PETITION TO LIST
ONE SPECIES OF HAWAIIAN YELLOW-FACED BEE
Hylaeus facilis
AS AN ENDANGERED SPECIES
UNDER THE U.S. ENDANGERED SPECIES ACT

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 bee *Hylaeus facilis* 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 this species, and the natural instability of small populations of island endemics lead us to conclude, unequivocally, that *Hylaeus facilis* is 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.

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I. EXECUTIVE SUMMARY

Hylaeus facilis is an extremely rare Hawaiian yellow-faced bee endemic to the Hawaiian Islands of Oahu, Molokai, Lanai and Maui that is in imminent danger of going extinct.

There is strong evidence of significant decline of *H. facilis* (Magnacca 2005, Magnacca 2007). Perkins, whose 1892-1906 survey of the *Hylaeus* is the basis for most of the historic records of the genus in Hawaii, called *Hylaeus* species "almost the most ubiquitous of any Hawaiian insects" (Perkins 1913). Recent surveys indicate that most *Hylaeus* species are in decline, many are extremely rare, and several are possibly extinct (Daly and Magnacca 2003, Magnacca 2005, Magnacca 2007). Perkins (1899) remarked that *H. facilis* was among the most common and widespread *Hylaeus* species on Oahu and all of Maui Nui (Lanai, Molokai, and Maui) (Magnacca 2007). However, *H. facilis* has not been found in recent searches of most of its historic collection localities, and is among the most endangered of Hawaiian *Hylaeus* species (Magnacca 2007). Thirty-nine sites on Oahu, Maui, Lanai and Molokai were recently searched for *H. facilis*, including 13 historic collection sites. *Hylaeus facilis* was only collected at four of these locations. It has likely been extirpated from Lanai, and it is questionable whether any viable populations still exist on Maui, since its only collections there are from an unknown site over 40 years ago, and of a single specimen in 1990 that was taken in a residential area devoid of native plants, and was probably a straggler (Magnacca 2007).

Because populations of *H. facilis* are small and isolated, they are especially vulnerable to habitat loss, predation, stochastic events, and other changes to their habitat. It prefers dry and mesic forest and shrubland, which are increasingly rare and patchily distributed, particularly within its range (Magnacca 2005, Cuddihy and Stone 1990). The only remnant populations on protected lands are at Kuololimu Point on Molokai and the Poamoho Trail on Oahu (Daly and Magnacca 2003, K. Magnacca, pers. comm., Jan. 2008). However, even in habitats protected from development, *Hylaeus* populations are still vulnerable to decline because their habitat is not actively managed to protect them from threats such as fire, feral ungulates, invasive invertebrates and the replacement of native vegetation by invasive plants (Magnacca 2007).

Conservation of *H. facilis* will require the active control and management of natural areas where populations are known to exist. The continued impact of development, fire, feral ungulates, invasive ants, and the loss of native vegetation to invasive plant species will undoubtedly have a negative impact on the remaining populations of *H. facilis* and may cause its extinction if habitat is not managed for conservation of this species (Magnacca 2007).

The rarity of this species, the threats it faces, and the natural instability of small populations of island endemics lead us to conclude, unequivocally, that *Hylaeus facilis* is threatened with extinction and must be given protection under the Endangered Species Act.

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

Hylaeus facilis is listed as a Species of Concern in the State of Hawaii (Magnacca 2005). It has a Global Heritage Status Ranks of GNR, meaning that its rank has not yet been assessed. It is listed as Critically Imperiled on the Xerces Society for Invertebrate Conservation's Red List of Pollinator Insects (Magnacca 2005).

Magnacca (2007) assigned conservation status ranks to *Hylaeus* species on a scale of 1 to 6, with relatively safe and abundant species ranked "1," and increasingly threatened species given higher

ranks, with those species that are endangered or possibly extinct ranked "6." *Hylaeus facilis* was given a rank of 5, indicating that it is "very rare and potentially endangered."

Hylaeus facilis was listed by the United States federal government as a "Category 2" Candidate Species in 1984 based on the recognition that Hawaiian *Hylaeus* species were generally in decline but that little was known about their specific conservation status (USFWS 1984). In 1996 the U.S. Fish and Wildlife Service and Hawaii Division of Forestry and Wildlife moved all Category 2 Candidate Species to federal and state lists of "Species of Concern" or "Special Status Species" (USFWS 1996, Magnacca 2005).

III. TAXONOMY

The taxonomy of *Hylaeus facilis* is uncontested. *Hylaeus facilis* is a small bee 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). *Hylaeus facilis* is 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 facilis was first described as *Prosopis facilis* by Smith (1879). It was later transferred to the new genus *Nesoprosopis* by Perkins (1899). Meade-Waldo (1923) reduced *Nesoprosopis* to a subgenus of *Hylaeus.* The most recent taxonomic treatment for *H. facilis* is Daly and Magnacca (2003). Smith (1879) gave Maui as type locality, but Blackburn and Cameron (1886, 1887) stated that the species' true type locality is Oahu, in Pauoa Valley (Daly and Magnacca 2003).

H. facilis is a member of the *difficilis* species group. It is closely related to *H. chlorostictus* and *H. simplex*. Its large gonoforceps distinguish it from its sister species *H. simplex,* which also has enlarged gonoforceps, but they cannot be seen externally (Daly and Magnacca 2003, Magnacca 2005).

IV. SPECIES DESCRIPTION

A. Adult

Hylaeus species have a wasp-like 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 facilis is a medium-sized bee with smoky wings. The male has an oval yellow mark on its face that covers the entire clypeus, a narrow stripe besides the eyes, and is otherwise unmarked. The process of the eighth sternum is thin, and not dilated, and hairs of the point of the abdomen are brown and appressed. The large gonoforceps that are visible externally distinguish *H. facilis* from its sister species *H. simplex*.

The female is entirely black, and indistinguishable from females of *H. difficilis* and *H. simplex* (Daly and Magnacca 2003, Magnacca 2005).

B. Immature

The egg, larval and pupal stages of *H. facilis* are unknown.

V. POPULATION DISTRIBUTION AND STATUS

A. Historic Distribution

Historic collection sites are listed in Figure 1 and marked on maps in Appendix 1a-d.

Historic records for Hawaiian *Hylaeus* species are based largely on collections made by Perkins between 1892 and 1906 (Daly and Magnacca 2003). Perkins collected on all of the higher islands with the exception of Kahoolawe (Hawaii, Oahu, Kauai, Maui, Lanai and Molokai) (Liebherr and Polhemus 1997). He called the Hawaiian *Hylaeus* "almost the most ubiquitous of any Hawaiian insects" (Perkins 1913), but more recent surveys indicate that most *Hylaeus* species are in decline, many are extremely rare, and several are possibly extinct (Daly and Magnacca 2003, Magnacca 2007, Magnacca 2005). Perkins (1899) remarked that *H. facilis* was among the most common and widespread *Hylaeus* species on Oahu and all of Maui Nui (Lanai, Molokai, and Maui) (Magnacca 2007). It was the most common *Hylaeus* species in dryland habitats (Daly and Magnacca 2003). An abundance of specimens in the historic collections at the Bishop Museum in Honolulu further demonstrate how abundant this species once was (Magnacca 2007). However, *H. facilis* has not been found in recent searches of any of its historic collection localities, and is now among the most endangered of Hawaiian *Hylaeus* species (Magnacca 2007).

Hylaeus facilis is historically known from the Hawaiian Islands of Maui, Molokai, Lanai and Oahu, in dry shrubland to wet forest habitats from coastal to montane elevations (up to 1000 m/3281 ft)(Gagne and Cuddihy 1999, Daly and Magnacca 2003). Although it was historically collected in a wide range of habitats and was very widely distributed, it probably prefers dry to mesic forest and shrubland (Magnacca 2005). Perkins listed one specimen from Hilo at 4000 ft elevation (Daly, H. V., unpublished data), but this specimen was misidentified and was actually *H. simplex* (K. Magnacca, pers. comm., Oct. 2008).

Perkins collected *H. facilis* from the following localities (Daly and Magnacca 2003):

Oahu (see Appendix 1a): Honolulu (coast and 610 m/2000 ft); Honolulu Mountains (457 m/1500 ft); Makaha, Waianae (914 m/3000 ft); Kaala Mountains (610 m/2000 ft); "Oahu," Tantalus; Waianae Mountains (610 m/2000 ft).

Maui (see Appendix 1b): Haleakala (1524 m/5000 ft); Iao Valley; "Maui," "west Maui mountains" (610 m/2000 ft); Wailuku, on sandy isthmus (Wailuku Sand Hills/Waiehu Dunes).

Lanai (see Appendix 1c): "center of the island, forest above Koele" (610 m/2000 ft); Haalelepaakai (914 m/3000 ft); "Lanai," Koele Mountains (over 610 m/2000 ft).

Molokai (see Appendix 1d): east mountains (610 m/2000 ft); Molokai mountains (3000, >3000 and 3500 ft).

B. Current Distribution

There was a gap of about 70 years between major collecting efforts of Hawaiian *Hylaeus* species. Information on current distribution is largely based on collecting efforts by K. Magnacca between 1998 and 2005. Additional recent collections were made between 1975 and 1997 (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008). Magnacca attempted to search for *Hylaeus* species in all habitats where they were likely to occur, but could not access some sites because of restricted access, weather, and time (Magnacca 2007).

There is strong evidence of significant decline of *H. facilis.* *Hylaeus facilis* has most certainly been extirpated from the majority of its range (Daly and Magnacca 2003, Magnacca 2007). In the time between final historic collections in the 1930s and recent collections, the species almost entirely disappeared. *Hylaeus facilis* was once widely distributed, but its range has decreased significantly and it is now restricted to only 3 known sites, as seen in the maps in Appendix 1 (Daly and Magnacca 2003, Magnacca 2005). One additional collection was made in 1967, but the collection site is unknown (Magnacca 2005). *H. facilis* was absent from all of its historical localities that were revisited by K. Magnacca between 1998 and 2006 (Magnacca 2007). It was also absent from many additional sites with suitable habitat, many from which other native *Hylaeus* species have been recently collected (Figure 1; Daly and Magnacca 2003, K. Magnacca pers. comm., Jan. 2008, July 2008).

There have been only four recent collections of *H. facilis*: from Oahu in 1975 (Poamoho Trail), from Maui in 1967 (unknown location) and 1990 (Kokomo, near Makawao, 457 m/1500 ft), and from Molokai in 2005 (Kuololimu Point, coast) (Daly and Magnacca 2003, K. Magnacca, pers. comm., Jan 2008). It has likely been extirpated from Lanai, since habitat there has been extensively searched and the species was not found. It is questionable whether any viable populations still exist on Maui, since its only collections there are from an unknown site over 40 years ago, and of a single specimen in 1990 that was taken in a residential area void of native plants, and was probably a straggler (Magnacca 2007). It has likewise not been seen on Oahu for over 30 years despite intensive collecting around the island. There are no known populations of *H. facilis* on protected land besides those at Kuololimu Point and the Poamoho Trail.

Forty sites on Oahu, Maui, Lanai and Molokai were recently searched for *H. facilis*, including 13 historic collection sites. K. Magnacca visited two historic collection sites on Oahu, Honolulu and Makaha, Waianae, where all historical *Hylaeus* habitat has been lost to development or overcome by invasive species (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., July 2008).

In addition to the 13 historic sites that were searched, recent searches for *Hylaeus* species have been conducted at 26 other sites that presently contain suitable habitat. *Hylaeus facilis* was surprisingly absent from many sites that still have native vegetation where other *Hylaeus* species, including the closely related *H. laetus* and *H. difficilis* have recently been collected (Daly and Magnacca 2003, Magnacca 2007).

Sites where searches have been conducted, and where specimens have been collected, are outlined below in Figure 1. The location of these sites is indicated in the maps in Appendix 1a-d.

Figure 1. Historic and recent collections, and recent search effort for *Hylaeus facilis.*
Perkins' collection sites from 1892-1906 with unspecified locations are in quotation marks and associated boxes are shaded. o = absent; x = present; empty box = not searched. NAR =State Natural Area Reserve.

	Elevation	Perkins' historic collections of *H. facilis* (1892-1906)	Recent searches and collections of *H. facilis* (1997-2008)	Other native *Hylaeus* species recently collected from the same site?
Oahu				
"Oahu"		x		
Honolulu	Coast	x	o	o
Honolulu 2K	610 m/2000 ft	x	o	x
Honolulu Mtns 1.5K	450 m/1500 ft	x	o	x
Makaha, Waianae	915 m/3000 ft	x	o	o
Kaala Mtns (Kaala NAR)	610 m/2000 ft	x		
Tantalus	appx. 460 m/ 1500 ft	x	o	x
Waianae Mtns/Pahole NAR	610 m/2000 ft	x	o	x
Poamoho Trail	Unknown		x	o
Makapuu	Coast		o	o
Barber's Point	Coast		o	o
Kaena Point	Coast		o	x
Manana Trail	430 m/1400 ft		o	x
Honouliuli - Moho Gulch Ridge	580 m/1900 ft		o	x
Maui				
"Maui"		x		
"W. Maui Mtns"	610 m/2000 ft	x		
Wailuku Sand Hills (sandy isthmus/Waiehu dunes)	30 m/100 ft	x	o	x
Wailuku Sand Hills - Kahului Section	30 m/100 ft	x	o	o
Haleakala	1500 m/5000 ft	x		
Iao Valley	610 m/2000 ft	x		
Hanaula, above Puu Anu	915 m/3000 ft		o	x
Waihee Ridge Trail	610 m/2000 ft		o	x
Kanaio NAR	610 m/2000 ft		o	x
Lahainaluna	550 m/1800 ft		o	x
Manawainui Gulch	Coast		o	x
Puu Kukui Watershed (PKW) fence	670 m/2200 ft		o	x
Puu Kukui Road	790 m/2600 ft		o	x
Waikapu	120 m/390 ft		o	x

Kokomo, nr. Makawao	460 m/1500 ft		x	o
1967 collection, unknown location	Unknown		x	
Lanai				
"Lanai"	610 m/2000 ft	x		
Koele Mountains >2K	>610 m/2000 ft	x	o	x
Haalelepaakai (Perkins' Halepaakai)	914 m/3000 ft	x	o	x
Garden of the Gods	430 m/1400 ft		o	x
Kahue	430 m/1400 ft		o	x
Kanepuu Preserve, Kahue Unit	490 m/1600 ft		o	x
Manele	180 m/600 ft		o	x
Polihua Rd	300 m/1000 ft		o	x
Shipwreck Beach	Coast		o	x
Molokai				
E. Mountains	610 m/2000 ft	x		
Molokai Mtns 3K/ Kamakou Road	915-975 m/3000-3200 ft	x	o	x
Molokai Mtns >3K/ Puu Kolekole	>915 m/3000 ft	x	o	x
Molokai Mtns 3.5 K/ Kawela Gulch	1070 m/3500 ft	x	o	x
Kuololimu Point	Coast		x	o
Hoolehua	Coast		o	x
Kaupikiawa	Coast		o	x
Moomomi	Coast		o	x

VI. HABITAT REQUIREMENTS

A. Overview

Hylaeus facilis inhabits a wide range of habitats from the coast to the mountains, but probably prefers dry to mesic forest and shrubland, an increasingly rare and patchily distributed habitat (Mueller-Dombois 1973, Smith 1985, Medeiros *et al.* 1986, Magnacca 2005). It is endemic to the islands of Oahu, Maui, Lanai and Molokai (Magnacca 2005).

1. Habitat distribution

a. Mesic forest habitat

In the Hawaiian Islands, mesic forests occur on leeward slopes in areas transitional between dry and wet areas, in rain shadows caused by orographic interception, in shaded valleys in areas of low rainfall, or at higher elevations above a temperature inversion layer usually between 1,525 and 2,135 m (5,000 to 7,000 ft); lowland mesic forests are found up to 500 – 1000 m (1640 – 3280 ft) (Blumenstock and Price 1967). Mesic forests receive between 1,250 to 2,500 mm (50-100 in) rainfall annually (Cuddihy and Stone 1990). Mesic forest canopies on the Hawaiian Islands are typically dominated by *Acacia koa* (koa), *Diospyros sandwicensis* (lama), or *Metrosideros polymorpha* (ohia); a diversity of understory trees and native shrubs grow in

the understory (Cuddihy and Stone 1990, Wagner *et al.* 1999). Mesic forests dominated by other tree species exist but are rare (Cuddihy and Stone 1990).

b. Dry forest habitat

Dry forests on the Hawaiian Islands occur on leeward slopes receive up to 1250 mm (50 in) rainfall annually. Lowland dry forests occur up to 500 to 1000 m (1640-3280 ft), and montane dry forests from 500 to 2000 m (1640 to 6560 ft)(Cuddihy and Stone 1990). Lowland dry forests are typically dominated by *Diospyros sandwicensis* (lama) or *Metrosideros polymorpha* (ohia); montane dry forests are typically dominated by *Acacia koa* (koa), *Sophora chrysophylla* (mamane), *Metrosideros polymorpha* (ohia), and rarely, *Chamaesyce olowaluana* (akoko). A diversity of native shrubs grows in the understory (Cuddihy and Stone 1990, Wagner *et al.* 1999).

c. Dry shrubland habitat

Dry shrubland habitats on the Hawaiian Islands occur from the lowlands up to the subalpine zone, around 2610 m (8500 ft) elevation. They receive up to 1250 mm (50 in) rainfall annually (Cuddihy and Stone 1990, Gagne and Cuddihy 1999). Dry shrublands likely once extended to the coast in many locations (Zimmerman 1948) but now only remain in areas that were not altered by intensive agriculture or grazing. Dry shrublands with intact native plant communities are dominated by *Dodonaea viscosa* (aalii), *Styphelia tameiameiae* (pukiawe), and low-growing *Metrosideros polymorpha* (ohia); other plants typically present include *Wikstroemia* spp. (akia), *Chenopodium oahuense* (‘aweoweo), *Bidens* spp. (kookoolau), *Psydrax odoratum* (alahee), *Geranium* spp. (nohoanu), *Myoporum sandwicense* (naio), and *Sophora chrysophylla* (mamane). Dry shrubland is usually characterized by mixed stands with one or two of these species as dominant. Non-native grasses are also abundant in dry shrublands (Cuddihy and Stone 1990).

d. Wet forests

Wet forests occur from lowland to montane elevations on the Hawaiian Islands (up to 2000 m (6560 ft)). They are the result of northeasterly tradewinds that bring moist air to northeast-facing slopes. The majority of lowland wet forests are dominated by *Metrosideros polymorpha* (ohia), with understory trees such as *Psychotria* spp. (kopiko) and *Antidesma platyphyllum* (hame). Lowland wet forests were widely cultivated by the late 18th century or overcome by non-native species such as *Aleurites moluccana* (kukui) and *Psidium guajava* (common guava). Higher elevation wet forests have not been as heavily impacted by humans as lowland wet forests, and large tracts remain on the major islands (Cuddihy and Stone 1990). Most montane wet forests are also dominated by *Metrosideros polymorpha* (ohia), with native trees, shrubs and tree ferns (*Cibotium* spp.) in the understory (Cuddihy and Stone 1990).

e. Coastal habitats

Hylaeus facilis has been collected from coastal habitats; the most recent collection is from a coastal site on Molokai. In the Hawaiian Islands, coastal strand habitat occurs in a relatively narrow belt around each island. Coastal strand community composition is strongly influenced by the ocean, and vegetation must withstand salinity in the root zone, salt spray, and geologic shoreline processes (Richmond and Mueller-Dombois 1972, Cuddihy and Stone 1990, Alpha *et al.* 1996). Undisturbed coastal strand communities support a unique assemblage of native shrubs and sedges. The dominant native vegetation in coastal strand habitats is the shrub *Scaevola sericea* (naupaka kahakai) (Alpha *et al.* 1996). Other common native plant species are *Ipomoea pes-caprae* (beach morning-glory), *Sporobolus virginicus* (beach dropseed),

Jacquemontia ovata (pau o Hiiaka), and *Sesuvium portulacastrum* (akulikuli or sea purslane) (Cuddihy and Stone 1990).

2. Relationships with plants

All Hawaiian *Hylaeus* species strongly depend on an intact community of native vegetation (Daly and Magnacca 2003, Magnacca 2007). 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). They require a habitat with a diversity of plants that flower throughout the year so that a consistent forage source is available (Magnacca 2007).

Although *Hylaeus* species are very rarely found visiting non-native species, some *Hylaeus* species, including *H. facilis*, have been observed visiting the alien *Tournefortia argentea* (tree heliotrope) (Daly and Magnacca 2003, Magnacca 2007). The native host plants of *H. facilis* are unknown. It is likely that *H. facilis* visits several taxa that other *Hylaeus* species are known to visit frequently, 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). Several species in the genera visited by *Hylaeus* species are extremely rare: several species in the genera *Scaevola* and *Chamaesyce* are listed as endangered species under the U.S. Endangered Species Act (USFWS 2008).

3. Nesting requirements

Nest site availability is another habitat requirement for *Hylaeus* populations; ground-nesters need relatively dry conditions (Zimmerman 1972, Daly and Magnacca 2003). The nests of *H. facilis* are unknown, but it probably nests in the ground like related *Hylaeus* species such as *H. chlorostictus* and *H. simplex* (Daly and Magnacca 2003, Magnacca 2005).

B. Diet

1. Larvae

Larvae of *H. facilis* are unknown. In other species of *Hylaeus*, and likely in *H. facilis*, the mated female provides the young with nectar and pollen that is left alongside eggs in brood cells within the nest (see known foraging sources below, under *Adult*). Upon emerging, the larvae consume these provisions. *Hylaeus* lack external pollen-carrying morphological structures, and instead the mated female carries pollen internally, usually mixed with nectar, in her crop. The food is provided in liquid form to the young (Michener 2000).

2. Adult

Adult *Hylaeus* consume nectar for energy; *H. facilis* host plants other than the non-native *T. argentea* (tree heliotrope) are unknown (Daly and Magnacca 2003).

C. Life Cycle

The egg, pupa, larva and nests of *H. facilis* 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 mated female 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 or nectar 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 mated female, pupate, and eventually emerge as adults (Michener 2000).

D. Habitat Status

There are no known populations of *H. facilis* on protected land besides the recently discovered population at Kuololimu Point in the Kalaupapa National Historic Park on Molokai, and the population on the Poamoho Trail on Oahu (Canfield 1990, Daly and Magnacca 2003, K. Magnacca, pers. comm., Jan 2008). However, even in habitats protected from development, *Hylaeus* populations are still vulnerable to decline if their habitat is not actively managed to protect them from threats such as fire, feral ungulates, non-native insects and the replacement of native vegetation by non-native plants (Magnacca 2007). Conservation of *H. facilis* will likely require active management of protected areas, which can include exclusion and removal of feral ungulates, control and removal of non-native plant and insect species, control of fire, and the restoration of native vegetation.

In general, the main Hawaiian Islands are more heavily vegetated now than they were during the period when Perkins collected. During that time period (1892-1906), most lowland native habitat had been denuded by feral ungulates, and that which remained was in very small patches that were easily located. Grazing by feral ungulates has since decreased and non-native vegetation has grown back in the place of native plant communities (Liebherr and Polhemus 1997). Remnant patches of native vegetation that might support *Hylaeus* populations are now more difficult to locate (K. Magnacca, pers. comm., July 2008). The photos in Figure 2 illustrate the change in vegetative cover that has taken place in the Honolulu mountains, and is representative of land use patterns in many areas on the Hawaiian islands. The loss of native habitat on Oahu since human occupation is illustrated in the maps in Appendix 2a-b. Although recorded from several sites currently considered to be wet forest, it is possible that *H. facilis* would not inhabit this zone in a natural state. Certain sites (e.g., the summit of Lanai and ridges above Honolulu) were considerably drier during the early collecting period due to the more open understory vegetation.

The habitat status of all historic and recent collection sites for *Hylaeus facilis* are discussed in detail below, with the exception of unknown sites labeled by Perkins as "Maui," "west Maui mountains," "Lanai" and "Oahu."

1. Oahu

Hylaeus facilis has been collected recently in only one location on Oahu. A map of recent and historic search sites on Oahu is in Appendix 1a. Maps of habitat loss on Oahu since human occupation are in Appendix 2. Photos of habitat change in the Honolulu Mountains since Perkins' collecting period are in Figure 2.

a. Honolulu, coast

Perkins collected *H. facilis* in coastal habitat at Honolulu. Honolulu is the primary urban area in the state of Hawaii, and has been the most populated area since the late 1800s (Schmitt 1977). As illustrated in the maps in Appendix 2, the Honolulu area was once characterized by a mix of native habitat, but these ecosystems have been eliminated from the area. Habitat has been converted for tourism or other urban development, and covered with roads, structures, and alien vegetation, or intentionally reforested with non-native species (Wester 1983, Liebherr and Polhemus 1997, Magnacca 2005). Much of the remaining habitat is dominated by tangles of second-growth non native species (Liebherr and Polhemus 1997). Several native Hawaiian insects that once inhabited this area are presumed extinct (Gagne 1981). K. Magnacca

observed that there is no native *Hylaeus* habitat remaining in Honolulu (K. Magnacca, pers. comm., July 2008).

b. Honolulu Mountains 1.5 K, Honolulu 2K (610 m/2000 ft; 460 m/1500 ft)
This area is for the most part largely undeveloped, but many areas have been overcome with non-native vegetation. In Perkins' time, the valleys behind Honolulu were open ranch and farmland, but have since been replaced with urban development (Liebherr and Polhemus 1997). As illustrated in the photographs in Figure 2, many areas in the lowlands above Honolulu are more heavily vegetated now than they were during the period when Perkins collected. During that time period (1892-1906), most lowland vegetation had been removed by feral ungulates; grazing has since decreased and non-native vegetation has grown back in the place of native plant communities (K. Magnacca, pers. comm., July 2008). The exact location of Perkins' collections is unknown, but they were probably made around Waiolani Ridge, Lanihuli Ridge, Nuuanu Valley, and Konahuanui, where he is known to have collected (Evenhuis 2007). Similar habitat nearby to the east has been searched recently for *Hylaeus* species; other *Hylaeus* species were collected, but *H. facilis* was absent (Daly and Magnacca 2003).

c. Makaha, Waianae (915 m/3000 ft)
Perkins (1899) collected *H. facilis* in the upper part of Makaha Valley, north of Waianae in southwest Oahu. There have been no recent search efforts for *Hylaeus* at this site, but K. Magnacca observed that *Hylaeus* habitat has been developed or degraded (K. Magnacca, pers. comm., Aug. 2008). This historical collection site is not protected. Some of the upper reaches of the valley contain remnant native habitat, but much of the native vegetation has been destroyed by brush fires (Liebherr and Polhemus 1997). Habitat loss in this area is illustrated in the maps in Appendix 2.

d. Kaala
Perkins (1899) collected *H. facilis* in middle elevation habitat at 610 m (2000 ft) on Mt. Kaala. This area is a mix of wet and mesic shrub and forest communities (HDLNR 2008). Much of the area is in a State Natural Area Reserve and retains the same general character as when Perkins collected there (Liebherr and Polhemus 1997). However, native habitats are threatened by feral pigs and the proliferation of non-native plants in remaining native habitat. Hunting of feral pigs is encouraged (HDLNR 1990). The increase of non-native plant species is especially a concern in lowland dry and mesic forests below 2000 ft. The Reserve management plan calls for control of non-native weed species in areas with native vegetation (HDLNR 1990).

e. Waianae Mountains (610 m/2000 ft)
Perkins (1899) collected *H. facilis* in the Waianae Mountains, upland from Waianae. Dry lowland habitats were once much more extensive in these mountains, as illustrated in Appendix 2. This area of habitat is protected within the state Waianae-Kaala Forest Reserve but is not intensively managed for native species. There is protected habitat nearby in the Pahole Natural Area Reserve (NAR). K. Magnacca searched this Reserve but did not find *H. facilis* (K. Magnacca, pers. comm., July 2008).

f. Tantalus
Perkins collected *H. facilis* in lowland mesic habitat at Tantalus (Perkins 1899, Evenhuis 2007). This area is close to the urban development of Honolulu. Although the site is still relatively undeveloped, it has been overcome by non-native vegetation that cannot support *Hylaeus* species. The dominant species, which are all non-native, include various species of bamboo,

Acacia confusa (Formosa koa), *Eucalyptus robusta* (swamp mahogany), and *Aleurites moluccana* (kukui) (NRCS 1978). The photos in Appendix 2 illustrate the change in habitat that has occurred in the Tantalus area since Perkins' time. Tantalus is visible in the background of the upper right corner of the photos in Figure 2 of Pauoa Valley. Pauoa Valley is the type locality of *H. facilis.*

g. Poamoho Trail

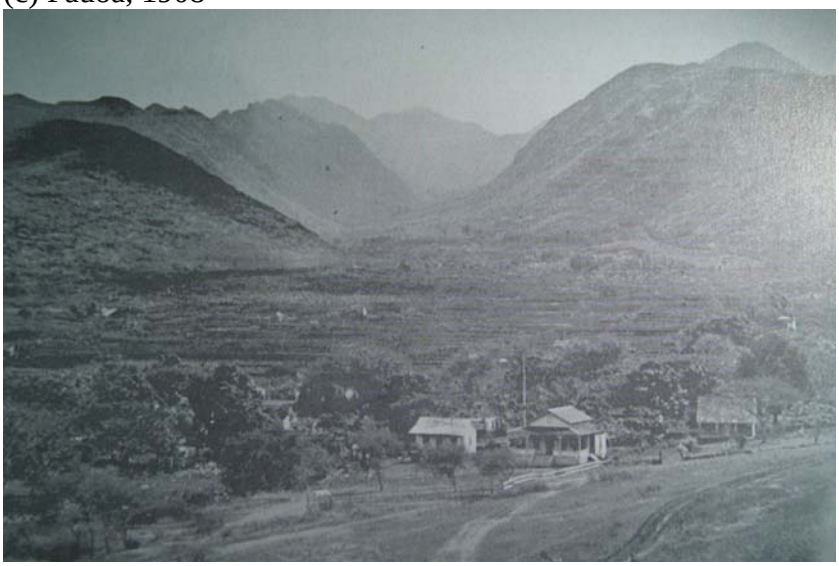
G. Nishida collected *Hylaeus facilis* from the Poamoho Trail in December 1975. The Poamoho Trail is part of the Na Ala Hele trail and access system, and is within the Ewa Forest Reserve (HDLNR 2000). The adjacent land, including the access road to the Reserve, is owned by the Dole Food Company. The Poamoho Trail traverses a public hunting area, and the land surrounding the access road have been leased to the Army for training purposes. Thus, access is only allowed on weekends and holidays, and by permit only. All-terrain vehicles (ATVs), bikes and horses are not permitted in the Reserve. Permits to access the Reserve are issued by the Hawaii Department of Forestry and Wildlife. The Poamoho Trail is near cow pasture and abandoned pineapple fields, but vegetation on the trail as it approaches the summit of Koolau is largely native wet forest with a thick canopy. Dominant vegetation includes uluhe fern (*Dicranopteris linearis*), koa (*Acacia koa*), and ohia *(Metrosideros polymorpha*) (HDLNR 2000).

Figure 2. Historic and recent photos of (a) Nuuanu, 1889 (Ray Jerome Baker [Ronck 1984]); (b) Nuuanu, 1996 (D. Polhemus); (c) Pauoa, 1908 (William Tufts Brigham [E.B. Scott 1968]) and (d) Pauoa, 1996 (D. Polhemus). Photos are adapted from Liebherr and Polhemus (1997).

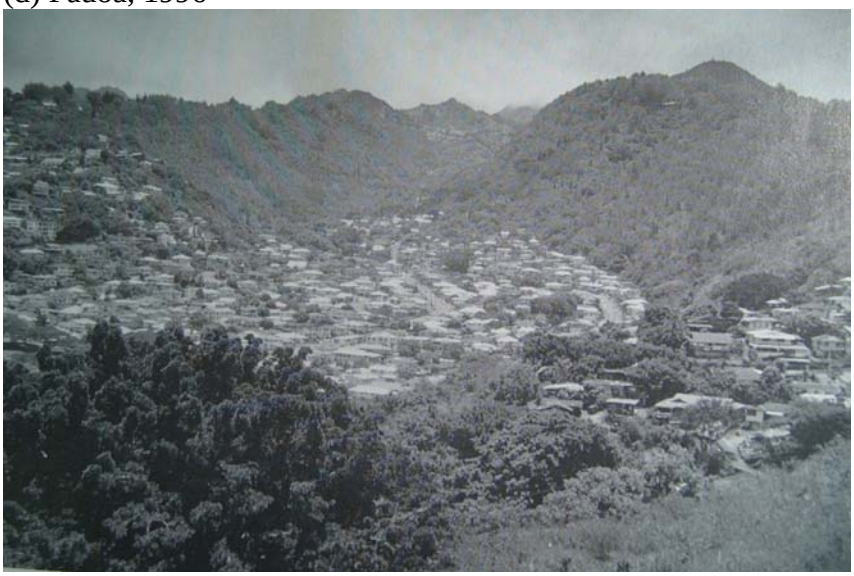
(a) Nuuanu, 1889

(b) Nuuanu, 1996

(c) Pauoa, 1908



(d) Pauoa, 1996



2. Maui

There have been only two recent collections of *H. facilis* on Maui, but neither is from a distinct population that can be located. One collection was made in 1967 (Magnacca 2005), but the location is unknown (K. Magnacca, pers. comm., Sept. 2008). A second collection was made in 1990, but the single specimen collected was taken in a residential area devoid of native plants, and was probably a straggler (Magnacca 2005). For a list of collection and search sites on Maui, see Figure 1. For a map of collection and search sites on Maui, see Appendix 1b.

a. Haleakala (1524 m/5000 ft)

Perkins (1899) collected *H. facilis* in mid-elevation habitat on Haleakala at 1524 m/5000 ft elevation, probably in the Olinda area. The habitat inhabited by *H. facilis* in this area at the time was mesic forest. These forests were once abundant at Perkins' collection site and up to 6000 ft elevation across the western slope of Haleakala, but have now been completely converted to pasture and agriculture. While the wetter forests to the east remain intact, species with similar habitat requirements to *H. facilis* (e.g. *H. difficilis*, *H. volcanicus*) are not found there.

b. Iao Valley

Perkins' collection includes *H. facilis* from lowland habitat in Iao Valley at about 610 m (2000 ft) (H. V. Daly, unpublished data). This area is inland from the Wailuku Sand hills/Waiehu Dunes. Iao Valley is in the West Maui Mountains, and the rugged and wet terrain was difficult for Perkins to access; he relied on assistants to collect specimens from this area (Liebherr and Polhemus 1997).

c. West Maui mountains (610 m/2000 ft)

Perkins collected *H. facilis* from the West Maui Mountains at 610 m/2000 ft. Much of the habitat in this area retains the native character it had in Perkins' time (Liebherr and Polhemus 1997).

d. Wailuku sand hills (Waiehu dunes/ "sandy isthmus") and Wailuku Sand Hills - Kahului Section

The Wailuku sand hills were Perkins' primary collection site for *Hylaeus* on Maui (Magnacca 2007). Perkins labeled this collection site for *H. facilis* "on sandy isthmus." All that remains of this native habitat is a very small (less than 1 ha) remnant of sand dune coastal habitat on state lands near a golf course at Waiehu, north of Wailuku. The rest of the dunes are either developed or overgrown with *Prosopis pallida* (kiawe). K. Magnacca observed that the Kahului section of the dunes, which is south of the native remnant, no longer contains suitable habitat for *Hylaeus* species (K. Magnacca, pers. comm., July 2008, Oct. 2008).

K. Magnacca collected *Hylaeus longiceps* from the Waiehu dunes in 1999 and 2001, but *H. facilis* and the other six species once collected there by Perkins were absent (Daly and Magnacca 2003, Magnacca 2007).

Activities at Waiehu include off-road vehicle use (Daly and Magnacca 2003, Magnacca 2007, K. Magnacca, pers. comm., July 2008).

e. Kokomo, near Makawao (457 m/1500 ft)

P. Gambino collected *H. facilis* from a residential area in Kokomo, near Makawao, in 1990. The single specimen collected was taken in a residential area devoid of native plants, and was probably a straggler. This is the only known recent collection made on Maui.

3. Lanai

Perkins found *H. facilis* to be common on Lanai. No recent collections of the species have been made on Lanai, although habitat has been extensively searched. All of Lanai is privately owned. For a list of collection and search sites on Lanai, see Figure 1. For a map of collection and search sites on Lanai, see Appendix 1c.

a. Koele Mountains (>610 m/2000 ft)

Perkins collected *H. facilis* from upper elevation habitat above 610 m/2000 ft elevation on Mt. Koele. Perkins' collecting site was probably the area northwest of Puu Alii (830 m/2700 ft). Today the region contains mixed native and non-native vegetation. K. Magnacca searched this area along the Munro Trail and Kaiholena ridge in 1999 and 2001 and obtained three *Hylaeus* species, but *H. facilis* was absent (K. Magnacca, pers. comm., July 2008).

b. Haalelepaakai (915 m/3000 ft)

Perkins collected *H. facilis* from montane habitat on Haalelepaakai. Haalelepaakai is the summit of the mountains on Lanai. Perkins misspelled the name of this locality "Halepaakai" (K. Magnacca, pers. comm., July 2008). K. Magnacca searched this area along the Munro Trail in 1999 and 2001, and collected four other *Hylaeus* species but not *H. facilis* (K. Magnacca, pers. comm., July 2008).

4. Molokai

For a list of collection and search sites on Molokai, see Figure 1. For maps of collection and search sites on Molokai, see Appendix 1d.

a. East mountains (610 m/2000 ft)

Perkins collected *H. facilis* from habitat in the East Mountains on Molokai at about 610 m/ 2000 ft elevation. This collection site was probably Makakupaia, which is the only locations in

the Molokai Mountains where Perkins is known to have collected *Hylaeus* from (Evenhuis 2007).

b. Molokai mountains (915 m/3000 ft, >915 m/3000ft, 1070 m/3500 ft)
Perkins collected *H. facilis* in the Molokai mountains at three distinct elevations in montane habitat. These locations were probably between Makakupaia and the rim of Pelekunu Valley, where Perkins did most of his collecting (Evenhuis 2007). This area is currently within the Nature Conservancy's Kamakou Preserve. K. Magnacca has searched extensively in similar high elevation habitat nearby Perkins' collecting area, such as at Kamakou Road (975 m/3200 ft), Puu Kolekole (1040 m/3400 ft) and Kawela Gulch (2000 m/3600 ft), and found other *Hylaeus* species but *H. facilis* was absent (Daly and Magnacca 2003).

c. Kuololimu Point (coast)
Hylaeus facilis was collected in coastal habitat at Kuololimu Point, on the southeastern coast of the Kalaupapa Peninsula, in 2005 (K. Magnacca, pers. comm., Jan 2008). The site is protected as part of the Kalaupapa National Historical Park. The east side of the peninsula is largely barren but contains pockets of native coastal vegetation similar to habitat at South Point on the island of Hawaii (Magnacca 2007). The park is cooperatively managed by the National Park Service, Department of Hawaii Homelands, and the State of Hawaii Departments of Health, Transportation, and Land and Natural Resources (NPS 2006).

E. Current Conservation Efforts
The federal and state governments have not developed any conservation agreements for *H. facilis*, nor have they made any targeted efforts to preserve or restore habitat for this species.

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. facilis* are not clearly understood (Magnacca 2005), but are likely related to the loss of its habitat (Mueller-Dombois 1973, Smith 1985, Medeiros *et al.* 1986, Magnacca 2005), and the encroachment of non-native plant species that are displacing native plant communities in its habitats (Cuddihy and Stone 1990).

1. Habitat loss
Habitat loss, and the degradation of habitat, has contributed to the decline of *H. facilis.* Although this species is known to inhabit a wide range of ecosystems, including coastal, lowland dry forest and shrubland, and wet montane areas, it prefers dry to mesic forest and shrubland habitat (Magnacca 2005). The habitat loss that has taken place on Oahu since human occupation is illustrated in the maps in Appendix 2a-b. Dry and mesic forests and shrubland are increasingly rare, and at high risk of loss to fire and degradation due to the influx of non-native plant species.

a. The loss of mesic forest
The mesic forest that *H. facilis* prefers (along with dry forest and shrubland) 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 (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 mesic forest that remains is in small patches usually on unusable or inaccessible land (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 forests on Oahu are now occupied by the military, including parts of Schofield Barracks and a naval base. 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).

b. The loss of dry forest and shrubland

Hylaeus facilis also prefers dry forest and shrubland habitats. 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). Dry lowland forest was once abundant and considered one of the most diverse of all Hawaiian habitat types but is now very rare (Magnacca 2007); they have been all but eliminated on most of the Hawaiian Islands. More than 90% of dry forests in Hawaii have been destroyed (Mehrhoff 1993, Bruegmann 1996), and there are concerns that remaining areas could disappear without targeted conservation and restoration efforts (Cabin *et al.* 2000). The loss of dry lowland forest has been greatest on the middle islands of Maui Nui and Oahu (Gagne 1988, Magnacca 2005). Less than 1% of dry forest and shrubland remains on Oahu, Molokai and Lanai, less than 2% remains on Maui, and less than 17% remains on Hawaii (Sakai *et al.* 2002).

Lowland dry shrublands have also been heavily impacted, particularly on Maui Nui and Oahu, and only remain in a few areas that were not altered by intensive agriculture or grazing. Large areas of montane shrubland remain on Kauai and Hawaii, but are largely gone from Maui Nui and Oahu except for the subalpine area of Haleakala, where *H. facilis* has never been collected. Dry shrubland with intact native plant communities are usually characterized by mixed stands with one or two dominant species. Other types of shrubland remain in very limited areas, and their presence suggests that these rare shrublands once had broader ranges and were reduced by disturbance (Cuddihy and Stone 1990). Non-native grasses are also abundant in dry shrublands.

c. The loss of coastal strand habitat

Coastal strand habitat is one of the most endangered habitats on the Hawaiian Islands (Wagner *et al.* 1985, Cuddihy and Stone 1990, Magnacca 2007). The coastal strand habitat that remains is in small remnant patches, and most of these remnants have been overtaken by invasive plant species and have relatively low diversity (Cuddihy and Stone 1990). Most of the coast of the Hawaiian Islands lacks significant amounts of native foraging plants besides *Scaevola sericea* (naupaka kahakai), which cannot support *Hylaeus* populations on its own (Magnacca 2007). The restricted and isolated nature of coastal strand habitat makes species that depend on these areas even more at risk (Sakai *et al.* 2002).

Most of the former coastal strand habitat has been converted for urban development, tourist resorts, pasture, military use, lost to fire or overcome with invasive vegetation (Wagner *et al.* 1985). Increased access to coastal areas, and resulting habitat disturbance, has been facilitated by coastal development and road-building (Cuddihy and Stone 1990).

Hylaeus facilis was once widespread and was common in coastal strand habitat. It has been recently collected in only one coastal site, at Kuololimu Point on Molokai (K. Magnacca, pers. comm., Jan. 2008). *Hylaeus facilis* is now absent from all of Perkins' historical coastal collection localities, which have been developed or taken over by invasive plant species. These areas include the Waianae area and Honolulu on Oahu and the Wailuku sand hills on Maui (Cuddihy and Stone 1990, Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Magnacca (2007) outlined the reasons that this habitat and the *Hylaeus* species that inhabit it are so susceptible to extinction:

> Coastal strand habitat is the most endangered in Hawaii for a number of reasons: it is highly valued for development, popular for recreation, typically dry and therefore vulnerable to fire, susceptible to invasion by exotic plants, and it covers a small area by definition. On most of the Islands, only one coastal site with diverse native vegetation is protected, making the [*Hylaeus*] bees that inhabit them vulnerable to single catastrophes.

d. The loss of lowland and montane wet forest habitat

Wet forests were once one of the dominant ecosystem types in lowland areas on the main Hawaiian Islands. Most of this habitat was lost to agricultural uses in the 18th and 19th centuries, and remaining areas were overtaken by non-native aggressive plant species such as kukui (*Aleurites moluccana*) and guava (*Psidium guajava*). Remnants of native lowland wet forest can be found in rocky or steep terrain, such as on some peaks and summit ridges on Oahu, Molokai and West Maui (Cuddihy and Stone 1990).

Wet forests at montane elevations have fared better; substantial areas of native wet forest remain on Maui, and on the steep ridges, peaks and slopes of Oahu and Molokai (Cuddihy and Stone 1990, Liebherr and Polhemus 1997). However, although much wet forest remains, and closely related species were present, *H. facilis* was absent from all of the wet habitats searched on Oahu, Lanai, Maui and Molokai.

2. The replacement of native vegetation with invasive plant species

The majority of lowland habitats on the Hawaiian Islands below 600 m (1969 ft) are dominated by invasive plant species (Wagner *et al.* 1985). Aggressive non-native species are increasingly replacing native flora in these lowland areas, and in higher elevation habitats (Cuddihy and Stone 1990). Many native plant species that are being replaced are foraging resources for numerous *Hylaeus* species (Cox and Elmqvist 2000, Daly and Magnacca 2003, USFWS 2008). The spread of invasive plant species is a threat to populations of *H. facilis* because *Hylaeus* species depend closely on native vegetation for nectar and pollen and are almost entirely absent from habitats dominated by invasive vegetation (Daly and Magnacca 2003). *Hylaeus facilis* prefers dry and mesic forest and shrubland habitats (Daly and Magnacca 2003), and the greatest proportion of endangered or at risk Hawaiian plant taxa are limited to these same habitats; 25% of listed plant species are from dry forest and shrubland alone (Sakai *et al.* 2002). Is it suspected that dry lowland forest once supported a more diverse *Hylaeus* community than it now does, because many *Hylaeus* foraging plants are now extirpated (Magnacca 2007). The loss of native plant species from dry lowland habitats is one of the main causes of decline of *Hylaeus* species (Sakai *et al.* 2002, Liebherr 2005).

Most of the coastline of the major Hawaiian Islands does not have any native vegetation besides *Scaevola sericea* (naupaka kahakai), which *Hylaeus* cannot survive on alone. Native coastal vegetation in many areas, such as on Moomomi Beach on Molokai, is threatened by *Prosopis pallida* (kiawe), an invasive deciduous thorny tree. Other non-native plant species abundant in coastal habitats include *Melinus minutiflora* (molasses grass), *Leucaena leucephala* (koa haole), and *Cenchrus ciliaris* (buffelgrass). Species that commonly invade dry forest include *Lantana camara* (lantana), *Leucaena leucocephala* (koa haole), *Melinus minutiflora* (molasses grass), *Pennisetum clandestinum* (kikuyu grass), *Psidium guajava* (guava), and *Schinus terebinthifolius* (Christmas berry). Species known to commonly invade mesic forest include *Aleurites moluccana* (kukui), *P. clandestinum* (kikuyu grass), *Blechnum occidentale*, *Clidemia hirta* (Koster's curse), *L. leucocephala* (koa haole), and *Lantana camara* (lantana). Species known to invade montane mesic and dry forest habitats include *A. moluccana* (kukui), *C. hirta* (Koster's curse) and *Psidium cattleianum* (strawberry guava). Wet forests are also threatened by non-native plant species such as the invasive *Ageratina adenophora* (Maui pamakani), *C. hirta* (Koster's curse), and *Paspalum conjugatum* (Hilo grass) in lowland wet forests, and *Axonopus fissifolius* (narrow-leaved carpet grass) in montane wet forests (USFWS 1999).

Native Hawaiian plant species depend almost entirely on endemic pollinators such as *Hylaeus* species for reproduction and must be cross-pollinated (Sakai *et al.* 1995, Cox and Elmqvist 2000). Invasive plant species have distinct reproductive advantages over Hawaiian endemics; plant species endemic to islands are rarely apomictic or able to reproduce by self-pollination or vegetative means, while many invasive species do have the ability to reproduce in these ways (Simberloff and Von Holle 1999).

The decline of populations of *Hylaeus* might further exacerbate the loss of native plants, since they are important pollinators of many native plant species and are not easily replaced by non-native pollinators (Sahli *et al.* 2008). Recent studies of visitation records of Hawaiian *Hylaeus* to native flowers (Daly and Magnacca 2003) and pollination studies of native plants (Sakai *et al.* 1995, Cox and Elmqvist 2000, Sahli *et al.* 2008) have illustrated the important role of *Hylaeus* species as pollinators of many native Hawaiian plants. Sahli *et al.* (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 replaced by non-native pollinators, and that *Hylaeus* are very important for the reproduction of native plants. The loss of populations of *H. facilis* may exacerbate the decline of dependent plant species (Cox and Elmqvist 2000).

Many taxa of native plants that serve as 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). More than 75% of the plant species in danger of extinction on Oahu are from lowland mesic forests (Wagner *et al.* 1985). Four native Hawaiian plant taxa from coastal strand habitats and seventeen taxa from lowland dry or mesic forests are federally listed as endangered species and included in the USFWS Recovery Plan for Multi-Island Plants (USFWS 1999). Three of these species are known to be visited by *Hylaeus* species (USFWS 2008). *Hylaeus* host species that are listed as endangered under the Endangered Species Act include *Chamesyce* spp. (akoko), *Scaevola coriacea* (naupaka), and *Sesbania tomentosa* (ohai). Some of these species are threatened by lack of adequate pollination (USFWS 1999) due at least in part to the decline of *Hylaeus* species in its habitat.

3. Habitat disturbance by feral ungulates

Feral ungulates have contributed to the decline of native Hawaiian plant communities, which likely has had a negative impact on *Hylaeus* species. A number of coastal and lowland plant species listed as endangered by the federal government are threatened by the presence of feral ungulates (USFWS 1999). Some of these are confirmed foraging sources for *Hylaeus* species and are likely foraging

sources for *H. facilis* (Daly and Magnacca 2003). 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). Feral ungulates present in or around coastal and lowland shrub and forest areas on the Hawaiian Islands include feral pigs (*Sus scrofa*), cattle (*Bos taurus*), and goats (*Capra hircus*). Other ungulates that might be present are axis deer (*Axis axis*) and mule deer (*Odocoileus hemionus*) (USFWS 2006).

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 invasive plant species. Feral ungulates' excrement increases the nutrient content of soils, benefiting invasive plants that are better adapted to richer soils than are native species (Cuddihy and Stone 1990).

Pomace flies (*Drosophila* species) are another group of endemic Hawaiian invertebrates that also depend closely on native vegetation. Several species of rare and endemic Hawaiian *Drosophila* (pomace flies) are federally listed as endangered species under the Endangered Species Act (USFWS 2006). *Drosophila* species are negatively impacted by pig-inflicted damage to native vegetation (Foote and Carson 1995). Foote and Carson (1995) showed that excluding pigs from *Drosophila* habitat increased populations of these rare *Drosophila* species. Excluding pigs from native habitat would probably offer similar protection to *Hylaeus* species. Active management to control feral ungulates typically involves building exclusionary fences and hunting (Cuddihy and Stone 1990).

4. Fire

Fires were uncommon in the Hawaiian Islands until the arrival of humans about 2000 years ago (Smith and Tunison 1992). Native habitat in the Hawaiian Islands has been increasingly colonized by fire-adapted invasive plant species that take the place of native plant species (Smith and Tunison 1992, D'Antonio *et al.* 2000). Many invasive plant species are able to proliferate after fire comes through a habitat whereas most native species' populations do not recover (Cuddihy and Stone 1990). Fire can dramatically alter the species composition of the plant community in coastal and lowland habitats, thus impacting *Hylaeus* populations. This process has been facilitated by feral ungulates, which alter the floral composition of native habitats, making conditions more conducive to fire. They remove or damage native vegetation, allowing seeds of invasive plant species to establish. These invasive species are much better adapted to fire than native Hawaiian species, as the invasive species will burn more easily and recolonize more rapidly than natives (Cuddihy and Stone 1990). Ordnance-induced fires on Army land have increased the frequency and intensity of fires in some areas (USFWS 2006).

5. Recreation

Some of the best habitat for *Hylaeus* species are popular recreational sites. Human impacts at recreational sites may include removal or trampling of vegetation on or nearby trails and the compaction of vegetation by off-road vehicles. One of the few recent collection sites for *H. facilis*, the Poamoho Trail, may be deleteriously impacted by recreation. Recreational activities at the Poamoho Trail include hunting and hiking (DLNR 2000).

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. facilis*, which is extremely rare and has 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). The native Hawaiian invertebrate fauna evolved in the absence of all social insects (Zimmerman 1948, Wilson and Taylor 1967, Howarth 1985), and are not adapted to defend themselves from highly aggressive social species such as ants (Stone and Anderson 1988). Several ant 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).

Of all non-native ant species in Hawaii, *Pheidole megacephala* (the big-headed ant), *Anoplolepis gracilipes* (syn. *longipes*) (the crazy or long-legged ant), and *Linepithema humile* (the Argentine ant) pose the biggest threat to remaining populations of *H. facilis*. These three species are generalist predators, and are very abundant and aggressive (Holway *et al.* 2002). *Pheidole megacephala* is primarily restricted to dry lowland habitats below 1000 m (3289 ft) and is almost always the dominant ant in its habitat. *Anoplolepis gracilipes* primarily occurs from sea level to 800 m but has been found up to 1200 m (Medieros *et al.* 1986). These two species are the most ubiquitous invasive ant species in lowland areas, and are known to colonize both undisturbed native areas and areas dominated by non-native vegetation. *Linepithema humile* is primarily restricted to cooler habitats at elevations above 1000 m (3280 ft), and is most common between 900 and 2000 m (2950-6560 ft), in dry and mesic montane areas (Reimer 1994).

Hylaeus populations are drastically reduced in ant-infested areas (Medeiros *et al.* 1986, Stone and Loope 1987, Cole *et al.* 1992, Reimer 1994). 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). Some ant species may impact *Hylaeus* species indirectly by predating on seeds of native plants (Bond and Slingsby 1994). Invasive ants' largest ecosystem-level effect has been on pollination, partially due to predation on *Hylaeus* species (Reimer 1994).

Invasive ants have severely impacted ground-nesting *Hylaeus* species (Cole *et al.* 1992, Medeiros *et al.* 1986); *Hylaeus* brood 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. *Hylaeus facilis* likely nests in the ground like closely related *H. chlorostictus* and *H. simplex*, and thus its brood might be especially susceptible to ant predation (Magnacca 2005).

Pheidole megacephala is known to actively rob nectar from flowers without pollinating them (Howarth 1985). Lach (2008) found that *Hylaeus* species that regularly collect pollen from ohia trees (*Metrosideros polymorpha*) were entirely absent from flowers visited by *P. megacephala.*

2. Non-native bee species

There are 15 species of non-native bees in Hawaii (Snelling 2003), which includes two non-native *Hylaeus* species. Most non-native bees inhabit areas dominated by non-native vegetation and thus are not competing with natives (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* for nectar and pollen (Daly and Magnacca 2003, Snelling 2003). *Apis mellifera* was first introduced to the Hawaiian Islands in 1875, and it currently inhabits areas from sea level to tree line (Howarth 1985). The major parasites that have decimated populations of *A. mellifera* in the continental United States are largely absent from the Hawaiian Islands, although the varroa mite (*Varroa destructor*) was recently discovered on Oahu and Hawaii (Ramadan 2007). *Apis mellifera* have been observed foraging on *Hylaeus* host plants such as *Scaevola* (Magnacca 2007). Populations of *A. mellifera* are not as vulnerable to predation by invasive ant species as are *Hylaeus.* Lach (2008) found that *Hylaeus* species that regularly collect pollen from ohia trees (*Metrosideros polymorpha*) were entirely absent from flowers visited by the ant *P. megacephala*, but visits by *A. mellifera* were not affected.

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

3. *Vespula pensylvanica* (The western yellow jacket wasp)

Vespula pensylvanica (the western yellowjacket 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. *Vespula pensylvanica* is an aggressive opportunist generalist predator, and predates on *Hylaeus*, although *Hylaeus* is not its primary prey source (Gambino *et al.* 1987). Because of the rarity of *H. facilis*, 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

Currently, no Federal, State, or local laws, treaties, or regulations specifically protect habitat for *Hylaeus facilis.* There are only two known populations of *H. facilis* on protected land, at Kuololimu Point in Kalaupapa National Historical Park on Molokai, and on the Poamoho Trail on Oahu (Magnacca 2005, K. Magnacca, pers. comm., July 2008). However, the population on Poamoho Trail may no longer be extant, since it was last observed in 1975.

It is important to note that even in areas protected from development, populations of *H. facilis* are still vulnerable to decline if their habitat is not actively managed to protect them from threats such as fire, feral ungulates, non-native invertebrate and the replacement of native vegetation by non-native plants (Magnacca 2007). Conservation of *H. facilis* will likely require active management of protected areas, which can include exclusion and removal of feral ungulates, control and removal of non-native plant and insect species, and the restoration of native vegetation. Existing regulatory mechanisms are inadequate to provide the necessary active management to protect *H. facilis.*

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 tsunamis or droughts. They may also experience a loss of genetic variability and reduced fitness due to the unavoidable inbreeding that occurs in such small populations (Cox and Elmqvist 2000). *Hylaeus facilis* is rare and has very small populations, and is likely more vulnerable to habitat change and stochastic events due to low genetic variability.

2. Global climate change

Global climate change may threaten *H. facilis*. A changing climate may cause shifts in the range of host plant species and can be especially detrimental to dependent pollinators when combined with habitat loss (NRC 2007). 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. *Hylaeus facilis* is restricted to habitat patches where host species are present, and is not likely to disperse far to find new habitat. Thus, the ecology of this species, combined with the patchy distribution of its remaining habitat, might hinder dispersal made necessary by climate change (Michener 1974, Daly and Magnacca 2003) and cause the extirpation of remaining populations.

Climate change may also have a deleterious effect on *H. facilis* with changes in rainfall patterns, since this species prefers relatively dry habitats, some of which lack groundwater sources (K. Magnacca, pers. comm., Oct 2008). Furthermore, a predicted rise in sea level in the Hawaiian Islands (Baker *et al.* 2006) might threaten coastal strand populations of *H. facilis.* One study predicted sea level rise in the Northwestern Hawaiian Islands to cause a median projected loss of land of 3 to 65% with a 48 cm sea level rise, and a maximum loss of 5 to 75% with a 88 cm sea level rise (Baker *et al.* 2006). Although *H. facilis* does not occur on the Northwestern Hawaiian Islands, sea level rise will also have an effect, albeit a smaller one, on the larger, higher elevation major islands it inhabits, and some coastal habitat will likely be lost.

3. The vulnerability of island endemics

Hylaeus facilis is endemic to the Hawaiian Islands of Oahu, Lanai, Maui and Molokai. Species that are endemic to islands are particularly vulnerable to population decline and extinction because they evolved in isolation from many aggressive species that have been introduced to the Hawaiian Islands (Stone and Scott 1985). Furthermore, many Hawaiian species, such as *H. facilis*, 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).

These Hawaiian *Hylaeus* species form a diverse and large lineage that evolved in an unusually short amount of time relatively recently (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 is *H. facilis* (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

There is strong evidence of significant decline of *H. facilis.* *Hylaeus facilis* was among the most common and widespread *Hylaeus* bees in its habitat during the early period of Hawaiian insect collecting (1892-1930) (Daly and Magnacca 2003, Magnacca 2007), but it has almost completely disappeared. *Hylaeus facilis* has declined sharply despite the fact that a substantial amount of its habitat still remains intact, and other closely related *Hylaeus* species can still be collected in these locations. *H. facilis* was absent from extensive searches in many locations where they had been historically collected (Magnacca 2007). There have only been four recent collections of this species: one from Molokai (2005), two from Maui (1967 and 1990) and one from Oahu (1975). It was absent from many of its historical localities that were revisited by K. Magnacca between 1998 and 2005, and from many sites with suitable habitat, many from which other *Hylaeus* species have been recently collected.

The primary threats to *H. facilis* are:

1. Scarcity of habitat, and habitat loss due to development or land conversion (Cuddihy and Stone 1990, Magnacca 2007)
2. The displacement and decline of native flora by invasive plant species, fire, and feral ungulates (Cuddihy and Stone 1990, Daly and Magnacca 2003).
3. Predation by invasive ants such as *Anoplolepis gracilipes* (the long-legged ant) and *Pheidole megacephala* (the big-headed ant) (Cole *et al.* 1992, Daly and Magnacca 2003).
4. Competition for resources with invasive honey bees (*Apis mellifera*) (Daly and Magnacca 2003, Magnacca 2007).
5. Predation by *Vespula pensylvanica* (the western yellow-jacket wasp) (Gambino *et al.* 1987).

Furthermore, the decline of *H. facilis* may exacerbate threats to endangered native plant species that depend on endemic pollinators (Sakai *et al.* 1995, Cox and Elmqvist 2000, Sahli 2008).

The above threats, the rarity of this species, and the natural instability of small populations of island endemics lead us to conclude, unequivocally, that *Hylaeus facilis* is threatened with extinction and must be given protection under the Endangered Species Act.

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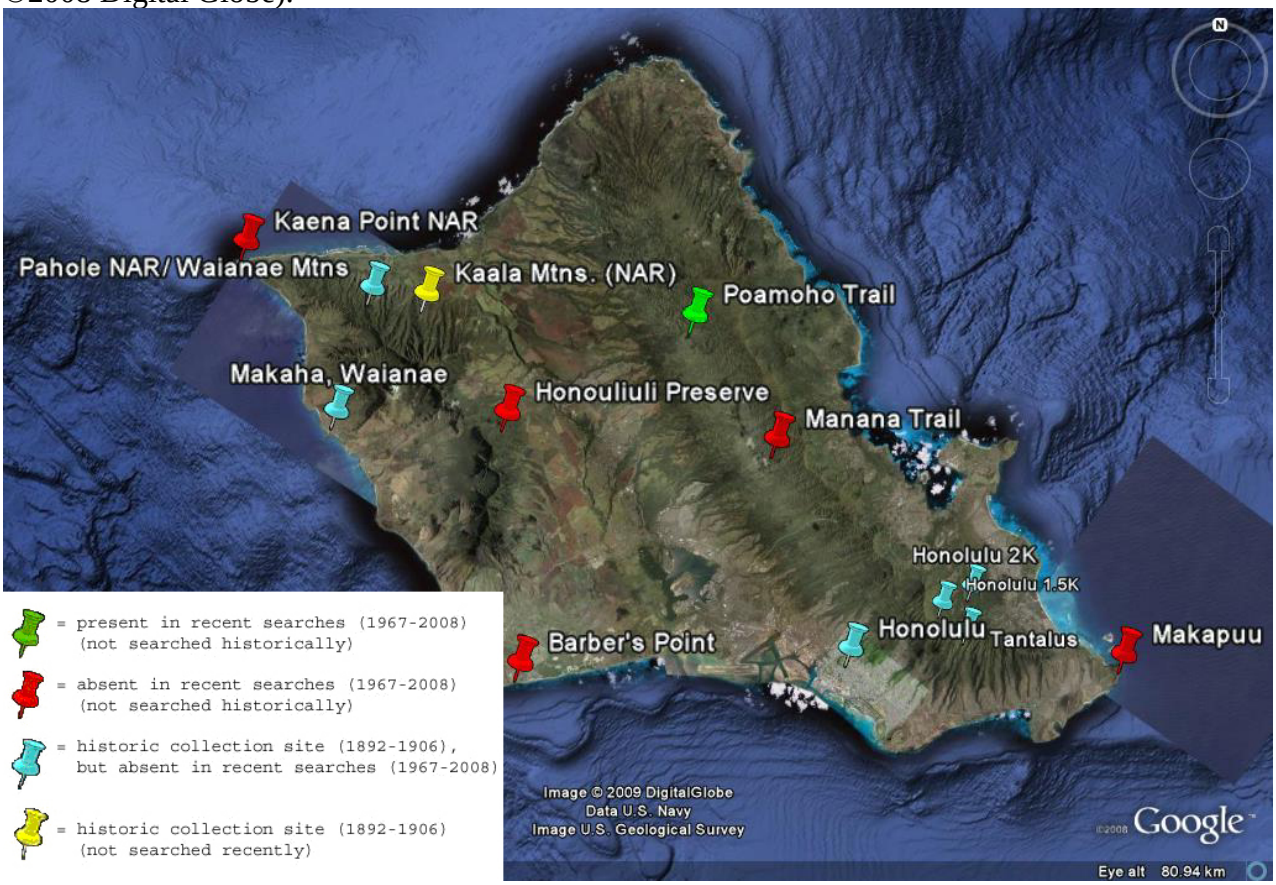
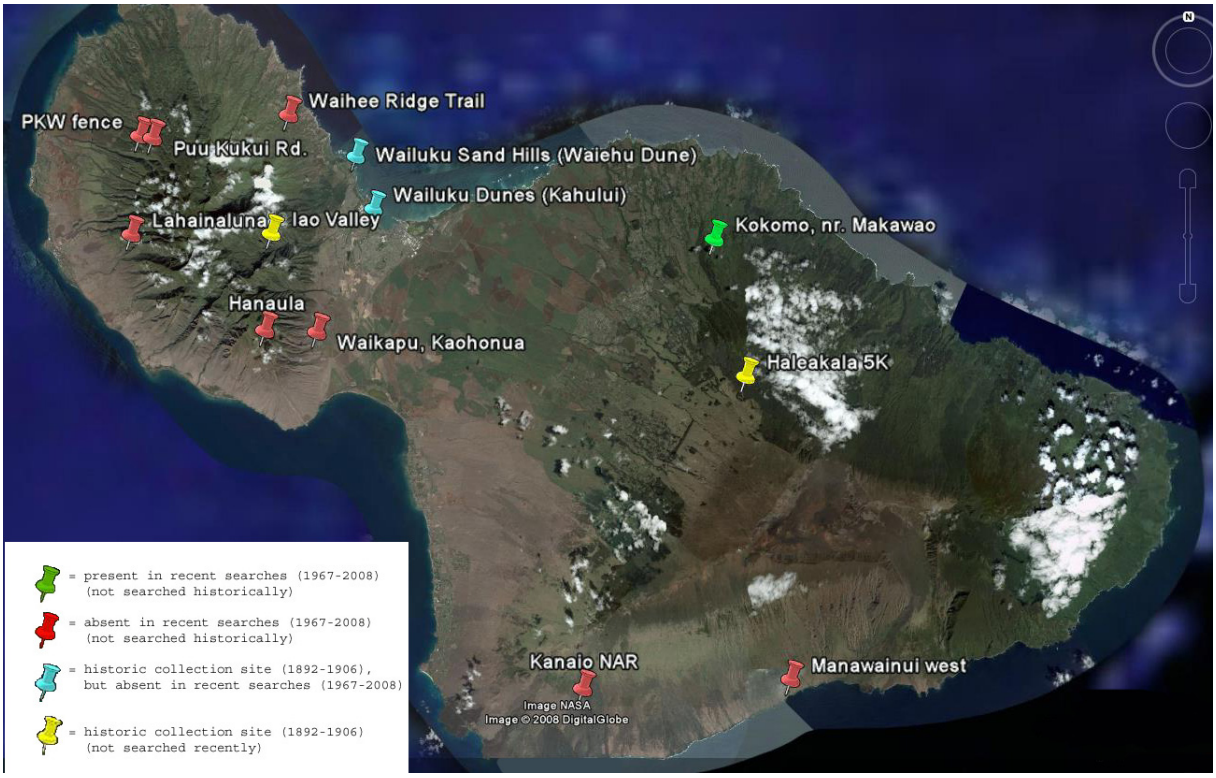
X. APPENDIX 1a-d. Locations of recorded specimens of *Hylaeus*

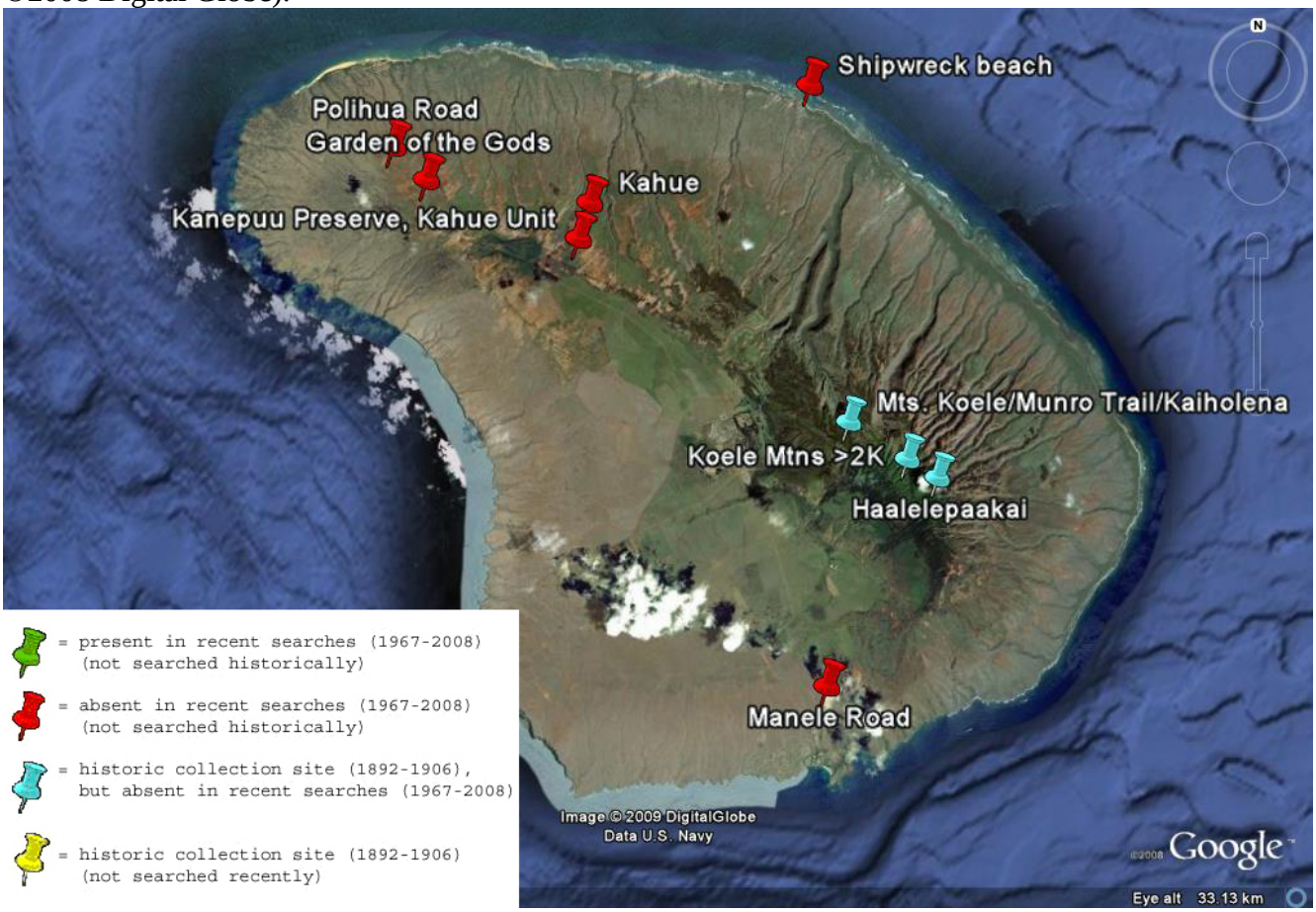
Appendix 1a. Map of Oahu showing recent and historic collection sites for *Hylaeus facilis* (map ©2008 Digital Globe).



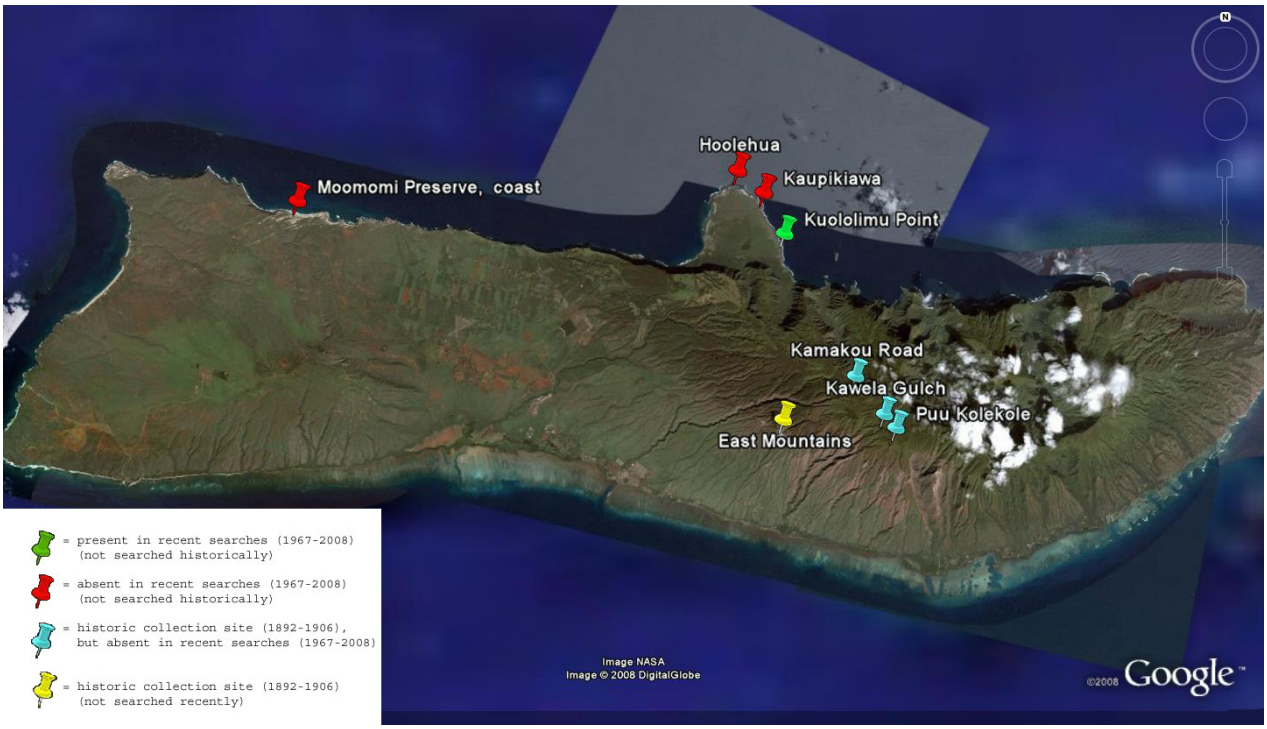
Appendix 1b. Map of Maui showing recent and historic collection sites for *Hylaeus facilis* (map ©2008 Digital Globe).



Appendix 1c. Map of Lanai showing recent and historic collection sites for *Hylaeus facilis* (map ©2008 Digital Globe).

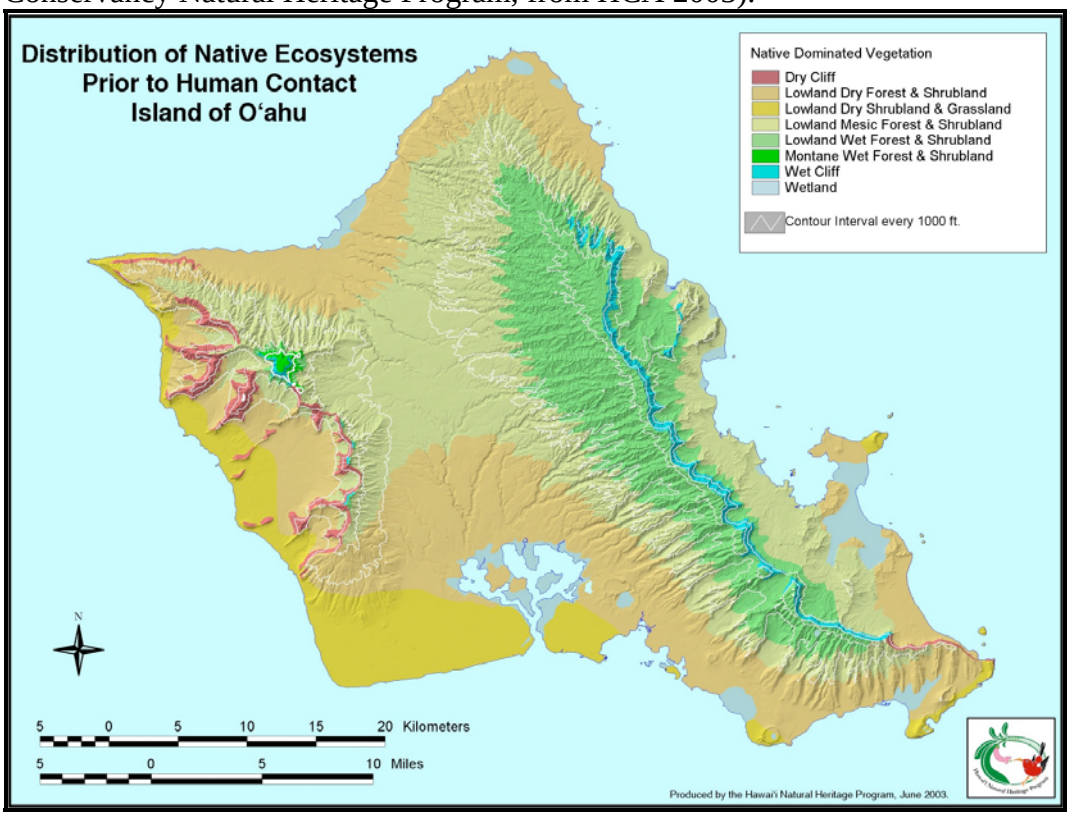


Appendix 1d. Map of Molokai showing recent and historic collection sites for *Hylaeus facilis* (map ©2008 Digital Globe).



XI. Appendix 2A-B: Distribution of native ecosystems (A) prior to human contact and (B) currently on the island of Oahu (maps courtesy of The Nature Conservancy Natural Heritage Program, from HCA 2003).

Appendix 2A. Distribution of native ecosystems prior to human contact (map courtesy of The Nature Conservancy Natural Heritage Program, from HCA 2003).



Appendix 2B. Distribution of native ecosystems currently on the island of Oahu (maps courtesy of The Nature Conservancy Natural Heritage Program, from HCA 2003).