PACIFIC COOPERATIVE STUDIES UNIT
UNIVERSITY OF HAWAI`I AT MĀNOA
Dr. David C. Duffy, Unit Leader
Department of Botany
3190 Maile Way, St. John #408
Honolulu, Hawai'i 96822

Technical Report 139

Plant inventory of the `Ōla`a Trench at Hawai`i Volcanoes National Park

April 2007

Mashuri Waite[1] and Linda Pratt[2]

[1] Pacific Cooperative Studies Unit (University of Hawai`i at Mānoa), NPS Inventory and Monitoring Program, Pacific Island Network, PO Box 52, Hawai`i National Park, HI 96718

[2] USGS Pacific Island Ecosystems Research Center, P.O. Box 44, Hawai`i National Park, HI 96718

TABLE OF CONTENTS

List of Figures i

Abstract 1

Introduction 1

Study Area 2

Methods 3
- Vouchers 4
- Coordination and Logistics 5

Observations and Discussion 6
- Description of Vegetation 6
- Description of Craters 7
  - Main Crater 7
  - Western Hilltop 8
  - Second Crater 8
  - Third Crater 8
  - Fourth Crater 9
  - Fifth Crater 9
- Rare Native Plant Species 9
  - Cyrtandra tintinnabula 9
  - Species of Concern and Other Lobelioids 10
  - Rare Tree Species 11
  - Other Uncommon Plants 11
- Other Observations 12
  - Birds 12
  - Bats 12

Summary and Recommendations 12

Acknowledgements 13

Literature Cited 14

Appendix: `Ōla`a Trench Vascular Plant Checklist 16

LIST OF FIGURES

Figure 1. Vicinity map of Hawai`i Volcanoes National Park 2

Figure 2. Topographic map of `Ōla`a Tract 3

Figure 3. `Ōla`a Trench map 4

Figure 4. View inside the main crater 8

ABSTRACT

The `Ōla`a Trench is a complex of craters in the remote northeastern quarter of `Ōla`a Tract in Hawai`i Volcanoes National Park. Because the feature had never been formally surveyed, an inventory of vascular plants was carried out in June and July, 2001. A large main crater, three of four small craters and a hill associated with the feature were surveyed; one of the small craters was inaccessible. Vegetation cover in the area was montane wet `ōhi`a (*Metrosideros polymorpha*) forest with an open canopy. Native sedge bogs were observed on the floors of craters, and native matted ferns and shrubs were the dominant vegetation on steep slopes. While the canopy and understory plants of the forest were primarily native, ground cover was disturbed by feral pigs and contained a number of alien plant species. Few individuals of highly invasive alien plant species, such as yellow Himalayan raspberry (*Rubus ellipticus*) and strawberry guava (*Psidium cattleianum*), were noted in the area. The most notable native plant observed was the endangered *Cyrtandra tintinnabula*. A small population of this shrub occurred at three sites within the feature. This species is a new record for the park. Koli`i (*Trematolobelia grandifolia*), a species of concern, was also seen within the main crater. A few individuals of six rare to uncommon shrub and tree species and three other native plants vulnerable to pig damage were observed at several sites within the feature.

INTRODUCTION

The National Park Service (NPS) held a Biological Inventories Workshop in Kailua-Kona, Hawai`i on January 27, 2000. At this meeting, members of the Inventory & Monitoring program – Vegetation Working Group agreed that existing and historic inventories have, with a few exceptions, already documented over 90% of vascular plant taxa likely to occur within the Hawaiian parks of the Pacific Island Network (PACN). The exceptions noted were un-surveyed areas of parks recently acquired or sites remote and difficult to access. One such area, informally known as the `Ōla`a Trench, was identified in Hawai`i Volcanoes National Park (HAVO) at a series of craters in the remote northeastern quarter of `Ōla`a Tract at an elevation of 1,080-1,120 m (Figure 1, Figure 2). This section of `Ōla`a was not thoroughly examined by botanists in previous surveys. It was hoped that some of the craters might be pig-free or that steep crater slopes might be inaccessible to feral pigs and provide habitat for uncommon native plant species. Feral pigs are implicated in decreasing native plant populations and diversity by direct grazing of certain species and by interfering with seedling recruitment through trampling and digging up of the soil in search of earthworms and rhizomes (Stone 1985, Cuddihy & Stone 1990). In order to contribute to the primary inventory goal of the NPS Inventory and Monitoring program, a survey of the site and inventory of vascular plant species was conducted in June and July, 2001 by the Pacific Cooperative Studies Unit (PCSU), University of Hawai`i at Manoa and U.S. Geological Survey botanists in cooperation with the National Park Service, Pacific Island Network.

STUDY AREA

The `Ōla`a Trench is relatively small, so sampling covered much of the area (except for the very steep, inaccessible walls). The trench feature is made up of a large, oblong crater followed down-slope by a string of four progressively smaller craters in a line from west to east (Figure 2, Figure 3). At the western end of the main crater is a large, crescent-shaped hill. The position and shape of the hill and craters suggest the feature may be an extinct volcanic vent with a cone formed in conjunction with the craters, similar to many hills and adjacent craters mapped on Kilauea Volcano (Holcomb 1987). The underlying substrate of most of the `Ōla`a Tract is composed of Mauna Loa flows that have been dated as >4,000 years old (Lockwood and Lipman 1987). The substrate is soil on the trench bottom and weathered rock on the trench walls. The total length of the trench feature from the west end of the main crater (not including the hill) to the east end of the fifth crater is 1,300 m.

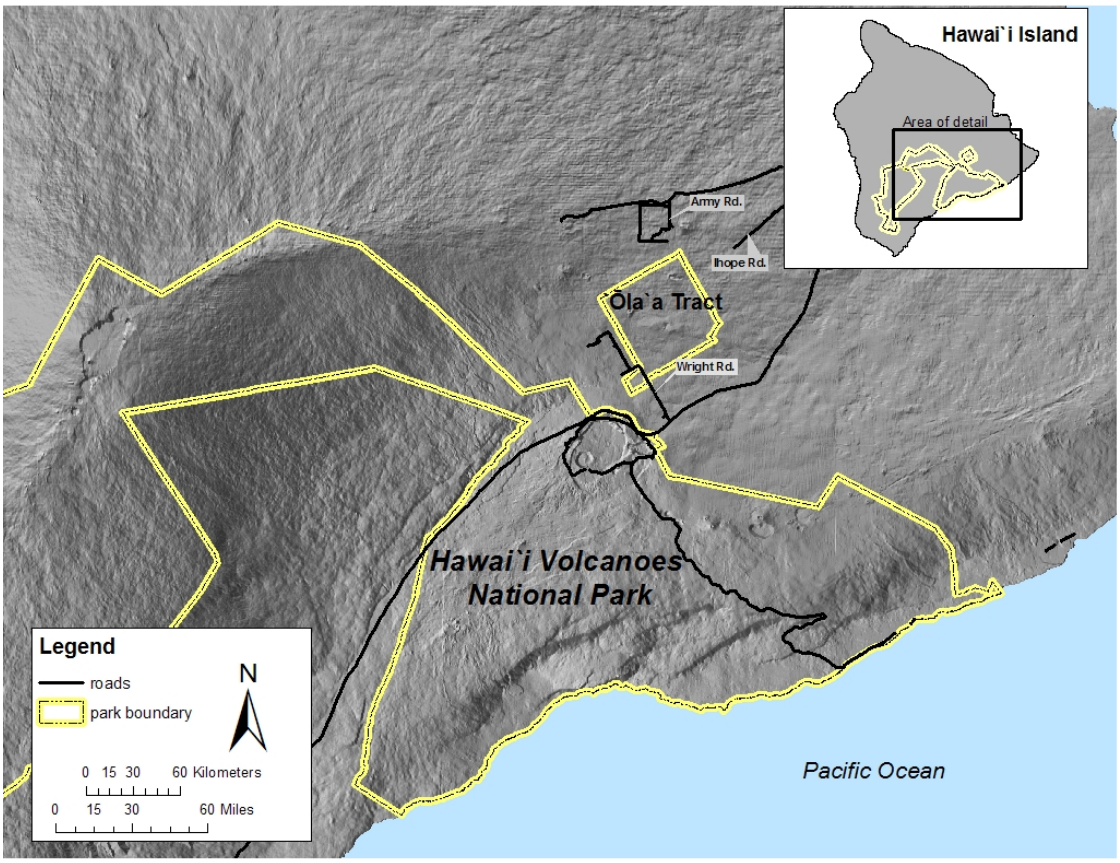

Figure 1. Vicinity map of Hawai`i Volcanoes National Park, including the `Ōla`a Tract.

METHODS

Sampling consisted of directed searches of the accessible parts of the main crater, western hill, crater perimeter, and floors and walls of the shallow secondary craters. We made a checklist of all vascular plant species encountered, and collected specimens of uncommon plants, species thought to be new to the park, and species that could not be identified in the field. Survey teams carried the existing plant species list for HAVO from NPSpecies, the NPS Biodiversity Database. If taxa were encountered that were new to the HAVO species list, or listed as Threatened, Endangered, Candidate Endangered or Species of Concern (T&E, SOC) by the U.S. Fish and Wildlife Service, attribute data (height, phenology, signs of herbivore damage) were to be recorded on field forms and coordinates collected with a GPS unit with a field identification number assigned in the data logger to key the spatial and tabular data. No specimens were to be collected for T&E species and SOC. NPSpecies was updated based on data collected in this inventory.

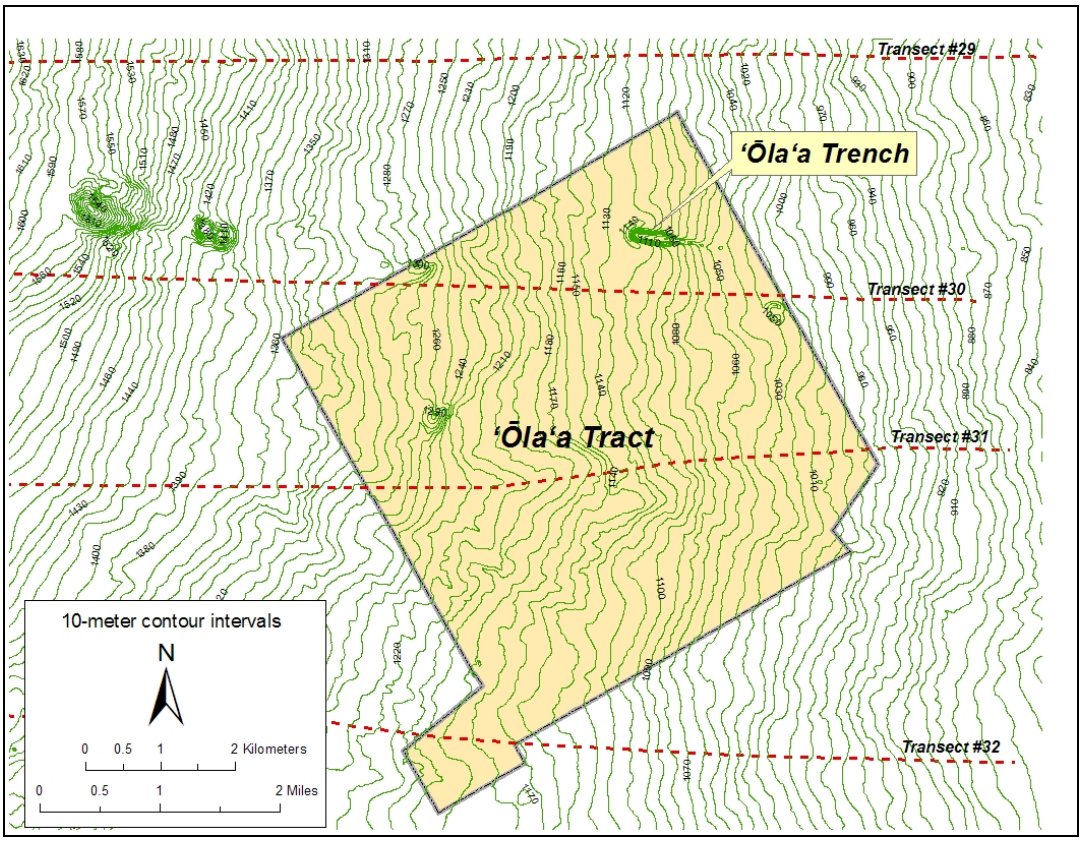

Figure 2. Topographic map of `Ōla`a Tract showing the `Ōla`a Trench in the top corner. Hawai`i Forest Bird Survey transects are shown in red.

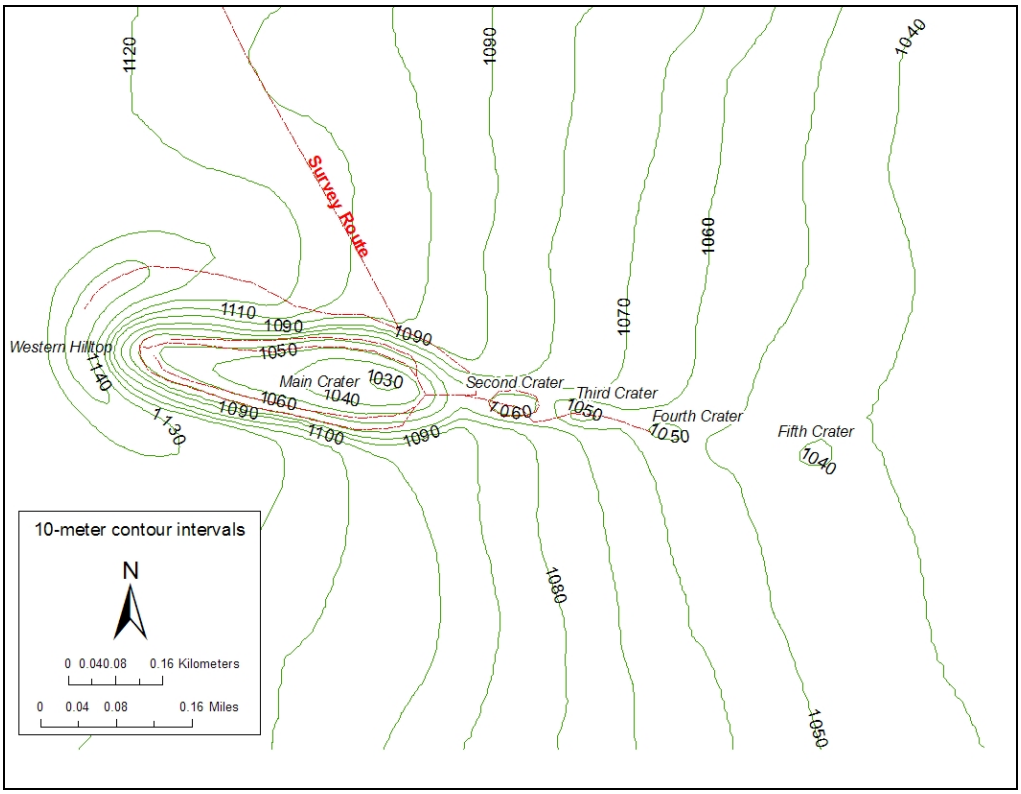

Figure 3. `Ōla`a Trench map with approximate route of survey team indicated by dotted line.

The survey team of three to four botanists spread out (with 5-10 m between individuals) and walked the perimeter of the crater floor and accessible slopes of the crater walls of the first three craters. The fourth crater was inaccessible due to the steepness of the walls, so we chose a vantage point on the southwest side and recorded all species recognizable through binoculars. The fifth crater was visited during prior trail reconnaissance by Mashuri Waite (PCSU) and William Haines (PCSU). The hill to the west of the main crater was searched during the second expedition via a route along the north side of the main crater rim to the top of the hill and back (Figure 3).

Vouchers

Twenty-eight voucher specimens were collected at the `Ōla`a Trench; these included one species new to the park and several species not known or poorly documented from `Ōla`a Forest. Specimens of uluhe lau nui (*Diplopterigyium pinnatum*) and kīlau (*Dryopteris glabra* var. *nuda*) were also collected; these two ferns are known from the park but are not represented by specimens in the HAVO herbarium. Uncommon native trees, significant alien plants, and a few ferns of uncertain identification were also collected. Specimens have been pressed, dried, frozen, and stored in the natural history collections room. After labels are written, these will be mounted, processed, and accessioned into the park herbarium. All specimen labels will be provided to NPS curators for entry into the Automated National Catalog System (ANCS).

Coordination and Logistics

There seems to be little overlap in the area sampled in the current project and previous plant surveys. The `Ōla`a Trench lies between two transects (#29 and 30) sampled by the U.S. Fish and Wildlife Service Hawai`i Forest Bird Survey in 1978-81 (Scott *et al.* 1986) and it intersects neither one (Fig. 2). The northeastern corner of `Ōla`a Tract was surveyed by one transect in 1988 as part of a joint Resources Management and Research project to inventory invasive weeds and rare plants of `Ōla`a Forest (Anderson *et al.* 1988); this transect passed just south of the main crater.

No roads or established trails extend to the trench feature. Three possible routes to the remote site were evaluated. From the end of Wright Road (western route), it is about 6.6 km to the trench feature; this route passes through dense forest along transects in the Pu`u and New Units of the `Ōla`a Tract. Access on the east of `Ōla`a is from the end of Ihope Road (eastern route); the study area is a distance of 4.3 km through State Forest Reserve and Pu`u Maka`ala Natural Area Reserve (NAR). However, this route is known to be difficult because of dense palmgrass (*Setaria palmifolia*) cover. Palmgrass has numerous sharp hairs which makes traversing it very uncomfortable. The third possible route (northern route) begins at Disappointment (or Army) Road in the Pu`u Maka`ala NAR, north of `Ōla`a, and the distance is 3.3 km to the main trench.

The western and northern routes were walked to determine travel time and difficulty; the eastern route was rejected. The western route started at a jeep road extending from the end of Wright Road, followed an access trail to the fenced park boundary, and continued along pig exclusion fences around the Pu`u Unit to Transect 4 within the New Unit, a monitoring transect established to collect data on pig activity and invasive plants. At the end of Transect 4, a new trail was flagged to the trench. The second attempted route (northern route) used Transect 11, in the Pu`u Maka`ala NAR; this flagged line runs from the `Akū Unit fence south to the `Ōla`a Tract NPS boundary. From the end of Transect 11 a direct route to the main trench was navigated using GPS and compass. The second route was shorter than the western trail and lacked major impediments. Vegetation was relatively open, palmgrass cover was not dense, terrain was not rough, and there were few fallen trees to make walking difficult.

The survey was conducted in two stages in June and July 2001. The June expedition was an exploratory one-day survey of the main crater conducted by Linda Pratt (USGS), Laurie Gold (PCSU), Thomas Belfield (PCSU), and Mashuri Waite. The goal of this first expedition was to survey one side of the trench from both the rim and the bottom. However, travel from Volcano to Pu`u Maka`ala NAR and the walk to the trench left only enough time to survey one side from the bottom. On this visit, we determined that a longer three-day, two-night expedition was needed for a more complete survey. This was accomplished in July 2001 by Linda Pratt, Mashuri Waite and Ian Cole (State of Hawaii DLNR). The expedition members walked to the site, while their camping gear, food, and water were sling-loaded by helicopter to a temporary camp site in the main crater at the eastern edge of a *Carex alligata* sedge bog.

OBSERVATIONS AND DISCUSSION

The dominant vegetation of the `Ōla`a Trench is open canopy, montane, wet `ōhi`a (*Metrosideros polymorpha*) forest. Plant communities dominated by native sedges and native ferns are also prominent at the feature. The upper forest canopy is approximately 12-15 m tall and is dominated by native-tree species, as is the understory. By contrast, ground cover is largely alien, except on steep slopes dominated by native matted ferns. The main crater supports the greatest number of observed plant species, but several craters and the adjacent western hill have one or more native plant species not seen elsewhere at the trench. Of a total of 131 vascular-plant species encountered within the survey area (Appendix), only 34 (26%) are alien. One endangered plant species and a "species of concern" occur within the trench feature. Low numbers of two lobelioid shrubs, five rare and uncommon tree species, and three plant species thought to be vulnerable to feral pigs are also found at the study site.

Description of Vegetation

In general the vegetation of the entire feature can be divided into four zones: flat poorly drained *Carex alligata* dominated bogs at the bottom of three of the craters; open-canopy `ōhi`a forest with ground cover heavily damaged by pigs on flat to slightly sloping land; open canopy `ōhi`a forest with little pig damage and consequently more native understory vegetation on steeper slopes; and steep to vertical slopes dominated by native shrubs and matted ferns, primarily uluhe (*Dicranopteris linearis*) and uluhe lau nui. A less common vegetation type of alien shrubs with wind-dispersed seeds occurs on a few relatively recent landslides that lack `ōhi`a canopy cover; Asiatic butterfly bush (*Buddleia asiatica*) and sourbush (*Pluchea carolinensis*) dominate these landslides. The hill at the western end of the main crater supports `ōhi`a forest with several native tree species not found in the craters or surrounding forest.

Pig damage is evident throughout the trench except where the terrain is steep or covered with boulders. Areas too steep for pigs are slopes where human hikers need to use their hands to hold trees and rocks for support. Obvious signs of pig presence are diggings with exposed bare soil, pig trails, hoof prints, and scats.

Alien-weed density is relatively low within the craters. Some recent landslides have thick concentrations of palmgrass, and parts of the grassy floor of the main crater have a dense cover of Vasey grass (*Paspalum urvillei*). The most frequently seen alien species, the fern *Deparia petersenii*, is scattered throughout the forest floor. Strawberry guava (*Psidium cattleianum*) and yellow Himalayan raspberry (*Rubus ellipticus*) are present as scattered individuals; no large stands of these species were encountered. However, without control, strawberry guava and raspberry can be expected to increase and eventually form dense stands. Kahili ginger (*Hedychium gardnerianum*) is notably absent from the site. *Selaginella kraussiana*, a weedy clubmoss that has recently become well-established in the understory in Pu`u Maka`ala NAR, does not occur at the trench feature, but grows near the park boundary with the NAR.

The bogs are almost monocultures of the native sedge *Carex alligata* except for large patches of alien Vasey grass edging the community. Stunted `ōhi`a trees grow within the bog of the main crater. The *Carex* bog vegetation type is very rare in HAVO, and the community is considered vulnerable in the State (The Nature Conservancy 1987). The `Ōla`a Trench bogs are among the largest occurrences known in HAVO. The Vasey grass patches are probably the result of disturbance by pigs, and it is hard to predict what would happen if pigs are excluded. The alien grass might naturally be replaced by *Carex*; the grass might persist indefinitely; or the grass might further displace the native sedge. A few other small wetland weeds such as water smartweed (*Persicaria punctata*) and pipili (*Drymaria cordata*) are found in the bogs.

Description of Craters

The dominant feature of the `Ōla`a Trench is a large and deep, elliptical-oblong crater with densely forested lower slopes and a mixture of forest and bog on the crater floor. This main crater is separated from a second, shallower crater by a low saddle-shaped ridge. Three smaller craters are distributed in a line extending eastward from the main and second craters. Details of size and vegetation cover of the individual craters are given in the following section.

Main Crater

The bottom of the main trench is about 550 m long by 110 m wide and 60 m deep. The outside rim on top of the main trench is 1,500 m in total circumference. Entry into the main crater is from the eastern end where the crater is shallower and the crater-wall slope is gentle enough to allow access without ropes. There is a saddle of land that separates the main crater from the secondary crater adjacent to the east. The bottom of the main crater has a large grassy area of *Carex alligata* and Vasey grass with scattered `ōhi`a trees (Figure 4). Palmgrass cover is thick in some recent landside areas. We saw two clumps of the invasive alien shrub, cane tibouchina (*Tibouchina herbacea*). The wetter parts of the near-vertical cliffs support many native shrubs, most notably `ōhā wai (*Clermontia parviflora*), hāhā (*Cyanea pilosa* subsp. *longipedunculata*), and *Hedyotis centranthoides*. Species found rarely along the bases of the cliff walls are koli`i (*Trematolobelia grandifolia*), `ilihia (*Cyrtandra platyphylla*), `aiea (*Nothocestrum longifolium*), the mint *Stenogyne calaminthoides,* the endangered *Cyrtandra tintinnabula*, and pala or Douglas mules' foot fern (*Marattia douglasii*).

Figure 4. View inside the main crater looking toward the west end (William Haines, March 2001).

Western Hilltop

This hill rises above the western rim of the main crater. The summit has a diverse forest of common native plants, and supports the only `ohe mauka (*Tetraplasandra oahuensis*) and alani (*Melicope pseudoanisata*) trees seen during the survey. Signs of pig activity were conspicuous throughout the forest on the hill.

Second Crater

Adjacent to the east end of the main crater, this crater is 80 m long by 35 m wide on the bottom, 20 m deep, and 190 m in circumference on the top rim. Access is possible from many points but is especially easy at the western end, down the slope of the ridge that separates it from the main crater. The slopes of the crater walls too steep for pig activity have high numbers of hāhā and kāmakahala (*Labordia hedyosmifolia*), as well as a small population of the endangered *Cyrtandra tintinnabula*. The presence of seedlings of hāhā and *Cyrtandra tintinnabula* indicate reproducing populations of both species.

Third Crater

The third crater is 40 m long by 20 m wide at the bottom, about 6 m deep, and has a 105 m circumference along the top rim. The site has a single ōpuhe (*Urera glabra*) tree and several manono (*Hedyotis hillebrandii*) trees at the bottom. Hāhā and *Cyrtandra tintinnabula* shrubs are present on the sides steep enough to be free of pig activity. The deepest, eastern part of this crater has been severely damaged by pigs.

Fourth Crater

The fourth crater, an inaccessible pit, is completely encircled by vertical walls. The bottom of the crater is 55 m long by 25 m wide and the circumference along the top rim is 140 m. The approximately 15 m vertical crater walls make the crater inaccessible to pigs. We used binoculars from the crater rim to identify plant species. The forest canopy in the crater is a mix of native trees common in `Ōla`a, such as `ōlapa (*Cheirodendron trigynum*), large manono (*Hedyotis hillebrandii* and *H. terminalis*), kōpiko `ula (*Psychotria hawaiiensis*), māmaki (*Pipturus albidus*), and pilo (*Coprosma ochracea*) with a lower subcanopy of tree ferns (*Cibotium glaucum* and *C. menziesii*). `Ōhi`a, the dominant tree species of `Ōla`a rainforest, is absent from the crater floor forest but is present as saplings on the crater wall. At least one large ōpuhe was noted at the base of the steep crater wall. Bare ground is not visible from above, unlike the other craters where pigs are present. Two weed species, palmgrass and strawberry guava, are present in small numbers. We did not see any species unobserved in the other craters, although it is possible that small rare species such as *Anoectochilus* orchids are hidden under the canopy or on the lower walls of the crater. Two clusters of loulu (*Pritchardia beccariana*) palms were observed on the north and south rims of this steep crater. The group on the south rim consists of six trees, and includes several low-stature, young palms.

Fifth Crater

The fifth (and last) crater is 55 m long by 45 m wide at the bottom and 160 m in circumference at the top rim. This small crater is not deep; the depression is only 2-3 meters below the level of the surrounding forest. The entire crater floor is a treeless *Carex alligata* bog with interspersed Vasey grass. None of the crater wall is steep enough to stop pig disturbance, and few native species besides *Carex* persist in this crater.

Rare Native Plant Species

One endangered plant species, not previously known to occur within HAVO (*Cyrtandra tintinnabula*), is now documented within the `Ōla`a Trench. One relatively rare lobelioid (*Trematolobelia grandifolia*) was seen within the two larger craters. Low numbers of individuals of five tree species considered rare or uncommon in HAVO were observed at one or more of the craters. One fern species, a mint, and a common shrub thought to be vulnerable to pig damage were each noted at one or two sites within the feature. Three fern species rarely seen in the park were collected during the survey.

Cyrtandra tintinnabula

This field survey discovered a previously unknown population of *Cyrtandra tintinnabula*, a shrub in the Gesneriaceae or African violet family. This endangered species is a new record for HAVO, and the sighting extends its known range more than 30 km to the south. *Cyrtandra tintinnabula* is currently known to be extant in the Laupahoehoe area (Wagner *et al.* 1999), on the eastern slope of Mauna Kea. Little is known of the life history of the species (U. S. Fish and Wildlife Service 1996). The discovery of the `Ōla`a Trench population is especially exciting because it seems to be a viable, reproducing

population with numerous individuals (at least 50) of several size classes, from seedlings to adults. *Cyrtandra tintinnabula* plants were found in at least three sites within the trench complex: on the north side of the main trench (two plants); on the eastern wall of the secondary trench or second crater; and at the base of the third pit crater. The concentration of these plants on steeper slopes of the trench and pit craters suggests they are surviving in areas with little feral pig activity. The medium-term prospects for this population are good even without management action because the terrain protects them from the direct threat of pigs. The long-term prospects without active management are uncertain, because invasive weed species, such as yellow Himalayan raspberry and strawberry guava, are scattered throughout the area and will likely increase in the trench. Both of these alien species are capable of forming monotypic stands, which prevent the growth of native understory species through a combination of dense shade, competition, and possibly allelopathic chemicals (Stratton 1990; Smith 1985).

Cyrtandra tintinnabula is superficially similar to the more common `ilihia or *Cyrtandra platyphylla*, an understory shrub typical of wet forests in HAVO. Both are pubescent with reddish brown hairs on wide leaves. They differ in the shape of the inflorescence and the base of the leaves. `Ilihia leaves are round with a cordate base (curved and heart-shaped), while *Cyrtandra tintinnabula* leaves are characterized by unequal, cordate to obtuse leaf bases. The inflorescence of `ilihia is longer than that of *C. tintinnabula* (Wagner *et al.* 1999). Because the species are similar and few plants were bearing flowers in July, we did not at first realize we were looking at a new species for HAVO. Many *Cyrtandra* species are known to hybridize with one another (Wagner *et al.* 1999), and we assumed that sterile plants were hybrids of `ilihia and another unobserved species. However, *Cyrtandra* plants of the study area were consistently different from typical `ilihia, and there were no other *Cyrtandra* species present as potential parent species. It was only during the second expedition that one *C. tintinnabula* was found in flower, and we were able to confirm its identity by comparing fertile specimens to published descriptions after our return from the field. Because we interpreted the sterile *Cyrtandra* as a hybrid in the field, we failed to collect GPS points and detailed measurements of individuals at the site. Reception on GPS units was very poor within the `Ōla`a Trench, particularly when it was raining.

Species of Concern and Other Lobelioids

Koli`i (*Trematolobelia grandifolia*), a plant listed as a "species of concern" by the U. S. Fish and Wildlife Service (U. S. Fish and Wildlife Service 2004), was found at only two sites within the main trench. A group of more than 12 plants was growing epiphytically at the base of the southern wall of the trench. Several adult plants had recently produced fruiting capsules and died. The second group of koli`i was found in the same area and contained approximately 10 plants. Hāhā (*Cyanea pilosa* subsp. *longipedunculata*), a species considered rare in HAVO, was sighted in a number of locations within the main trench and pit craters. No count of individuals was made, but both adult plants and seedlings were observed. A third member of the Lobelia subfamily, `ōhā wai or *Clermontia parviflora,* was occasionally seen as an epiphyte in the area. Both *Cyanea* and *Clermontia* are weak-stemmed woody plants vulnerable to pigs when on the ground.

Rare Tree Species

Several tree species were seen only rarely within the trench feature. `Ohe mauka was observed only once, on the hill at the western extremity of the main trench. `Aiea was observed only at the base of the northern wall of the main trench. Ōpuhe was found in three localities. Individual trees were seen on the wall of the main trench, on the floor of the third crater, and at the base of the inaccessible fourth crater. All three tree species are considered rare in HAVO (Pratt and Abbott 1997). Manono (*Hedyotis hillebrandii*) was seen at a few sites on the floors of the pit craters; this species is relatively uncommon within `Ōla`a Forest. Loulu palms were found primarily on the western and southern walls and lower slopes of the main trench and near the rim of the smaller craters. These palms occurred as single trees or clusters of several (up to six) trees at a site. This paucity of loulu palms is unexpected, since much higher numbers were previously reported from the area of the trench complex. Several hundred palms were sighted on the walls of the trench during a helicopter flight over `Ōla`a Forest in the mid-1980s (L. Pratt, personal observation); these trees were no longer present in 2001. The loss of hundreds of palms and the absence of any remains of dead trunks are surprising and unexplained. Seed predation by rodents, feral pigs, and invertebrates is known to have detrimental effects on loulu palm reproduction (Male and Loeffler 1997). However, lack of reproduction does not explain the large decrease in adult trees that apparently occurred at the `Ōla`a Trench.

Other Uncommon Plants

Several native plants were observed in unusually low numbers within the trench. `Ilihia, a relatively common species of HAVO rainforests, was seen only on the southern slopes of the main trench. *Stenogyne calaminthoides*, the most common native mint in the park, was present only as a few vines on the hilltop and on the southern slope of the main trench, and pala or Douglas mule's foot fern was noted only on the southern slope of the main trench and in the third crater. All three of these terrestrial species are known to be vulnerable to damage by feral pigs (Stone 1985).

Three ferns that are very poorly documented in HAVO were observed in the `Ōla`a Trench. `Iwa`iwa lau nui (*Tectaria gaudichaudii*) was found on a steep wall of the second crater of the complex. This terrestrial fern has been collected only once in HAVO (Fosberg 1966) and has been recently observed only at Kipuka Puaulu. Kīlau (*Dryopteris glabra* var. *nuda*), an epiphyte reported from HAVO but not documented in the park herbarium, was collected at the base of the southern wall of the main trench. The identity of this specimen should be confirmed, as Palmer (2003) does not list this variety from Hawai`i Island. *Huperzia erosa*, an endemic fern ally, was seen only once in the main crater; this tiny epiphyte has been rarely observed in the western half of `Ōla`a Forest. On a subsequent trip to the `Ōla`a Trench site in 2006, a recently described species of fern (*Pneumatopteris pendens* D. D. Palmer and Yuko Johnson) was noted on steep rocky walls of the second crater. Previously, this new species was known within the national park only from the Thurston Lava Tube area (D. D. Palmer, pers. comm. 2003).

Other Observations

The focus of this inventory was vascular plants, but a few observations of birds and mammals were made during the two survey trips. For more information on the distribution and abundance of native forest birds in the `Ōla`a Forest, see Scott *et al.* 1986.

Birds

Few birds were seen within the trench feature, and native birds were almost entirely absent. Alien-bird species most apparent were Japanese White-eye (*Zosterops japonicus*) and Northern Cardinal (*Cardinalis cardinalis*). The only native birds noted were `Apapane (*Himatione sanguinea*) heard occasionally and seen at flowering `ōhi`a trees.

Bats

A bat was seen at dusk flying over the main crater during an informal visit in March 2001; this was almost certainly an individual of the endangered Hawaiian hoary bat, *Lasiurus cinereus semotus*. No bats were observed during the July visit.

SUMMARY AND RECOMMENDATIONS

One important conservation action that park managers could undertake at the `Ōla`a Trench would be fencing to exclude feral pigs from the crater interior. Most of the main crater perimeter appears too steep for pigs to enter, except for the eastern end where the trench walls are shorter. Approximately 500 m of fencing would probably be sufficient to block access, although the site should be evaluated by fencing experts. Removal of remaining pigs from the trench and implementation of a weed control regime would be needed to prevent an increase of weedy alien plant species. The current density of weeds is low, but large areas of ground have been disturbed by pig uprooting. Weeds are likely to increase in cover and density in the first few years following pig removal, and this may interfere with native plant recovery (Loh and Tunison 1999). Pig removal and weed control would contribute to protection of the existing *Cyrtandra tintinnabula* population and allow its numbers to increase. Currently, pig activity makes much of the trench unsuitable as rare plant habitat. Pig removal would also benefit other vulnerable native plants such as pala fern and koli`i. If managed, the site might be a potential out-planting site for rare and endangered species currently found only in the western half of the `Ōla`a Tract, such as `ānunu (*Sicyos alba*), `akū (*Cyanea tritomantha*), and the mint *Phyllostegia floribunda*.

A much more ambitious project may increase habitat for native birds by fencing the unprotected northeastern quarter of `Ōla`a Tract. The eastern half of the `Ōla`a Tract is not currently slated for fencing and pig removal because of the severity of the weed problem (T. Tunison, pers. comm. 2005). The cost to control all highly invasive weeds in this large area would likely be prohibitively high. The major weeds of eastern `Ōla`a are strawberry guava and yellow Himalayan raspberry in the subcanopy, and palmgrass in

the ground layer. A forest dominated by these disruptive alien species would be of little value for preserving rare native understory plants. However, one of the consequences of leaving the area unfenced is the continued presence of feral pigs, which hollow out tree fern trunks and create mosquito breeding habitat. Mosquitoes (*Culex quinquefasciatus*) spread avian malaria fatal to many native birds (van Riper *et al.* 1986; Atkinson *et al.* 1995). Even though the upper canopy of the forest around the trench is dominated by the most important food species for the native `apapane (*Himatione sanguinea*) and `i`iwi (*Vestiaria coccinea*), the populations of native birds seem relatively low. What might otherwise be good native bird habitat is currently little used by native forest birds.

The `Ōla`a Trench is a unique geological feature within HAVO and supports the only known population of a critically endangered plant species within the Park. While *in situ* protection of the endangered *Cyrtandra tintinnabula* population is desirable, it is also prudent to propagate the species and establish it elsewhere (U. S. Fish and Wildlife Service 1996). It is possible that more accessible areas within managed units of `Ōla`a Forest may be suitable as out-planting sites. Basic monitoring of *Cyrtandra tintinnabula* at the trench is warranted to indicate the status of the population and to identify the reproductive phenology of the species. Managers of Hawai`i Volcanoes National Park have an opportunity to play an important role in the conservation and recovery of this endangered species.

ACKNOWLEDGEMENTS

We would like to thank the botanists who assisted us with field surveys at the `Ōla`a Trench: Laurie Gold and William Haines, formerly of PCSU; Thomas Belfield, PCSU Rare Plant Specialist; and Ian Cole of the State Division of Forestry and Wildlife, Natural Area Reserve System. Andrika Kuhle and Viet Doan (PCSU) of the PACN Inventory and Monitoring program assisted us with formatting, editing, and figures, for which we are grateful. We also appreciate the manuscript review by David Helweg of USGS, Pacific Island Ecosystems Research Center.

This research was made possible in part thanks to support from the Pacific Island Ecosystems Research Center, U. S. Geological Survey. This project was carried out under a cooperative agreement (Task Agreement No. CA 8012-AO-001,) between the National Park Service, Pacific Island Network and the Pacific Cooperative Studies Unit, University of Hawai`i at Mānoa.

LITERATURE CITED

Anderson, S. J., P. K. Higashino, J. T. Tunison, and L. W. Cuddihy. 1988. Botanical survey of the `Ōla`a Forest, Large Tract. Unpublished data, Biological Resources Disclipline, U. S. Geological Survey and Resources Management Division, Hawai`i Volcanoes National Park.

Atkinson, C. T., K. L. Woods, R. J. Dusek, L. S. Sileo, and W. M. Iko. 1995. Wildlife disease and conservation in Hawaii: pathogenicity of avian malaria (*Plasmodium relictum*) in experimentally infected Iiwi (*Vestiaria coccinea*). Parasitology 11 (Supplement): S59-S69.

Cuddihy, L.W. and C.P. Stone. 1990. Alteration of native Hawaiian vegetation: effects of humans, their activities and introductions. Cooperative National Park Studies Unit, University of Hawai`i at Manoa. University of Hawai`i, Department of Botany, Honolulu, HI.

Fosberg, F. R. 1966. Vascular plants. Pp. 153-238 in M. S. Doty and D. Mueller-Dombois. Atlas for bioecology studies in Hawaii Volcanoes National Park. University of Hawaii, Hawaii Botanical Science Paper No. 2. Honolulu, HI.

Holcomb, R. T. 1987. Eruptive history and long-term behavior of Kilauea Volcano. Pp. 261-350 in R. W. Decker, T. L. Wright, and P. H. Stauffer (editors). Volcanism in Hawaii, volume 1. U. S. Geological Survey Professional Paper 1350. U. S. Government Printing Office, Washington, D. C.

Lockwood, J. P., and P. W. Lipman. 1987. Holocene eruptive history of Mauna Loa Volcano. Pp. 509-535 in R. W. Decker, T. L. Wright, and P. H. Stauffer (editors). Volcanism in Hawaii, volume 1. U. S. Geological Survey Professional Paper 1350. U. S. Government Printing Office, Washington, D. C.

Loh, R. K., and J. T. Tunison. 1999. Vegetation recovery following pig removal in `Ōla`a-Koa rainforest unit, Hawaii Volcanoes National Park. Technical Report 123. Pacific Cooperative Studies Unit, University of Hawai`i at Mānoa. Honolulu, HI.

Male, T., and W. Loeffler. 1997. Patterns of distribution and seed predation in a population of *Pritchardia hillebrandii*. Newsletter of the Hawaiian Botanical Society 36 (1):1-11.

Palmer, D. D. 2003. Hawai`i's ferns and fern allies. University of Hawai`i Press, Honolulu, HI.

Pratt, L. W., and L. L. Abbott. 1997. Rare plants within managed units of `Ōla`a Forest, Hawai`i Volcanoes National Park. Technical Report 115. Cooperative National Park Studies Unit, University of Hawai`i at Mānoa. Honolulu, HI.

Scott, J. M., S. Mountainspring, F. L. Ramsey, and C. B. Kepler. 1986. Forest bird communities of the Hawaiian Islands: their dynamics, ecology, and conservation. Studies in Avian Biology No. 9, Cooper Ornithological Society. Allen Press, Lawrence, KS.

Smith, C. W. 1985. Impact of alien plants on Hawai`i's native biota. Pp. 180-250 in C. P. Stone and J. M. Scott (editors). Hawai`i's terrestrial ecosystems: preservation and management. Cooperative National Park Resources Study Unit, University of Hawai`i, Honolulu.

Stone, C. P. 1985. Alien animals in Hawai`i's native ecosystems: toward controlling the adverse effects of introduced vertebrates. Pp. 251-297 in C. P. Stone and J. M. Scott (editors). Hawai`i's terrestrial ecosystems: preservation and management. Cooperative National Park Resources Studies Unit, University of Hawai`i, Honolulu, HI.

Stratton, L. 1996. The impact and spread of *Rubus ellipticus* in `Ōla`a Forest Tract Hawai`i Volcanoes National Park. Cooperative National Park Studies Unit, University of Hawai`i at Mānoa. Technical Report 107. University of Hawai`i, Department of Botany, Honolulu, HI.

The Nature Conservancy. 1987. Biological overview of Hawaii's Natural Area Reserve System; Appendices. Prepared for Hawaii State Department of Land and Natural Resources by Hawaii Heritage Program, The Nature Conservancy of Hawaii, Honolulu, HI.

U. S. Fish and Wildlife Service. 2004. U. S. Fish and Wildlife Service Species List-Plants. [List of Endangered, Threatened, Candidate, and Species of Concern.] October 21, 2004. Unpublished list maintained by Ecological Services Office, Honolulu, HI. 24 pp.

U. S. Fish and Wildlife Service. 2006. Recovery plan for the Big Island plant cluster. U.S. Fish and Wildlife Service, Portland OR. 202 pp. & appendices.

van Riper, C., S. G. van Riper, M. L. Goff, and M. Laird. 1986. The epizootiology and ecological significance of malaria in Hawaiian land birds. Ecological Monographs 56(4):327-344.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. Manual of the flowering plants of Hawai`i, revised edition. Bishop Museum Special Publication 97. University of Hawai`i Press and Bishop Museum Press, Honolulu, HI.

APPENDIX: `ŌLA`A TRENCH VASCULAR PLANT CHECKLIST

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Asplenium lobulatum Mett.	pi`ipi`i lau manamana	Aspleniaceae	Fern	Indigenous	Uncommon	Epiphytic (LWP 3253)
Asplenium polyodon G. Forst.	pūnana manu	Aspleniaceae	Fern	Indigenous	Uncommon	Epiphytic
Asplenium sp. 1		Aspleniaceae	Fern	Native	Uncommon	Epiphytic (LWP3216)
Asplenium sp. 2		Aspleniaceae	Fern	Native	Rare	Epiphytic (LWP 3217)
Athyrium microphyllum (Sm.) Alston	`ākōlea	Athyriaceae	Fern	Endemic	Uncommon	
Deparia petersenii (Kunze) M. Kato	no common name	Athyriaceae	Fern	Alien	Abundant	
Diplazium sandwichianum (C. Presl) Diels	hō`i`o	Athyriaceae	Fern	Endemic	Common	
Sadleria cyatheoides Kaulf.	`ama`u, `āma`uma`u	Blechnaceae	Fern	Endemic	Uncommon	
Sadleria pallida Hook. & Arn.	`ama`u, `āma`uma`u	Blechnaceae	Fern	Endemic	Uncommon	
Sadleria souleytiana (Gaudich.) T. Moore	`ama`u, `āma`uma`u	Blechnaceae	Fern	Endemic	Uncommon	Tall trunk
Microlepia strigosa (Thunb.) C. Presl var. *strigosa*	palapalai	Dennstaedtiaceae	Fern	Indigenous	Uncommon	
Cibotium chamissoi Kaulf.	meu	Dicksoniaceae	Fern	Endemic	Rare	Rare in trench, more common outside
Cibotium glaucum (Sm.) Hook. & Arn.	hāpu`u pulu	Dicksoniaceae	Fern	Endemic	Abundant	
Cibotium menziesii Hook.	hāpu`u `i`i	Dicksoniaceae	Fern	Endemic	Uncommon	

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Dryopteris fusco-atra (Hillebr.) W. J. Rob.	`i`i	Dryopteridaceae	Fern	Endemic	Uncommon	
Dryopteris glabra (Brack.) Kuntze var. *glabra*	kīlau, hohiu	Dryopteridaceae	Fern	Endemic	Uncommon	(LWP 3249)
Dryopteris glabra (Brack.) Kuntze var. *nuda*? (Underw.) Fraser-Jenk.		Dryopteridaceae	Fern	Endemic	Rare	Seen once (LWP 3221)
Dryopteris wallichiana (Spreng.) Hyl.	laukahi	Dryopteridaceae	Fern	Indigenous	Uncommon	
Nothoperanema rubiginosa (Brack.) A. R. Sm. & D. D. Palmer	maku`e, pauoa	Dryopteridaceae	Fern	Endemic	Uncommon	
Tectaria gaudichaudii (Mett.) Maxon	`iwa`iwa lau nui	Dryopteridaceae	Fern	Endemic	Rare	One plant on steep end wall of secondary trench (LWP 3246)
Elaphoglossum crassifolium (Gaudich.) W. R. Anderson & Crosby	`ēkaha, hoe a Māui	Elaphoglossaceae	Fern	Endemic	Rare	Epiphytic, seen once
Elaphoglossum paleaceum (Hook. & Grev.) Sledge	`ēkaha, māku`e	Elaphoglossaceae	Fern	Indigenous	Common	Epiphytic
Elaphoglossum parvisquameum Skottsb.	`ēkaha, hoe a Māui	Elaphoglossaceae	Fern	Endemic	Uncommon	Epiphytic (LWP 3251)
Elaphoglossum pellucidum Gaudich.	hoe a Māui	Elaphoglossaceae	Fern	Endemic	Rare	Epiphytic, seen once

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Dicranopteris linearis (Burm. f.) Underw. f. *linearis*	uluhe	Gleicheniaceae	Fern	Indigenous	Abundant	
Diplopterygium pinnatum (Kunze) Nakai	uluhe lau nui	Gleichenaceae	Fern	Indigenous	Common	On steep walls (LWP 3224)
Sticherus owhyhensis (Hook.) Ching	uluhe	Gleicheniaceae	Fern	Endemic	Common	On steep walls
Adenophorus hymenophylloides (Kaulf.) Hook. & Grev.	pai	Grammitidaceae	Fern	Endemic	Uncommon	Epiphytic
Adenophorus pinnatifidus Gaudich.	kihi, kihe	Grammitidaceae	Fern	Endemic	Rare	Epiphytic
Adenophorus tamariscinus (Kaulf.) Hook. & Grev.	wahine noho mauna	Grammitidaceae	Fern	Endemic	Uncommon	Epiphytic
Adenophorus tripinnatifidus Gaudich.	no common name	Grammitidaceae	Fern	Endemic	Uncommon	Epiphytic
Grammitis hookeri (Brack.) Copel.	māku`e lau li`i	Grammitidaceae	Fern	Indigenous	Uncommon	Epiphytic
Grammitis tenella Kaulf.	kolokolo, mahinalua	Grammitidaceae	Fern	Endemic	Common	Epiphytic
Callistopteris baldwinii (D. C. Eaton) Copel.	no common name	Hymenophyllaceae	Fern	Endemic	Rare	Terrestrial, on steep south slope of secondary trench
Mecodium recurvum (Gaudich.) Copel.	`ōhi`a kū	Hymenophyllaceae	Fern	Endemic	Common	Epiphytic
Sphaerocionium lanceolatum (Hook. & Am.) Copel.	palai hinahina	Hymenophyllaceae	Fern	Endemic	Common	Epiphytic
Vandenboschia davallioides (Gaudich.) Copel.	kīlau, kalau, palai hihi	Hymenophyllaceae	Fern	Endemic	Uncommon	

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Sphenomeris chinensis (L.) Maxon	pala`ā, palapala`ā	Lindsaeaceae	Fern	Indigenous	Uncommon	
Huperzia erosa Beitel & W. H. Wagner	no common name	Lycopodiaceae	Fern Ally	Indigenous	Rare	Only one seen (LWP 3252)
Huperzia phyllantha (Hook. & Arn.) Holub	wāwae `iole, hanging fir moss	Lycopodiaceae	Fern Ally	Indigenous	Rare	Epiphytic (LWP 3218)
Lycopodiella cernua (L.) Pic. Serm.	wāwae `iole	Lycopodiaceae	Fern Ally	Indigenous	Common	
Marattia douglasii (C. Presl) Baker	pala, kapua `ilio	Marattiaceae	Fern	Endemic	Rare	Epiphytic, 1 in main trench and 3 plants in first pit crater
Nephrolepis cordifolia (L.) C. Presl	kupukupu, ni`ani`au	Nephrolepidaceae	Fern	Indigenous	Uncommon	Epiphytic
Nephrolepis exaltata (L.) Schott subsp. *hawaiiensis* W. H. Wagner	kupukupu, ni`ani`au	Nephrolepidaceae	Fern	Endemic	Uncommon	
Nephrolepis multiflora (Roxb.) F. M. Jarrett ex C. V. Morton	hairy swordfern	Nephrolepidaceae	Fern	Alien	Uncommon	On rock face
Ophioderma pendulum (L.) C. Presl subsp. *falcatum* (C. Presl) R. T. Clausen	puapua moa, adder's tongue	Ophioglossaceae	Fern	Indigenous	Rare	Epiphytic (LWP 3247)
Lepisorus thunbergianus (Kaulf.) Ching	`ēkaha `ākōlea, pākahakaha	Polypodiaceae	Fern	Indigenous	Uncommon	Epiphytic
Polypodium pellucidum Kaulf. var. *pellucidum*	`ae	Polypodiaceae	Fern	Endemic	Uncommon	Epiphytic

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Psilotum complanatum Sw.	moa, pipi	Psilotaceae	Fern Ally	Indigenous	Uncommon	Epiphytic
Psilotum nudum (L.) P. Beauv.	moa, pipi	Psilotaceae	Fern Ally	Indigenous	Uncommon	
Coniogramme pilosa (Brack.) Hieron.	lo`ulu	Pteridaceae	Fern	Endemic	Uncommon	
Selaginella arbuscula (Kaulf.) Spring	lepelepe a moa	Selaginellaceae	Fern Ally	Endemic	Uncommon	On rock face
Amauropelta globulifera (Brack.) Holttum	palapalai a Kamapua`a	Thelypteridaceae	Fern	Endemic	Common	Terrestrial (LWP 3255)
Macrothelypteris torresiana (Gaudich.) Ching	no common name	Thelypteridaceae	Fern	Alien	Uncommon	
*Pneumatopteris pendens*D. D. Palmer and Yuko Johnson	no common name	Thelypteridaceae	Fern	Endemic	Uncommon	
Pneumatopteris sandwicensis (Brack.) Holttum	hō`i`o kula	Thelypteridaceae	Fern	Endemic	Common	
Alyxia oliviformis Gaud.	maile	Apocynaceae	Dicot	Endemic	Uncommon	
Ilex anomala Hook. & Arnott	kāwa`u	Aquifoliaceae	Dicot	Indigenous	Uncommon	
Cheirodendron trigynum (Gaud.) A. Heller subsp. *trigynum*	`ōlapa	Araliaceae	Dicot	Endemic	Common	
Tetraplasandra oahuensis (A. Gray) Harms	`ohe mauka	Araliaceae	Dicot	Endemic	Rare	One tree seen on hill (LWP 3239)
Ageratina riparia (Regel) R. King & H. Robinson	Hāmākua pāmakani	Asteraceae	Dicot	Alien	Uncommon	
Ageratum conyzoides L.	ageratum, maile hohono	Asteraceae	Dicot	Alien	Uncommon	(LWP 3254)
Conyza bonariensis (L.) Cronq.	hairy horseweed	Asteraceae	Dicot	Alien	Rare	Only one seen

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Dubautia scabra (DC) D. Keck var. *scabra*	na`ena`e	Asteraceae	Dicot	Endemic	Rare	Seen once on south slope of main trench
Erechtites valerianifolia (Wolf) DC	fireweed	Asteraceae	Dicot	Alien	Rare	
Pluchea carolinensis (Jacq.) G. Don	sourbush	Asteraceae	Dicot	Alien	Rare	On landslide
Youngia japonica (L.) DC	oriental hawksbeard	Asteraceae	Dicot	Alien	Common	
Cardamine flexuosa With.	bittercress	Brassicaceae	Dicot	Alien	Uncommon	
Buddleia asiatica Lour.	Asiatic butterfly bush, dog tail	Buddleiaceae	Dicot	Alien	Rare	On landslide
Clermontia parviflora Gaud. ex A. Gray	`ōhā wai	Campanulaceae	Dicot	Endemic	Uncommon	
Cyanea pilosa A. Gray subsp. *longipedunculata* (Rock) Lammers	hāhā	Campanulaceae	Dicot	Endemic	Uncommon	On rock face
Trematolobelia grandifolia (Rock) Degener	koli`i	Campanulaceae	Dicot	Endemic	Rare	Epiphytic, ca. four groups seen
Drymaria cordata (L.) Willd. ex Roem. & Schult. var. *pacifica* Mizush.	drymaria, pipili	Caryophyllaceae	Dicot	Alien	Common	On floor of trench
Perrottetia sandwicensis A. Gray	olomea	Celastraceae	Dicot	Endemic	Uncommon	
Hypericum mutilum L.	St. John's wort	Clusiaceae	Dicot	Alien	Uncommon	
Vaccinium calycinum Sm.	`ōhelo kau lā`au	Ericaceae	Dicot	Endemic	Uncommon	
Vaccinium reticulatum Sm.	`ōhelo	Ericaceae	Dicot	Endemic	Rare	Secondary trench, steep south slope

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Cyrtandra platyphylla A. Gray	`ilihia	Gesneriaceae	Dicot	Endemic	Uncommon	(LWP 3248)
Cyrtandra tintinnabula Rock	no common name	Gesneriaceae	Dicot	Endemic	Rare	Endangered species, first record in HAVO (LWP 3256)
Scaevola chamissoniana Gaud.	naupaka kuahiwi	Goodeniaceae	Dicot	Endemic	Uncommon	
Broussaisia arguta Gaud.	kanawao, pū`ahanui	Hydrangeaceae	Dicot	Endemic	Uncommon	
Stenogyne calaminthoides A. Gray	no common name	Lamiaceae	Dicot	Endemic	Rare	Few seen
Labordia hedyosmifolia Baill.	kāmakahala	Loganiaceae	Dicot	Endemic	Rare	
Cuphea carthagenensis (Jacq.) Macbr.	tarweed	Lythraceae	Dicot	Alien	Uncommon	On floor of trench
Tibouchina herbacea (DC) Cogn.	cane tibouchina	Melastomataceae	Dicot	Alien	Rare	Seen once (LWP 3219)
Myrsine lessertiana A. DC	kōlea lau nui	Myrsinaceae	Dicot	Endemic	Rare	
Metrosideros polymorpha Gaud. var. *glaberrima* (H. Lev.) St. John	`ōhi`a lehua	Myrtaceae	Dicot	Endemic	Common	
Metrosideros polymorpha Gaud. var. *incana* (H. Lev.) St. John	`ōhi`a lehua	Myrtaceae	Dicot	Endemic	Uncommon	
Metrosideros polymorpha Gaud. var. *macrophylla* (Rock) St. John	`ōhi`a lehua	Myrtaceae	Dicot	Endemic	Common	

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Psidium cattleianum Sabine	strawberry guava	Myrtaceae	Dicot	Alien	Common	
Ludwigia palustris (L.) Elliott	water purslane	Onagraceae	Dicot	Alien	Common	
Passiflora edulis Sims	liliko`i	Passifloraceae	Dicot	Alien	Rare	Only on hill, fruit green
Passiflora ligularis Juss.	sweet granadilla	Passifloraceae	Dicot	Alien	Uncommon	
Passiflora tarminiana Coppens & Barney	banana poka	Passifloraceae	Dicot	Alien	Uncommon	
Peperomia cookiana C. DC	`ala`ala wai nui	Piperaceae	Dicot	Endemic	Uncommon	Epiphytic
Peperomia hypoleuca Miq.	`ala`ala wai nui	Piperaceae	Dicot	Endemic	Common	Epiphytic (LWP 3222, 3245)
Peperomia macraeana C. DC	`ala`ala wai nui	Piperaceae	Dicot	Endemic	Rare	Terrestrial (LWP 3244)
Peperomia tetraphylla (G. Forster) Hook. & Arnott	`ala`ala wai nui	Piperaceae	Dicot	Indigenous	Rare	Epiphytic (LWP 3223)
Persicaria punctata (Elliott) Small	water smartweed	Polygonaceae	Dicot	Alien	Common	
Anemone hupehensis Lemoine var. *japonica* (Thunb.) Bowles & W. Stern	Japanese anemone	Ranunculaceae	Dicot	Alien	Common	
Rubus argutus Link	prickly blackberry	Rosaceae	Dicot	Alien	Rare	Only on western hilltop
Rubus ellipticus Sm. var. *obcordatus* Focke	yellow Himalayan raspberry	Rosaceae	Dicot	Alien	Uncommon	
Rubus hawaiensis A. Gray	`ākala	Rosaceae	Dicot	Endemic	Uncommon	

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Rubus rosifolius Sm.	thimbleberry	Rosaceae	Dicot	Alien	Uncommon	
Coprosma ochracea W. Oliver	pilo	Rubiaceae	Dicot	Endemic	Common	*C. pubens* may also be present
Hedyotis centranthoides (Hook. & Arnott) Steud.	no common name	Rubiaceae	Dicot	Endemic	Common	(LWP 3220)
Hedyotis hillebrandii (Fosb.) W. L. Wagner & Herbst	manono	Rubiaceae	Dicot	Endemic	Uncommon	(LWP 3241)
Hedyotis terminalis (Hook. & Arnott) W. L. Wagner & Herbst	manono	Rubiaceae	Dicot	Endemic	Uncommon	
Psychotria hawaiiensis (A. Gray) Fosb. var. *hawaiiensis*	kōpiko `ula	Rubiaceae	Dicot	Endemic	Uncommon	
Melicope clusiifolia (A. Gray) T. Hartley & B. Stone	alani	Rutaceae	Dicot	Endemic	Uncommon	
Melicope pseudoanisata (Rock) T. Hartley & B. Stone	alani	Rutaceae	Dicot	Endemic	Rare	Seen only on hill
Nothocestrum longifolium A. Gray	`aiea	Solanaceae	Dicot	Endemic	Rare	Two trees seen in trench (LWP 3257)
Pipturus albidus (Hook. & Arnott) A. Gray	māmaki	Urticaceae	Dicot	Endemic	Common	
Urera glabra (Hook. & Arnott) Wedd.	ōpuhe	Urticaceae	Dicot	Endemic	Rare	One tree in trench and pit crater (LWP 3240)
Pritchardia beccariana Rock	loulu	Arecaceae	Monocot	Endemic	Uncommon	<20 seen
Carex alligata Boott	no common name	Cyperaceae	Monocot	Endemic	Common	Localized

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Machaerina angustifolia (Gaud.) T. Koyama	`uki	Cyperaceae	Monocot	Indigenous	Rare	On south slope main trench
Machaerina mariscoides (Gaud.) J. Kern subsp. *meyenii* (Kunth) T. Koyama	`uki	Cyperaceae	Monocot	Indigenous; Endemic subsp.	Common	On walls
Uncinia uncinata (L. f.) Kukenth.	no common name	Cyperaceae	Monocot	Indigenous	Common	
Juncus polyanthemos Buchenau	no common name	Juncaceae	Monocot	Alien	Common	Localized (LWP 3250)
Juncus tenuis Willd.	rush (no common name)	Juncaceae	Monocot	Alien	Uncommon	Mixed with *Juncus polyanthemos* and *Carex alligata* in secondary trench bog
Astelia menziesiana Sm.	pa`iniu	Liliaceae (Asteliaceae)	Monocot	Endemic	Uncommon	Epiphytic
Arundina graminifolia (D. Don) Hochr.	bamboo orchid	Orchidaceae	Monocot	Alien	Uncommon	On rock face
Phaius tankarvilleae (Banks ex L'Her.) Blume	Chinese ground orchid	Orchidaceae	Monocot	Alien	Uncommon	At edge of trench
Freycinetia arborea Gaud.	`ie`ie	Pandanaceae	Monocot	Indigenous	Uncommon	On trench walls
Andropogon virginicus L.	broomsedge	Poaceae	Monocot	Alien	Rare	At edge of trench
Axonopus fissifolius (Raddi) Kuhlm.	narrowleaf carpetgrass	Poaceae	Monocot	Alien	Uncommon	At edge of trench, also on edge of bog
Isachne distichophylla Munro ex. Hillebr.	`ohe	Poaceae	Monocot	Endemic	Uncommon	

Species[1]	Common name	Family	Division	Status[2]	Abundance[3]	Notes and collector #[4]
Paspalum urvillei Steud.	Vasey grass	Poaceae	Monocot	Alien	Common	
Sacciolepis indica (L.) Chase	Glenwood grass	Poaceae	Monocot	Alien	Uncommon	
Setaria palmifolia (J. Konig) Stapf	palm grass	Poaceae	Monocot	Alien	Common	

[1] Nomenclature of flowering plants follows: Wagner, W. L., D. H. Herbst, and S. Y. Sohmer. 1999. Manual of the flowering plants of Hawai`i, revised edition. Bishop Museum Special Publication 97. University of Hawai`i Press and Bishop Museum Press, Honolulu, HI. 1919 pp.

Nomenclature of ferns and fern allies follows: Palmer, D. D. 2003. Hawai`i's ferns and fern allies. University of Hawai`i Press, Honolulu, HI. 324 pp.

[2] **Status**. Endemic species are unique (native only) to the Hawaiian Islands; Indigenous species are native to Hawai`i and other lands; Alien species are non-native, introduced either accidentally or intentionally. Several unidentified ferns are called "Native." Status information in this appendix can differ from information entered into NPSpecies, because NPSpecies definitions do not distinguish between endemic and indiginous status and native status in NPSpecies refers to the national park rather than the island chain.

[3] **Abundance**. Abundance is estimated for the `Ōla`a Trench and immediate vicinity. Abundant plants occur in large numbers and cover a large area. Common plants occur in large numbers, but do not cover large areas. Uncommon plants occur in low or moderate numbers or occur in uncommon habitats. Rare plants occur in low numbers or are restricted to rare habitats. Abundance estimates follow NPSpecies guidelines.

[4] **Collector #.** The collector number was assigned by the collector in the field. This number will be included on the label once the specimen is accessioned into the HAVO herbarium.