PETITION TO LIST

TWO SPECIES OF HAWAIIAN YELLOW-FACED BEES

(*Hylaeus mana* and *Hylaeus kuakea*)

AS ENDANGERED SPECIES

UNDER THE U.S. ENDANGERED SPECIES ACT

Hylaeus mana, photo by Karl Magnacca

Prepared by

Lisa Schonberg, The Xerces Society
Sarina Jepsen, The Xerces Society
Scott Hoffman Black, The Xerces Society

Submitted by

The Xerces Society for Invertebrate Conservation

March 23, 2009

Ken Salazar
Secretary of the Interior
Office of the Secretary
Department of the Interior
1849 C Street N.W.
Washington D.C., 20240

Dear Mr. Salazar:

The Xerces Society hereby formally petitions to list the Hawaiian yellow-faced bees *Hylaeus kuakea* and *Hylaeus mana* as endangered pursuant to the Endangered Species Act, 16 U.S.C. §§ 1531 *et seq.* This petition is filed under 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14 (1990), which grants interested parties the right to petition for issue of a rule from the Secretary of the Interior.

Petitioners also request that critical habitat be designated concurrent with the listing, as required by 16 U.S.C. § 1533(b)(6)(C) and 50 C.F.R. § 424.12, and pursuant to the Administrative Procedure Act (5 U.S.C. § 553).

Multiple threats including habitat loss, the rarity of these species, and the natural instability of small populations of island endemics lead us to conclude, unequivocally, that *Hylaeus kuakea* and *Hylaeus mana* are threatened with extinction and must be given protection under the Endangered Species Act.

We are aware that this petition sets in motion a specific process placing definite response requirements on the U.S. Fish and Wildlife Service and very specific time constraints upon those responses. 16 U.S.C. § 1533(b).

Sincerely,

Scott Hoffman Black, Executive Director
Xerces Society
4828 SE Hawthorne Blvd.
Portland, OR 97215
503-232-6639

The Xerces Society is an international, nonprofit organization that protects wildlife through the conservation of invertebrates and their habitat. The Society works with scientists, land managers, and citizens to protect invertebrates and their habitats through education, outreach, applied research, advocacy and policy.

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

Hylaeus mana and *Hylaeus kuakea* are extremely rare bees endemic to the island of Oahu that are in imminent danger of going extinct. Perkins, whose early turn of the twentieth century survey of the *Hylaeus* is the basis for most of the historic records of the genus in Hawaii, called *Hylaeus* "almost the most ubiquitous of any Hawaiian insects" (Perkins 1912), but more recent surveys (Daly and Magnacca 2003) indicate that many *Hylaeus* species are extremely rare, and several are possibly extinct (Daly and Magnacca 2003, Magnacca 2007, Shepherd *et al.* 2005). That *H. kuakea* and *H. mana* were not found until 1997 and 2002, respectively, suggests that they are extremely rare and their populations are small and isolated, making them especially vulnerable to habitat loss, predation, stochastic events, and other changes to their habitat.

Hylaeus kuakea and *Hylaeus mana* are likely critical pollinators of native Hawaiian plant species, and their decline might exacerbate the loss of Hawaiian plants. Hawaiian *Hylaeus* species almost exclusively visit native plant species, and are very likely keystone species in maintaining the diversity of native flora in Hawaiian forests. The role of bees as pollinators that maintain communities of native flora in a diversity of habitats has been recognized (Cane and Tepedino 2001, Kremen *et al.* 2007, NRC 2007). Recent studies of visitation records of Hawaiian *Hylaeus* species to native flowers (Daly and Magnacca 2003) and pollination studies of native plants (Sakai *et al.* 1995, Cox and Elmqvist 2000, Sahli 2008) have illustrated the important role of *Hylaeus* species as pollinators of many native Hawaiian plants. Sahli (2008) found that *Hylaeus* were less abundant at lower elevations, and that there were lower visitation rates of pollinators to native plants at these elevations. She concluded that *Hylaeus* were not easily replaceable by non-native pollinators, and that *Hylaeus* are very important for the reproduction of native plants.

Conservation of *H. kuakea* and *H. mana* will require the active control and management of natural areas where populations are known to or may exist. The continued impact of fire, feral ungulates, non-native ants, and the loss of native vegetation to invasive plant species will undoubtedly have a negative impact on the remaining populations of *H. kuakea* and *H. mana* and may cause their extinction if their habitat is not protected. Additional populations of these species may exist in suitable lowland mesic forest habitat on Oahu, and intensive searching for populations should be undertaken in order to identify populations and protect their habitat. Precautionary measures to protect possible populations of these species should be followed, and lowland mesic forest habitats with intact native plant communities should be protected.

The threats, the extreme rarity of these species, and the natural instability of small populations of island endemics lead us to conclude, unequivocally, that *Hylaeus mana* and *Hylaeus kuakea* are immediately threatened with extinction and must be given protection under the Endangered Species Act.

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

Hylaeus mana and *H. kuakea* have Global Heritage Status Ranks of GNR; their ranks have not yet been assessed. Both species are on the Xerces Society for Invertebrate Conservation's Red List of Pollinator Insects (Shepherd *et al.* 2005). All species in their subgenus *Nesoprosopis* are considered "species of greatest conservation need" by the Hawaii Department of Forestry and Wildlife's Comprehensive Wildlife Conservation Strategy (HDLNR 2005). Magnacca (2007) assigned conservation status ranks to *Hylaeus* species based on the IUCN (2001) system. *Hylaeus kuakea* and

H. mana were both given a rank of 5 on a scale of 1 to 6, indicating they are "very rare and potentially endangered."

III. TAXONOMY

The taxonomy of *Hylaeus kuakea* and *Hylaeus mana* is uncontested. *Hylaeus kuakea* and *H. mana* are small bees in the family Colletidae. The genus *Hylaeus* is widespread and very diverse in the Hawaiian Islands, with 60 native species, including 20 that are endemic to single islands (Magnacca 2007). They are in the subgenus *Nesoprosopis*, which includes all 60 *Hylaeus* species native to the Hawaiian Islands (Michener 2000, Magnacca and Danforth 2006). *Hylaeus* species are commonly known as yellow-faced bees or masked bees, for the yellow to white markings on their face. Hawaiian *Hylaeus* species form a diverse and large lineage that evolved relatively recently and in an unusually short amount of time (Magnacca and Danforth 2006, Magnacca and Danforth 2007).

Hylaeus kuakea was first described by Daly and Magnacca (2003) from specimens taken in 1997 in the Waianae Mountains, Honolulu County, Hawaii. *H. kuakea* does not fit into any of the well-defined *Hylaeus* species groups. Its facial marks are similar to those of the *H. difficilis* group and *H. anthracinus*, but it can be distinguished by its unusual ivory facial marks. *H. kuakea* is similar to *H. anthracinus*, but has denser, more distinct punctuation of the front, longer hairs on the head, and generally narrower marks next to the compound eyes (Daly and Magnacca 2003, Magnacca 2005a).

Hylaeus mana was first described by Daly and Magnacca (2003) from specimens taken in 2002 in the leeward Koolau Mountains, Honolulu County, Hawaii. *H. mana* is a member of the *dumetorum* species group. It is the smallest of all Hawaiian *Hylaeus* species. It can be distinguished from the sympatric *H. mimicus* and *H. specularis* by its extremely small size, the male's narrow, strongly arched process of the 8th sternum, and the female's extensive facial marks, more widely spaced pits of the frons, and transverse rather than longitudinal clypeal mark (Daly and Magnacca 2003, Magnacca 2005b).

IV. SPECIES DESCRIPTION

A. Adult

Hylaeus species have a wasplike appearance; they appear hairless but actually have plumose hairs on the body that are longest on the sides of the thorax. They can be distinguished from wasps by their branched (plumose) hairs (Michener 2000).

Hylaeus kuakea is a small black bee with slightly smoky wings, a single ivory mark covering the clypeus and a narrow strip of the paraocular area, and a weakly dilated process of the 8th sternum. The male holotype has a wing length of 4.2 mm (.165 inch). The female is unknown (Daly and Magnacca 2003).

Hylaeus mana is an extremely small, gracile black bee with yellow markings on the face. The male holotype has a wing length of 2.9 mm (.114 inch). The male's face is largely yellow below the antennae, extending dorsally in a narrowing stripe; the pronotum and legs are extensively marked. The scape has a shallow groove underneath; the process of the 8th sternum is narrow and not dilated. The female's face has three yellow lines, one against each eye and a transverse stripe at the apex of the clypeus. The other marks are as in the male (Daly and Magnacca 2003).

B. Immature
The egg, larval and pupal stages of *H. kuakea* and *H. mana* are unknown.

V. POPULATION DISTRIBUTION AND STATUS

A. Historic Distribution
The first collections of *H. kuakea* and *H. mana* were made in 1997 and 2002, respectively, so their historic range and abundance are unknown. These two species were not found in surveys of suitable habitat in these areas by Perkins (1899, 1910, 1911) on which the historic distribution for most Hawaiian *Hylaeus* species is based on.

B. Current Distribution
The full ranges of *H. kuakea* and *H. mana* are unknown, but are probably not large (Magnacca 2005a, b). The type locality for *H. kuakea* is Moho Gulch Ridge, at the northern end of Honouliuli Preserve in the Waianae mountains of Oahu, at an elevation of about 579 m (1900 ft). Only two specimens, both adult males, were collected; the female is unknown. The type locality for *H. mana* is the Manana Trail in the leeward Koolau Mountains of Oahu, at an elevation of about 427 m (1400 ft). Only four adult specimens were collected (Daly and Magnacca 2003). More intensive searching may reveal additional specimens, especially because these species were not found alongside other *Hylaeus* species, and were collected more or less by accident (Magnacca 2007). However, the extreme rarity of these species, their absence from nearby sites, and the fact that they were not discovered until very recently, indicates that very few populations remain.

VI. HABITAT REQUIREMENTS

A. Overview
Hylaeus kuakea and *H. mana* likely have narrow habitat requirements. *Hylaeus kuakea* and *H. mana* inhabit lowland mesic forest. They likely depend strictly on this increasingly rare and patchily distributed habitat (Mueller-Dombois 1973, Smith 1985, Mederios *et al.* 1986).

In the Hawaiian Islands, lowland mesic forests occur on leeward slopes in areas transitional between dry and wet areas, in shaded valleys in areas of low rainfall, or in rain shadows caused by orographic interception (Blumenstock and Price 1967). Lowland mesic forests can be found up to 500 – 1000 m (1640 – 3280 ft) in elevation and receive between 1,250 to 2,500 mm (50-100 in) rainfall annually (Cuddihy and Stone 1990). The *H. mana* type specimens were collected from lowland mesic forest dominated by koa (*Acacia koa*); few *Hylaeus* bees have been found in this habitat on Oahu (Daly and Magnacca 2003).

All Hawaiian *Hylaeus* species depend very closely on native vegetation. They are very rarely found visiting non-native plants for nectar and pollen (Magnacca 2007), and are almost completely absent from habitats dominated by exotic plant species (Daly and Magnacca 2003). Furthermore, *Hylaeus* species require a diversity of plants that flower throughout the year and provide a consistent forage source (Magnacca 2007).

Hylaeus mana was collected while visiting flowers of *Santalum freycinetianum* (iliahi, sandalwood), a native plant endemic to Kauai, Oahu, and Molokai. Only one other *Hylaeus* species has recently been documented visiting this plant species (Daly and Magnacca 2003). The host plants of *H. kuakea* are unknown. It is likely that *H. kuakea* and *H. mana* visit species in several taxa that other *Hylaeus* species are known to frequently visit, including community-dominant members of a few small genera

of native Hawaiian plants, such as *Acacia koa, Metrosideros polymorpha, Styphelia tameiameiae* (pukiawe, Epacridaceae), *Scaevola* spp. (naupaka, Goodeniaceae), and *Chamaesyce* spp. Several larger genera of native plants serve as secondary host plants for many species of *Hylaeus* (Daly and Magnacca 2003).

Hylaeus kuakea and *H. mana* may be more likely to be present alongside even a few individuals of a rare but preferred host plant than in sites with higher diversity of only common and widespread species (Magnacca 2007). A single isolated tree of a rare *Hylaeus* host plant (*Chamaesyce olowaluana*) found in dry and mesic forests on Hawaii was host to nine *Hylaeus* species, whereas almost no *Hylaeus* were found on nearby flowering trees (Magnacca 2007).

Hawaiian *Hylaeus* almost exclusively visit native plant species to collect nectar and pollen, and in the process, pollinate these plants. The role of bees as pollinators that maintain communities of native flora in a diversity of habitats has been recognized (Cane and Tepedino 2001, Kremen *et al.* 2007, NRC 2007), and it follows that *Hylaeus* species are very likely keystone species in maintaining the diversity of native flora in Hawaiian forests. Recent studies of visitation records of Hawaiian *Hylaeus* species to native flowers (Daly and Magnacca 2003) and pollination studies of native plants (Sakai *et al.* 1995, Cox and Elmqvist 2000, Sahli 2008) have illustrated the important role of *Hylaeus* species as pollinators of many native Hawaiian plants. Sahli (2008) found that *Hylaeus* were less abundant at lower elevations, and that there were lower visitation rates of pollinators to native plants at these elevations. She concluded that *Hylaeus* were not easily replaceable by non-native pollinators, and that *Hylaeus* are very important for the reproduction of native plants. Thus, *H. kuakea* and *H. mana* are likely critical pollinators of one or more native Hawaiian plant species and their extinction might cause the decline of dependent plant species (Cox and Elmqvist 2000).

Nest site availability is another habitat requirement for *Hylaeus* populations; ground-nesters need relatively dry conditions and wood-nesters live in relatively wetter areas (Zimmerman 1972, Daly and Magnacca 2003). Neither species has been directly observed, but both *H. kuakea* and *H. mana* are related to the wood-nesting species (Magnacca and Danforth 2006).

B. Diet

1. Larvae

Larvae of *H. kuakea* and *H. mana* are unknown, but diet is likely similar to other *Hylaeus* species. In other *Hylaeus* species, the solitary female provides her young with nectar and pollen that is left alongside eggs in brood cells within the nest. Upon emerging, the larvae consume these provisions. *Hylaeus* lack external pollen-carrying morphological structures, and instead the queens carry pollen internally, usually mixed with nectar, in their crop. The food is provided in liquid form to the young (Michener 2000).

2. Adult

Adult *Hylaeus* consume nectar for energy; *H. mana* is known to visit *Santalum freycinetianum* (iliahi, sandalwood). *H. kuakea* host plants are unknown. Both species may also visit native Hawaiian plants known from lowland mesic forests that are visited by other *Hylaeus* species, such as *Acacia koa, Metrosideros polymorpha, Styphelia tameiameiae* (pukiawe, Epacridaceae), *Scaevola* spp. (naupaka, Goodeniaceae), and *Chamaesyce* spp. (Daly and Magnacca 2003).

C. Life Cycle

The egg, pupa, larva and nests of *H. kuakea* and *H. mana* are unknown, but they are likely similar to other *Hylaeus* species. *Hylaeus* species make solitary nests in pre-existing cavities in hollow stems,

wood, under bark, crevices, under rocks, or in the ground. *Hylaeus* lack strong mandibles and other structural adaptations for digging; thus, many species rely on nest burrows made by other species (O'Toole and Raw 1999, Daly and Magnacca 2003). The queen deposits eggs in brood cells that she constructs in the nest. She lines her brood cells with a self-secreted cellophane-like material. *Hylaeus* do not carry pollen externally; they instead store their food in the crop and regurgitate it upon returning to their nests. Upon hatching, larvae eat provisions left for them by the female, pupate, and eventually emerge as adults (Michener 2000).

D. Habitat Status

Hylaeus mana was collected on the Manana Trail, which is part of the Na Ala Hele Hawaii Statewide Trail and Access System (HDLNR 2007). It is in a State Forest Reserve managed by the Department of Land and Natural Resources of the State of Hawaii, Division of Forestry and Wildlife. It is classified as "wildland, sensitive, non-motorized" by the Federal Recreational Trails Program (Sumiye 2002). The trail is six miles long; the beginning of the trail is dominated by alien plant species, but it leads into an area of native forest where naupaka, koa, and ohia are common (HDLNR 2000). At the elevation that *H. mana* was collected, most of the other ridges in the area that are accessible by trails are dominated by adventive plant species (Magnacca 2007). There is bicycling, pedestrian activity, and pig hunting in the area of the Manana Trail. Targeted herbicides have been applied to control noxious invasive plant species along the trail (HDLNR 2007).

Hylaeus kuakea was collected within the Honouliuli Preserve in the Waianae Range, which encompasses 3,582 acres. This park is managed by the Nature Conservancy and is protected from development. Although only two specimens were collected, this preserve contains a large amount of potential habitat that might harbor additional populations of this species (Magnacca 2007). However, none were collected during searches of the middle and southern portion of the preserve, at Puu Kaua and Palikea, although other *Hylaeus* species were found. Even though this site is protected, invasive plants can still replace native vegetation, and *Hylaeus* habitat can be lost.

E. Current Conservation Efforts

The federal and state governments have not developed any conservation agreements for *H. kuakea* and *H. mana*, nor have they made any targeted efforts to preserve or restore habitat for these species. *Hylaeus kuakea* inhabits the Honouliuli Preserve, which is protected by The Nature Conservancy and undergoing restoration efforts (TNC 2000). The Nature Conservancy is restoring native vegetation in the Honouliuli Preserve, where *H. kuakea* was collected (TNC 2000).

VII. CURRENT AND POTENTIAL THREATS – SUMMARY OF FACTORS FOR CONSIDERATION

A. The present or threatened destruction, modification, or curtailment of its habitat or range

The primary threats to *H. kuakea* and *H. mana* are the loss of their lowland mesic forest habitat (Mueller-Dombois 1973, Smith 1985, Medeiros *et al.* 1986), and the encroachment of non-native plant species that are displacing native plant communities in lowland mesic forests (see Appendix IIIA-D for photos of land use change above Honolulu). *Hylaeus* species depend upon intact native plant communities. The process of displacement of native vegetation is being facilitated by the presence of feral ungulates and the increase in frequency and intensity of fire (Cuddihy and Stone 1990).

1. The loss of native lowland mesic forest on Oahu

The lowland mesic forest that both *H. kuakea* and *H. mana* inhabit is one of the most threatened habitat types in Hawaii (Wagner *et al.* 1985, Cuddihy and Stone 1990) and has one of the highest numbers of

candidate taxa to be listed by the Endangered Species Act (Sakai *et al.* 2002). This habitat was once abundant and considered the most diverse of all Hawaiian forest types (Rock 1913), but is now very rare on Oahu (Cuddihy and Stone 1990, Magnacca 2007). Much of it has been converted to pasture, military or agricultural use, or lost to urbanization or fire (Cuddihy and Stone 1990). The lowland mesic forest that remains is in small patches usually on unusable or inaccessible land (Cuddihy and Stone 1990). However, *Hylaeus* species are capable of maintaining populations in small patches of suitable habitat (Magnacca 2007), and thus, additional populations may exist in some of these small remnant patches.

By the early nineteenth century large tracts of native forest on Oahu had already been cleared for agricultural use. Ranches were a major component of agriculture on Oahu, frequently associated with lowland sugar plantations. Early conversion of forests to pasture on Oahu destroyed almost all forests between 210 and 550m in elevation. Major agricultural uses on Oahu have included pineapple, coffee, macadamia, papaya, and sugar cane. Commercial logging of native forests has also contributed to a loss of lowland mesic forests (Cuddihy and Stone 1990).

Much lowland mesic forest has been lost to military use, including the construction of military installations and missile sites (Wagner *et al.* 1985). A significant area of lowland mesic forest on Oahu is now occupied by the military, including parts of Schofield Barracks and a naval base, which are in close proximity to the Honouliuli Reserve. A recent Environmental Impact Statement for the proposed permanent stationing of the 2/25th Stryker Brigade Combat Team describes lowland mesic forests dominated by *Metrosideros polymorpha* (ohia) and *Acacia koa* (koa) that would be impacted by the proposal (US Army 2008).

2. The replacement of native vegetation with adventive species in lowland mesic forest on Oahu

The majority of lowland habitats on Oahu below 600 m are dominated by non-native plant species (Wagner *et al.* 1985). Aggressive adventive plant species are increasingly replacing native flora in lowland mesic forest habitat (Cuddihy and Stone 1990). More than 75% of the plant species in danger of extinction on Oahu are from lowland mesic forests (Wagner *et al.* 1985). This loss of native plant diversity from lowland forests (Sakai *et al.* 2002) is one of the primary causes of the decline of Hawaiian *Hylaeus* species (Magnacca 2007). *Hylaeus* species are almost entirely absent from habitat dominated by non-native flora. They depend closely on native vegetation for nectar and pollen, and very few non-native plant species are ever visited (Daly and Magnacca 2003). Several species of aggressive perennial African grasses commonly replace native vegetation on the Hawaiian Islands (D'Antonio and Vitousek 1992). *Melinis minutiflora* is one of the primary adventive plant species that has aggressively colonized lowland mesic forest on Oahu (USFWS 2006). Non-native plant species have distinct reproductive advantages over Hawaiian endemics: plant species endemic to islands are rarely apomictic or able to spread easily by self-pollination or vegetative means, whereas many invasive species can reproduce in these ways (Simberloff and Von Holle 1999). Native plants instead depend almost entirely on endemic pollinators for reproduction and must be cross-pollinated (Sakai *et al.* 1995, Cox and Elmqvist 2000).

Many taxa of native plants that serve as primary or secondary hosts to numerous *Hylaeus* species are in decline (Daly and Magnacca 2003, USFWS 2008), and many exist in only very small populations (Cox and Elmqvist 2000). Several plant taxa that are visited by *Hylaeus* are listed as endangered species under the Endangered Species Act (USFWS 2008). *Hylaeus* host species that live in lowland mesic forest and are listed as endangered by the Endangered Species Act include several *Chamesyce* species (akoko). The region where *H. mana* was collected is mostly inhabited by adventive plant species, at

least on ridges with trail access (Magnacca 2007), thus the population from which the type locality was collected may be endangered if alien plant species outcompete the remaining native plant community.

3. Habitat disturbance by feral ungulates

Feral ungulates have contributed to the decline of native Hawaiian plant communities, thus they have likely also had a negative impact on *Hylaeus* species. The native Hawaiian flora evolved in the absence of browsing mammals such as ungulates (Wagner *et al.* 1985, Blackmore and Vitousek 2000). Hawaiian native plants largely lack defensive structures such as thorns, spines, stinging hairs, and unpalatable or poisonous chemicals that deter herbivory. Feral ungulates damage native plants by browsing, trampling and digging vegetation (Stone 1985, Cuddihy and Stone 1990). Some feral ungulates carry seeds in their hair, facilitating the colonization of new habitat by adventive plant species. The excrement of feral ungulates increases the nutrient content of soils, which benefits non-native plants that are better adapted to richer soils than some native species (Cuddihy and Stone 1990).

Feral ungulates alter the floral composition of forests, making forest conditions more conducive to fire. They remove or damage native vegetation, allowing seeds of invasive species to establish themselves. These non-native species are much better adapted to fire than native Hawaiian species. The non-native species burn more easily and can recolonize rapidly. Thus, the presence of feral ungulates improves conditions for fire, further impacting communities of native plants which cannot re-establish easily after fire (Cuddihy and Stone 1990).

Several species of feral ungulates have been introduced to the Hawaiian Islands by humans, and their populations have spread into many natural areas (Cuddihy and Stone 1990). Introduced species of feral ungulates present in or around lowland mesic forest on Oahu include feral pigs (*Sus scrofa*), cattle (*Bos taurus*), and goats (*Capra hircus*). Cattle ranching began in the Hawaiian Islands in the mid-nineteenth century. Cattle grazing still occurs in the lowlands of the Northern portion of the Waianae Mountains. The population of goats on Oahu is currently concentrated in the upper slopes of the Waianae Mountains, at higher elevations than the type locations of *H. kuakea* and *H. mana*. However, the population is expanding, so it may pose a future threat to *H. kuakea* and *H. mana* (USFWS 2006).

Research on other endemic Hawaiian invertebrates that also depend closely on native vegetation has shown that pig-inflicted damage to native vegetation negatively impacted invertebrate populations. Several species of rare and endemic Hawaiian *Drosophila* (Picture-winged flies) are federally listed as endangered species under the Endangered Species Act (USFWS 2006). Foote and Carson (1995) showed that excluding pigs from *Drosophila* habitat increased populations of these rare *Drosophila* species (Foote and Carson 1995).

4. Fire

Fire was uncommon in the Hawaiian Islands until the arrival of humans about 2000 years ago (Smith and Tunison 1992). Lowland mesic forest habitat in the Hawaiian Islands has been increasingly colonized by fire-adapted adventive plant species. On Oahu, the non-native grass *Melinis minutiflora* has aggressively colonized lowland mesic forests (USFWS 2006). Non-native species such as *M. minutiflora* are able to proliferate after fire comes through a habitat whereas most native species' populations do not recover as well (D'Antonio and Vitousek 1992). Fire can dramatically alter the species composition of the plant community in lowland mesic forests, thus impacting *Hylaeus* populations. This process has been facilitated by feral ungulates, which trample and dig up native vegetation, making room for invasive species to move in (Cuddihy and Stone 1990). Ordnance-induced fires on Army land have increased the frequency and intensity of fires in some areas (USFWS 2006).

B. Overutilization for commercial, recreational, scientific, or educational purposes

1. Collecting

Insect collecting is a valuable component of research including taxonomic work, and is often necessary for documenting the existence of populations and population trends. In general, because of the high fecundity of individual insects, the collection of insects does not pose a threat to their populations. However, in the case of *H. kuakea* and *H. mana*, which are extremely rare and have small populations, the collecting of a small number of individuals could significantly reduce production of offspring.

C. Disease or predation

1. Invasive ants

Humans have facilitated the introduction of 40 species of ants to the Hawaiian Islands (Reimer 1994), mostly within the past one hundred years (Reimer *et al*. 1990). All of these species have been recorded from Oahu, likely because it is the major point of entry to the Hawaiian Islands. The native Hawaiian invertebrate fauna evolved in the absence of all social insects - there are no ant species native to the Hawaiian Islands (Zimmerman 1948, Wilson and Taylor 1967, Howarth 1985). Thus, native invertebrates are not adapted to defend themselves from highly aggressive social species such as ants (Stone and Anderson 1988). Several of these species have had a deleterious impact on the native Hawaiian invertebrate fauna (Perkins 1913, Gagne 1979, Krushelnycky *et al.* 2005), including *Hylaeus* species (Cole *et al.* 1992, Daly and Magnacca 2003), and likely caused the extinction of some native invertebrate species (Perkins 1913, Zimmerman 1948).

Aggressive ant species' primary impact on the native invertebrate fauna is via predation (Reimer 1994), and they also compete for nectar (Howarth 1985, Holway *et al.* 2002, Daly and Magnacca 2003, Lach 2008) and nest sites (Krushelnycky *et al.* 2005). *Hylaeus* species populations are drastically reduced in ant-infested areas (Cole *et al.* 1992, Medeiros *et al.* 1986, Stone and Loope 1987, Reimer 1994). Some ant species may impact *Hylaeus* species indirectly by consuming seeds (Bond and Slingsby 1984) of native plants. Invasive ants' largest ecosystem-level effect has been on pollination, partially due to their predation of *Hylaeus* species (Reimer 1994). Invasive ants have especially affected ground-nesting *Hylaeus* species (Cole *et al.* 1992, Medeiros *et al.* 1986) (although it is unknown whether *H. mana* and *H. kuakea* nest in the ground or in wood); *Hylaeus* brood of ground-nesting species are more vulnerable to attack by aggressive ants than adult *Hylaeus* (Daly and Magnacca 2003) because they are immobile and their nests are easily accessible and in or near the ground.

Among ant species present in Oahu, *Pheidole megacephala* (the big-headed ant) and *Anoplolepis gracilipes* (syn. *longipes*) (the crazy or long-legged ant) pose the biggest threat to remaining populations of *H. kuakea* and *H. mana*. They are the most ubiquitous invasive ant species in lowland areas, and are known to colonize both undisturbed native areas and areas dominated by alien vegetation (Reimer 1994). *P. megacephala* and *A. gracilipes* have certain characteristics in common that allow them to be successful in overcoming the native invertebrate fauna, such as multiple queens per nest (polygyny), multiple nests per colony (polydomy), and minimal intraspecific aggression. They are generalist predators, and are very abundant and aggressive (Holway *et al.* 2002). *Anoplolepis gracilipes* occurs from sea level to 800 m elevation but has been found up to 1200 m (Medeiros *et al.* 1986). *P. megacephala* is primarily found in lowland dry and mesic areas (below 1000 m elevation), and is almost always the dominant ant in its habitat (Reimer 1994). Lach (2008) found that *Hylaeus* species that regularly collect pollen from ohia trees (*Metrosideros polymorpha*) were entirely absent from flowers visited by *P. megacephala*. *Pheidole megacephala* is known to actively rob nectar from flowers without pollinating them (Howarth 1985). *Hylaeus* brood are more susceptible to attack by *P. megacephala* than are adult *Hylaeus* (Daly and Magnacca 2003). The extreme rarity and very

localized distribution of *H. kuakea* and *H. mana* parallels that of other invertebrate species that have been eliminated from the range of invasive ants (Krushelnycky *et al.* 2005), and the persistence and spread of colonies of aggressive ant species threatens remaining populations of *H. kuakea* and *H. mana.*

2. Adventive bee species

There are 15 species of non-native bees in Hawaii (Snelling 2003), which includes two adventive *Hylaeus* species. Most adventive bees inhabit areas dominated by non-native vegetation and thus are not competing with *Hylaeus* species (Daly and Magnacca 2003). *Apis mellifera* (the European honey bee) is a major exception; this social species is often very abundant in areas with native vegetation, and aggressively competes with *Hylaeus* species nectar and pollen (Daly and Magnacca 2003, Snelling 2003). *Apis mellifera* was first introduced to the Hawaiian Islands in 1875 for pollination and honey production, and it currently inhabits areas from sea level to tree line (Howarth 1985). The major parasites that have decimated populations of *Apis mellifera* in the continental United States are largely absent from the Hawaiian Islands (Hoopingarner and Waller 1992), although the varroa mite (*Varroa destructor*) was recently discovered on Oahu and Hawaii (Ramadan 2007). *Apis mellifera* visit a wide variety of both native and non-native species and are able to forage in inclement weather and throughout the day. They have been observed foraging on *Hylaeus* host plants such as *Metrosideros* spp. and *Scaevola* (Magnacca 2007). Populations of *A. mellifera* are not as vulnerable to predation by non-native ant species as are *Hylaeus.* Lach (2008) found that *Hylaeus* that regularly collect pollen from ohia trees (*Metrosideros polymorpha*) were entirely absent from flowers visited by *P. megacephala,* but visits by *A. mellifera* were not affected by the presence of the ant species.

Other non-native bee species present in areas of native vegetation include *Ceratina* spp., *Hylaeus albonitens*, and *Lasioglossum impavidum* (Magnacca 2007). These may have a great impact on native *Hylaeus* spp. such as *H. kuakea* and *H. mana* through competition for pollen, because they are more similar in size and probably visit similar flowers. The impact of these species on native *Hylaeus* has not been studied (Magnacca 2007).

3. Wasps

a. Parasitoid wasps

Native and non-native parasitoid wasps parasitize some *Hylaeus* species, and may pose a threat to *H. kuakea* and *H. mana.* *Hylaeus* species brood are known to be attacked by encyrtid and eupelmid parasitoid wasps. It is unknown whether parasitoid wasps use *H. kuakea* and *H. mana* as hosts. Parasitoid wasps might also compete for nectar with *Hylaeus* species (Daly and Magnacca 2003).

b. *Vespula pensylvanica* (western yellow jacket wasp)

Vespula pensylvanica (the western yellow jacket wasp) is a social wasp native to the mainland of North America. It was first reported from Oahu in the 1930s (Sherley 2000), and an aggressive race became established in 1977 (Gambino *et al.* 1987). In temperate climates, *V. pensylvanica* has an annual life cycle, but in Hawaii's tropical climate, colonies of this species persist through a second year, allowing them to have larger numbers of individuals (Gambino *et al.* 1987) and thus a greater impact on prey populations. Most colonies are found between 600 and 1050 m elevation (1969 to 3445 ft) (Gambino *et al.* 1990), although they can also be found down to sea level, and in lowland mesic forests. *Vespula pensylvanica* is an aggressive opportunist generalist predator, and predates on *Hylaeus* species, although *Hylaeus* is not its primary prey source (Gambino *et al.* 1987). Because of the extreme rarity of *H. kuakea* and *H.*

mana, the presence of any *V. pensylvanica* colonies within their range might easily extirpate populations. *Vespula pensylvanica* might also compete for nectar with *Hylaeus* species.

D. The inadequacy of existing regulatory mechanisms

Hylaeus kuakea and *H. mana* receive no federal or state protection. The collection site for *H. kuakea* is protected by The Nature Conservancy, and the preserve is being managed for restoration of native plants, but no conservation efforts are focused specifically on *H. kuakea*. The collection site for *H. mana* is in a State Forest Reserve that is protected from development, but there are no targeted efforts to protect this species.

E. Other natural or manmade factors affecting its continued existence

1. Small population size and stochastic events

Small populations are generally at greater risk of extirpation from normal population fluctuations due to predation, disease, and changing food supply, as well as from natural disasters such as floods or droughts. Both *H. kuakea* and *H. mana* are extremely rare and have very small populations, and they are likely more vulnerable to habitat change and stochastic events due to low genetic variability.

2. Global climate change

Global climate change could impact remaining populations of *H. kuakea* and *H. mana*. The Hawaiian Islands are predicted to be affected by ongoing climate change (Benning *et al.* 2002, Baker *et al.* 2006), with increases in temperature and sea level rise. An increase in temperature might increase the frequency and intensity of fires. As climate changes, species that cannot adapt by shifting their range are at greater risk of decline (Benning *et al.* 2002). *Hylaeus kuakea* and *H. mana* are likely restricted to small habitat patches (Daly and Magnacca 2003) and may have difficulty dispersing to accommodate shifts in the range of host plants. Most native bees have difficulty crossing geographical barriers and tend to fly only during good weather (Michener 2000), and successive generations of solitary species tend to nest in the same area year after year.

3. The vulnerability of island endemics

Species that are endemic to islands are particularly vulnerable to population decline and extinction. Hawaiian endemic species evolved in isolation, and are not adapted to compete with the many aggressive species that have been introduced to the Islands (Stone and Scott 1985). Furthermore, many Hawaiian species, such as *H. kuakea* and *H. mana*, have small populations that are patchily distributed and highly localized, making them especially vulnerable to habitat disturbance and stochastic events (Daly and Magnacca 2003, Magnacca 2007).

The Hawaiian *Hylaeus* species form a diverse and large lineage that evolved relatively recently and in an unusually short amount of time (Magnacca and Danforth 2006, Magnacca and Danforth 2007). Lineages of island endemics with high proportions of recently evolved taxa are at higher risk of extinction when associated with high narrow habitat specificity (Sakai *et al.* 2002) as are *H. kuakea* and *H. mana* (Daly and Magnacca 2003). Furthermore, the close interdependence of Hawaiian endemic flora and their endemic pollinators (Sakai *et al.* 1995) makes them vulnerable to reciprocal decline and extinction (Cox and Elmqvist 2000).

VIII. CONCLUSION

Hylaeus mana and *Hylaeus kuakea* are extremely rare bees endemic to the island of Oahu that are in imminent danger of going extinct. *Hylaeus kuakea* is known from only two specimens collected in 1997 in the Waianae Mountains. *Hylaeus mana* is known from only four specimens collected in 2002

in the leeward Koolau range of Oahu. The primary threats to *H. mana* and *H. kuakea* are the loss of their lowland mesic forest habitat, the displacement of native flora by adventive species, damage to habitat by feral ungulates by either browsing or digging up native plants, and the increase in frequency and intensity of fire. Additional threats include predation by adventive invertebrate species such as the long-legged ant (*Anoplolepis longipes*), the big-headed ant (*Pheidole megacephala*), and competition for resources with non-native honey bees (*Apis mellifera*).

The above threats, the extreme rarity of these species, and the natural instability of small populations of island endemics lead us to conclude, unequivocally, that *Hylaeus mana* and *Hylaeus kuakea* are immediately threatened with extinction and must be given protection under the Endangered Species Act.

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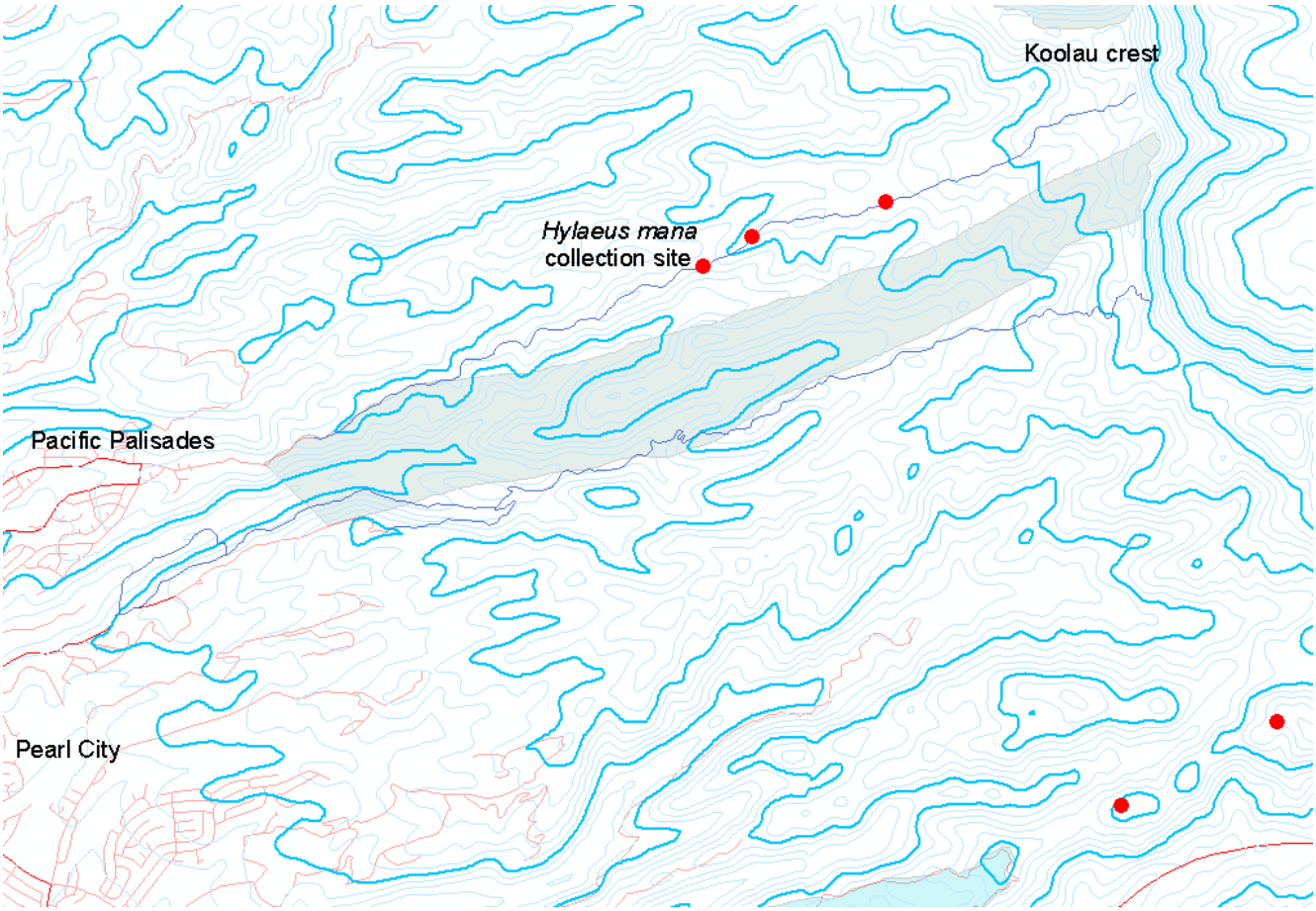
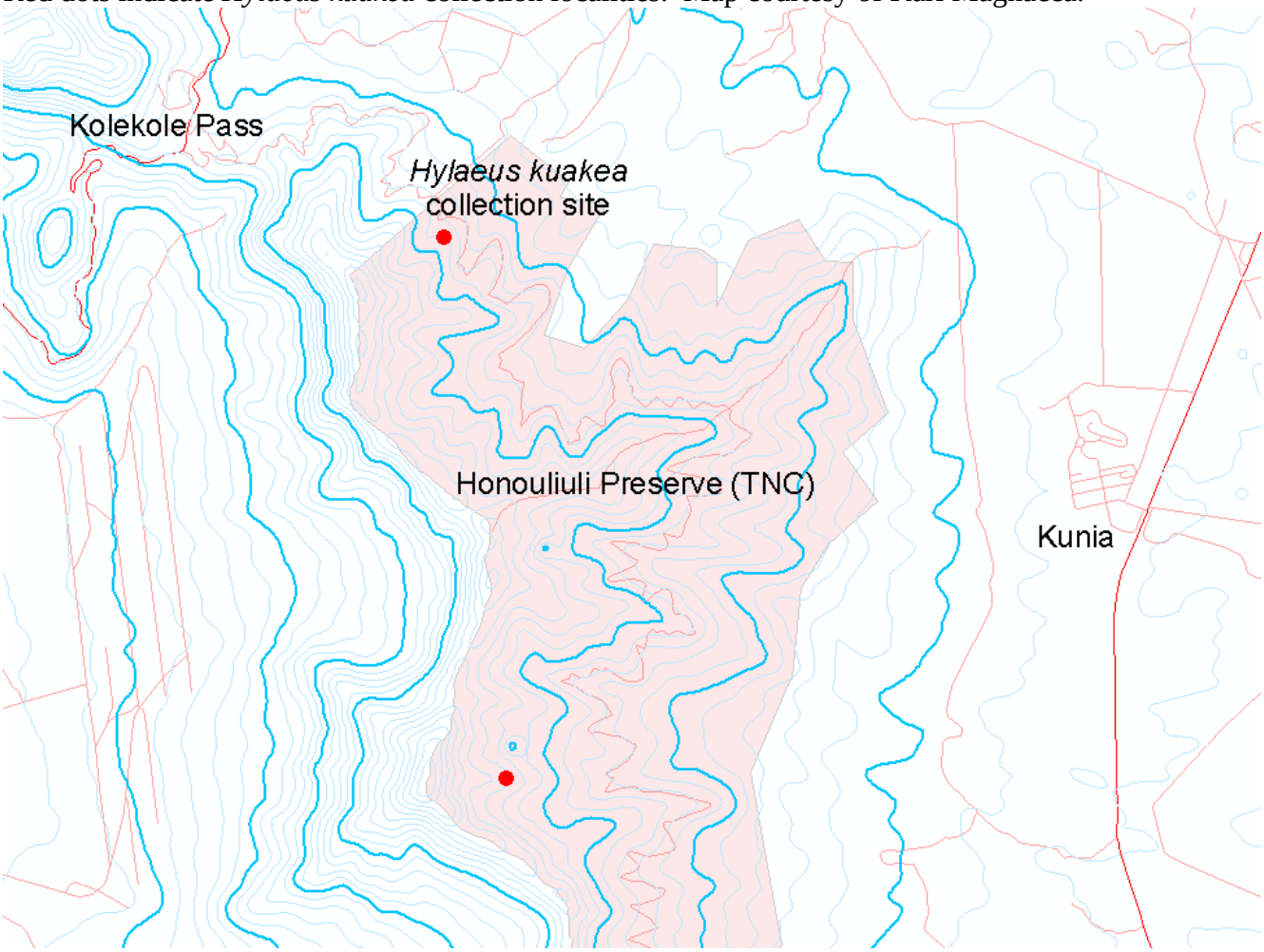
APPENDIX I. LOCATION OF RECORDED POPULATIONS OF *HYLAEUS MANA* AND *HYLAEUS KUAKEA*

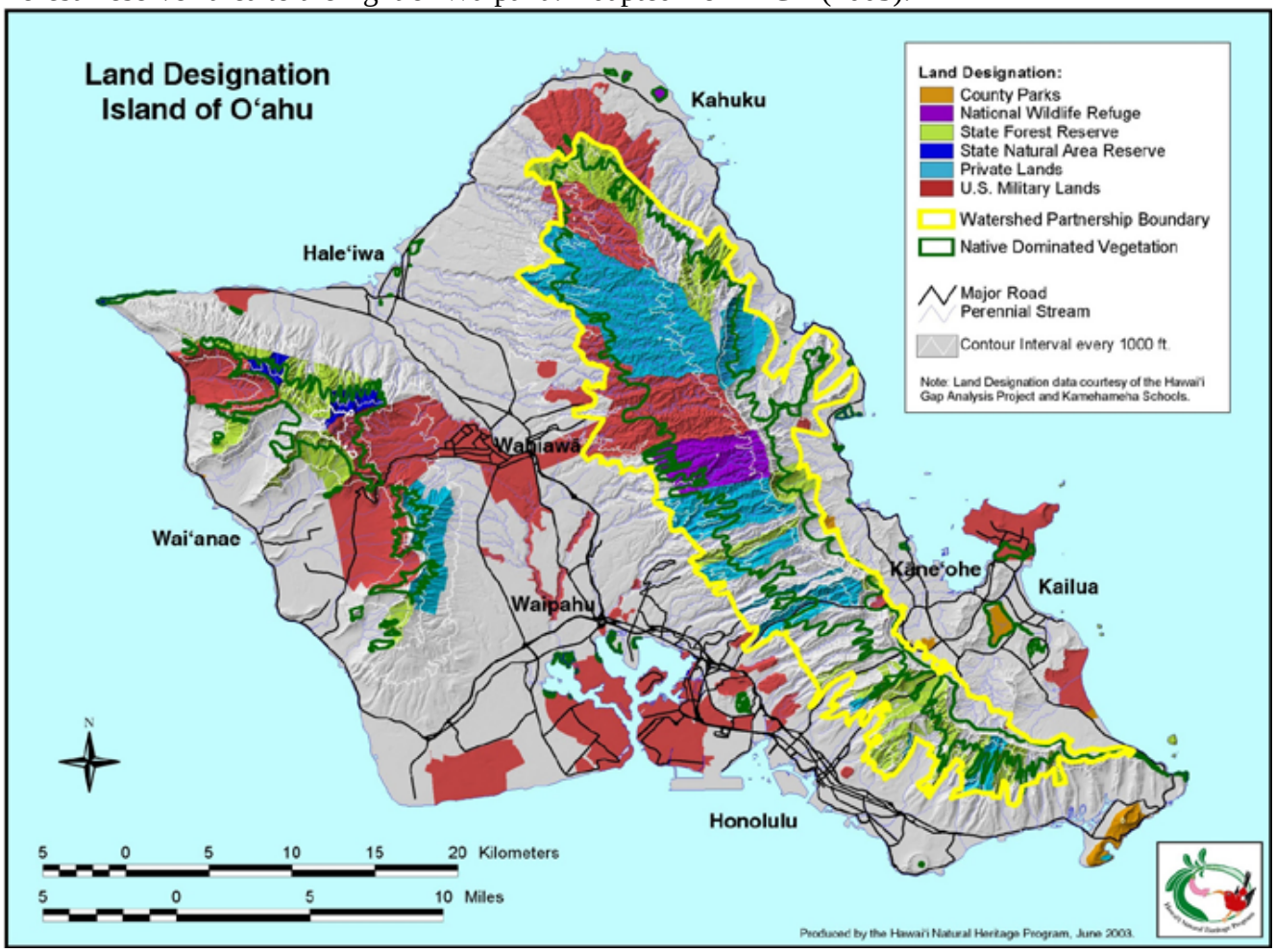
Appendix IA. *Hylaeus mana* type locality: Manana Trail, leeward Koolau range, Oahu, Hawaii. Red dots indicate *H. mana* collection localities. Map courtesy of Karl Magnacca.



Appendix IB. *Hylaeus kuakea* type locality: Honouliuli Reserve, Waianae Mountains, Oahu, Hawaii. Red dots indicate *Hylaeus kuakea* collection localities. Map courtesy of Karl Magnacca.

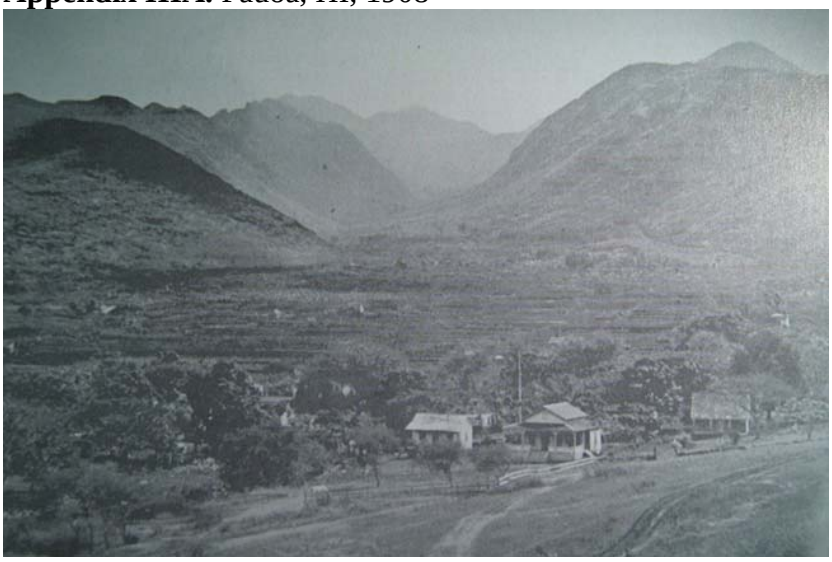


APPENDIX II. Map of Honouliuli Reserve and Manana Trail on O'ahu. Honouliuli Reserve is in the "private lands" turquoise area. The Manana Trail is in the area indicated by the light green "State Forest Reserve" area to the right of Waipahu. Adapted from HCA (2003).



APPENDIX IIIA-D. Photos of land use change in the lowlands above Honolulu, about 10 miles from *H. mana* collection locality: A) Pauoa, HI, 1908 (William Tufts Brigham [E.B. Scott 1968]); B) Pauoa, HI, 1996 (D. Polhemus); C) Nuuanu, HI, 1889 (Ray Jerome Baker [Ronck 1984]); D) Nuuanu, HI, 1996 (D. Polhemus). These photos are adapted from Liebherr and Polhemus (1997).

Appendix IIIA. Pauoa, HI, 1908



Appendix IIIB. Pauoa, HI, 1996

Appendix IIIC. Nuuanu, HI, 1889

Appendix IIID. Nuuanu, HI, 1996