūlani area has some of the highest densities of native forest birds on the island. This relative abundance is due to large tracts of intact, upper elevation native forest. Kūlani may also be considered as a potential future release site for captively-raised Hawaiian crow, or ‘alalā (*Corvus hawaiiensis*). Although this species is not historically known from this area, ‘alalā are known historically from nearby (Hawaii Volcanoes National Park) and neighboring Keauhou is being considered as a possible release site. Other native birds known from the area include the endangered Hawaiian hawk or ‘io (*Buteo solitarius*), nēnē (*Branta sandvicensis*), Hawaiian owl or pueo (*Asio flammeus sandwichensis*) and Pacific golden-plover or kōlea (*Pluvialis fulva*). Additionally, the ‘ua‘u or Hawaiian petrel (*Pterodroma sandwichensis*) and the ‘akē‘akē or band-rumped storm petrel (*Oceanodroma castro*) may overfly the NAR going to nesting areas on the upper, eastern slopes of Mauna Loa.

**Table 2. Native birds historically and/or currently found in or near Pu‘u Maka‘ala NAR.**

<b>Taxon</b>	<b>Common Name</b>	<b>Status</b>
<i>Corvus hawaiiensis</i>	‘alalā, Hawaiian crow	endemic - endangered
<i>Asio flammeus sandwichensis</i>	pueo, Hawaiian owl	endemic
<i>Branta sandvicensis</i>	nēnē, Hawaiian goose	endemic - endangered
<i>Buteo solitarius</i>	‘io, Hawaiian hawk	endemic - endangered
<i>Chasiempis sandwichensis</i>	‘elepaio	endemic
<i>Hemignathus munroi</i>	‘akiapōlā‘au	endemic - endangered
<i>Hemignathus virens</i>	‘amakihi	endemic
<i>Himatione sanguinea</i>	‘apapane	endemic
<i>Loxops coccineus</i>	Hawai‘i ‘ākepa	endemic - endangered
<i>Oceanodroma castro</i>	‘akē‘akē, band-rumped storm petrel	indigenous - candidate
<i>Oreomystis mana</i>	Hawai‘i creeper	endemic - endangered
<i>Myadestes obscurus</i>	‘ōma‘o	endemic
<i>Pluvialis fulva</i>	kōlea, Pacific golden plover	indigenous
<i>Psittirostra psittacea</i>	‘ō‘ū	endemic – endangered

<i>Pterodroma sandwichensis</i>	‘ua‘u or Hawaiian petrel	endemic - endangered
<i>Vestiaria coccinea</i>	‘i‘iwi	endemic

Non-native birds including Japanese white-eye (*Zosterops japonicus*), red-billed leiothrix (*Leiothrix lutea*), northern cardinal (*Cardinalis cardinalis*) and kalij pheasant (*Lophura leucomelanos*) are common in the NAR.

Appendix B provides a list of native and non-native bird species currently and/or historically known from Pu‘u Maka‘ala.

Although native invertebrates were only incidentally noted during 1989 surveys, a high diversity of representative insects, spiders and snails, particularly *Succinia* spp. was observed. An arthropod survey conducted in 1995 using malaise traps, pitfall and pan traps, general collecting using an aerial sweep net, and visual searching collected and recorded 217 species of insects, related arthropods and land snails from the Wright Road unit of Pu‘u Maka‘ala. Of those identified, 58% were native species. Appendix C provides a list of invertebrates collected from the Pu‘u Maka‘ala section of the NAR during a 1995 survey, including non-native invertebrates and land snails. Table 3 summarizes notable insects found during the 1995 survey including: three species of picture wing flies (*Drosophila* spp.), three endemic genera of leaf hoppers (*Leialoha*, *Nesodyne*, and *Nesothoe*), and one species of endemic damselfly (*Megalagrion hawaiiense*). Portions of the NAR were surveyed for an endemic lineage of spiders: the genus *Tetragnatha*. Although spiders are one of the most important groups of predators in the Hawaiian forests, they are virtually unknown; perhaps because of they are almost exclusively nocturnal (Gillespie 1992). The NAR is federally designated as critical habitat for *Drosophila mulli*, a listed endangered picture wing fly which is dependant on the native loulu (*Pritchardia beccariana*). In 2011, the NARS Invertebrate Program organized a four-day invertebrate Bioblitz in the Kūlani section of the Reserve. This effort will result in an updated invertebrate species list for the Reserve as well as provide information for future management actions targeting native invertebrates.

Although the lava tube caves in the area have not been investigated, research in adjacent areas has documented a well-preserved cave fauna. Lava tube caves harbor specialized invertebrate species dependent on native forests above the caves (Mueller-Dombois et al. 1981).

Hawai‘i’s only endemic land mammal, the ‘ōpe‘ape‘a or endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), also uses the area but the Reserve has not been sampled for bat activity.

A variety of non-native animals such as feral pigs, rats (*Rattus* spp.), mice (*Mus musculus*), cats (*Felis catus*), and mongoose (*Herpestes auro punctatus*) are present in the Reserve. Coqui frogs (*Eleutherodactylus coqui*) have been found at Kūlani, at the facility complex, and in areas adjacent to the NAR such as along Stainback Highway.

**Table 3. Notable Native Insects in Pu‘u Maka‘ala NAR (summarized from Preston 1995).**

<b>TAXA</b>	<b>DESCRIPTION</b>
<b>COLEOPTERA</b> Aglycyderidae (Proterinid Weevils)	These tiny (less than 3 mm long) primitive weevils are remarkably diverse in Hawai‘i. About 175 species are known only from Hawai‘i; these constitute more than 90% of the world’s fauna in the family. The larvae are wood borers, mostly in twigs and stems of native plants, and most species are host specific. Unidentified species were collected in the NAR
<b>DIPTERA</b> Drosophilidae (Pomace Flies) <i>Drosophila</i> spp. (picture wing group)	Hawaiian Drosophilidae are one of the best studied examples of adaptive radiation. Over 600 species have been described, and another 200 species are known but not yet named. The existence of such a diverse fauna in Hawai‘i provides an ideal natural laboratory for comparative studies in evolutionary biology. At least 3 species belonging to the large "picture wing" group were collected. The NAR is critical habitat for the listed endangered species <i>Drosophila mulli</i> (not detected in the 1995 surveys by Preston).
Muscidae (House Flies and relatives) <i>Lispocephala confluens</i> (Malloch, 1928) <i>Lispocephala dexioides</i> (Grimshaw, 1901) <i>Lispocephala ingens</i> (Grimshaw, 1901)	The endemic genus <i>Lispocephala</i> contains over 100 known species, which are all predatory on other insects. Thirty species are known from the Big Island, and of these only 3 species were collected: <i>Lispocephala confluens</i> previously only known from Moloka‘i and Maui, <i>L. dexioides</i> , known only from Maui and the Big Island, and <i>L. ingens</i> , known from Oahu, Moloka‘i, Maui and the Big Island.
<b>HETEROPTERA</b> Miridae (Plant Bugs) <i>Hyalopeplus pellucidus</i> (Stål, 1859) <i>Orthotylus</i> spp. <i>Sarona</i> sp.	Hawaiian plant bugs remain poorly known (about 50 species have been named, but at least another 100 species are in collections). Most species are plant feeders, but many are predaceous or omnivorous. Many species are found only in a small geographical area and feed on a single species of plant. Three native species were identified: <i>Hyalopeplus pellucidus</i> is a common species with a wide host range, including guava and other alien plant species; <i>Orthotylus</i> , a widespread genus; and the endemic genus <i>Sarona</i> .
Nabidae (Damsel Bugs) <i>Nabis oscillans</i> Blackburn, 1888	The damsel bugs are all predatory on other insects. There are 30 Hawaiian species, but new species continue to be discovered. <i>Nabis oscillans</i> Blackburn, 1888 was collected.
Pentatomidae (Stink Bugs and Shield Bugs)	<i>Coleotichus blackburniae</i> , the koa bug, is the largest and most conspicuous native true bug (nearly an inch long and iridescent blue, green, maroon, and yellow). Once common on koa and a‘alii throughout Hawai‘i, it is now rare due to the introduction of several parasites for biological control of the pestiferous southern green stink bug in the 1960’s. Historically known from the NAR, but none were seen during this survey.
<b>HOMOPTERA</b> Cicadellidae <i>Nesophrosyne</i> spp.	Seven endemic genera of leaf hoppers, plant hoppers, and psyllids were collected. Several species in the native genus <i>Nesophrosyne</i> (Cicadellidae) were abundant.
Cixiidae <i>Iolania perkinsi</i> Kirkaldy, 1902 <i>Oliarus</i> (2 species)	<i>Iolania perkinsi</i> Kirkaldy, 1902 a native cixiid restricted to Hawai‘i island and associated with native ferns, was common. Specimens of two species in the other native genus <i>Oliarus</i> were also collected.
Delphacidae <i>Leialoha</i> sp. <i>Nesosydne</i> (2 species) <i>Nesothoe</i> sp.	Three endemic genera of leaf hoppers were common in Pu‘u Maka‘ala: <i>Leialoha</i> , <i>Nesosydne</i> , and <i>Nesothoe</i> .
<b>HYMENOPTERA</b> Ichneumonidae (Ichneumon wasps)	These wasps are parasites of other insects; the adult female searches for, and lays eggs in, suitable hosts. Individuals of several species were collected sporadically as expected. In addition, on one occasion, dozens

<p><i>Enicospilus nigrolineatus</i> Ashmead, 1901  <i>Enicospilus</i> (2 species)  <i>Spolas</i> nr. <i>hawaiiensis</i> (Ashmead, 1901)  <i>Spolas</i> (2 species)</p>	<p>of individuals of the native genus, <i>Enicospilus</i>, were collected. <i>Enicospilus nigrolineatus</i> (Ashmead, 1901), a very large and showy species was collected in every Malaise trap sample. Two undetermined <i>Enicospilus</i> spp. were also present in the trap in larger numbers. Three species in the native genus <i>Spolas</i> were also found as well as the ever abundant and purposely introduced parasite, <i>Ichneumon purpuripennis</i> Cresson, 1877. Other native species of wasps were collected in and around the trap sites, but identification will have to wait for specialists.</p>
<p><b>LEPIDOPTERA</b>  Crambidae (Crambid Moths)  <i>Eudonia</i> (5 species)  <i>Mestolobes minuscula</i> (Butler, 1881)  <i>Mestolobes</i> sp.</p>	<p>The crambids are a diverse group of mostly small moths, which are exceptionally well-represented in Hawai'i (206 named species). The genus <i>Mestolobes</i> with 33 species is endemic to Hawai'i. <i>Mestolobes minuscula</i> (Butler, 1881) is a common moth in the lowlands yet nothing is known of its biology. Adults of many <i>Eudonia</i> species resemble the lichens upon which they rest, and the larvae are probably associated with lichens. There are over 100 species in the genus, but many remain undescribed.</p>
<p>Geometridae (Inchworms)  <i>Eupithecia monticolens</i> Butler, 1881  <i>Scotorythra artemidora</i> Meyrick, 1899  <i>Scotorythra brunnea</i> (Warren, 1896)  <i>Scotorythra euryphaea</i> Meyrick, 1899  <i>Scotorythra pachyspila</i> Meyrick, 1899</p>	<p>The genus <i>Scotorythra</i> contains 38 species, all endemic to the Hawaiian Islands. Two species, <i>S. diceraunia</i> Meyrick, 1928 and <i>S. euryphaea</i> Meyrick, 1899 are new records for the island of Hawai'i. Specimens of the predatory inchworm <i>Eupithecia monticolans</i> Butler, 1881 were also trapped.</p>
<p>Lycanidae and Nymphalidae (Blue and Brush-footed Butterflies)  <i>Vanessa tameamea</i> Eschscholtz, 1821</p>	<p>Only two species of butterflies are native to Hawai'i, a blue (Blackburn's butterfly, or <i>Udara blackburni</i> (Tuely, 1878), which feeds on koa, a'alii and other legumes) and an admiral or brush-footed butterfly (Kamehameha butterfly or <i>Vanessa tameamea</i> Eschscholtz, 1821, which feeds on mamaki and other Urticaceae). Both species are locally common where their hosts are found. Only the Kamehameha butterfly was observed flying near both trapping sites.</p>
<p><b>ODONATA</b>  Coenagrionidae (Damselflies)  <i>Megalagrion hawaiiense</i> (McLachlan, 1883)</p>	<p>There are 29 species in the endemic genus <i>Megalagrion</i>. <i>M. hawaiiense</i> (McLachlan, 1883) was frequently encountered in rain puddles throughout the Reserve. The historic record yielded 5 other species of damselflies known to inhabit the Reserve. <i>M. calliphya microdemas</i> (Perkins, 1899), <i>M. peles</i> (Perkins, 1899) and two alien species: <i>Enallagma civile</i> (Hagen, 1862) and <i>Ischnura ramburii</i> (Selys-Longchamps).</p>
<p><b>ORTHOPTERA</b>  Gryllidae (Crickets)  <i>Laupala</i> spp.  <i>Paratrigonidium</i> sp.</p>	<p>There are 243 native species of crickets known from Hawaii (Otte 1994), which is more than twice as many as the total number known from the rest of the United States. Most native species have restricted ranges; some are known from only small areas within single islands. Their great diversity makes them ideal for evolutionary studies (Otte, 1994). Hawaiian crickets live mostly in trees and shrubs, but some forage in the leaf litter. Most are omnivores, feeding on both plant and animal material. Two native genera of swordtail crickets (<i>Trigonidium</i> and <i>Laupala</i>) were collected in Pu'u Maka'ala.</p>

**PU‘U MAKA‘ALA NAR: SOCIOCULTURAL RESOURCES*****Land Use***

All of Pu‘u Maka‘ala NAR is located within the State Conservation District. The Reserve includes both the Protective and Resource Subzones. Conservation District Use Permit no. SH-3/9/81-1340 approves the creation and management of the NAR as a permitted use of the Conservation District. Under the 2005 Hawai‘i County General Plan, all of Pu‘u Maka‘ala is designated as Conservation by the Land Use Pattern Allocation Guide. The area is not within the County’s Special Management Area. The Pu‘u Maka‘ala Management Plan is consistent with or implements portions of numerous existing plans and cooperative efforts (Table 4).

In July 2009, the Division of Public Safety announced the closure of the 7,244 acre (2,932 ha) Kūlani Correctional Facility. In May 2010, The NARS Commission recommended the addition of portions of Kūlani to Pu‘u Maka‘ala NAR, which was approved by the Board of Land and Natural Resources (BLNR) in September 2010. In November 2010, the Governor signed Executive Order 4338 adding 6,600 ac (2,671 ha) of Kūlani to Pu‘u Maka‘ala NAR.

The NAR surrounds approximately 600 ac (243 ha) of state lands formerly used by Kūlani Correctional Facility. The main campus of the former Kūlani Correctional Facility (approximately 280 ac (113 ha)) is being used by DOD-YCA under a revocable permit from DLNR (Figure 15). DOFAW has access, utility and conservation easements over this area, and DOD-YCA and DOFAW are required to develop a memorandum of agreement regarding access by DOFAW over the internal roads, conservation management, road maintenance, and conditions under which public access will be permitted, etc. The memorandum of agreement will be presented to the BLNR by January 28, 2011. DOD-YCA is planning to use these lands until they find a new location for their program and/or the State Division of Public Safety decides to reopen Kūlani Correctional Facility. DOFAW will be requesting approximately 342 ac (138 ha) of former pasture as an addition to Pu‘u Maka‘ala NAR (Figure 15). DOFAW currently has a right of entry permit for this area for data collection, survey and conservation management while this request is processed. This area is a high priority for addition to the NAR due to the recovery of ‘ōhi‘a - koa forests following the removal of cattle in 2005 and the presence of rare and endangered plants and animals.

Public access is allowed in the NAR for recreational and cultural uses. Current public use of Pu‘u Maka‘ala primarily includes hiking, bird watching, and hunting. Hunting in portions of the NAR is regulated by Chapter 13-123, Hawaii Administrative Rules (Rules Regulating Game Mammal Hunting), and areas where hunting is allowed are designated as part of Hunting Unit K. Some uses, including hiking or nature study with groups larger than ten, research, scientific collecting, gathering (including Native Hawaiian religious and customary gathering rights) and commercial uses require a Special Use Permit from the Executive Secretary of the NARS Program in Honolulu (808-587-0063) (Hawai‘i Administrative Rules 13-209).

**Table 4. Consistency with other plans and cooperative efforts.**

<b>Plan/Cooperative Effort</b>	<b>Comment</b>
The Rain Follows the Forest - A Plan to Replenish Hawaii's Source of Water (DLNR, November 2011)	The Reserve is identified as a priority watershed area on the island of Hawai'i
DOFAW Statewide Assessment and Resource Strategy (SWARS) 2010	Identifies areas of greatest need and opportunity for forests in Hawaii and develops a long-term strategy for management. Objectives include: 1.1. Identify and conserve high-priority forest ecosystems and landscapes; 2.2. Identify, manage and reduce threats to forest and ecosystem health; 3. 3. Enhance public benefits from trees and forests; 3.1. Protect and enhance water quality and quantity; 3.5. Protect, conserve and enhance wildlife and fish habitat; 3.7. Manage and restore trees/forests to mitigate and adapt to global climate change.
U.S. Fish and Wildlife Designation of Critical Habitat for 12 Species of Picture-Wing Flies From the Hawaiian Islands (2009)	Supports recommendations for habitat management for <i>Drosophila mulli</i>
Three Mountain Alliance (TMA) Management Plan (2008) and TMA Weed Management Plan (2009)	Supports mission and goals of the TMA watershed partnership and TMA weed management
Puna Community Development Plan (2008)	Mentions Pu'u Maka'ala NAR and discusses the importance of preserving native forests and species.
U.S. Fish and Wildlife Revised Recovery Plan for Hawaiian Forest Birds (2006)	Supports recovery actions 1 and 2: protect and manage ecosystems for the benefit and recovery of native forest birds.
Hawai'i Comprehensive Wildlife Conservation Strategy (2005)	Implements objectives 1, 2, 3, 4, and 5
County of Hawai'i General Plan (2005)	8.2(c) Protect and promote the prudent use of Hawaii's unique, fragile, and significant environmental and natural resources. 8.2 (d) Protect rare or endangered species and habitats native to Hawai'i. 8.3 (b) Encourage a program of collection and dissemination of basic data concerning natural resources. 8.3 (e) Encourage an overall conservation ethic in the use of Hawai'i resources by protecting, preserving, and conserving the critical and significant natural resources of the County. 8.3 (o) Encourage the continued identification and inclusion of unique wildlife habitat areas of native Hawaiian flora and fauna with the NARS.
U.S. Fish and Wildlife Final Designation and Nondesignation of Critical Habitat for 46 Plant Species From the Island of Hawaii, HI (2003)	Supports recommendations for habitat management for <i>Sicyos alba</i> , <i>Cyrtandra giffardii</i> , <i>Cyanea stictophylla</i> , and <i>Phyllostegia velutina</i>
U.S. Fish and Wildlife Service Recovery Plan for the Multi-Island Plants (1999)	Supports objective 1: protect habitat and control threats for <i>Adenopherus periens</i>
U.S. Fish and Wildlife Service. Big Island II: Addendum to the Recovery Plan for the Big Island Plant Cluster (1998a)	Supports objective 1: protect current populations and manage threats for <i>Phyllostegia racemosa</i> , <i>Phyllostegia velutina</i> and <i>Sicyos alba</i> .
U.S. Fish and Wildlife Service Final Recovery Plan for Four Species of Hawaiian Ferns (1998b)	Supports objective 1: protect current populations and manage threats for <i>Asplenium peruvianum</i> var. <i>insulare</i>
U.S. Fish and Wildlife Recovery Plan for the Hawaiian Hoary Bat (1998c)	Supports objective 2: protect and manage current populations and identify and manage threats
U.S. Fish and Wildlife Recovery Plan for the Big Island Plant Cluster (1996)	Supports objective 1: protect current populations and manage threats for <i>Clermontia lindseyana</i> , <i>Clermontia peleana</i> , <i>Cyanea copelandii</i> , <i>Cyanea stictophylla</i> ,

<i>Cyrtandra giffardii</i> , and <i>Cyrtandra tintinnabula</i> .
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### ***Cultural Resources***

In 2004, Kumu Pono Associates prepared *He Mo'olelo 'Āina: A Cultural Study of the Pu'u Maka'ala Natural Area Reserve, District of Hilo and Puna, Island of Hawai'i*, a detailed study of historical and archival literature and limited oral history interviews and consultation with kama'aina and others with knowledge of the land. This document is an important reference for cultural resources management in the NAR. Excerpts from the study are included below. The complete study is available at <http://hawaii.gov/dlnr/dofaw/nars/reserves/big-island/puumakaala>.

“The Natural Area Reserve takes its name from Pu'u Maka'ala, literally, Stay-alert Hill—named by State Forester, Ralph Daelher in the early 1960s—the summit of which is situated a little more than 3,600 feet above sea level. While the name of the *pu'u* is of recent origin, no older name identifiable with the hill was located. Many *pu'u* on the uplands slopes of the Hilo and Puna Districts are named, and it is likely that in traditional times this hill too had a name or names, depending on the area it was viewed from.

The native traditions and historical accounts associated with the neighboring lands of the upper Hilo-Puna forests span many centuries, from Hawaiian antiquity to the later period following western contact. The narratives describe customs and practices of the native people who resided on these lands, walked the trails, and who were sustained by the wealth of the forest lands.

Among the most detailed descriptions of the Hilo-Puna forest lands, including documentation of traditional and customary rights, are those found in the Kingdom collections, documenting the history of land tenure, and defining the boundaries of *ahupua'a* of Waiākea and 'Ōla'a. Detailed oral testimonies from elder native tenants were taken in court proceedings of the mid to late 1800s, document the occurrence of traditional and customary practices, and nature of the resources within given *ahupua'a*. In those records, we learn of the traditional knowledge and occurrence of native practices in the lands which today are a part of, and adjoin the Pu'u Maka'ala NAR.

Because the lands of the upper 'Ōla'a and Waiākea region were remote, it appears that access was most frequently made by specialists in the collection of bird feathers, the makers of canoes, and collectors of other unique items for which the region may have been known. Except for the detailed narratives of the tradition of Pikoi-a-ka-'alalā, most other traditions, and early historical accounts by native Hawaiians, seem to place the routes of travel beyond the limits of the lands within the Pu'u Maka'ala NAR. The main routes being out of Hilo through 'Ōla'a, *mauka*, near its boundary with Kea'au, or *mauka* between Kīlauea, across Keauhou (of Kapāpala in Ka'ū), within view of the boundary between 'Ōla'a (Pu'u Kūlani), and out across the Waiākea and Humu'ula lands of the Hilo District. Thus, there appears to be little specific reference in the historical record to the immediate study area lands.

From the journals, letters, and articles of historic visitors traveling the routes mentioned above, we are given a glimpse into the nature of the landscape, and a record of changes

thereon, with the passing of time. As outlying lands were changed—resulting from the impacts of introduced grazing animals, and in some instances from lava flows of Mauna Loa—we develop a sense of why the Pu‘u Maka‘ala NAR is important to the future well-being of the Hawaiian natural environment. The NAR is a remnant of the unique cultural and natural landscape as described in the traditional accounts.

In Hawai‘i prior to western contact, all land, ocean and natural resources were held in trust by the high chiefs (*ali‘i ‘ai ahupua‘a* or *ali‘i ‘ai moku*). The use of land, fisheries and other resources was given to the *hoa‘āina* (native tenants) at the prerogative of the *ali‘i* and their representatives or land agents (*konohiki*), who were generally lesser chiefs as well. By 1845, the Hawaiian system of land tenure was being radically altered, and the foundation for implementing the *Māhele ‘Āina* (a fee simple right of ownership) was set in place by Kamehameha III. Following implementation of the *Māhele*, the King also initiated a land grant program, issuing fee simple “Royal Patents” on granted land. In addition to the sale of fee-simple interests in land, the Crown and Government lands were also made available for leases and, in some cases, for sale. Together, these three land programs opened the door for the development of the large ranching interests in the lowlands below ‘Ōla‘a and Waiākea, and on the Keauhou-Kapāpala forest lands. Because of the remote nature of the lands and dense forests of the ‘Ōla‘a-Waiākea lands that make up the Pu‘u Maka‘ala NAR, no leases or conveyances were recorded for those lands. This said, it is likely that Hawaiian visitation collection of resources associated with traditional and customary practices continued in the Pu‘u Maka‘ala NAR lands for some time through the middle to late 1800s.

In 1862, a Commission of Boundaries (the Boundary Commission) was established in the Kingdom of Hawai‘i to legally set the boundaries of *ahupua‘a* that had been awarded to *Ali‘i*, *Konohiki*, and foreigners during the *Māhele*. In 1874, the Commissioners of Boundaries were authorized to certify the boundaries for lands brought before them (W.D. Alexander in Thrum 1891:117-118). The primary informants for the boundary descriptions were old native residents of the areas being discussed (generally born between the 1780s to 1820s).

Native testimonies describe a wide range of traditional practices in the uplands of Waiākea, ‘Ōla‘a, and in adjoining lands. The types of usage includes: travel on native trails, land use in a wide range of elevational zones; collection of resources; the collection of, or “hunting” of birds; canoe making; and the subsequent practices associated with hunting introduced ungulates—all under the control of *Konohiki*. In regards to hunting, it will be noted that descriptions of traditional hunting practices are limited to native species of birds, including the *ua‘u*, *nēnē*, *mamo* and *‘ō‘ō*; while description of historical hunting practices are limited to goats, which were hunted under contract of *Konohiki*, the Crown, or the Government. The testimonies also record that changes had occurred on the landscape during the lifetime of the witnesses. It is of importance to note that the boundaries were known by the native tenants, and the rights to take or hunt resources in traditional times were fiercely protected—individuals without chiefly, genealogical claims, or residency ties to given lands were not allowed to trespass and take resources from the *ahupua‘a*.

Our review of more than 60,000 native Hawaiian land documents dating from 1846 to 1910



revealed many references to *pua‘a* (pigs), but nearly every reference was in the context of them being near-home and as being cared for (raised), not hunted. In the same review of the native Hawaiian land documents and a large collection of writings from native authors (e.g., D. Malo, 1951; J.P. Ii, 1959, S.M. Kamakau 1961, 1964 & 1976), every reference to traditional collection or “hunting” (a word seldom used in the historical records), was in the context of native birds—those used either for food or from which feathers were collected for royal ornaments and symbolic dress.

After ca. 1815, we find that when native Hawaiians went hunting in the uplands—as described in testimonies and historical texts of the time—they were hunting bullocks, goats and other introduced grazers, and this was generally done on the demand of their landlords, and later for the growing ranches being established in the islands. The first full-scale efforts of western-style hunting in the Humu‘ula-Waiākea and Keauhou (Ka‘ū) region does not appear in reference until around 1840 (cf. Kamakau, 1961; Government Communications in this study). Those early outings were focused on collection of hides and tallow; and controlling wild herds of animals that were a threat to travelers, agricultural fields, residences, and forest resources.

Because of the remote nature of the ‘Ōla‘a and Waiākea forest lands which comprise the present-day Pu‘u Maka‘ala NAR, no government communications pertaining to historic trails or government road projects exist for the region. Boundary Commission testimonies describe trails through the forest lands, rising from the lowlands of Waiākea, ‘Ōla‘a, Keauhou and Humu‘ula. Based on the native traditions and *kama‘āina* testimonies, it is likely that “practitioner” trails existed throughout the forest region. Features such as “*kauhale manu*” (bird-catcher’s shelters), “*kahua kalaiwaa*” (canoe-makers clearings), “*oioina*” (trailside resting places and shelters), the “*ala hele*” (trails), and other features associated with traditional and customary accesses, would leave little evidence in the present-day, as the traditional features and uses generally had minimal impact on the natural landscape. Those things left behind, not cared for or maintained, were simply reabsorbed into the landscape.

In the early 1900s, the Hilo and ‘Ōla‘a forest lands were determined to be of significance, and worthy of protection. In between 1905 to 1928, the lands of the ‘Ōla‘a and Waiākea Forest Reserves, and the neighboring Kīlauea Forest Reserve were dedicated to the public interest as unique natural resources.

It appears that it was not until the late 1940s, that a road was cut up through the Waiākea-‘Ōla‘a forest lands, and this in conjunction with the opening of the Kūlani Prison Farm.

Hawaiian traditions and beliefs, shared spiritual and familial relationships with the natural resources around them. Each aspect of nature from the stars in the heavens, to the winds, clouds, rains, growth of the forests and life therein, and everything in the land and in the ocean, was believed to be alive. Indeed, every form of nature was a body-from of some god or lesser deity. As an example, in this context, and in association with lands which are now included in a part of the landscape of the Pu‘u Maka‘ala NAR, we find the Kū-ka-‘ōhi‘a-Laka, is a defied guardian of the ‘ōhi‘a growth of ‘Ōla‘a; *Ua-kuahine*, is the body form of a

goddess of the rains in ‘Ōla‘a; and *Kū-lili-ka-ua* is the god of the thick mists that envelop the forests of the upper Puna, Waiākea, and Keauhou lands. Indeed, tradition also tells us that the gods and goddesses of these forest lands were very protective of them. In olden times, travel through them was accompanied by prayer, and care. Traditions tell us that many a careless traveler, or collector of resources, found themselves lost in a maze of overgrowth and dense mists, for disrespectful and careless actions.

In the Hawaiian mind, care for each aspect of nature, the *kino lau* (myriad body-forms) of the elder life forms, was a way of life. This concept is expressed by Hawaiian *kūpuna* (elders) through the present day, and is passed on many native families. When discussing the relationship of native families with the lands and resources around them, it is not uncommon to hear *kūpuna* express the thought — “*E mālama i ka ‘āina, a e mālama ho ‘i ka ‘āina iā ‘oe! E mālama i ke kai, a e mālama ho ‘i ke kai iā ‘oe!*” (Care for the land, and the land will care for you! Care for the sea, and the sea will care for you!). This concept is one that is centuries old and is rooted the spirituality of the Hawaiian people. Importantly, the converse is that when one fails to care for, or damages nature—the *kino lau*—around them, they are in-turn punished. This is expressed in many traditional sayings, one being, “*Hana ‘ino ka lima, ‘ai ‘ino ka waha!*” (When the hands do dirty-defiling work, the mouth eats dirty-defiled food!). In this cultural context, anything which damages the native nature of the land, forests, ocean, and *kino lau* therein, damages the integrity of the whole.

Writing in the late 1860s and early 1870s, native historian, S.M. Kamakau, related to readers some aspects of the Hawaiian association and understanding of the mountain lands and forests. While describing traditional knowledge of the divisions of land, Kamakau wrote:

Here are some other divisions of the islands, together with their descriptive names.

Heights in the center or toward the side of a land, or island, are called *mauna*, mountains, or *kuahiwi*, “ridge backs.” The highest places, which cover over with fog and have great “flanks” behind and in front (*kaha kua, kaha alo*)—like Mauna Kea—are called *mauna*; the place below the summit, above where the forests grow is the *kuahiwi*. The peak of the mountain is called *pane po ‘o* or *piko*; if there is a sharp point on the peak it is called *pu ‘u pane po ‘o*; if there is no hill, *pu ‘u*, and the peak of the mountain spreads out like the roof of a house, the mountain is described as a *kauhuhu mauna* (house ridgepole mountain); and if there is a precipitous descent, *kaolo* [from the peak] to the *kauhuhu mauna* below this is called a *kualo* (“block”). If there are deep ravines (*‘alu ha ‘aha ‘a*) in the sides of the mountain it is called a *kahi po ‘ohiwi mauna* (“shoulder edge” mountain). A place that slopes down gradually (*hamo iho ana*) is called a *ho ‘oku ‘u* (a “letting down”); a sheer place is called a *pali lele koa ‘e* (cliff where *koa ‘e* birds soar), or a *holo* (“slide”), or a *waihi* (a “flowing down”). Rounded ridges that extend from the mountains or “ridge backs” or hills are called *lapa* or *kualapa* or *mo ‘o*—and, if they are large, *olapalapa* or *‘omo ‘omo ‘o*. Depressions between *lapa* or *mo ‘o* are *awawa*, valleys.

Here are some names for [the zones of] the mountains—the *mauna* or *kuahiwi*. A mountain is called a *kuahiwi*, but *mauna* is the overall term for the whole mountain, and there are many names applied to one, according to its delineations (*'ano*). The part directly in back and in front of the summit [Kamakau 1976:8] proper is called the *kuamauna*, mountaintop; below the *kuamauna* is the *kuahea*, and *makai* of the *kuahea* is the *kuahiwi* proper. This is where small trees begin to grow; it is the *wao nahele*. *Makai* of this region the trees are tall, and this is the *wao lipo*. *Makai* of the *wao lipo* is the *wao 'eiwa*, and *makai* of that the *wao ma'ukele*. *Makai* of the *wao ma'ukele* is the *wao akua*, and *makai* of there the *wao kanaka*, the area that people cultivate. *Makai* of the *wao kanaka* is the *'ama'u*, fern belt, and *makai* of the *'ama'u* the *'apa'a*, grasslands.

A solitary group of trees is a *moku la'au* (a “stand” of trees) or an *ulu la'au*, grove. Thickets that extend to the *kuahiwi* are *ulunahеле*, wild growth. An area where *koa* trees suitable for canoes (*koa wa'a*) grow is a *wao koa* and *mauka* of there is a *wao la'au*, timber land. These are dry forest growths from the *'apa'a* up to the *kuahiwi*. The places that are “spongy” (*naele*) are found in the *wao ma'ukele*, the wet forest.

*Makai* of the *'apa'a* are the *pahe'e* [*pili* grass] and *'ilima* growths and *makai* of them the *kula*, open country, and the *'apoho* hollows near to the habitations of men. Then comes the *kahakai*, coast, the *kahaone*, sandy beach, and the *kalawa*, the curve of the seashore—right down to the *'ae kai*, the water's edge.

That is the way *ka po'e kahiko* named the land from mountain peak to sea. [Kamakau 1976:9]

Among the native terms listed by Kamakau above, is one which stands out in reference to the Waiākea-‘Ōla‘a forest lands of the Pu‘u Maka‘ala NAR—this zone is the *wao akua* (zone or region of the gods and deities). The *wao akua* is so named because of the pattern of cloud cover and precipitation which settles upon the mountain slope—this covering was interpreted as concealing from view the activities of the gods and deities therein (cf. David Malo 1959:16-18; and M.K. Pukui, pers. comm. 1975).

In the traditional context above, we find that the mountain landscape, its' native species, and the intangible components therein, are a part of a sacred Hawaiian landscape. Thus, the landscape itself is a highly valued cultural property. Its protection, and the continued exercise of traditional and customary practices, in a traditional and customary manner, are mandated by native custom, and State and Federal Laws (as those establishing the ‘Ōla‘a and Waiākea Forest Reserves, the Pu‘u Maka‘ala NAR, and the Endangered Species Act).

In this discussion, protection does not mean the exclusion, or extinguishing of traditional and customary practices, it simply means that such practices are done in a manner consistent with cultural subsistence, where each form of native life is treasured and protected. *Kūpuna* express this thought in the words, “*Ho'ohana aku, a ho'ōla aku!*” (Use it, and let it live!).”

Additional information on the cultural resources of the Reserve is contained in cultural study for Keauhou, an adjacent area (Maly 2005). This study contains boundary commission testimonies for Keauhou and includes descriptions of adjacent areas, including Kūlani (Kūlani Cone and Pu‘u Kipu); the history of the establishment of the ‘Ōla‘a, Waiākea and Kīlauea Forest Reserves; and a description of Kūlani Cone by Joseph Rock in 1919.

### *Archaeological and Historic Sites*

The State Historic Preservation Division has no records of historic properties or archeological sites from Pu‘u Maka‘ala NAR. Most of this dense forest area has not been surveyed for sites. Previous archeological surveys for fence construction projects did not identify any archeological sites. Trails, small forest shrines, burial caves and lava tube shelters are the types of features that may be present, as the greater area was used historically by Hawaiians for activities such as bird hunting, harvesting timber for canoe-making and gathering forest plants for medicinal uses.

In a study for a sewage treatment plant for Kūlani Correctional Facility, Rechman (2001) reported that project site falls within the rainforest zone as defined by McEldowney (1979). The archeological expectations for the general area are very limited. Pre-contact period bird catchers may have ventured into the forest seasonally and established temporary residences. Such sites would have been constructed of perishable materials.

Rechman’s report (2001) noted that the summit of Pu‘u Kūlani or Kūlani Cone marks the traditional land divisions of South Hilo, Puna and Kā‘u and this Pu‘u should be considered a cultural property due to references in chant and legend.

The Puu ‘Ō‘ō trail, a historic cattle crossing route from Keauhou to Humu‘ula, is just above the Kūlani portion of the Reserve.

The Kūlani portion of the Reserve was used since 1946 as a prison camp, and certain areas were used for logging, ranching and other activities. Hawai‘i Tribune Herald newspaper printed a series of articles on the history of Kūlani Correctional Facility and Kūlani Rd by Kent Warshauer in 2001. The Kūlani road was completed in 1945 by prison work crews from Waiākea prison camp, which was moved to Kūlani in 1946. The road from the main facility complex to an area that would become Mauna Loa Boys School, a home for delinquent boys, was completed in 1946. Construction of the Boy’s School was completed in 1952 and the facility opened as Mauna Loa Forestry Camp - modeled after the Civilian Conservation Corps camps. One proposed activity for the boys would be to plant koa and naio to replace timber cut by Kūlani inmates. The Camp had numerous issues with boys escaping, including the fatality of one boy. When Territorial House members toured the camp in 1953 they called the project “one of the most expensive and impractical projects ever constructed in the Territory of Hawai‘i,” and they closed the facility later that year. Since closure the facility was used intermittently by Kūlani Correctional Facility and by the military for training.

Warshauer (2002) also wrote about the history of the Army Rd area of the Reserve, which was used by the military from 1964 - 1970 for the testing of chemical and biological weapons.

### ***Infrastructure***

Infrastructure within Pu‘u Maka‘ala NAR primarily consists of roads, unimproved trails, and fencing. No recreational facilities (e.g., bathrooms, freshwater sources, improved campsites) exist within Pu‘u Maka‘ala NAR.

Public access into the NAR is primarily via Wright Road or Stainback Highway (Figure 11).

DOFAW has an access, utility and conservation easement for staff management purposes through the internal roads of the Kūlani Facility (area under revocable permit to DOD-YCA).

The Reserve contains the Mauna Loa Boy’s School facility which has not been maintained and is in currently in severe disrepair. Other former correctional facility infrastructure is also present in the Reserve (e.g. old ranch fencing, water tanks, water catchments, and roads).

### ***Regional Partnerships***

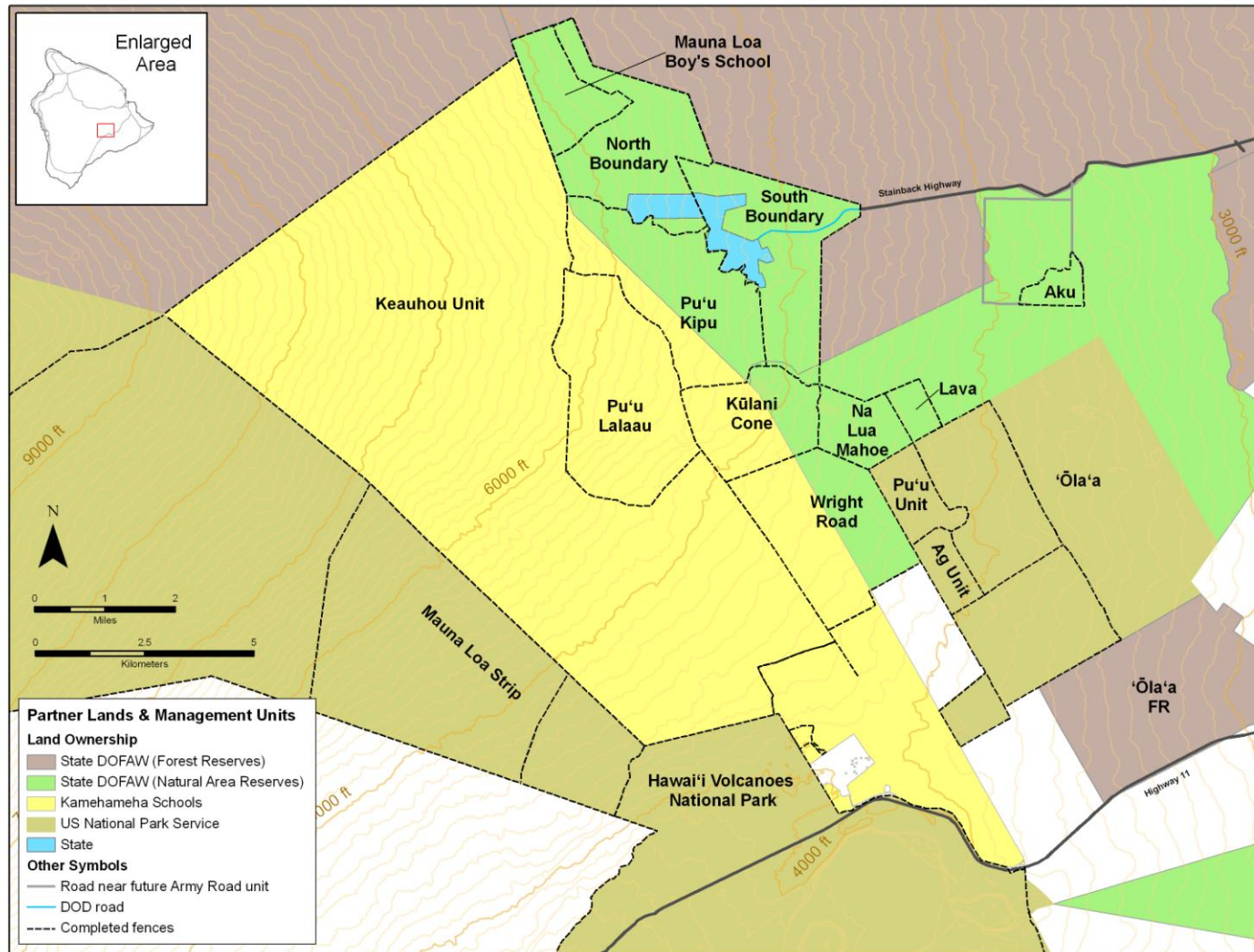
Existing management of Pu‘u Maka‘ala NAR has significantly benefited from cooperation with adjacent landowners, particularly the ‘Ōla‘a -Kīlauea Partnership (now called the Three Mountain Alliance (TMA)) (Figure 5). The TMA is a voluntary public-private partnership of landowners and agencies with a management interest in the landscape and a goal to coordinate conservation management on a landscape level. The overall management goal of TMA is to sustain the multiple ecosystem benefits, provided by the three mountains of Kīlauea, Mauna Loa, and Hualālai, by responsibly managing its watershed areas, native habitat and species, historical, cultural, and socio-economic resources for all who benefit from the continued health of the three mountains.

The intact montane native forest area including Pu‘u Maka‘ala was the initial focus of the TMA and forms the core of conservation management in the region. The TMA assisted with the construction and maintenance of existing fencing, including fencing at Kūlani, and collaboration with the TMA has increased the effectiveness of monitoring, weed and ungulate control efforts in the NAR. Fencing at Pu‘u Maka‘ala is linked to fencing in adjacent areas (Kamehameha Schools lands and Hawai‘i Volcanoes National Park) to make a much larger protected area, enhancing joint management for conservation across the larger landscape. Three fenced units in the NAR cross ownership boundaries and include both NAR and Kamehameha Schools lands (Pu‘u Kipu, Kūlani Cone and Wright Rd. units) (Figure 5). These units were constructed to take advantage of existing roads and cleared areas and protect native forest on an ecosystem level rather than by land ownership.

The TMA has fenced and removed ungulates from over 14,000 ac (5,666 ha), and ungulate control work is underway in an additional 20,000 ac (8,094 ha) that has already been fenced. These units on Pu‘u Maka‘ala NAR and Kamehameha Schools lands (Keauhou and Kīlauea) are adjacent to an additional 15,000 ac (6,070 ha) of existing fenced management units in Hawai‘i Volcanoes National Park (‘Ōla‘a Tract and Mauna Loa Strip Road) (Figure 5). The fenced units include some of the best quality native forest in Hawai‘i, and they are now being used as recovery areas for native ecosystems and rare and endangered species.

TMA members are collaborating on numerous management initiatives in addition to fencing and ungulate control including weed control, rare plant reintroduction, forest bird monitoring, reforestation and educational programs.

Figure 5. Three Mountain Alliance Land Ownership and Management Units.



## SUMMARY OF MAJOR THREATS

### *Invasive Species - Ungulates*

The primary ungulates of concern in Pu‘u Maka‘ala are feral pigs, although feral goats (*Capra hircus*), feral sheep (*Ovis aries*) and mouflon sheep (*Ovis musimon*) are known from adjacent lands and could potentially become a threat to the NAR in the future. Feral pigs destroy native vegetation and prevent its regeneration by eating, trampling, and digging up plants, and may accelerate the invasion of weed species by dispersing seeds on their coats and in their droppings. Pig disturbance of native ground cover through rooting and wallowing facilitates the invasion and establishment of weeds. In addition, pig wallows and pig-hollowed out hāpu`u trunks provide mosquito-breeding sites that can promote the spread of avian diseases such as avian malaria and pox – the two most deadly diseases for native forest birds. The continued presence of feral pigs contributes to loss of native plants and loss of ground cover that adversely affects groundwater retention.

Portions of Pu‘u Maka‘ala NAR are designated as part of Hunting Unit K under Chapter 13-123, Hawaii Administrative Rules (Rules Regulating Game Mammal Hunting). Hunters should check with the DOFAW office (19 East Kawili Ave., Hilo, HI 96720) to get current information on hunting rules and any changes in special conditions, bag limits, seasons and open areas.

### *Invasive Species - Plants*

Invasive non-native plants, or weeds, constitute a severe threat to the native ecosystems in the NAR. Certain priority weeds are problematic because they can establish and survive in undisturbed native forest; disperse long distances via wind or birds; affect large portions of land; displace native vegetation; grow and reproduce rapidly; convert diverse assemblages of native plants to monocultures of alien species; and encourage fire by increasing fuels on formerly natural fire breaks (i.e. lava flows). These weeds can displace distinctive native flora, resulting in a loss of species diversity and eventually in more pronounced and permanent changes to ecosystem function such as alteration of primary productivity and nutrient cycling. Many invasive weed species completely replace native vegetation resulting in total loss of native habitats thereby negatively affecting native bird, arthropod and snail communities.

Invasive weeds with great potential for spreading and causing habitat modification are identified in this plan as high priority for control or eradication. Weed species were prioritized based on observed invasiveness and other criteria including growth form, dispersal mechanisms, ability to displace native vegetation and ability to alter ecosystem cycles (water, nutrients and succession). High priority invasive weeds currently present in Pu‘u Maka‘ala include:

- Strawberry guava (*Psidium cattleianum*)
- Banana poka (*Passiflora tarminiana*)
- Himalayan raspberry (*Rubus ellipticus*)
- Cane tibouchina (*Tibouchina herbacea*)
- Kāhili ginger (*Hedychium gardnerianum*)
- Palm grass (*Setaria palmifolia*)



- Australian tree fern (*Sphaeropteris cooperi*)
- Clidemia or Koster's curse (*Clidemia hirta*)
- Tropical ash (*Fraxinus uhdei*)
- Silver-leaf cotoneaster (*Cotoneaster pannosus*)

Other weed species are not considered as highly threatening in the NAR as those listed above but are still a problem in localized areas. These weeds will be controlled during weed control work (e.g. Japanese anemone (*Anemone hupehensis*), *Selaginella kraussiana*, blackberry (*Rubus argutus*) and thimbleberry (*Rubus rosifolius*)) but are not generally a target of management.

Additional weed species that are a serious concern to land managers are present in adjoining areas and have not yet been detected in the NAR. It is a high priority to prevent the establishment of these species in the NAR. Species of concern include but are not limited to miconia (*Miconia calvescens*) and night-blooming jasmine (*Cestrum nocturnum*). Other weed species may be added to the NAR priority weed list if monitoring shows their range and abundance increasing in native ecosystems targeted for management.

‘Ōhi‘a dieback has been observed in Pu‘u Maka‘ala, particularly at lower elevations. Dieback is a natural successional phenomenon in which old stands of trees die synchronously, leaving gaps in the forest canopy. The gaps created in the forest canopy by dieback provide an opportunity for the invasion of non-native weeds which prevents regeneration by ‘ōhi‘a and other native plants.

### ***Invasive Species - Other Animals***

A variety of non-native small animals have the potential to become serious pests to the biodiversity found in Pu‘u Maka‘ala. Feral cats, rats, mice, mongoose, dogs, birds, amphibians and reptiles are known to consume or compete with native species and may contribute the spread of invasive weeds. Feral cats kill birds, which nest, feed, and roost in trees, as well as native sea birds and other species that nest on the ground or in burrows. Rats prey on native birds (particularly females on the nest), eggs, nestlings, native land snails and are also known to eat the seeds, fruits and/or strip the bark of native plants. The NAR has been invaded by non-native forest birds (e.g. Japanese white-eye, northern cardinal, Japanese bush warbler (*Cettia diphone*) and other species). Non-native birds may compete with native forest birds for food and other resources and act as reservoirs for avian diseases. Non-native birds also contribute to the spread of weeds by eating the fruits of weedy species (e.g. yellow Himalayan raspberry, banana poka and kāhili ginger) and spreading seeds. Both Jackson’s chameleon (*Chamaeleo jacksonii*) and coqui frogs (*Eleutherodactylus coqui*) have growing populations in areas adjacent to the NAR, and these species can consume native invertebrates, such as insects, spiders, and small snails.

Non-native invertebrates are present, but largely undocumented, and can consume native plants, interfere with plant reproduction, predate or act as parasites on native species, transmit disease, affect food availability for native birds, and disrupt ecosystem processes. The invasion of the yellowjacket wasp (*Vespula pennsylvanica*), voracious predators of numerous species of native invertebrates, is of concern, and these wasps have been implicated in the local extinction of two species of endemic *Drosophila* in the adjacent ‘Ōla‘a Tract. Slugs (*Milax gagates*, *Limax*

*maximus*, *Veronicella* spp.) consume fruit from native plants and prey on seedlings and mature plants. The two-spotted leafhopper (*Sophonia rufofascia*) is a major concern for the *uluhe* fern, which is particularly sensitive to leafhopper feeding. Mosquitoes (*Aedes albopictus* and *Culex quinquefasciatus*) transmit deadly diseases to native birds.

### ***Fire***

Due to the high rainfall in most portions of Pu‘u Maka‘ala, fire is not normally a concern in the NAR. However, fire does pose a threat to the NAR, particularly in the drier portions of Kūlani during times of drought and in roadside areas accessible to human activity. Continued feral ungulate damage to native ecosystems can convert native forest to non-native grasses and shrubs, which are more vulnerable to fires caused by lightning strikes or humans. Wildfires leave the landscape bare and vulnerable to erosion and non-native weed invasions. Hawaii’s flora evolved with infrequent, naturally-occurring episodes of fire, so most native species are not fire-adapted and are unable to recover well after wildfires. Alien plants, particularly grasses, are often more fire-adapted than native species and will quickly exploit suitable habitat after a fire. The principal human-caused ignition threats are catalytic converters and other hot surfaces of vehicles or heavy equipment. Careless disposal of cigarettes also presents a very real threat. The principal natural ignition sources are lava flows and lightning.

### ***Additional Threats - Disease, Climate Change, Volcanic Activity, Illegal Human Activity***

Introduced diseases and pathogens can threaten both native animals and plants. The introduction of new diseases and pathogens, in addition to those currently known, is possible. Avian pox and avian malaria are mosquito-transmitted diseases that currently affect native Hawaiian birds. In the extreme isolation of the Hawaiian Islands, birds evolved in the absence of these diseases and lost their natural immunity. Avian pox is caused by a virus (*Avipoxvirus*) and avian malaria by a single-celled parasite (*Plasmodium relictum*). For some bird species infection with these diseases is almost always fatal.

Introduced plant diseases such as ‘ōhi‘a rust (*Puccinia psidii*) and koa wilt have the potential to impact the major components of the forest throughout the NAR. ‘Ōhi‘a rust affects other Myrtaceae taxa. In severe infections, growing tips wither and die back. Koa wilt is a serious, often fatal disease of the native tree koa. Trees affected with the disease rapidly lose their canopies and may die within a few months.

Climate change may affect the NAR through altering rainfall patterns and amounts. Changing climate may affect the abundance and seasonality of precipitation, thereby altering forest composition, growth and structure. Rare ecosystems and species may be affected by relatively rapid changes in precipitation, temperature, and humidity that result from a rapid and drastic change in regional or local climate patterns. Detrimental invasive species may change their distribution and abundance due to changes in the climate (e.g. mosquitoes may be more frequently found at higher elevations due to warming temperatures). Increases in mosquito populations in the upper elevations would increase the incidence of avian disease, negatively affecting remaining native forest bird populations.

Volcanic activity has the potential to impact the NAR as the Reserve is situated on Mauna Loa, an active volcano. The Reserve is on the northwest rift zone and is vulnerable to eruptions originating at vents on that flank. The Reserve is classified by USGS as being within lava hazard Zones 2 and 3. About 20 percent of the Zone 2 area has been covered by lava in historical time, 5 percent since 1950. The 1984 Mauna Loa flow came within a mile of Kūlani. Volcanic gases from nearby vents can cause high concentrations of gases that affect native plants, animals and people.

Illegal human activity occurs on a small scale, primarily in the form of illegal harvesting (maile, hāpu‘u, and other native trees and plants), vandalizing signs and fences and occasional illegal motorized vehicle use. Marijuana cultivation may also occur. These activities destroy infrastructure and native species. Some illegal activities create openings in the forest that can be invaded by weeds.

## **OVERVIEW OF EXISTING MANAGEMENT**

In general, management at Pu‘u Maka‘ala has primarily included ungulate management (construction and maintenance of fencing and ungulate control), weed control and habitat protection, and rare species restoration. Major accomplishments from these management programs are summarized below. NAR staff also work on monitoring, education and outreach, and review special use permits for certain activities proposed in the NAR. A cultural study for the Reserve was completed in 2004.

### ***Ungulate Management***

Between 1991 and 2003, NAR staff and partners constructed nine fenced ungulate-proof management units totaling approximately 9,600 ac (3,885 ha) in the Kūlani and Pu‘u Maka‘ala sections of the Reserve, to protect the NAR from feral ungulates (Figure 5).

The Kūlani units (Mauna Loa Boys School, Pu‘u Kipu, South Boundary and North Boundary) as well as Wright Road unit and the Kūlani Cone unit were constructed as projects of the ‘Ōla‘a - Kīlauea Partnership (now known as the TMA). The Wright Road unit, Pu‘u Kipu unit and the Kūlani Cone unit each encloses a portion of the western edge of the NAR as well as a portion of adjacent Kamehameha Schools property in Kīlauea forest. These fenced areas are jointly managed by NARS staff and the TMA. Two additional fenced units (Na Lua Mahoe and Lava Flow units) are adjoining the Wright Road and Kūlani Cone units to the east. Finally, the ‘Akū unit, in the Army Road area, protects the endangered ‘ānunu (*Sicyos alba*).

NAR and TMA staff completed feral pig control in these nine units (Lava Flow, Na Lua Mahoe, Kūlani Cone, Pu‘u Kipu, Wright Road, ‘Akū, Mauna Loa Boys School, South Boundary and North Boundary). These units have had all feral pigs removed and are currently pig-free.

Fence inspection and maintenance is a critical ongoing management activity. All fences are inspected and maintained on a monthly basis to monitor for and prevent pig ingress.

### *Weed Management*

NAR staff and partners have monitored all species of non-native plants along four different sets of transects since 1988. Initially, 7.7 miles (12.4 kilometers (km)) of transect were monitored for weeds by the Hawai'i Heritage Program to gather information to support the development of a comprehensive management plan. In 1995, 17 miles (27 km) of new transects were installed across the higher elevation portions of the Reserve above 3,281 ft (1,000 m). As fenced units were built, additional finer scale transects were installed and monitored within specific units to document vegetation changes following ungulate removal including 2.5 miles (4.1 km) in 'Akū Unit (2000, 2008) and 6.6 miles (10.6 km) in the NAR portion of the Wright Rd Unit (2003, 2006 and 2008). Na Lua Mahoe and Lava units were monitored for weeds in 2000. Figures 6 - 8 show weed presence for certain priority weed species along monitoring transects.

In the Kūlani portion of the Reserve, USGS monitored weeds along transects in Pu'u Kipu and Kūlani Cone and Mauna Loa Boy's School units for three years (1999-2001). These data provide a valuable baseline for weed distribution and abundance. USGS monitored each transect for presence or absence of 80 different weed species divided into three different priority groups and did cover estimates of weeds encountered. USGS staff also took incidental data on the presence of priority weeds during other survey and research work. Maps of priority weed distribution along the Kūlani transects are included in the TMA weed management plan [http://hawp.org/\\_library/documents/three-mountain-alliance/tmaweedplanjune2009.pdf](http://hawp.org/_library/documents/three-mountain-alliance/tmaweedplanjune2009.pdf). The North and South Boundary units of the Kūlani portion of the NAR have never been systematically monitored for weeds.

NARS and USGS monitoring results indicate target weed densities are generally low (<5%) in the higher elevation (>4,199 ft (1,280 m)) fenced units (Pu'u Kipu, Mauna Loa Boys School, Kūlani Cone, Wright Rd, Na Lua Mahoe, and Lava Units) except localized populations of Himalayan yellow raspberry and banana poka, and weeds in open wetland sites and previously disturbed areas. Isolated individuals of kāhili ginger, strawberry guava, palm grass and Australian tree fern have been identified and controlled within these fenced units. Weed densities increase in lower elevations, particularly for banana poka, Himalayan yellow raspberry, strawberry guava, palm grass and cane tibouchina. Within the 'Akū unit weed cover values are typically low, but many target weeds including strawberry guava are widely distributed throughout the unit.

Weed surveys and management are a critical second step following the removal of pigs. Weed management within Pu'u Maka'ala NAR is focused on the ungulate-free fenced units. The lowest elevation portion of the Reserve, where fencing has not been proposed is highly weedy and is not currently managed for weeds unless high priority incipient weeds are detected (e.g. miconia). Early detection and rapid response weed monitoring/control is conducted quarterly along invasion corridors (e.g., roads, trails, and fence lines) in and adjacent to fenced management units. NAR staff also does weed control sweeps in the 'Akū and Wright Road units. With weed sweeps, all target non-native species are mechanically and/or chemically controlled within fenced units by ground crews. Units are divided into management blocks, which are systematically swept on 3 – 5 year intervals with the exception of high infestation sites, which are revisited annually. Blocks are prioritized for control based on weed density, proximity to managed sites, logistical feasibility and staff resources.

NARS and TMA staff has controlled priority weeds within Kūlani with a focus of areas along roads to prevent weed invasion into forested areas. High quality native forest in the Kūlani portion of the Reserve is adjacent to highly disturbed areas with former prison infrastructure (e.g. buildings, pastures, reservoir, cinder pit, sewage treatment facility and roads) that contain larger populations of high priority weeds.

**Figure 6. Pu‘u Maka‘ala NAR Priority Weed Distribution (Kāhili Ginger, Palm Grass and Cane Tibouchina).**

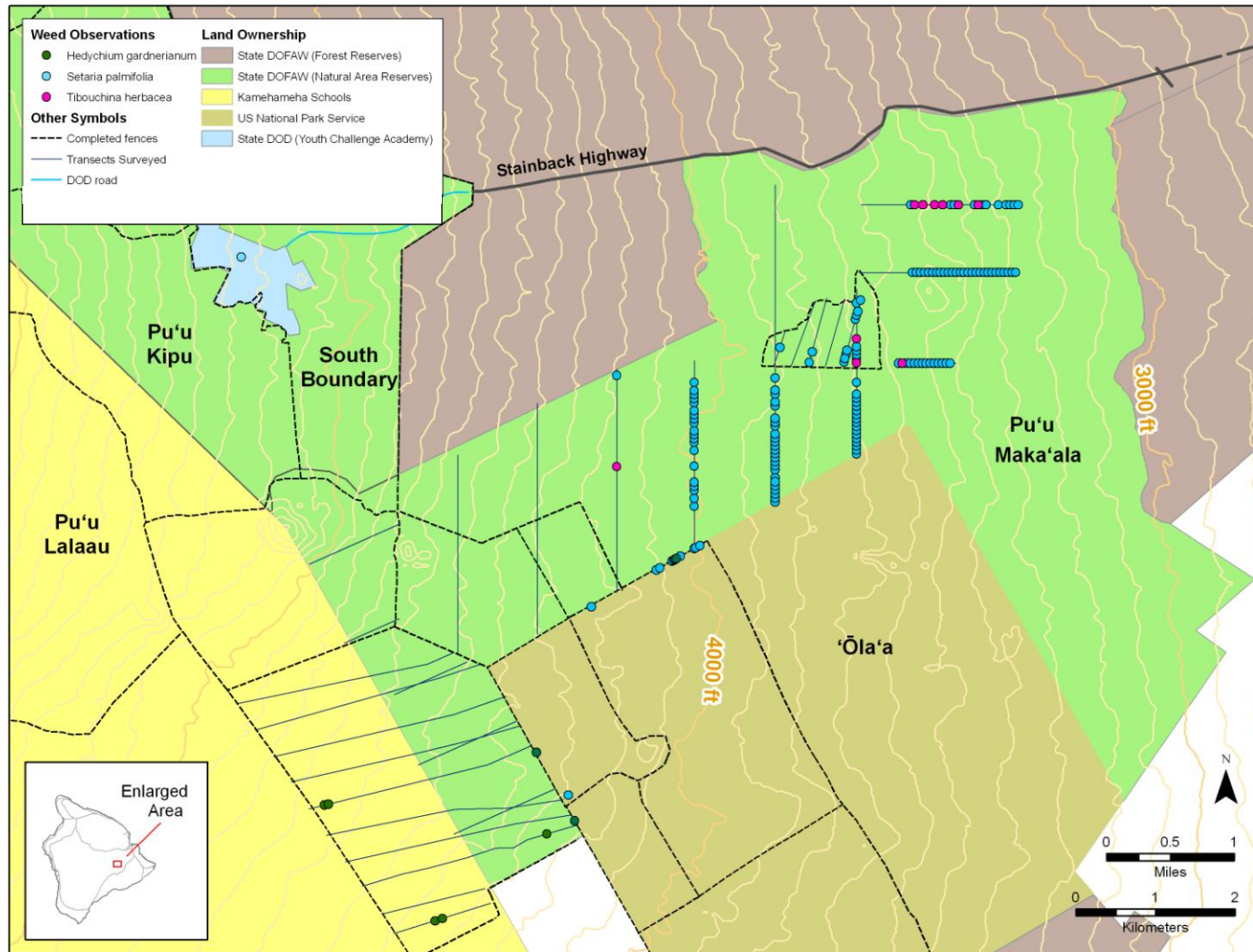


Figure 7. Pu'u Maka'ala NAR Priority Weed Distribution (Banana Poka and Strawberry Guava).

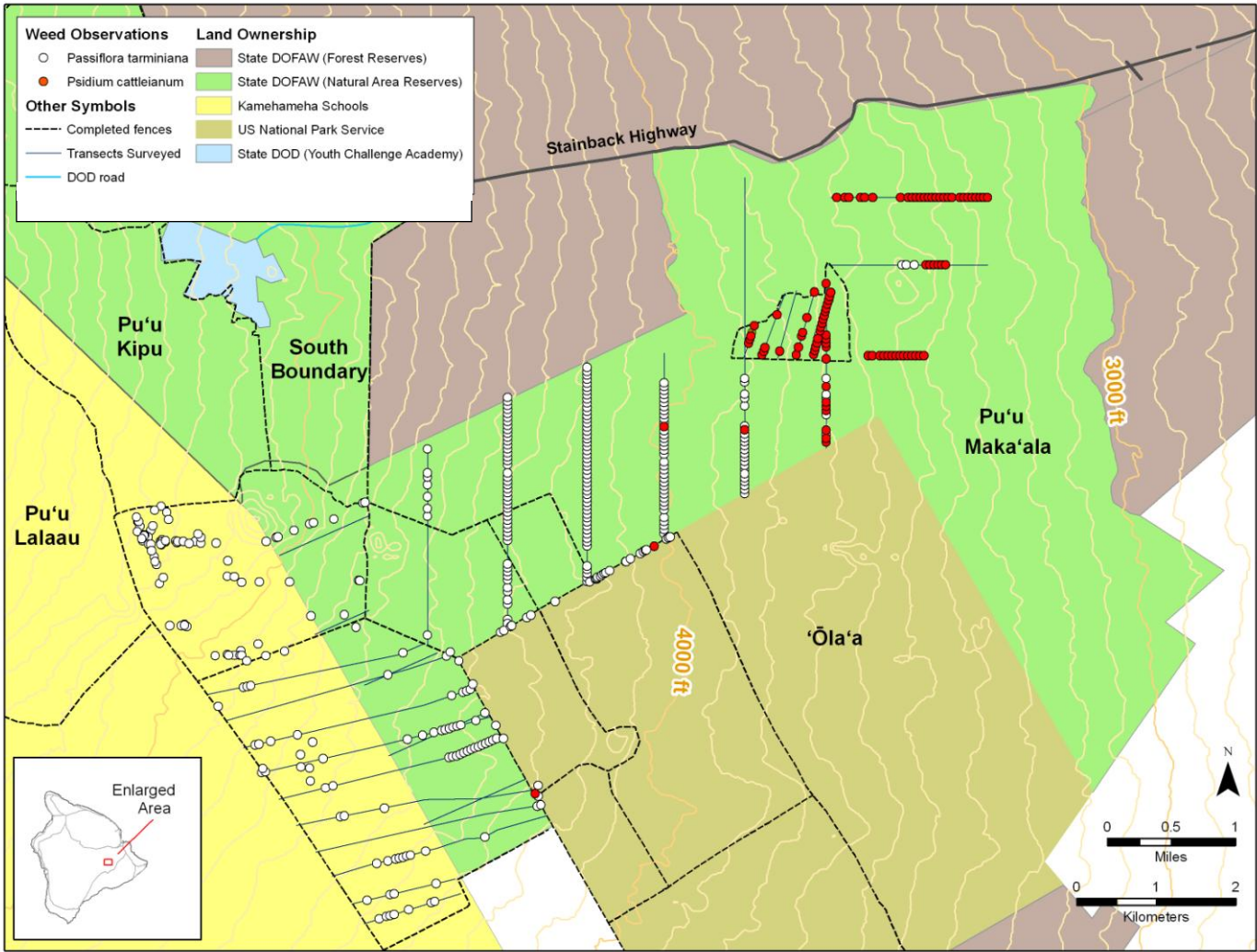
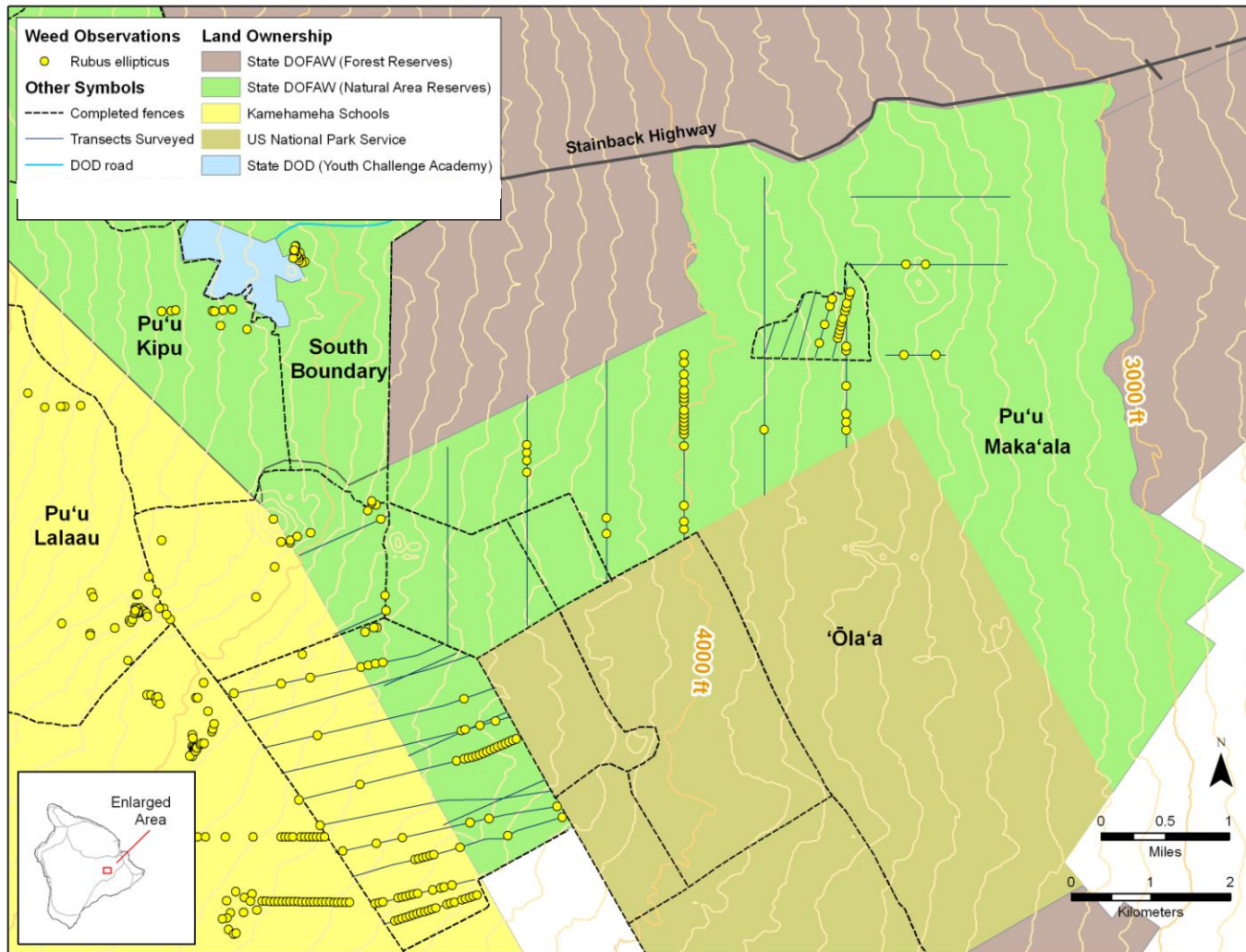


Figure 8. Pu‘u Maka‘ala NAR Priority Weed Distribution (Yellow Himalayan Raspberry).





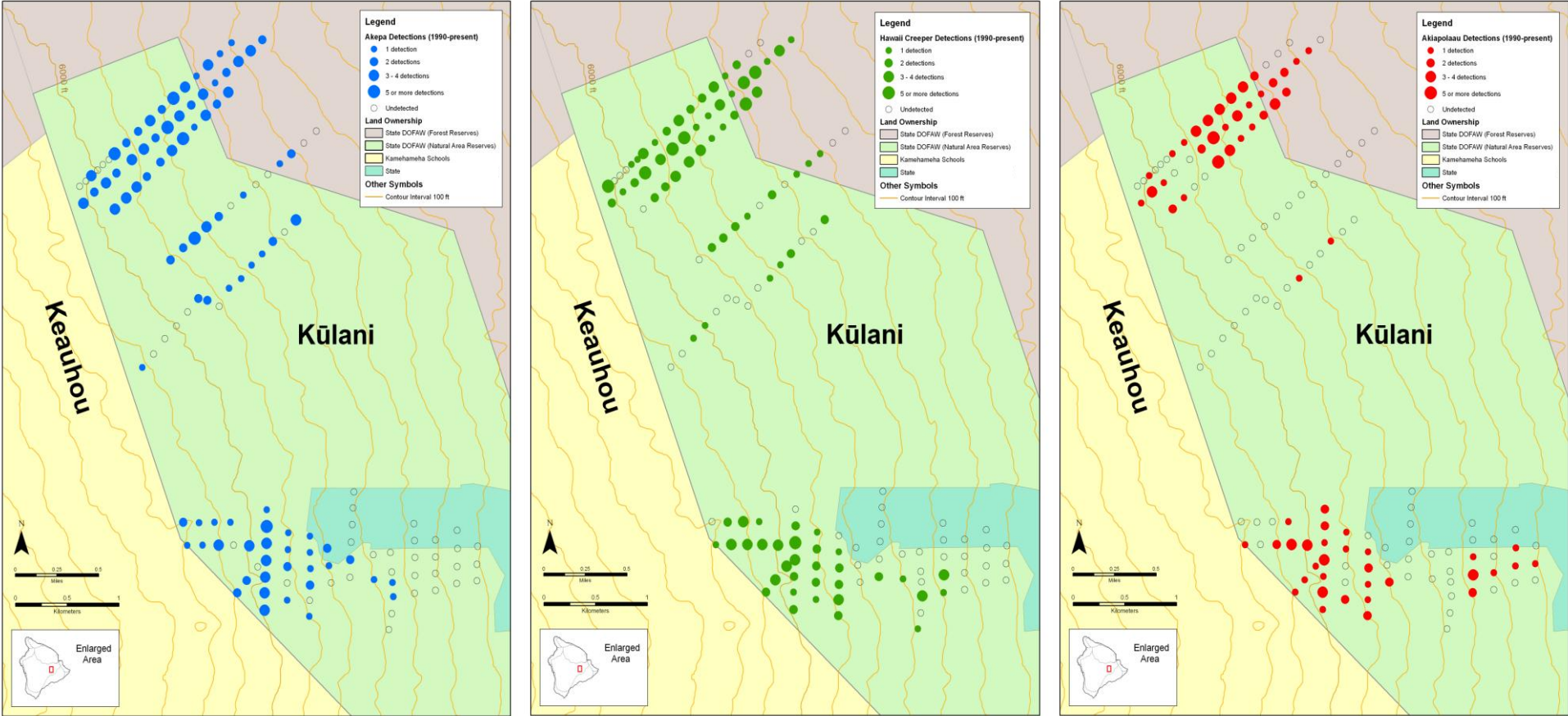
### ***Habitat Protection and Rare Species Restoration***

In 2001 and 2008 NAR staff quantified ground cover, select target native species frequency and density, and nonnative species frequency and cover along transects in the 'Akū unit to monitor changes in the forest as a result of ungulate control. Plant cover in the understory changed dramatically following eight years of feral pig exclusion. The frequency of exposed soil decreased from >50 percent in 2000 to only 11 percent in 2008, largely due to increases in herb and grass/sedge cover. In addition, the density and/or frequency of five native target understory species increased significantly following pig exclusion. Data from this study indicates that past pig activity in the NAR limited the establishment and spread of native understory species, and that pig removal results in native understory species recovery.

Numerous species of rare and endangered plants have been outplanted in Pu'u Maka'ala NAR to assist with recovery efforts for these species. Rare plants reintroduced into the NAR through outplanting include *Argyroxiphum kauense*, *Anoectochilus sandvicensis*, *Clermontia lindseyana*, *Clermontia peleana*, *Cyanea shipmanii*, *Cyanea stictophylla*, *Joinvillea ascendens ssp. ascendens*, *Phyllostegia velutina*, *Phyllostegia floribunda*, *Platydesma spathulata*, *Pritchardia beccariana*, *Sicyos alba*, *Schieda diffusa*, and *Stenogone scrophularioides*. NAR staff tag and map all rare outplanted plants as well as regularly monitor their survival and growth.

TMA has conducted surveys of endangered, native, and alien bird species once per year in the Kūlani portion of the Reserve as well as the adjacent Kīlauea Forest. Detections of endangered birds along transects in this area is shown in Figure 9. Bird population trend information allows for an evaluation of changes in distribution and abundance over time which can be evaluated relative to active or inactive management programs. A sharp decline in native species or an increase in alien bird species can be detected by this method, and may be an important indicator of need for additional management response to a new threat (e.g., increase in avian disease or predation) in an area. The Hawai'i Forest Bird Interagency Database Project analyzes the monitoring data every five years and produces reports on forest bird densities and population trends. The most recent analysis was completed in 2005, and is available at: [http://biology.usgs.gov/pierc/HFBIDPSite/Central\\_Windward\\_OFR\\_2005-1441.pdf](http://biology.usgs.gov/pierc/HFBIDPSite/Central_Windward_OFR_2005-1441.pdf).

Figure 9. Endangered Forest Bird Occurrence along monitoring transects in the Kūlani portion of the Reserve



## MANAGEMENT PROGRAM

The overall management goal is to manage threats to the integrity, diversity and functioning of Pu‘u Maka‘ala NAR ecosystems so that the unique natural and cultural resources are protected, maintained, and enhanced.

Management programs that support this overall goal include the following:

1. Ungulate Management
2. Weed Management
3. Habitat Protection and Rare Species Restoration
4. Fire Prevention and Response
5. Monitoring
6. Public Access, Outreach and Education
7. Enforcement
8. Partnership Collaboration
9. Infrastructure and Other Actions

Cultural resources are addressed through the protection of the natural resources through the programs above. According to Maly (2004), "...the mountain landscape, its' native species, and the intangible components therein, are a part of a sacred Hawaiian landscape. Thus, the landscape itself is a highly valued cultural property."

### *Ungulate Management*

Objective: Preserve and protect native forest and watershed from feral ungulate damage by maintaining existing fenced units, increasing the total acreage of ungulate-free areas through the construction of four new fenced management units, and completely removing ungulates from all fenced management areas.

Actions:

1. Maintain integrity of nine existing fenced units (Kūlani Cone, Wright Rd, ‘Akū, Na Lua Mahoe, Lava, Pu‘u Kipu, Mauna Loa Boys School, North Boundary and South Boundary) and new fenced units through regular inspection, maintenance and replacement of existing fencing.
2. Monitor existing nine fenced ungulate-free units for ungulate ingress, and control ungulates, if necessary.
3. Construct approximately 17 miles (27 km) of new fencing within the NAR to subdivide an existing management unit in the Kūlani section of the NAR and create four new fenced management units between the existing fenced units of the Kūlani and Pu‘u Maka‘ala sections of the NAR, and Hawai‘i Volcanoes National Park.
4. Install pedestrian walkovers and gates for pedestrian access into fenced units.
5. Implement feral ungulate control using a variety of methods that may include special public hunts, trapping, staff control, and snaring to completely remove animals from fenced units after fence construction.
6. Monitor new units for ungulate presence following complete removal and control ingress ungulates, if necessary.

Ungulate management, primarily for feral pigs, is the highest priority management program in the NAR. Although public hunting currently accounts for some pigs taken from the Reserve, more animals need to be removed in order to protect the biological and water resources of the Reserve and limit damage to native Hawaiian ecosystems. To reduce feral pig numbers sufficiently to protect the resources of the NAR, a combination of fencing and animal removal from fenced units is needed. Without fencing, ungulate control requires ongoing effort, due to reproduction of existing populations and continued ingress from adjacent properties.

Maintenance of existing fences and monitoring for ungulate presence is necessary to prevent reinvasion of currently ungulate-free areas. Construction of new fencing, when completed, will protect an additional approximately 5,000 ac (2,023 ha) of the NAR from damage by ungulates (Figure 10). Fencing will be completed based upon the availability of funding for labor and materials. NAR and/or TMA staff and/or contractors will implement fence construction in phases. Proposed new fenced management units have been prioritized based on quality of native ecosystems and presence of existing fencing from adjacent units. Other considerations in the design of the fenced units include logistics, accessibility, delineation of NAR boundary, and feasibility for effective feral ungulate control. Initial field surveys have been conducted to identify approximate locations for the planned fence alignments, and final fence alignments will be sited to avoid any impacts to botanical, faunal, and archaeological resources. Approximately 17 miles (27 km) of new fencing is needed to construct the four planned management units, at an estimated average cost of approximately \$100,000 per mile (labor, materials and helicopter).

As fence construction is completed, various methods will be used to remove ungulates from the fenced units. Public hunting will be encouraged during the first phase of ungulate removal, but additional control methods including drives, trapping, staff control with dogs, and snaring, may be needed to remove all the ungulates. Upon completion of proposed new fencing and ungulate control, approximately 14,600 ac (5,908 ha) or 78% of Pu‘u Maka‘ala will be ungulate free.

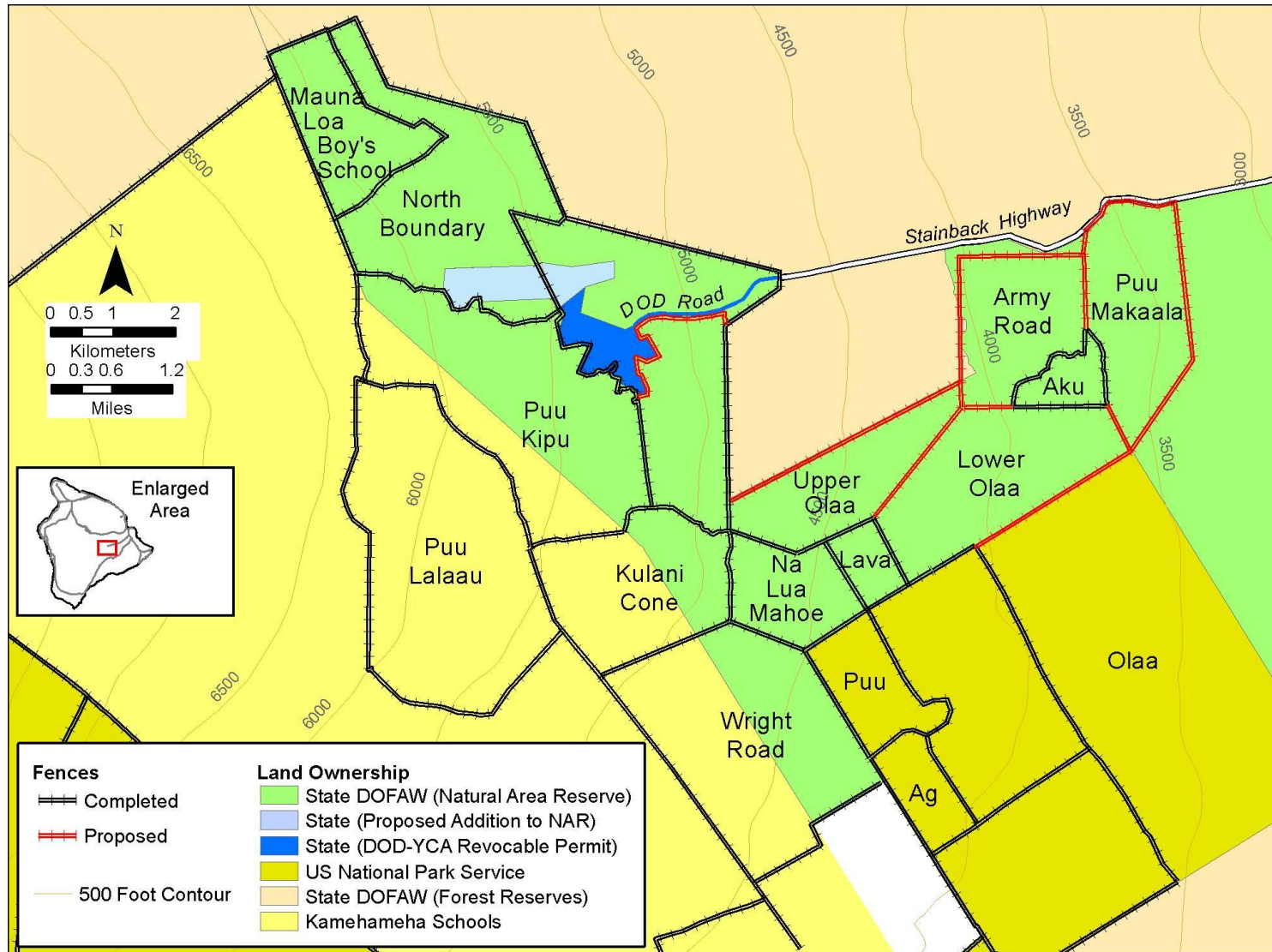
The lower, eastern portion of the NAR (including the Ihope road region adjacent to the National Park ‘Ōla‘a tract up to the 3,400 feet (1,036 meters) elevation) is not currently a priority for fencing. While still native-dominated, high densities of weeds make this section a lower priority for fencing and animal removal.

Proposed New Fencing (in order of priority) (Figure 10):

- Kūlani South Boundary Unit - Subdivide the existing unit by fencing 2 miles (3,219 m) around the perimeter of the Facility and along Stainback Highway. Subdividing this large unit will help with management, should ingress of ungulates occur.
- Upper ‘Ōla‘a Unit - 1,000 ac (405 ha) will require 4.3 miles (6,900 m) of new fencing. This unit will tie into existing fenced units (Kūlani Cone, South Boundary, Na Lua Mahoe and Lava).
- Army Road Unit - 1,000 ac (405 ha) will require 4 miles (6,400 m) of new fencing. This unit will tie into existing fencing of Upper ‘Ōla‘a unit and the ‘Akū unit. Fencing will follow the existing road corridor. When fencing of this unit is completed Army Road will be converted to a public, pedestrian trail.

- Lower 'Ōla'a Unit - 1,570 Ac (635 ha) will require 2.5 miles (4,100 m) of new fencing. This unit will tie into existing fencing (Lava unit as well as a portion of Hawai'i Volcanoes National Park 'Ōla'a tract fencing).
- Pu'u Maka'ala Unit - 1,215 ac (492 ha) will require 4 miles (6,400 m) of new fencing. This unit will be the lowest elevation unit currently proposed for the NAR, and will include the pu'u known as Pu'u Maka'ala.

**Figure 10. Pu‘u Maka‘ala NAR Existing Management Units and Proposed Fencing**



## ***Weed Management***

Objective: Protect intact native areas within the NAR by eradicating incipient weeds along common invasion corridors (e.g. roads, trails, fences), and if possible, eradicate or contain select high priority weeds in fenced units within the NAR.

Actions:

1. Identify highest priority intact native areas for intensive weed control. The highest priority areas are generally fenced, ungulate-free management units.
2. Monitor and map the distribution of high priority weeds and develop a control strategy.
3. Control weeds along invasion corridors (e.g., roads, trails, fences) and within management units using approved methods (chemical, manual and/or biocontrol).
4. Maintain procedures to prevent introduction of new weeds (i.e., sanitation protocols).
5. Support state-wide weed early detection and prevention programs and weed control research including new chemical, mechanical and biological control techniques, and participate, where appropriate, in experimental weed control management methods.
6. Monitor management efficacy in intact native areas to determine if weed control measures are effective and whether re-visitation intervals can be lengthened.
7. Monitor weeds to detect changes in long term distribution and abundance.

NAR priority areas for weed management are generally fenced, ungulate-free management units. Removal of ungulates from fenced units is a critical first step in weed control because it allows for the recovery of native vegetation by minimizing ground disturbance and reducing the spread of weeds by ungulates. Certain incipient weeds (high priority weeds that are just beginning to invade the area) may be targeted in unfenced areas to prevent their establishment and spread within the NAR.

The NAR has an ongoing weed monitoring and mapping program, and this data provides a valuable baseline for weed distribution and abundance. Weed mapping is essential to developing a comprehensive control strategy. Distribution mapping includes compiling transect monitoring data, incidental observations and reconnaissance surveys to map the distribution and abundance of weeds. Results from surveys will then be used to better delineate the weed populations core extent and outlying individuals, and permit the development of an effective control strategy. NAR staff monitor weed control areas to evaluate the effectiveness of control efforts.

Weed control goals for the existing Pu‘u Maka‘ala management units and proposed new fenced units include early detection and preventing the establishment of incipient, habitat modifying weeds that are not currently present in the NAR (e.g. miconia) or are still localized. For priority weeds already present in the NAR, the goal is to eliminate all known occurrences within targeted control areas and/or to contain the spread of priority species. Due to limited resources for monitoring and control throughout these dense rainforest areas, NAR staff will focus control efforts in disturbed areas such as roads, trails, and fence lines as these often serve as corridors for weed establishment and spread. Prevention is a critical component of the weed management program, and it is important to avoid and/or reduce the inadvertent introduction and spread of

weeds by researchers, managers and students working in and visiting the area. NARS staff and volunteers will follow protocols for cleaning of boots, equipment and vehicles prior to entry into the NAR.

NAR staff will also completely sweep fenced management units as funding and resources become available. Units are divided into management blocks, and these blocks are prioritized for control based on weed density, proximity to managed sites, and logistical feasibility. Blocks are systematically swept at 3 – 5 year intervals, although highly weed infested sites may be re-visited annually for follow-up control. Staff will focus on removing all priority species within fenced units but will also remove other non-native weeds encountered.

A combination of control techniques including manual, mechanical and herbicides are used to remove weeds. The technique used is based on the characteristics of the target species, the sensitivity of the area in which the species is found, and the effectiveness of the control technique. Weed control research into new monitoring, mapping (including remote sensing) and control methods will be integrated into the weed management program over the course of this plan as appropriate. Due to widespread and heavy infestations of certain weeds (e.g. banana poka and strawberry guava) and limited resources, NARS staff and partners intend to test the efficacy of approved biocontrol agents within the Reserve, when available. The banana poka fungal biological control agent (*Septoria passiflorae*) has been approved and shown to be successful in tests elsewhere on the island, and the effectiveness of this agent needs to be determined for the NAR.

Proposed Weed Control Projects (in priority order):

- Early detection and rapid response weed monitoring and control on a quarterly basis along invasion corridors in and adjacent to fenced management units.
- ‘Akū Unit – Complete sweeps for priority weeds including palm grass, strawberry guava, selaginella, banana poka, and yellow Himalayan raspberry. Palm grass will be targeted initially because this species is relatively localized in the southeast portion of the unit. All priority species will be targeted in subsequent sweeps.
- Wright Rd Unit – This unit is too large for complete control sweeps with currently available resources so staff will focus on sweeps in weed hot spots for priority species including banana poka, kāhili ginger, and yellow Himalayan raspberry. More complete sweeps of the unit will be made as additional resources are available.
- Pu‘u Kipu, South Boundary, North Boundary, Mauna Loa Boys School, Kūlani Cone, Na Lua Mahoe, and Lava units - These higher elevation units have relatively low densities of weeds, and the focus of control in these areas will continue to be weed invasion corridors and known weed hotspots, until resources are available for more complete weed control sweeps. Priority weeds in these areas are primarily banana poka and yellow Himalayan raspberry.
- New fenced units – These lower elevation units have more weed problems than the existing units currently targeted for weed control. As new fenced units are completed and ungulates are removed, these areas will become a higher priority for weed management. NARS staff will follow a similar strategy for weed control in these areas (e.g. installation of weed monitoring transects, control in invasion corridors and more complete sweeps if resources are available).



- Weed monitoring and mapping will be conducted every five years along transects in fenced management units and every 10 years in the unfenced sections of the NAR to detect changes in weed distribution and abundance over time as well as detect incipient invaders.

### ***Habitat Protection and Rare Species Restoration Program***

Objective: Manage high quality forest habitats, rare, threatened and endangered plant and animal species at sustainable community and population levels.

Actions:

1. Maintain the integrity of high quality forest habitats to the extent possible through the maintenance and expansion of fencing, feral ungulate control and weed control programs.
2. Prevent the introduction of incipient habitat-modifying species and new threats (e.g. new weed species, coqui frogs etc) and remove them before they become established.
3. Map, monitor and protect existing wild populations of rare and endangered species to contribute to their population stabilization and recovery.
4. Re-introduce certain species of rare and endangered plants in appropriate protected habitat through outplanting, and coordinate outplanting and other management actions with the PEPP and other agencies and organizations working on rare plant recovery.
5. Enhance habitats for forest birds, nēnē, and ‘ua‘u or Hawaiian petrel through small mammalian predator removal and other habitat management (reducing larval habitat for mosquitoes and controlling yellow-jacket wasps).
6. Release ‘alalā (Hawaiian crow) and other endangered birds in appropriate habitat.
7. Implement native habitat restoration projects (e.g. forest restoration in disturbed areas, *Carex* wetland restoration) and monitor the results of management activities.

Fencing and ungulate removal is discussed in the section on the Ungulate Management program. Fencing and the creation of ungulate-free areas is critical to the long-term health and recovery of native ecosystems including rare plants, forest birds and other native species. These management actions, along with weed management and the prevention of new habitat-modifying species are the most critical actions needed to protect existing native habitat and rare species. NAR staff may need to implement other habitat restoration and species management, as necessary.

In some instances, large scale habitat protection and restoration through the implementation of priority management actions is not enough to recover certain rare and endangered plants. These species may have wild populations that are so low that the species cannot survive and recover without additional management. Over the past decade, numerous species of rare plants have been propagated and reintroduced into fenced, ungulate-free areas of the NAR to contribute to their overall recovery in the wild. These species (Table 1) will continue to be a focus for the NAR rare species program. The goal of NAR rare plant management is to remove threats to these species and ensure their long-term survival in secure and self-sustaining wild populations.

NAR staff work will work cooperatively with other organizations and agencies on rare plant recovery including FWS, TMA, The Hawai‘i State Plant Extinction Prevention Program (PEPP) and the Volcano Rare Plant Facility (VRPF) of the University of Hawai‘i. Management actions

specific to rare plant recovery includes rare plant surveys to locate wild individuals, collection of propagation and genetic storage materials and reintroduction through outplanting. PEPP is focused on preventing the extinction of taxa with fewer than 50 individuals in the wild. The VRPF propagates all rare plants used in the NAR program.

NAR staff will follow rare plant collection and reintroduction guidelines recommended by the Hawaii Rare Plant Restoration Group (interagency group of rare plant experts) <http://www.hear.org/hrprg/>. Rare plants reintroduced into the NAR include *Argyroxiphum kauense*, *Anoectochilus sandvicensis*, *Clermontia lindseyana*, *Clermontia peleana*, *Cyanea shipmanii*, *Cyanea stictophylla*, *Joinvillea ascendens ssp. ascendens*, *Phyllostegia velutina*, *Phyllostegia floribunda*, *Platydesma spathulata*, *Pritchardia beccariana*, *Sicyos alba*, *Schieda diffusa*, and *Stenogone scrophularioides*. Additional rare and endangered species historically known from the NAR and/or nearby will be reintroduced to the Reserve, as appropriate (Table 1). NAR staff will tag and map the locations of all outplanted plants and monitor their survival and growth. They will do additional management of wild and/or reintroduced populations if needed (e.g. fencing wild plants that are not within fenced management units, control of damaging weeds, insects, slugs, plant disease and/or mammalian predators).

Small mammalian predator removal (e.g., removal of rats, mongoose, cats) may provide significant benefits to endangered birds and plants, but is extremely difficult and costly to implement on a large-scale using currently existing methods. NAR staff may implement predator removal in certain high priority areas (e.g. upper elevation, fenced management units, bird nesting sites) using existing, approved methods (trapping and application of rodenticides using bait stations). New methods for widespread control of these species across large conservation areas are currently being developed and will be implemented if they are approved and offer a cost-effective way to remove predators.

Other management may also benefit forest birds and will be implemented, as feasible. Upper elevations of the NAR in the Kūlani area will be targeted for these actions as these areas provide the most important habitat for native forest birds. NARS staff will work with adjacent landowners (e.g. Kamehameha Schools and State DOD YCA) to eliminate or treat larval habitats for mosquitoes (standing water associated with cattle troughs, water catchment and stock ponds that are located within or adjacent to forest bird recovery areas. Larval habitats associated with residential and agricultural development may be primary sources for mosquitoes responsible for seasonal epizootics of pox and malaria. Reducing or eliminating vespulid wasps (yellow jackets) may also provide benefits to forest birds, as these wasps prey on insects that provide food for forest birds.

The current captive population of ‘alalā is at the point where restoration of a wild population can proceed. The Kūlani portion of the Reserve has been identified as a high priority release site for re-establishment of this species in the wild due to the high quality of native forest and its ungulate-free status. The restoration of a wild population of ‘alalā will require minimizing threats, including implementing control of non-native mammalian predators. Releases and managing (e.g., providing supplemental food) will require semi-permanent infrastructure and a constant, long-term human presence. Holding or release aviaries will need to be erected at release sites. These will most likely be placed on scaffolding to minimize predator access.

DOFAW will attempt to place aviaries in natural openings in the forest; however, some clearing of native vegetation may be necessary. Given the need to have staff on site at all times, the construction of a remote cabin or weatherport will be needed. The release and monitoring team (3 – 5 individuals) will care for, feed, monitor, and track released birds. This team will need to maintain a constant presence at the release site for an undetermined length of time. It is difficult to estimate the length of time that the release and monitoring team will have to remain on site. Much will depend on the availability and use of wild foods by the ‘alalā, their dependence on supplementary food, their health, and how they adjust to their new environment. Other management actions involved with ‘alala release may require additional staff to control predators, monitor ‘io abundance, restore food plants, monitor vegetation recovery, track and control invasive species and check and repair fence.

Nēnē are present in the Kūlani portion of the Reserve and in adjacent areas. NARS staff will assist DOFAW Wildlife Staff in banding and monitoring nēnē in the general area and working with adjacent landowners, particularly DOD-YCA, to enhance overall nēnē efforts across the island of Hawai‘i. Other actions such as small mammalian predator control and habitat improvement may be implemented in localized areas to protect and manage nēnē.

NARS staff will also implement targeted habitat restoration projects as resources allow. Although the forest canopy in the Reserve is largely intact, certain localized areas that have been disturbed or invaded by weeds may require more intensive management. Non-native pasture grasses will be targeted for control in certain areas to enhance the natural regeneration of native trees and shrubs and prevent fire. *Carex* wetlands are also targeted for restoration as these areas were more disturbed by past feral pig activity and are subsequently more highly invaded by weeds. NAR staff and volunteers will eradicate invasive weeds and reintroduce native plant species to restore these wetlands.

### ***Fire Prevention and Response***

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

Actions:

1. Work with Hawai‘i island Protection Forester (DOFAW) to update fire response maps to show the Kūlani portion of the NAR to be a DOFAW primary response area.
2. Implement fire prevention measures, including educational outreach to neighbors and signage along roads.
3. Suppress fires safely and aggressively using appropriate means.
4. Continue NAR staff training and certifications for effective and safe fire response.

Due to the high rainfall at Pu‘u Maka‘ala, fire is not normally a concern for the project area. However, fire management is incorporated as part of this management plan because of the impact fire can have on native communities. It is recognized that, though unlikely, fire may be a risk in the project area, particularly in the drier Kūlani portion of the Reserve. Thus, strategies to prevent and minimize the impacts of fire are incorporated into this plan.

Many fires are caused by humans, so fire prevention measures will include increased educational efforts for those accessing the property, road or area closures in the event of extreme fire danger and suppression of non-native grasses in fire prone areas. Weed control and planting of common native species will be used to restore certain disturbed areas to prevent fire and/or following damage from fire.

In the event of fire, DOFAW will respond to fires in the Reserve. The most effective control of a fire will be through measures that result in the least amount of impact or disturbance to natural and archeological resources. The method of suppression will be determined by the on-site situation, with special regard to the potential expansion of fire damage to the resources within the Reserve. Minimum impact methods of suppression will be applied whenever such methods are sufficient. Bulldozing or other extreme fire control measures are justified when a fire cannot be otherwise controlled and the bulldozing damage is outweighed by a probable greater loss of natural and archeological resources. NARS staff will maintain current fire response certifications by attending regular required staff trainings.

### ***Monitoring***

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

#### Actions:

1. Continue ongoing monitoring programs for ungulates, weeds and rare plants to measure the success of management and detect changes in abundance and distribution.
2. Continue ongoing monitoring program for forest birds in the Kūlani portion of the Reserve in cooperation with TMA and the Hawai‘i Forest Bird Interagency Database Project.
3. Develop improved monitoring protocols, data management and analysis for existing monitoring programs.
4. Review and summarize past monitoring data and inventories.
5. Identify critical gaps in natural resource inventories for the NAR and initiate additional surveys.
6. Develop and/or identify appropriate monitoring protocols and implement monitoring for key community indicators that are not currently being monitored (e.g., native vegetation communities, invertebrates etc).

NAR staff regularly monitors ungulates, weeds and rare plants and are planning on continuing these monitoring programs. Ungulate monitoring is used in fenced units that are being managed for ungulates to detect the presence or absence of ungulates. Units that are free of ungulates are regularly monitored to detect ingress animals. Units with active ungulate control programs are monitored to assess the success of and/or direct control efforts.

Weed monitoring will continue to be conducted every five years along transects in fenced management units and every 10 years in the unfenced sections of the NAR to detect changes in

weed distribution and abundance over time as well as detect incipient invaders. Weed control areas are monitored to determine the success of management efforts.

Rare plant monitoring is conducted to assess the survival and growth of wild and re-introduced rare plants. NAR and PEPP program staff monitor rare plants to assess their survival and reproduction, collect propagation materials, search for additional wild individuals and determine whether additional management is necessary.

NAR staff has also monitored changes in native understory diversity and nonnative invasive plant distribution to assess the results of pig removal. This type of monitoring will be continued, as resources permit, to assess the long-term results of management actions.

The TMA has monitored forest birds in the Kūlani portion of the NAR as well as on adjacent Kamehameha Schools land and NARS is planning on working with the TMA to continue these annual surveys. Monitoring transects in the Mauna Loa Boy's School Unit, Pu'u Kipu Unit and Kūlani Cone unit have been monitored annually since the early 1990's. Monitoring data will be provided to the Hawai'i Forest Bird Interagency Database Project for analysis of bird population densities and trends.

NAR staff will refine and modify existing inventory and monitoring programs (monitoring protocols, data management and analysis) for ungulates, birds, weeds and rare plants in order to make the program more effective. It would be valuable to expand the monitoring program as time and resources permit to include surveys and monitoring of invertebrates as well as native plant communities. Establishing and implementing new long-term monitoring programs for key community indicators, especially in the face of new threats such as climate change and the introduction of new diseases and pathogens will be critical to informing future management of native ecosystems and species in the NAR. Collaboration with partners such as researchers, students and adjoining landowners may help improve and expand inventory and monitoring programs if NAR staff time and resources are limited.

### ***Public Access, Outreach and Education***

Objective: Provide public access to the Reserve and build public understanding and support for the NAR and the state's unique native resources through outreach and education.

Actions:

1. Enhance public access, hiking opportunities and interpretation of NAR resources by providing public access into the Kūlani portion of the Reserve as well as improving the Wright Road and Army Road trails for pedestrian use.
2. Hire Outreach Specialist to provide periodic interpretive trips to the Reserve for the general public as well as other outreach and educational activities listed below.
3. Maintain and expand opportunities for volunteer service trips, student internships and teacher workshops.
4. Maintain and expand NAR staff presentations and outreach to schools and community groups.

Public access to all portions of the Reserve is allowed for recreational and cultural uses. Recommended public access points are shown in Figure 11; however the public is allowed to access the Reserve in other areas as well (e.g. along Stainback Highway). Current public use of Pu‘u Maka‘ala primarily includes hiking, bird watching, and hunting. Hunting in portions of the NAR is regulated by Chapter 13-123, Hawaii Administrative Rules (Rules Regulating Game Mammal Hunting), and areas where hunting is allowed are designated as part of Hunting Unit K. Hunters should check with the DOFAW office (19 East Kawili Ave., Hilo, HI 96720) to get current information on hunting rules and any changes in special conditions, bag limits, seasons and open areas. Some public uses of the Reserve, including groups larger than ten individuals, research, scientific collecting, gathering (including Native Hawaiian religious and customary gathering rights) and commercial uses require a Special Use Permit from the Executive Secretary of the NARS Program in Honolulu (808-587-0063) (HAR§ 13-209-4).

Public access to all parts of the Kūlani portion of the NAR will be open for pedestrian use. The primary recommended access points are along Stainback Highway. NAR staff will improve trails into the area by clearing old trails and adding additional directional and interpretive signage along recommended routes (Figure 12). NARS staff and volunteers will also provide periodic guided educational tours of the Kūlani portion of the NAR for community groups and/or the general public. DOFAW will be developing a Memorandum of Agreement with with DOD-YCA to address public pedestrian access.

New proposed interpretive hiking opportunities within Pu‘u Maka‘ala will provide opportunities for the public to learn more about the NAR, its unique native species and ecosystems, threats to the NAR, and ongoing management activities. The two areas proposed for improvement (Army Rd. and Wright Rd) already have existing unimproved trails or roads and are the most accessible portions of the Reserve. In addition, trail improvements such as rest areas/benches, viewing platforms, and boardwalks over particularly wet areas of trail and the installation of interpretive signs at points of interest (e.g. significant trees, geologic features, wetlands and lookout areas) will improve the outdoor experience for general users and provide an enjoyable opportunity to learn about Hawaii’s native forests.

Proposed Interpretive Trail Development Projects (Figures 13 and 14):

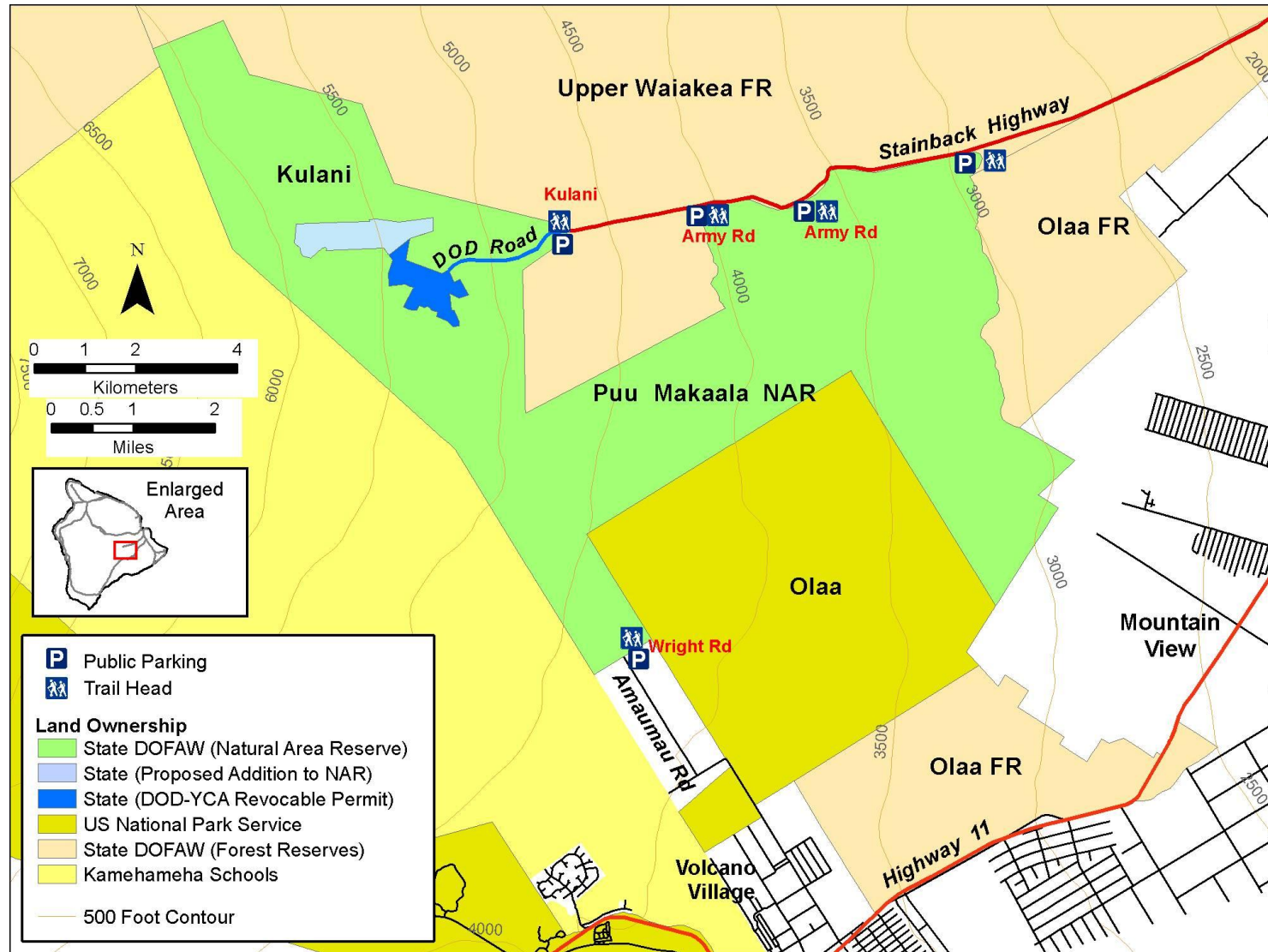
- At Wright Road, the current unimproved trail runs perpendicular to a management access road. Constructing a 1-2 mile (1.6 -3.2 km) new connector trail between the existing management access road and unimproved trail and would create a 3-4 mile (4.8-6.3 km) loop trail, located entirely within the fenced Wright Road unit. The newly constructed portion of trail will be located entirely on State land. In addition, the existing management access road and unimproved trail portions of the loop will be improved for public pedestrian use. This loop trail will provide new opportunities for public recreation in the NAR and will also enhance NAR management of the Wright Rd. unit by providing management access.
- At Army Road, an existing four-wheel drive road is currently open for public vehicular access in two sections (mauka and makai). Vehicle access between these two sections is blocked due to existing ‘Akū unit fencing (although public access is allowed on foot). This area is proposed to be fenced and become an ungulate-free management area (Army Rd. Unit). Proposed fencing will follow the road corridor. When the Army Rd. Unit is fenced, the existing road will be converted to a public trail with improvements such as rest areas,

covered picnic tables and interpretive signs. Access will be restricted to pedestrian use. Conversion of the road into a pedestrian trail will provide enhanced opportunities for the general public to learn about and enjoy the native forest.

At Pu‘u Maka‘ala, volunteer service trips are currently used to promote public understanding and support for conservation. Volunteer groups have regularly assisted with weed control; trail maintenance and restoration projects planting native species. Additionally, local students spend a week every year assisting with management efforts at Pu‘u Maka‘ala NAR through the Youth Conservation Corps summer program. The NAR program also regularly hires interns to assist with management and provide educational and training opportunities for students. NAR staff will continue these types of programs because they provide educational opportunities for interested groups and individuals to learn more about the Reserve and Reserve management programs. In addition, volunteers and interns contribute useful assistance in labor-intensive activities.

Beginning in 2008, NARS staff partnered with the TMA education program to jointly host standards-based teacher workshops to provide outdoor learning opportunities and lesson plans to local teachers. NAR staff also regularly provides slide shows, presentations and outreach to schools, local groups and at community events. NAR staff is planning on continuing all these activities, and expanding them as resources allow.

Figure 11 - Pu'u Maka'ala NAR Access





**Figure 12. Kulani Access and Proposed Trail Improvement**

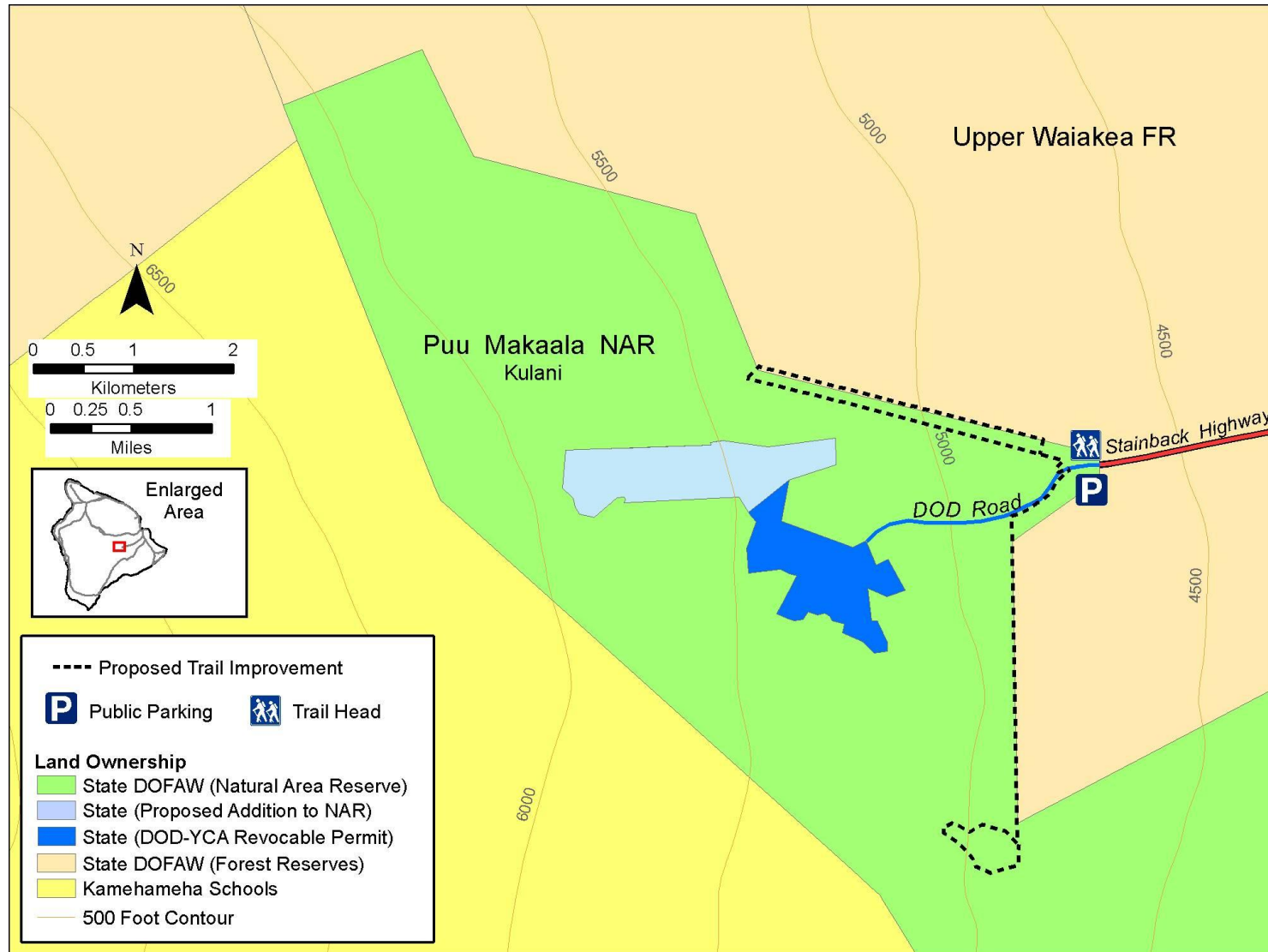
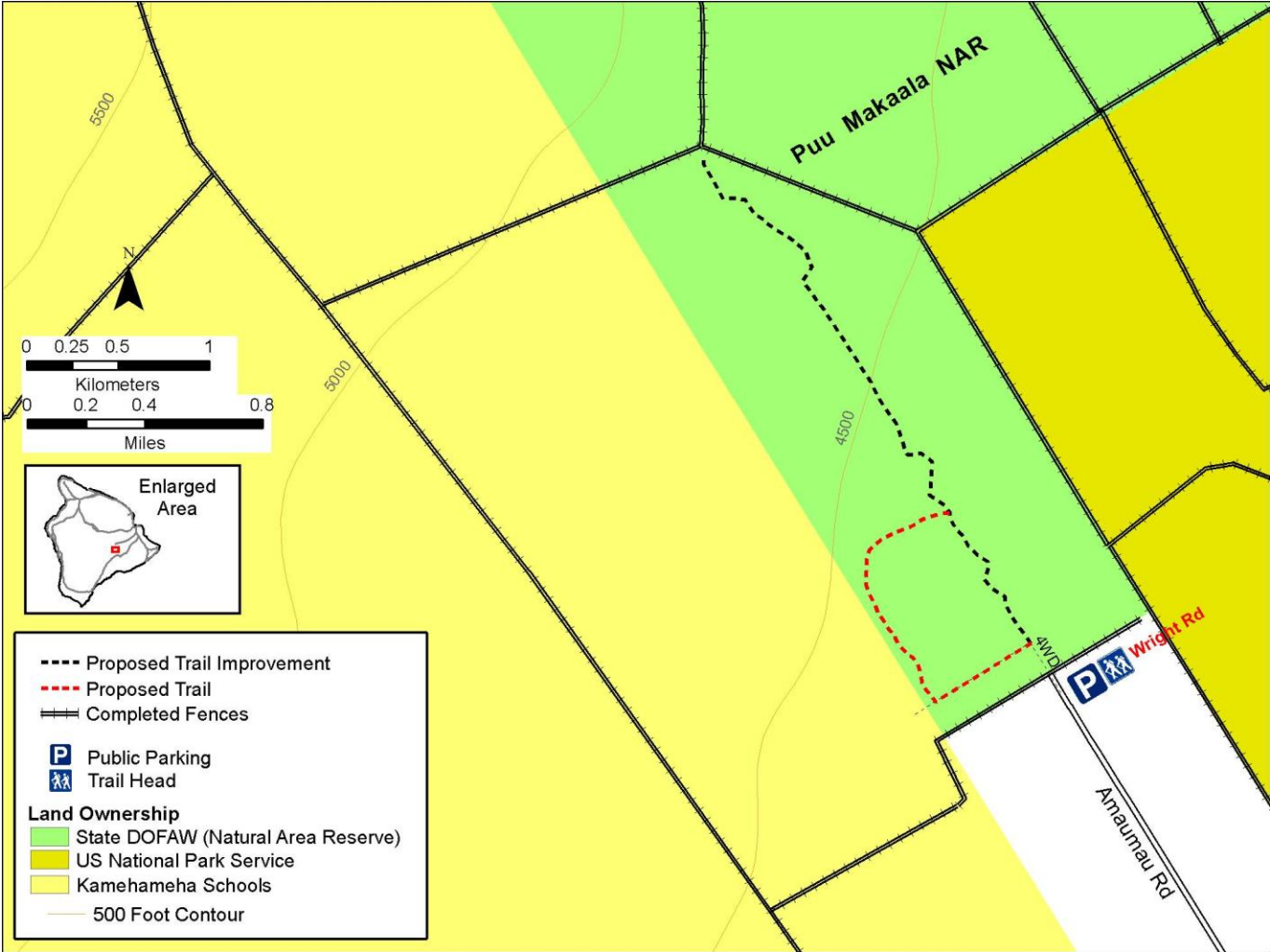
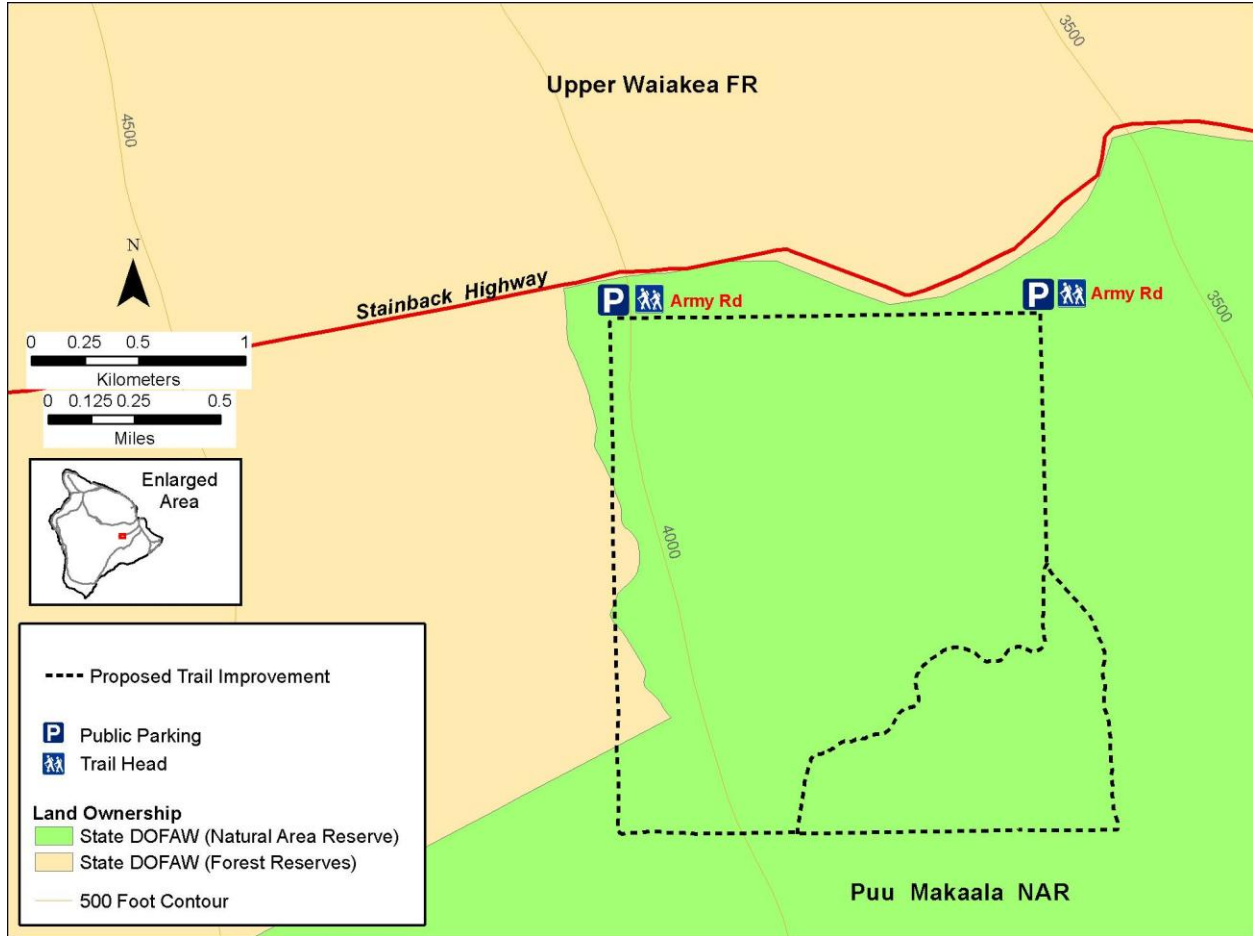


Figure 13. Wright Rd Proposed Trail and Trail Improvement.



**Figure 14. Army Rd. Proposed Trail Improvement.**



***Enforcement***

Objective: Ensure effective enforcement of laws that protect Pu‘u Maka‘ala NAR.

Actions:

1. Explore opportunities to collaborate with DLNR’s Division of Conservation and Resource Enforcement (DOCARE) to improve voluntary compliance with laws and strategies to improve the effectiveness of enforcement.
2. Encourage DOCARE to focus on illegal taking of natural resources and vandalism.

The DLNR’s DOCARE is responsible for enforcement of state laws at Pu‘u Maka‘ala, including laws regulating hunting and protection of resources (e.g. illegal harvesting, vandalism etc). Improved collaboration between the NAR program and DOCARE will improve the effective enforcement of laws that protect the Reserve.

### ***Partnership Collaboration***

Objective: Collaborate with external partners to support NARS mission and goals.

Actions:

1. Continue partnerships with adjacent landowners through the TMA to address threats and management needs on a regional basis.
2. Develop a memorandum of agreement with DOD-YCA to address access by DOFAW over the internal roads at Kūlani included in the the DOD-YCA revocable permit area, conservation management within the permit area, the parties' maintenance obligations for the internal roads, and conditions under which public access will be permitted, etc.
3. Work with the DOD-YCA to cooperatively address endangered species issues on the DOD-YCA area, joint threats (e.g. invasive species) and to provide environmental service-learning and educational programs for YCA students.
4. Partner with Hawaii County Fire Department to familiarize their staff with locations of management access roads and important resources for protection in case there is an emergency such as fire or rescue.
5. Continue working with other groups collaboratively to address joint management needs (e.g. invasive species management, rare plant management, education, monitoring and research).

Many of the threats to Hawaii's natural resources, such as feral ungulates, invasive weeds, fire, invasive insects, and introduced plant and animal diseases, occur across land ownership boundaries. Working with partners can increase the effectiveness and efficiency of management with limited resources. Continued collaboration with the TMA and TMA members, particularly adjacent landowners (e.g. National Park Service and Kamehameha Schools) will enhance the effectiveness of response to regional threats like feral ungulates, weeds and fire.

NARS participation in TMA initiatives for weed control work with adjacent communities, landowners and community organizations will help protect the NAR by providing a better weed buffer and reducing the spread of harmful weeds. TMA members are also collaborating on new weed mapping and monitoring technologies such as remote sensing. Involvement in the TMA will also provide opportunities for sharing of monitoring protocols and/or joint long-term monitoring of natural resources and threats (e.g. bird monitoring across a larger landscape, intensive monitoring of National Park Service resources through the NPS Inventory and Monitoring Program). The NAR will also work with the TMA increase joint educational and outreach efforts in order to reach a larger audience.

NARS staff will also work closely with the DOD-YCA on numerous issues including staff and public access, management of native species and educational opportunities for YCA students. NARS will also encourage DOD to join and participate in the TMA. NARS staff can assist DOD with management of native species, including endangered species present on DOD-YCA managed lands adjacent to the Reserve. It will also be critical to collaborate on the management of threats to the Reserve such as preventing the establishment of coqui frogs at the YCA and the removal of invasive weeds. In addition, NARS can provide environmental education, service learning and work training for YCA students on NARS lands, which will benefit both the

students and the land. NARS staff will work with DOD-YCA to develop a Memorandum of Agreement for various issues at the former Kūlani Correctional Facility area, including protocols for staff and public access over internal roads and conservation management in the DOD-YCA revocable permit area.

Continued collaboration with other groups in addition to the TMA will also assist NAR management in various areas. NAR staff will continue to work closely with the Big Island Invasive Species Committee (BIISC) to jointly address incipient invasive species of plants and animals that threaten the Reserve. NAR staff will continue to work closely with two organizations focused on rare plant recovery (VRPF and PEPP). NAR staff will also work with community groups and volunteers to assist with initial animal control in fenced units, prevent the spread of introduced species (e.g. invasive weeds and coqui), and to restore native habitat and species.

Pu‘u Maka‘ala NAR offers unique opportunities for research, and NAR staff review all research permits before they are approved. NARS staff will work with interested researchers in the academic community as well as scientists so their research can better address critical management needs.

### ***Infrastructure and Other Actions***

Objective: Manage existing infrastructure within the NAR and take other actions necessary to protect and effectively manage the NAR.

Actions:

1. Add 342 ac (138 ha) of former Kūlani pasture areas to the NAR to protect and enhance endangered species habitat (Figure 15).
2. Block off access to Mauna Loa Boy’s School structure through fencing and signage to reduce the safety hazard to the public.
3. Investigate the feasibility of renovating or demolishing of Mauna Loa Boy’s School structure to prevent safety hazard to the public.
4. Maintain water infrastructure (e.g. water tanks) in the Kūlani portion of the NAR for fire fighting and weed control activities.
5. Maintain management access roads to support management and educational programs.
6. Develop utility and access easements for entities requiring access through the NAR.

NARS will be pursuing the administrative process to add 342 ac (138 ha) of state lands to the NAR, including approval of the BLNR and an executive order from the Governor (Figure 15). DOFAW currently has a Right-of-Entry permit over this area for data collection, surveys and conservation activities. This area was formerly used for cattle ranching by the Kūlani Correctional Facility. These former pastures have not been used for cattle since 2005 and ranching is not an environmentally appropriate use of this land as it the native forest is naturally recovering and the area is known habitat for endangered plants and animals. This proposed addition is particularly important for endangered forest birds, as it provides high elevation forest habitat above the mosquito line. This area provides excellent opportunities for public service

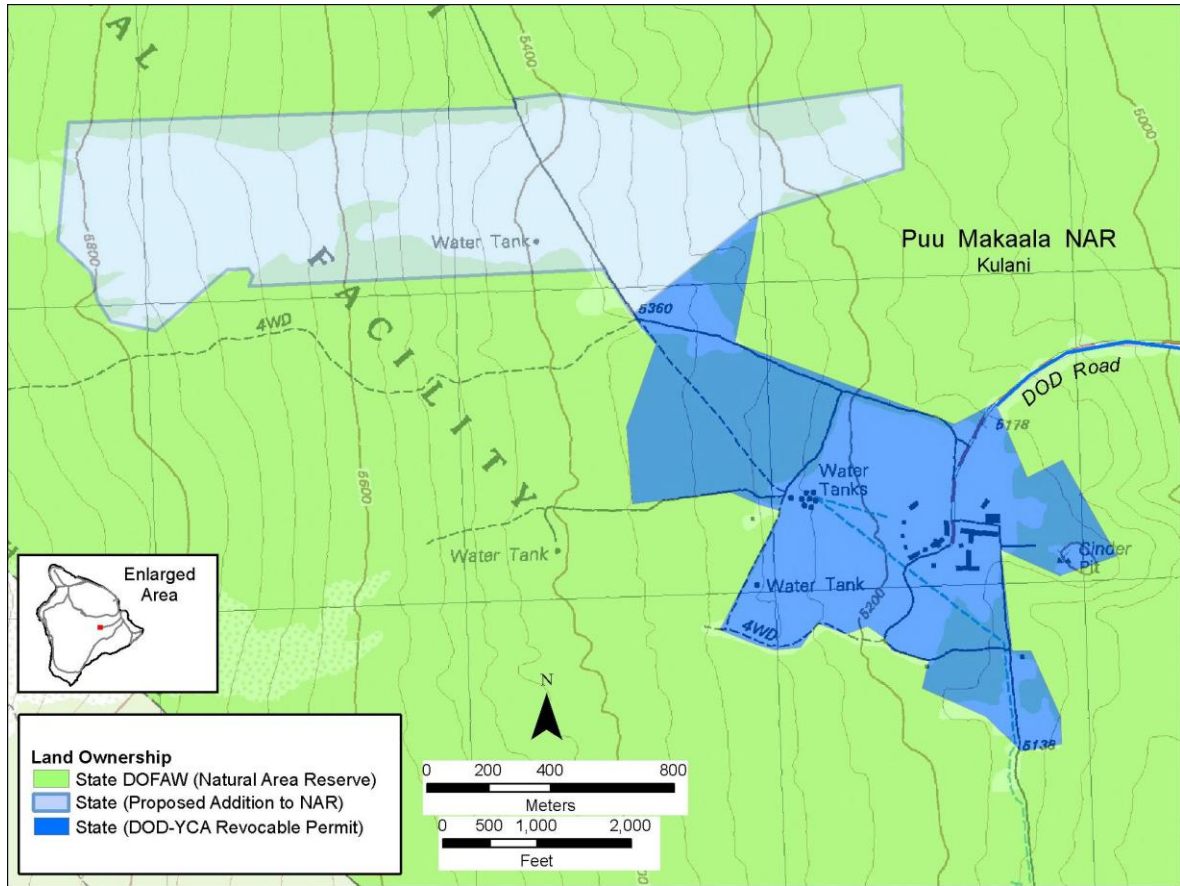
trips to work on tree planting and other restoration actions, and restoration of this area with koa-‘ōhi‘a forest will provide a critical link to connect surrounding intact forests.

The Reserve contains the Mauna Loa Boy’s School facility which has not been maintained and is in currently in severe disrepair. In the short-term, this structure may need to be blocked off with fencing and signage to reduce public safety hazard. NAR staff will investigate the cost and feasibility of renovating or demolishing this structure to remove it as a public safety hazard and implement the most feasible option. The Mauna Loa Boy’s School area was also previously used for military training and was investigated in 2010 by the U.S. Army following the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The Army’s report concludes that the majority of the area does not pose a significant threat to public health or the environment. However, a small burn pile area near the Boys’ School structure does contain levels of copper that exceed the US Environmental Protection Agency and the Hawaii Department of Health guidelines. The Army will be doing a follow-up study on the feasibility of remediating the 0.25 acre burn pile site. The burn pile site will be blocked from public access until the area is remediated and determined safe for public access.

Other former correctional facility infrastructure is also present in the Reserve (e.g. old ranch fencing, water tanks, water catchments, and roads). NAR staff would like to maintain some of this infrastructure; particularly management roads and water catchment for resources management purposes (e.g. fire fighting and weed control).

Various entities using Kūlani Cone as well as portions of the NAR for communications and utilities purposes do not have a utility and/or access easement through the NAR and other adjacent state lands. NAR staff will request that these entities work with DLNR Land Division to develop utility and access easements.

**Figure 15. Proposed Addition to Pu‘u Maka‘ala NAR**



**BUDGET**

NAR staff for the island of Hawai‘i work on all eight NAR on the island, including Pu‘u Maka‘ala. In 2009, NAR staff include five DOFAW staff, four University of Hawai‘i contractors (Pacific Cooperative Studies Unit) and 1-3 interns. The budget below assumes current budget levels/existing staff will provide labor, materials and supplies for many of the ongoing and proposed management actions. New funding will be required to hire additional NAR staff and/or contractors to complete major new proposed projects including new fence construction and the expansion of weed management into these new fenced units.

Item	Estimated Cost (15 years)	Comments (annual cost)	Existing or New cost
Ungulate Management Program			
Fence Inspection/Maintenance and Ungulate Monitoring (existing fenced units)	\$225,000	\$15K/year for staff, supplies/materials	existing budget
New Fence Construction	\$1,500,000	labor (additional staff and/or	new cost

(17 miles)		contractors), materials and helicopter @ 100K/mile	\$1,700,000
Animal Control/Monitoring (new fenced units)	\$225,000	\$15K/year for staff, supplies and materials	existing budget
Weed Management program			
Weed Management (existing fenced units)	\$900,000	\$60K/year for staff, supplies and materials	existing budget
Weed Management (new fenced units)	\$300,000	5 years @ \$60K/year for staff, supplies/ materials	new cost \$300,000
Habitat Protection and Rare Species Restoration Program	\$75,000	\$5K/year for staff, supplies (outplanting rare plants)	existing budget
Fire Prevention and Response	\$75,000	\$5K/year for staff, training/equipment	existing budget
Monitoring (weeds/rare plants)	\$75,000	\$5K/year for staff	existing budget
Outreach and Education			
Volunteer service trips , teacher workshops, general education	\$150,000	\$10K/year for staff, supplies/outreach materials	existing budget
Interpretive Trail Development	\$75,000	\$5K/year staff, trail materials (e.g. (signs)	existing budget
Enforcement	-----	minimal cost	existing budget
Partnership Collaboration	\$150,000	\$10K/year for staff, supplies, materials	existing budget
Infrastructure	\$150,000	\$10K/year for staff, supplies, materials	existing budget
Estimated Total	\$3,900,000	\$2,100,000 (\$140,000/year existing budget)	\$2,000,000 new cost

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## Appendix A – Plant Species List

These species lists (native plants, non-native plants are ferns) were compiled by updating the plant species list from the previous management plan (1989), consulting available literature sources to update names and consulting with NAR staff. Some species included on the list (particularly rare species and high priority weed species) may not be present in the NAR, however they are historically and/or currently known from adjacent areas.

**Status:** Federal and State endangered species list  
 END Endangered  
 T Threatened  
 C Candidate species  
 SOC Species of Concern (unofficial)

**Affinity:** N Non-native  
 P Polynesian introduction  
 I Indigenous  
 E Endemic

### Native Plants (Endemic and Indigenous)

Taxon	Common/Hawaiian name	Family	Affinity	Status
Acacia koa	koa	Fabaceae	E	
Agrostis avenacea	he'upueo	Poaceae	I	
Alyxia oliviformis	maile	Apocynaceae	E	
Anoectochilus sandvicensis	jewel orchid	Orchidaceae	E	SOC
Antidesma platyphyllum	hame	Euphorbiaceae	E	
Argyroxiphum kauense	Mauna Loa silversword	Asteraceae	E	END
Astelia menziesiana	pa'iniu, kakuaha	Liliaceae	E	
Broussaisia arguta	kanawao	Hydrangeaceae	E	
Carex alligata		Cyperaceae	E	
Carex echinata		Cyperaceae	I	
Carex macloviana		Cyperaceae	I	
Carex montis-eeka		Cyperaceae	E	
Carex thunbergii		Cyperaceae	I?	
Carex wahuensis		Cyperaceae	E	
Charpentiera obovata	pāpala	Amaranthaceae	E	
Cheirodendron trigynum	'ōlapa	Araliaceae	E	
Clermontia hawaiiensis	'ōhā kēpau, 'ōhā wai nui	Campanulaceae	E	
Clermontia lindseyana	'ōhā wai	Campanulaceae	E	END
Clermontia montis-loa	'ōhā wai	Campanulaceae	E	
Clermontia parviflora	'ōhā wai	Campanulaceae	E	
Clermontia peleana	'ōhā wai	Campanulaceae	E	END
Coprosma ernodeoides	kūkaenēnē	Rubiaceae	E	
Coprosma granadensis	mākole	Rubiaceae	E	
Coprosma montana	pilo	Rubiaceae	E	
Coprosma ochracea	pilo	Rubiaceae	E	
Coprosma pubens		Rubiaceae	E	

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<i>Coprosma rhynchocarpa</i>	pilo	Rubiaceae	E	
<i>Cryptandra tintinnabula</i>	ha'iwale	Gesneriaceae	E	END
<i>Cyane shipmanii</i>	hāhā	Campanulaceae	E	END
<i>Cyanea copelandii</i>	hāhā	Campanulaceae	E	END
<i>Cyanea floribunda</i>	hāhā	Campanulaceae	E	
<i>Cyanea giffardii</i>	hāhā	Campanulaceae	E	SOC
<i>Cyanea pilosa</i> var. <i>longipedunculata</i>	hāhā	Campanulaceae	E	
<i>Cyanea platyphylla</i>	'akū'akū	Campanulaceae	E	END
<i>Cyanea stictophylla</i>	hāhā	Campanulaceae	E	END
<i>Cyanea tritomantha</i>	'akū	Campanulaceae	E	
<i>Cyrtandra giffardii</i>	ha'iwale	Gesneriaceae	E	END
<i>Cyrtandra lysiosepala</i>	ha'iwale	Gesneriaceae	E	
<i>Cyrtandra paludosa</i>	moa, hahala	Gesneriaceae	E	
<i>Cyrtandra platyphylla</i>	'ilihia	Gesneriaceae	E	
<i>Deschampsia nubigena</i>		Poaceae	E	
<i>Dianella sandwicensis</i>	'uki'uki	Liliaceae	I	
<i>Dichantherium hillebrandianum</i>		Poaceae	E	
<i>Dubautia scabra</i>	na'ena'e	Asteraceae	E	
<i>Eleocharis obtusa</i>	spikerush, kohekohe, pīpīwai	Cyperaceae	I	
<i>Embelia pacifica</i>	kilioe	Myrsinaceae	E	
<i>Eurya sandwicensis</i>	ānini	Theaceae	E	SOC
<i>Fimbristylis dichotoma</i>		Cyperaceae	I	
<i>Fragaria chiloensis</i> var. <i>sandwicensis</i>	'ōhelo papa	Rosaceae	E	
<i>Freycinetia arborea</i>	'ie'ie	Pandanaceae	I	
<i>Gardenia remyi</i>		Rubiaceae	E	C
<i>Hedyotis accuminata</i>	au, pilo	Rubiaceae	E	
<i>Hedyotis centranthoides</i>		Rubiaceae	E	
<i>Hedyotis terminalis</i>	manono	Rubiaceae	E	
<i>Ilex anomala</i>	kāwa'u	Aquifoliaceae	I	
<i>Joinvillea ascendens</i> ssp. <i>ascendens</i>	'ohe	Joinvilleaceae	E	C
<i>Korthalsella complanata</i>	hulumoa, kaumahana	Viscaceae	I	
<i>Labordia hedyosmifolia</i>	kāmakahala	Loganiaceae	E	
<i>Leptecophylla tameiameia</i>	pūkiawe	Ericaceae	I	
<i>Liparis hawaiiensis</i>	'awapuhiakanaloa	Orchidaceae	E	SOC
<i>Ludwigia octovalvis</i>	primrose willow, kāmole	Onagraceae	Pol?	
<i>Luzula hawaiiensis</i>	wood rush	Juncaceae	E	
<i>Machaerina angustifolia</i>	'uki	Cyperaceae	I	
<i>Melicope clusiifolia</i>	kolokolo mokihana	Rutaceae	E	
<i>Melicope hawaiiensis</i>	mokihana kūkae moa	Rutaceae	E	
<i>Melicope pseudoanisata</i>	ālani	Rutaceae	E	
<i>Melicope radiata</i>	ālani	Rutaceae	E	
<i>Melicope volcanica</i>	ālani	Rutaceae	E	
<i>Metrosideros polymorpha</i>	'ōhi'a, 'ōhi'a lehua	Myrtaceae	E	

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Morelotia gahniiformis		Cyperaceae	I	
Myoporum sandwicense	naio	Myoporaceae	I	
Myrsine lessertiana	kōlea lau nui	Myrsinaceae	E	
Myrsine sandwicensis	kōlea lau li`i	Myrsinaceae	E	
Nothoecstrum longifolium	`aiea	Solanaceae	E	
Oreobolus furcatus		Cyperaceae	E	
Peperomia cookiana	'ala'ala wai nui	Piperaceae	E	
Peperomia hypoleuca	'ala'ala wai nui	Piperaceae	E	
Peperomia latifolia	'ala'ala wai nui	Piperaceae	E	
Peperomia macraeana	'ala'ala wai nui	Piperaceae	E	
Peperomia membranacea	'ala'ala wai nui	Piperaceae	E	
Perrottetia sandwicensis	olomea	Celastraceae	E	
Phyllostegia ambigua		Lamiaceae	E	SOC
Phyllostegia brevidens		Lamiaceae	E	SOC
Phyllostegia floribunda		Lamiaceae	E	C
Phyllostegia macrophylla		Lamiaceae	E	SOC
Phyllostegia racemosa	kīponapona	Lamiaceae	E	E
Phyllostegia velutina		Lamiaceae	E	E
Phyllostegia vestita		Lamiaceae	E	
Phytolacca sandwicensis	pōpolo kū mai	Phytolaccaceae	E	
Pipturus albidus	māmaki	Urticaceae	E	
Pittosporum confertiflorum	hō'awa	Pittosporaceae	E	
Pittosporum hawaiiense	hō'awa	Pittosporaceae	E	SOC
Pittosporum terminalioides	hō'awa	Pittosporaceae	E	
Plantago pachyphylla	laukahi kuahiwi	Plantaginaceae	E	
Platydesma spathulata	pilo kea	Rutaceae	E	
Psychotria hawaiiensis	kōpiko 'ula, 'opiko	Rubiaceae	E	
Pycreus polystachyos		Cyperaceae	I	
Rubus hawaiiensis	'ākala	Rosaceae	E	
Rubus macrei	'ākala	Rosaceae	E	
Rumex giganteus	pāwale, uhauhakō	Polygonaceae	E	
Rhynchospora chinensis	kuolohia	Cyperaceae	I	
Rhynchospora rugosa	pu'uko'a	Cyperaceae	I	
Santalum paniculatum		Santalaceae	E	
Scaevola chamissoniana	naupaka, naupaka kuahiwi	Goodeniaceae	E	
Schiedea diffusa		Caryophyllaceae	E	SOC
Sicyos alba	'ānunu	Cucurbitaceae	E	E
Sisyrinchium acre	mau'u lā'ili	Iridaceae	E	SOC
Smilax melastomifolia	hoi kuahiwi, aka'awa	Smilacaceae	E	
Solanum americanum	pōpolo, glossy nightshade	Solanaceae	I	
Sophora chrysophylla	māmane	Fabaceae	E	
Stenogyne calaminthoides		Lamiaceae	E	
Stenogyne macrantha		Lamiaceae	E	SOC
Stenogyne scrophularioides	mōihi	Lamiaceae	E	
Stenogyne sessilis		Lamiaceae	E	
Tetraplasandra kavaiensis	'ohe 'ohe	Araliaceae	E	



<i>Tetraplasandra oahuensis</i>	'ohe mauka	Araliaceae	E	
<i>Touchardia latifolia</i>	olonā	Urticaceae	E	
<i>Trematolobelia grandifolia</i>		Campanulaceae	E	SOC
<i>Uncinia uncinata</i>		Cyperaceae	I	
<i>Urera glabra</i>	ōpuhe	Urticaceae	E	
<i>Vaccinium calycinum</i>	ōhelo kau lā'au	Ericaceae	E	
<i>Vaccinium reticulatum</i>	ōhelo	Ericaceae	E	
<i>Vicia menziesii</i>		Fabaceae	E	E
<i>Viola maviensis</i>		Violaceae	E	
<i>Wikstroemia sandwicensis</i>	'ākia	Thymelaeaceae	E	
<i>Xylosma hawaiiense</i>	maua	Flocourtiaceae	E	
<i>Zanthoxylum kauaense</i>	a'e, mānele	Rutaceae	E	SOC

**Non- Native Plants**

<b>Taxon</b>	<b>Common/Hawaiian name</b>	<b>Family</b>
<i>Ageratina riparia</i>	Hamakua pamakani, mist flower	Asteraceae
<i>Ageratum conyzoides</i>	maile hohono	Asteraceae
<i>Agrostis stolonifera</i>	redtop, creeping bentgrass	Poaceae
<i>Amaranthus spinosus</i>	spiny pigweed, pakai kuku	Amaranthaceae
<i>Anagallis arvensis</i>	scarlet pimpernel	Primulaceae
<i>Andropogon virginicus</i>	broomsedge	Poaceae
<i>Anemone hupehensis</i>	Japanese anemone	Ranunculaceae
<i>Anthoxanthum odoratum</i>	sweet vernalgrass	Poaceae
<i>Arenaria serpyllifolia</i>	thyme-leaved sandwort	Caryophyllaceae
<i>Arundina graminifolia</i>	bamboo orchid	Orchidaceae
<i>Axonopus fissifolius</i>	narrow-leaved carpetgrass	Poaceae
<i>Bidens alba</i>	Spanish needle	Asteraceae
<i>Bidens pilosa</i>	Spanish needle	Asteraceae
<i>Brassica rapa</i>	radish	Brassicaceae
<i>Brugmansia candida</i>	angel's trumpet	Solanaceae
<i>Buddleja asiatica</i>	dog tail, Asiatic butterfly bush	Buddlejaceae
<i>Buddleja davidii</i>	butterfly bush	Buddlejaceae
<i>Bulbostylis capillaris</i>		Cyperaceae
<i>Cannabis sativa</i>	pakalolo, marijuana	Cannabaceae
<i>Cardamine flexuosa</i>	bittercress	Brassicaceae
<i>Castilleja arvensis</i>	indian paintbrush	Scrophulariaceae
<i>Centaurium erythraea</i>	bitter herb, European centauray	Gentianaceae
<i>Centella asiatica</i>	Asiatic pennywort, pohe kula	Apiaceae
<i>Cerastium fontanum</i>	chickweed	Gentianaceae
<i>Cestrum nocturnum</i>	night blooming jasmine	Solanaceae
<i>Cirsium vulgare</i>	bull thistle	Asteraceae
<i>Clidemia hirta</i>	Koster's curse	Melastomataceae
<i>Commelina diffusa</i>	honohono, makolokolo	Commelinaceae
<i>Conyza bonariensis</i>	hairy horseweed	Asteraceae
<i>Conyza canadensis</i>	Canada fleabane	Asteraceae
<i>Cotoneaster pannosus</i>		Rosaceae

<i>Crassocephalum crepidioides</i>		Asteraceae
<i>Crocoshia x crocosmiiflora</i>	montbretia	Iridaceae
<i>Cuphea carthagenensis</i>	tarweed	Lythraceae
<i>Cyperus halpan</i>		Cyperaceae
<i>Cyperus trinervous</i>		Cyperaceae
<i>Dactylis glomerata</i>	orchardgrass, cocksfoot	Poaceae
<i>Desmodium incanum</i>	Spanish clover, ka'imi	Fabaceae
<i>Digitaria ciliaris</i>	Henry's crabgrass	Poaceae
<i>Digitaria eriantha</i>	pangola grass	Poaceae
<i>Digitaria pentzii</i>		Poaceae
<i>Digitaria violascens</i>	smooth or violet crabgrass	Poaceae
<i>Dissotis rotundifolia</i>		Melastomataceae
<i>Drymaria cordata</i>	pipili	Caryophyllaceae
<i>Ehrharta stipoides</i>	meadow ricegrass	Poaceae
<i>Emilia sonchifolia</i>	Flora's paintbrush	Asteraceae
<i>Epilobium billardierianum</i>	willow herb	Onagraceae
<i>Epilobium ciliatum</i>		Onagraceae
<i>Eragrostis brownii</i>	sheepgrass	Poaceae
<i>Eragrostis elongata</i>	lovegrass	Poaceae
<i>Erechtites valerianifolia</i>	fireweed	Asteraceae
<i>Erigeron karvinskianus</i>	daisy fleabane	Asteraceae
<i>Euchiton sphaericus</i>	Japanese cudweed	Asteraceae
<i>Festuca rubra</i>	red fescue	Poaceae
<i>Fragaria vesca</i>	European strawberry	Rosaceae
<i>Fraxinus uhdei</i>	tropical ash	Oleaceae
<i>Fuchsia magellanica</i>	hardy fuchsia, earring flower	Onagraceae
<i>Geranium homeanum</i>		Geraniaceae
<i>Gnaphalium japonicum</i>		Asteraceae
<i>Gnaphalium purpureum</i>	purple cudweed	Asteraceae
<i>Hedychium coronarium</i>	white ginger	Zingiberaceae
<i>Hedychium flavescens</i>	yellow giner	Zingiberaceae
<i>Hedychium gardnerianum</i>	kāhili ginger	Zingiberaceae
<i>Holcus lanatus</i>	velvetgrass	Poaceae
<i>Hydrocotyle bowlesioides</i>	marsh pennywort	Apiaceae
<i>Hydrocotyle verticillata</i>	pohe	Apiaceae
<i>Hyparrhenia rufa</i>	thatching grass, jaragua	Poaceae
<i>Hypericum kouytchense</i>	St. John's wort	Clusiaceae
<i>Hypericum mutilum</i>	St. John's wort	Clusiaceae
<i>Hypericum parvulum</i>	St. John's wort	Clusiaceae
<i>Hypochoeris radicata</i>	hairy cat's ear	Asteraceae
<i>Juncus acuminatus</i>	rush	Juncaceae
<i>Juncus bufonius</i>	common or toad rush	Juncaceae
<i>Juncus effusus</i>	Japanese mat rush	Juncaceae
<i>Juncus ensifolius</i>	rush	Juncaceae
<i>Juncus planifolius</i>	rush	Juncaceae
<i>Juncus polyanthemos</i>	rush	Juncaceae

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<i>Juncus tenuis</i>	path rush	Juncaceae
<i>Kyllinga brevifolia</i>	kili'o'opu	Cyperaceae
<i>Leucanthemum vulgare</i>	ox-eye, white, or field daisy	Asteraceae
<i>Lonicera japonica</i>	honeysuckle	Caprifoliaceae
<i>Lotus subbiflorus</i>		Fabaceae
<i>Lotus uliginosus</i>		Fabaceae
<i>Ludwigia palustris</i>	marsh purslane	Onagraceae
<i>Lythrum maritimum</i>	loosestrife	Lythraceae
<i>Melinis minutiflora</i>	molasses grass	Poaceae
<i>Melinis repens</i>	Natal redtop	Poaceae
<i>Morella faya</i>	faya	Myrsinaceae
<i>Myosotis discolor</i>	forget me not	Boraginaceae
<i>Oenothera stricta</i>	evening primrose	Onagraceae
<i>Oxalis corniculata</i>	yellow wood sorrel	Oxalidaceae
<i>Panicum repens</i>	torpedo grass, quack grass	Poaceae
<i>Paspalum conjugatum</i>	Hilo grass	Poaceae
<i>Paspalum dilatatum</i>	dallis grass	Poaceae
<i>Paspalum urvillei</i>	vasey grass	Poaceae
<i>Passiflora edulis</i>	liliko`i, passion fruit	Passifloraceae
<i>Passiflora ligularis</i>	sweet granadilla	Passifloraceae
<i>Passiflora tarminiana</i>	banana poka	Passifloraceae
<i>Pennisetum clandestinum</i>	kikuyu grass	Poaceae
<i>Persicaria capitatum</i>	knotweed	Polygonaceae
<i>Persicaria punctatum</i>	water smartweed	Polygonaceae
<i>Phaius tankarvilleae</i>	Chinese ground orchid	Orchidaceae
<i>Physalis peruviana</i>	poha, cape gooseberry	Solanaceae
<i>Phytolacca octandra</i>	southern pokeberry	Phytolaccaceae
<i>Pinus spp.</i>		Pinaceae
<i>Plantago australis</i>	dwarf plantain	Plantaginaceae
<i>Plantago lanceolata</i>	narrow-leafed plantain	Plantaginaceae
<i>Plantago major</i>	laukahi, broad-leafed plantain	Plantaginaceae
<i>Pluchea symphytifolia</i>	sourbush	Asteraceae
<i>Poa annua</i>	annual bluegrass	Poaceae
<i>Poa pratensis</i>	Kentucky bluegrass	Poaceae
<i>Polygala paniculata</i>	milkwort	Polygalaceae
<i>Pritchardia beccariana</i>	loulou	Areaceae
<i>Prunella vulgaris</i>	selfheal, heal-all	Lamiaceae
<i>Prunus cerasifer x salicina</i>		Rosaceae
<i>Psidium cattleianum</i>	strawberry guava	Myrtaceae
<i>Psidium guajava</i>	common guava	Myrtaceae
<i>Pycreus sanguinolentus</i>		Cyperaceae
<i>Pyrocantha angustifolia</i>	firethorn	Rosaceae
<i>Ranunculus plebeius</i>	common Australian buttercup	Ranunculaceae
<i>Ranunculus repens</i>	creeping buttercup, butter daisy	Ranunculaceae
<i>Rhynchospora caduca</i>	beak rush	Cyperaceae
<i>Rubus argutus</i>	blackberry	Rosaceae

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Rubus ellipticus	yellow Himalayan raspberry	Rosaceae
Rubus glaucus		Rosaceae
Rubus niveus	hill or mysore raspberry	Rosaceae
Rubus rosifolius	thimbleberry	Rosaceae
Rumex acetosella	sheep sorrel	Polygonaceae
Rumex crispus	curly or yellow dock	Polygonaceae
Sacciolepis indica	Glenwood grass	Poaceae
Salvia spp.		Lamiaceae
Schizachyrium condensatum	beardgrass	Poaceae
Senecio madagascariensis	fireweed	Asteraceae
Senecio sylvaticus	wood groundsel	Asteraceae
Sequoia sempervirens		Taxiodaceae
Setaria gracilis	yellow or perennial foxtail	Poaceae
Setaria palmifolia	palmgrass	Poaceae
Sonchus asper	prickly sow thistle	Asteraceae
Sonchus oleraceus	sow thistle	Asteraceae
Spermacoce mauritiana		Rubiaceae
Sporobolus africanus	smutgrass, African dropseed	Poaceae
Sporobolus indicus	West Indian dropseed	Poaceae
Stachytarpheta dichotoma	ōwi, ōi	Verbenaceae
Stenotaphrum secundatum	St. Augustine grass, buffalo grass	Poaceae
Taraxacum officinale	dandelion	Asteraceae
Themeda villosa	Lyon's grass	Poaceae
Tibouchina herbacea	Cane tibouchina	Melastomataceae
Tibouchina longifolia	glorybush	Melastomataceae
Tibouchina urvilleana	Lasiandra, princess flower	Melastomataceae
Trifolium dubium	small hop clover	Fabaceae
Trifolium repens	white clover	Fabaceae
Tropaeolum majus	nasturtium	Tropaeolaceae
Verbascum thapsus	common mullein	Scrophulariaceae
Verbena litoralis	hau'owi, ōwi, ōi	Verbenaceae
Veronica plebeia	trailing or common speedwell	Scrophulariaceae
Veronica serpyllifolia	thyme-leaved speedwell	Scrophulariaceae
Vulpia bromoides	brome fescue	Poaceae
Vulpia myuros	rat tail fescue	Poaceae
Xyris platyleis	yellow eyed grass	Xyridaceae
Youngia japonica	oriental hawksbeard	Asteraceae

**Ferns (native and non-native)**

Taxon	Common/Hawaiian name	Family	Affinity	Status
Adenophorus hymenophylloides	pai, palai huna	Grammitidaceae	E	
Adenophorus periens	palai la'aū	Grammitidaceae	E	END
Adenophorus pinnatifidus		Grammitidaceae	E	
Adenophorus tamariscinus	wahine noho mauna	Grammitidaceae	E	
Adenophorus tripinnatifidus		Grammitidaceae	E	
Adiantum hispidulum		Pteridaceae	N	

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<i>Adiantum raddianum</i>	rough maidenhair fern	Pteridaceae	N	
<i>Amauropelta globulifera</i>	palapalai a Kamapua'a	Thelypteridaceae	E	
<i>Angiopteris evecta</i>	mule's-foot fern	Marattiaceae	N	
<i>Asplenium acuminatum</i>	lola	Aspleniaceae	E	
<i>Asplenium adiantum-nigrum</i>	'iwa'iwa	Aspleniaceae	I	
<i>Asplenium aethiopicum</i>	'iwa'iwa a Kāne	Aspleniaceae	I	
<i>Asplenium contiguum</i>		Aspleniaceae	E	
<i>Asplenium horridum</i>	'iwa, 'alae	Aspleniaceae	I	
<i>Asplenium insiticium</i>	pī'ipī'i lau manamana, 'anali'i	Aspleniaceae	I	
<i>Asplenium lobulatum</i>	pī'ipī'i lau manamana	Aspleniaceae	I	
<i>Asplenium macraei</i>	'iwa'iwa lau li'i	Aspleniaceae	E	
<i>Asplenium monanthes</i>		Aspleniaceae	I	
<i>Asplenium normale</i>		Aspleniaceae	I	
<i>Asplenium peruvianum</i> var. <i>insulare</i>		Aspleniaceae	E	END
<i>Asplenium polyodon</i>	pūnana manu	Aspleniaceae	I	
<i>Asplenium schizophyllum</i>		Aspleniaceae	E	
<i>Asplenium sphenotomum</i>		Aspleniaceae	E	
<i>Asplenium</i> spp.		Aspleniaceae	E	
<i>Asplenium trichomanes</i>	'oāl'i	Aspleniaceae	E	
<i>Asplenium unilaterale</i>	pāmoho	Aspleniaceae	I	
<i>Athyrium microphyllum</i>	'ākōlea	Athyriaceae	E	
<i>Botrychium subbifoliatum</i>	makou	Ophioglossaceae	E	
<i>Christella cyatheoides</i>	kakawaiō, kikawaioa, pakikawaiō	Thelypteridaceae	E	
<i>Christella dentata</i>	pai'i'hā	Thelypteridaceae	N	
<i>Christella parasitica</i>		Thelypteridaceae	N	
<i>Cibotium chamissoi</i>	hapu'u, meu	Dicksoniaceae	E	
<i>Cibotium glaucum</i>	hapu'u, hapu'u pulu	Dicksoniaceae	E	
<i>Cibotium menziesii</i>	hapu'u 'i'i	Dicksoniaceae	E	
<i>Coniogramme pilosa</i>	lo'ulu	Pteridaceae	E	
<i>Ctenitis latifrons</i>	'ākōlea	Dryopteridaceae	E	
<i>Cyrtomium caryotideum</i>	kā'ape'ape, āhina kuahiwi	Dryopteridaceae	I	
<i>Deparia petersonii</i>		Athyriaceae	N	
<i>Dicranopteris linearis</i>	uluhe	Athyriaceae	I	
<i>Diplazium sandwichianum</i>	hō'i'o	Athyriaceae	E	
<i>Diplopterygium pinnatum</i>	uluhe lau nui	Gleicheniaceae	E	
<i>Dryopteris fusco-atra</i>	'i'i	Dryopteridaceae	E	
<i>Dryopteris glabra</i>	kīlau, hohiu	Dryopteridaceae	E	
<i>Dryopteris hawaiiensis</i>		Dryopteridaceae	E	
<i>Dryopteris sandwicensis</i>		Dryopteridaceae	E	
<i>Dryopteris unidentata</i> var. <i>paleacea</i>	'akole	Dryopteridaceae	E	
<i>Dryopteris unidentata</i> var. <i>unidentata</i>	'akole	Dryopteridaceae	E	
<i>Dryopteris wallichiana</i>	'i'o nui, laukahi	Dryopteridaceae	E	
<i>Elaphoglossum crassifolium</i>	hoe a Maui, 'ekaha	Lomariaopsidaceae	E	
<i>Elaphoglossum paleaceum</i>	māku'e	Lomariaopsidaceae	I	

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<i>Elaphoglossum pellucidum</i>	hoe a Maui, 'ekaha 'ula	Lomariaopsidaceae	E	
<i>Elaphoglossum wawrae</i>	laukahi, hoe a Maui, 'ekaha 'ula	Lomariaopsidaceae	E	
<i>Gonocormus prolifer</i>		Hymenophyllaceae	I	
<i>Grammitis hookeri</i>	māku'e lau li'i	Grammitidaceae	I	
<i>Grammitis tenella</i>	kolokolo, mahinalua	Grammitidaceae	E	
<i>Huperzia filiformis</i>		Lycopodiaceae	I	
<i>Huperzia phyllantha</i>	wawae'iole	Lycopodiaceae	I	
<i>Huperzia serrata</i>	wawae'iole	Lycopodiaceae	I	
<i>Hypolepis hawaiiensis</i>	olua	Dennstaedtiaceae	E	
<i>Lellingeria saffordii</i>	kihe	Grammitidaceae	E	
<i>Lepisorus thunbergianus</i>	pākahakaha, 'ekaha ākōlea	Polypodiaceae	I	
<i>Lycopodium cernua</i>	wawae'iole	Lycopodiaceae	I	
<i>Lycopodium venustum</i>	wawae'iole	Lycopodiaceae	I	
<i>Macrothelypteris torresiana</i>		Thelypteridaceae	N	
<i>Marattia douglasii</i>	pala	Marattiaceae	E	
<i>Mecodium recurvum</i>	`ōhi`a kū	Hymenophyllaceae	E	
<i>Microlepia strigosa</i>	palapalai	Dennstaedtiaceae	I	
<i>Nephrolepis cordifolia</i>	narrow swordfern	Nephrolepidaceae	I	
<i>Nephrolepis exaltata</i> subsp. <i>hawaiiensis</i>	ni`ani`au, `ōkupu-kupu, pāmoho, kupukupu	Nephrolepidaceae	E	
<i>Nephrolepis multifora</i>	scaly swordfern	Nephrolepidaceae	N	
<i>Nothoperanema rubiginosa</i>	pauoa	Dryopteridaceae	E	
<i>Ophioderma pendulum</i>	puapua moa	Ophioglossaceae	I	
<i>Pityrogramma austroamericana</i>	gold fern, goldback fern	Pteridaceae	N	
<i>Pityrogramma calomelanos</i>	silver fern, silverback fern	Pteridaceae	N	
<i>Pneumatopteris sandwicensis</i>	hō'i'o-kula	Thelypteridaceae	E	
<i>Polypodium pellucidum</i>	'ae, 'ae lau nui	Polypodiaceae	E	
<i>Polystichum hillebrandii</i>	ka'upu, papa'oi	Dryopteridaceae	E	
<i>Pseudophegopteris keraudreniana</i>	waimaka-nui, 'ala'alai	Thelypteridaceae	E	
<i>Psilotum complanatum</i>	moa	Psilotaceae	I	
<i>Psilotum nudum</i>	pipi	Psilotaceae	I	
<i>Pteridium aquilinum</i>	kīlau, bracken fern	Dennstaedtiaceae	E	
<i>Pteris cretica</i>	'oāl'i, Cretan brake	Pteridaceae	I	
<i>Pteris excelsa</i>	waimakanui, 'iwa	Pteridaceae	I	
<i>Pteris irregularis</i>	māna	Pteridaceae	E	
<i>Sadleria cyatheoides</i>	'ama'u, ma'u	Blechnaceae	E	
<i>Sadleria pallida</i>	'ama'u, ma'u	Blechnaceae	E	
<i>Sadleria souleyetiana</i>	'ama'u, ma'u	Blechnaceae	E	
<i>Selaginella arbuscula</i>	lepelepe a moa	Sellaginellaceae	E	
<i>Selaginella kraussiana</i>	spreading selaginella	Sellaginellaceae	N	
<i>Sphaerocionium lanceolatum</i>	palai hinahina	Hymenophyllaceae	E	
<i>Sphaeropteris cooperi</i>	Australian tree fern	Cyatheaceae	N	
<i>Sphenomeris chinensis</i>	pala'ā	Lindsaeaceae	I	
<i>Sticherus owbyensis</i>		Gleicheniaceae	E	
<i>Vandenboschia davallioides</i>	kilau	Hymenophyllaceae	E	

**Appendix B - Pu‘u Maka‘ala Birds (birds historically/currently found in or near the NAR).**

Taxon	Common Name	Status
<i>Acridotheres tristis</i>	common myna	non-native
<i>Alauda arvensis</i>	Eurasian skylark	non-native
<i>Asio flammeus sandwichensis</i>	pueo, Hawaiian owl	endemic
<i>Branta sandvicensis</i>	nēnē, Hawaiian goose	endemic - endangered
<i>Buteo solitarius</i>	‘io, Hawaiian hawk	endemic - endangered
<i>Callipepla californica</i>	California quail	non-native
<i>Cardinalis cardinalis</i>	northern cardinal	non-native
<i>Carpodacus mexicanus</i>	house finch	non-native
<i>Cettia diphone</i>	Japanese bush warbler	non-native
<i>Chasiempis sandwichensis</i>	‘elepaio	endemic
<i>Fringilla erckelii</i>	Erckel’s francolin	non-native
<i>Garrulax canows</i>	hwamei, melodious laughing thrush	non-native
<i>Geopelia striata</i>	zebra dove	non-native
<i>Hemignathus munroi</i>	‘akiapōlā‘au	endemic - endangered
<i>Hemignathus virens</i>	‘amakihi	endemic
<i>Himatione sanguinea</i>	‘apapane	endemic
<i>Leiothrix lutea</i>	red-billed leiothrix	non-native
<i>Lonchura punctulata</i>	nutmeg mannikin	non-native
<i>Lophura leucomelanos</i>	kalij pheasant	non-native
<i>Loxops coccineus</i>	Hawai‘i ‘ākepa	endemic - endangered
<i>Oceanodroma castro</i>	‘akē‘akē, band-rumped storm petrel	indigenous - candidate
<i>Oreomystis mana</i>	Hawai‘i creeper	endemic - endangered
<i>Phaeornis obscurus</i>	‘ōma‘o	endemic
<i>Phasianus colchicus</i>	ring-necked pheasant	non-native
<i>Pluvialis fulva</i>	kōlea, Pacific golden plover	indigenous
<i>Psittirostra psittacea</i>	‘ō‘ū	endemic – endangered
<i>Pterodroma sandwichensis</i>	‘ua‘u or Hawaiian petrel	endemic - endangered
<i>Vestiaria coccinea</i>	‘i‘iwi	endemic
<i>Zosterops japonicus</i>	Japanese white-eye	non-native

**Appendix C - Insects and related arthropods, including land snails, collected and/or recorded from Pu'u Maka'ala NAR (Preston 1995).**

<b>TAXA</b>	<b>STATUS<sup>1</sup></b>
<b>ACARI</b>	
Oribatulidae	?
undetermined mites	?
<b>AMPHIPODA</b>	
Talitridae	?
<b>ARANEAE</b>	
<b>COLLEMBOLA</b>	
Entomobryidae	
<i>Entomobrya</i> spp.	end?
Isotomidae	
<i>Folsomia</i> sp.	end?
Sminthuridae	
nr. <i>Sminthurides</i> sp.	?
<b>COLEOPTERA</b>	
<sup>2</sup> Aglycyderidae	end
Anobiidae	
<i>Mirosternus lugubris</i> Perkins, 1910	end
<i>Xyletobius collingei</i> Perkins, 1910	end
Carabidae	
<i>Mecyclothorax</i> sp. nr. <i>paradoxus</i> (Blackburn, 1879)	end
<i>Mecyclothorax</i> sp. nr. <i>proximus</i> Britton, 1948	end
Ciidae	
<i>Cis</i> sp. nr. <i>setarius</i> Sharp, 1885	end?
Nitidulidae	
<i>Euptinus hawaiiensis</i> Sharp, 1878	end
Staphylinidae	
<i>Atheta</i> sp.	adv?
<i>Myllaena cognata</i> Sharp, 1908	end
<b>DIPTERA</b>	
Calliphoridae	
<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv
<i>Dyscritomyia</i> spp.	end
<i>Eucalliphora latifrons</i> (Hough, 1899)	adv
<i>Lucilia cuprina</i> (Wiedemann, 1830)	adv
Cecidomyiidae	?
Ceratopogonidae	
<i>Forcipomyia</i> prob. <i>hardyi</i> Wirth & Howarth, 1982	end
Chironomidae	
<i>Orthocladius</i> sp. A	end
<i>Orthocladius</i> sp. B	end
Chloropidae	
<i>Rhodesiella</i> sp.	end?
Dixiidae	adv
Dolichopodidae	
<i>Campsicnemus flaviventer</i> Hardy & Kohn, 1964	end
<i>Campsicnemus fumipennis</i> Parent, 1937	end
<i>Campsicnemus impariseta</i> Hardy & Kohn, 1964	end
<i>Campsicnemus longiquus</i> Tenorio, 1969	end
<i>Campsicnemus penicillatus</i> Parent, 1934	end
<i>Campsicnemus psychochaeta</i> Hardy & Kohn, 1964	end
<i>Campsicnemus scolimerus</i> Hardy & Kohn, 1964	end



<i>Campsicnemus</i> new sp. A (white specimens)	end
<i>Eurynogaster</i> sp. A	end
Drosophilidae	
<i>Drosophila suzukii</i> group	adv
<sup>2</sup> <i>Drosophila</i> spp. (picture wing group)	end
<i>Scaptomyza</i> spp.	end
Ephydriidae	
<i>Scatella</i> sp.	end
Muscidae	
<sup>2</sup> <i>Lispocephala confluens</i> (Malloch, 1928)	end
<i>Lispocephala dexioides</i> (Grimshaw, 1901)	end
<i>Lispocephala ingens</i> (Grimshaw, 1901)	end
Phoridae	
<i>Chonocephalus</i> sp.	end
<i>Megaselia</i> spp.	end
Psychodidae	
<i>Clogmia albipunctata</i> (Williston, 1893)	adv
<i>Psychoda</i> spp.	end?
Sarcophagidae	
<i>Ravinia lherminieri</i> (Robineau-Desvoidy, 1830)	adv
Sciaridae	
<i>Bradysia</i> sp.	end?
Sphaeroceridae	
<i>Leptocera abdominiseta</i> (Duda, 1925)	adv
<i>Leptocera</i> sp.	end?
Stratiomyidae	
<i>Wallacea albisetata</i> Meijere, 1907	adv
Syrphidae	
<i>Allograpta exotica</i> (Weidemann, 1830)	pur
Tipulidae	
<i>Limonia grimshawi</i> (Alexander, 1919)	end
<i>Limonia perkinsi</i> (Grimshaw, 1901)	adv
<i>Limonia stygipennis</i> (Alexander, 1919)	end
<i>Limonia</i> n. sp.	End
<i>Limnotes</i> sp.	adv
<b>HETEROPTERA</b>	
Lygaeidae	
<i>Neseis</i> sp.	end
<sup>2</sup> Miridae	
<i>Hyalopeplus pellucidus</i> (Stål, 1859)	end?
<i>Orthhotylus</i> spp.	end
<i>Sarona</i> sp.	end
Nabidae	
<i>Nabis oscillans</i> Blackburn, 1888	end
<b>HOMOPTERA</b>	
Aphididae	
<i>Aphis</i> sp.	adv
Cicadellidae	
<i>Nesophrosyne</i> spp.	end
Cixiidae	
<i>Iolania perkinsi</i> Kirkaldy, 1902	end
<i>Oliarus</i> sp. A	end
<i>Oliarus</i> sp. B	end
<sup>2</sup> Delphacidae	
<i>Leialoha</i> sp.	end

<i>Nesosydne</i> sp. A	end
<i>Nesosydne</i> sp. B	end
<i>Nesothoe</i> sp.	end
Flatidae	
<i>Siphanta acuta</i> (Walker, 1851)	adv
Psyllidae	
<i>Megatrioza</i> sp. A	end
<i>Megatrioza</i> sp. B	end
<i>Trioza</i> sp. A	end
<i>Trioza</i> sp. B	end
<i>Trioza</i> n. sp. [Nishida, et al, 1980]	end
<b>HYMENOPTERA</b>	
Agaonidae	
<i>Parapristina verticillata</i> (Waterston, 1921)	pur
<i>Pleistodontes froggatti</i> Mayr, 1906	pur
Aphelinidae	
<i>Aphelinus</i> sp. A	pur?
<i>Aphelinus</i> sp. B	pur?
Aphelinidae	
<i>Aphytis</i> nr. <i>chrysomphali</i> (Mercet, 1912)	pur?
<i>Encarsia</i> sp. A	pur?
<i>Encarsia</i> sp. B	pur?
<i>Encarsia</i> sp. C	pur?
Bethylidae	
<i>Sclerodermus</i> sp.	end
<i>Sierola</i> sp. A	end
<i>Sierola</i> sp. B	end
<i>Sierola</i> sp. C	end
Braconidae	
<i>Bracon terryi</i> (Bridwell, 1919)	adv
<i>Opius dissitus</i> Muesebeck, 1963	pur
<i>Opius</i> sp. A	pur?
<i>Opius</i> sp. B	pur?
Chalcididae	
<i>Brachymeria</i> sp.	pur?
Colletidae	
<i>Hylaeus</i> sp.	end
Diapriidae	
<i>Coptera silvestrii</i> (Kieffer, 1913)	pur
Dryinidae	
nr. <i>Tetrodontochelys</i> sp.	adv?
Encyrtidae	
<i>Anagyrus</i> sp. A	pur?
<i>Anagyrus</i> sp. B	pur?
<i>Anagyrus</i> sp. C	pur?
<i>Anagyrus</i> sp. D	pur?
nr. <i>Metaphycus</i> sp.	pur?
nr. <i>Ooencyrtus</i> sp.	pur?
Eucoilidae	
<i>Pseudeucoila</i> sp. A	end
<i>Pseudeucoila</i> sp. B	end
Eulophidae	
<i>Aprostocetus</i> sp.	pur?
<i>Chrysocharis</i> sp.	pur?
<i>Diglyphus begini</i> (Ashmead, 1904)	adv

Eupelmidae		
	<sup>2</sup> <i>Eupelmus</i> sp. A	end
	<i>Eupelmus</i> sp. B	end
	<i>Eupelmus</i> sp. C	end
	<i>Eupelmus</i> sp. D	end
	<i>Eupelmus</i> sp. E	end
Eurytomidae		
	<i>Eurytoma</i> sp.	adv
Ichneumonidae		
	<i>Diadegma blackburni</i> (Cameron, 1883)	adv
	<i>Diadegma</i> sp.	adv
	<sup>2</sup> <i>Enicospilus nigrolineatus</i> Ashmead, 1901	end
	<i>Enicospilus</i> sp. A	end
	<i>Enicospilus</i> sp. B	end
	<i>Ichneumon purpuripennis</i> Cresson, 1877	pur
	<i>Spolas</i> nr. <i>hawaiiensis</i> (Ashmead, 1901)	end
	<i>Spolas</i> sp. A	end
	<i>Spolas</i> sp. B	end
Mymaridae		
	<i>Anagrus</i> sp. A	pur?
Mymaridae		
	<i>Anagrus</i> sp. B	pur?
	<i>Polynema</i> sp.	end
Platygasteridae		
	<i>Amitus spiniferus</i> (Brethes, 1914)	pur
	<i>Fidiobia</i> sp.	pur?
	<i>Platygaster acciculus</i> Drake, 1969	adv
Proctotrupidae		
	<i>Brachyserphus hawaiiensis</i> (Ashmead, 1901)	adv?
	<i>Exallonyx trifoveatus</i> Kieffer, 1908	adv
Pteromalidae		
	<i>Spalangia</i> sp. A	?
	<i>Spalangia</i> sp. B	?
Scelionidae		
	<i>Baeus</i> sp.	pur
Sphecidae		
	<i>Ectemnius</i> sp. A	end
	<i>Ectemnius</i> sp. B	end
Trichogrammatidae		
	<i>Trichogramma</i> spp.	pur
Vespidae		
	<i>Odynerus</i> sp.	end
	<i>Vespula pensylvanica</i> (Saussure, 1857)	adv
<b>ISOPODA</b>		
Philosciidae		
	<i>Littorophiloscia</i> sp.	end?
Porcellionidae		
	<i>Porcellio</i> sp.	adv
<b>LEPIDOPTERA</b>		
Carposinidae		
	<i>Carposina</i> sp. A	end
	<i>Carposina</i> sp. B	end
Cosmopterigidae		
	<i>Hyposmocoma</i> sp. A	end
	<i>Hyposmocoma</i> sp. B	end

<i>Hyposmocoma</i> sp. C	end
<i>Hyposmocoma</i> sp. D	end
<i>Hyposmocoma</i> sp. E	end
<i>Hyposmocoma</i> sp. F	end
<i>Hyposmocoma</i> sp. G	end
<i>Hyposmocoma</i> sp. H	end
<sup>2</sup> Crambidae	
<i>Eudonia</i> sp. A	end
<i>Eudonia</i> sp. B	end
<i>Eudonia</i> sp. C	end
Crambidae	
<i>Eudonia</i> sp. D	end
<i>Eudonia</i> sp. E	end
<i>Mestolobes minuscula</i> (Butler, 1881)	end
<i>Mestolobes</i> sp.	end
<i>Omiodes accepta</i> (Butler, 1877)	end
<i>Omiodes asaphombra</i> Meyrick, 1899	end
<i>Udea argoscelis</i> (Meyrick, 1899)	end
Gelechiidae	
<i>Crasimorpha infuscata</i> Hodges, 1964	pur
<sup>2</sup> Geometridae	
<i>Eupithecia monticolens</i> Butler, 1881	end
<i>Scotorythra artemidora</i> Meyrick, 1899	end
<i>Scotorythra brunnea</i> (Warren, 1896)	end
<i>Scotorythra euryphaea</i> Meyrick, 1899	end
<i>Scotorythra pachyspila</i> Meyrick, 1899	end
Noctuidae	
<i>Haliophyle euclidias</i> (Meyrick, 1899)	end
<i>Hypena laceratalis</i> Walker, 1858	pur
<i>Pseudoschrankia</i> n. sp.	end
<i>Schrankia</i> sp.	end
Oecophoridae	
<i>Stoerberhinus testaceus</i> Butler, 1881	adv
<i>Thyrocopa</i> sp.	end
Sphingidae	
<i>Hyles wilsoni</i> (Rothschild, 1894)	end
Tineidae	
<i>Decadarchis</i> sp. A	adv
<i>Decadarchis</i> sp. B	adv
<i>Opogona omoscopia</i> (Meyrick, 1893)	adv
Tortricidae	
<i>Amorbia emigratella</i> Busck, 1910	adv
<i>Bactra straminea</i> (Butler, 1881)	adv
<i>Bradleyella</i> sp.	end
<sup>2</sup> <i>Cydia</i> sp. A	end
<i>Cydia</i> sp. B	end
<i>Cydia</i> sp. C	end
<i>Spheterista</i> sp.	end
<b>NEUROPTERA</b>	
Chrysopidae	
<i>Anomalochrysa</i> nr. <i>debilis</i> Perkins, 1899	end
<i>Chrysoperla comanche</i> (Banks, 1938)	adv
Hemerobiidae	
<i>Micromus brunnescens</i> (Perkins, 1899)	end

<i>Micromus vagus</i> (Perkins, 1899)	end
<b>ODONATA</b>	
<sup>2</sup> Coenagrionidae	
<i>Enallagma civile</i> (Hagen, 1862)	adv
<i>Megalagrion amaurodytum peles</i> (Perkins, 1899)	end
<i>Megalagrion calliphya microdemas</i> (Perkins, 1899)	end
<i>Megalagrion hawaiiense</i> (McLachlan, 1883)	end
<b>ORTHOPTERA</b>	
Gryllidae	
<i>Laupala</i> spp.	end
<i>Paratrigonidium</i> sp.	end
<b>PSOCOPTERA</b>	
Ectopsocidae	
<i>Ectopsocus</i> sp. A	adv
<i>Ectopsocus</i> sp. B	adv
Elipsocidae	
<i>Kilauella</i> nr. <i>erythrosticka</i> (Perkins, 1899)	end
<i>Palistreptus</i> spp.	end
Lepidopsocidae	
<i>Lepidopsocus</i> nr. <i>maculatus</i> Thornton, Lee & Chui, 1972	adv
Psocidae	
<i>Ptycta</i> sp. A	end
<i>Ptycta</i> sp. B	end
<i>Ptycta</i> sp. C	end
<b>LAND SNAILS</b>	
<i>Amastra armata</i>	nat
<i>Auriculella westerlundiana</i>	nat
<i>Cookeconcha</i> sp.	nat
<i>Cookeconcha thaanumi</i>	nat
<i>Euconulus gaetanoi</i>	nat
<i>Euconulus thaanumi</i>	nat
<i>Hawaiiia minuscula</i>	adv
<i>Hiona rufobrunnea</i>	nat
<i>Leptachatina</i> sp.	nat
<i>Leptachatina arborea</i>	nat
<i>Nesopupa anceyana</i>	nat
<i>Oxychilus alliaris</i>	adv
<i>Philonesia</i> sp.	nat
<i>Philonesia sericans</i>	nat

<sup>1</sup> Status codes: adv = adventive, end = endemic, nat = native, pur = purposely introduced

<sup>2</sup> Notable records.