

PETITION TO LIST
ONE SPECIES OF HAWAIIAN YELLOW-FACED BEE
Hylaeus assimulans
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 assimulans* 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 assimulans* 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 by advocating for at-risk species, producing informational materials, presenting educational activities, and implementing conservation projects.

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I. EXECUTIVE SUMMARY

Hylaeus assimulans is a rare bee endemic to the Hawaiian Islands that is in imminent danger of going extinct.

There is strong evidence of significant decline of the Hawaiian yellow-faced bee, *Hylaeus assimulans*, and it is one of the most highly endangered native Hawaiian *Hylaeus* species (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). *Hylaeus assimulans* was widespread in Perkins’ time, but not abundant in its habitat (Magnacca 2005). Recent surveys indicate that most *Hylaeus* species are in decline, many are extremely rare, and several are possibly extinct (Daly and Magnacca 2003, Shepherd *et al.* 2005, Magnacca 2007). Twenty-four sites on Oahu, Maui, Molokai, Kahoolawe and Lanai were recently searched for *H. assimulans*, including six historic collection sites and 19 sites that presently contain suitable habitat. *Hylaeus assimulans* was only present at 5 sites, and was absent from all of its historic localities that were recently searched. In two of the historic collection sites that K. Magnacca visited, all *Hylaeus* habitat has been lost to development or other land conversion (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., July 2008).

Because remnant populations of *H. assimulans* are small and isolated, they are especially vulnerable to habitat loss, predation, stochastic events, and other changes to their habitat. *Hylaeus assimulans* depends on coastal strand and lowland dry forest habitats, which are both increasingly rare and patchily distributed (Cuddihy and Stone 1990, Magnacca 2005). The only remnant populations on protected lands are in Kamohio on Kahoolawe, in the West Maui Natural Area Reserve (Appendix 1c), and on a very small native plant enclosure on Maui (Daly and Magnacca 2003, Magnacca 2005, K. Magnacca, pers. comm., July 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).

The decline of populations of this and other species 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 2008). *Hylaeus* might be important to the recovery of some threatened and endangered Hawaiian plants.

Conservation of *H. assimulans* will require the active protection 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. assimulans* and may cause its extinction if habitat is not managed for conservation of this species (Magnacca 2007).

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

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

Hylaeus assimulans is listed as a Species of Concern in the State of Hawaii (Magnacca 2005). It has a Global Heritage Status Rank 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 (Shepherd *et al.* 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 assimulans* was given a rank of 5, which indicates that it is “very rare” and “potentially endangered.”

Hylaeus assimulans 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 lists of “Species of Concern” or “Special Status Species,” respectively (USFWS 1996, Magnacca 2005).

III. TAXONOMY

The taxonomy of *H. assimulans* is uncontested. *Hylaeus assimulans* 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 38 that are endemic to a single island (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 in an unusually short amount of time relatively recently (Magnacca and Danforth 2006, Magnacca and Danforth 2007).

Hylaeus assimulans was described as *Nesoprosopis assimulans* by Perkins (1899). *Nesoprosopis* was reduced to a subgenus of *Hylaeus* by Meade-Waldo (1923), so the species is now called *Hylaeus assimulans* (Daly and Magnacca 2003). The most recent taxonomic treatment for *H. assimulans* is Daly and Magnacca (2003).

IV. SPECIES DESCRIPTION

A. Adult

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

Hylaeus assimulans was redescribed by Daly and Magnacca (2003). It is distinguished by its large size relative to other coastal *Hylaeus* species. *Hylaeus assimulans* has slightly smoky to smoky wings. The space from the base of the mandible and the bottom margin of the compound eye (malar space) is short. The male is black with yellow face marks, and an almost entirely yellow clypeus with additional marks on the sides that narrow dorsally (towards the top). The male also has brown appressed hairs on the tip of the abdomen. The female is entirely black, and large, and has no distinct punctation on the abdomen (Daly and Magnacca 2003, Magnacca 2005).

B. Immature

The egg, larva, pupa, and nest of *H. assimulans* are unknown (Magnacca 2005).

V. POPULATION DISTRIBUTION AND STATUS

A. Historic Distribution

Historic records for Hawaiian *Hylaeus* species are based largely on collections made by Perkins between 1892 and 1906 (Daly and Magnacca 2003). All historic records discussed in this paper are from this collecting period. 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 Hawaiian *Hylaeus* species “almost the most ubiquitous of any Hawaiian insects” (Perkins 1913), but more recent surveys (Daly and Magnacca 2003) indicate that most *Hylaeus* species are extremely rare, likely in decline, and several species are possibly extinct (Daly and Magnacca 2003, Shepherd *et al.* 2005, Magnacca 2007). *Hylaeus assimulans* is among the most endangered of Hawaiian *Hylaeus* species, and has not been found in recent searches of many of its historic collection localities, as detailed below under “current distribution” (see Figure 1 for a table of historic and recent collection sites).

Hylaeus assimulans is historically known from numerous coastal strand and dry lowland locations up to 610 m (2000 ft) elevation on the Hawaiian Islands of Maui, Lanai, Oahu, and Kahoolawe (Figure 1, Appendix 1a-d). Although there are no collection records of this species from Molokai, Daly and Magnacca (2003) predict that it historically occurred there because almost all Hawaiian *Hylaeus* historically known from Maui, Lanai and Oahu also occurred on Molokai (K. Magnacca, pers. comm., July 2008). *Hylaeus assimulans* probably occurred historically throughout much of the leeward and lowland areas on Maui Nui and Oahu, since its probable primary host plant, ilima, extended throughout this range. Nearly the entire habitat in this area has been either developed or degraded and is no longer suitable for *H. assimulans* (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., Sept 08).

On Maui, Perkins collected *H. assimulans* from coastal habitat at the Wailuku Sand Hills, and from an unknown site labeled “Maui” (Daly and Magnacca 2003). On Lanai, he found *H. assimulans* in coastal habitat at Awalua and in the Koele Mountains, but it was not common at either site (Perkins 1899). *Hylaeus assimulans* was found to be widespread but not relatively abundant in habitat on Oahu during Perkins’ historic collecting period (Magnacca 2005). Perkins collected *H. assimulans* on Oahu in Honolulu (K. Magnacca, pers. comm., July 2008), the Kaala Mountains, the Waianae Mountains, and the Waianae coast (Perkins 1899, Daly and Magnacca 2003). There are also specimens collected by Perkins on Oahu from unknown sites referred to as “Oahu” and “w. coast, near sea level.” There is one collection record for *H. assimulans* by Perkins (1899) from the island of Hawaii. However, K. Magnacca confirmed that Perkins’ specimen was misidentified, and that *H. assimulans* is not known from the island of Hawaii (K. Magnacca, pers. comm., July 2008). See Appendix 1 a-d for maps of Perkins’ collection sites for *H. assimulans*.

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 by other researchers 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, or time (Magnacca 2007).

There is strong evidence of significant decline of *H. assimulans*. *Hylaeus assimulans* was once widely distributed, but degradation and loss of its habitat has decreased its range significantly and it is now restricted to a few small patches of coastal and dry lowland habitat, as seen in the maps in Appendix 1

(Daly and Magnacca 2003, Magnacca 2005). *H. assimulans* was absent from all of its historic localities that were revisited by K. Magnacca between 1998 and 2006. It was also absent from many additional sites with suitable habitat, many from which other native *Hylaesus* species have been recently collected (Figure 1; Daly and Magnacca 2003, K. Magnacca pers. comm., Jan. 2008, July 2008). Recent collections of *H. assimulans* have been made in only 5 sites on Maui, Kahoolawe, and Lanai between 1997 and 2000. It has likely been extirpated from Oahu, since it was absent from the best remaining habitat there at Kaena Point Natural Area Reserve (Magnacca 2005).

Twenty-five sites on Oahu, Maui, Kahoolawe, Lanai and Molokai were recently searched for *H. assimulans*. Six historic collection sites were searched; in some of these historic sites all *Hylaesus* habitat has been lost to development or other land conversion (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., July 2008). In addition to these historic sites, recent searches for *Hylaesus* species have been conducted at 19 other sites that presently contain suitable habitat.

There are no known populations of *H. assimulans* on protected land besides those on Kahoolawe, in the West Maui Natural Area Reserve, and in a very small (< 10,000 ft²) remnant in the Waikapu Valley on Maui (Magnacca 2005).

Collection sites and habitats searched are outlined below in Figure 1. The location of these sites is indicated in the maps in Appendix 1a-e.

1. Maui (see Figure 1 and Appendix 1a)

Hylaesus assimulans is extremely rare on Maui, and remains only in small pockets of native vegetation (K. Magnacca, pers. comm., July 2008). K. Magnacca searched 6 sites on Maui between 1998 and 2006, and *H. assimulans* was only found in only 2 of these sites (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008). Two specimens were collected in dry forest on the western side of the island at Lahainaluna in the West Maui Natural Area Preserve in 1999 (550 m/1800 ft), and 4 specimens were collected at Waikapu, Kaohonua in 2000 (120 m/400 ft). Perkins collected *H. assimulans* and several other *Hylaesus* species from coastal habitat at the Wailuku sand hills (Waiehu dunes), which is the only known historic collection site for this species on Maui (the other historic site is labeled only as "Maui"). K. Magnacca searched this area in 1999 and 2001 and it, along with several other *Hylaesus* species collected there by Perkins, was absent. *Hylaesus assimulans* was also absent from sites where K. Magnacca collected other rare *Hylaesus* species in 1999, including lowland habitat (610 m/2000 ft) in Kanaio Natural Area Reserve and coastal habitat at Manawainui Gulch (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

2. Oahu (see Figure 1 and Appendix 1b)

There have been no recent collections of *H. assimulans* on Oahu, and it may have been extirpated from that island (Magnacca 2005, Magnacca 2007). At least 5 sites on Oahu, including one historic collection site, were recently searched for *Hylaesus* species, and *H. assimulans* was not found at any of these sites (Daly and Magnacca 2003). Goat Island, an islet offshore of Oahu, was also searched, and *H. assimulans* was not present, although another rare coastal *Hylaesus* species was collected (S. Plentovich, pers. comm., Oct 2008).

Kaena Point Natural Area Reserve contains the best remaining coastal habitat for *Hylaesus* on Oahu. Other rare coastal and lowland *Hylaesus* species were collected at Kaena Point on Oahu in multiple visits by several researchers between 1998 and 2008 but *H. assimulans* was absent (Daly and Magnacca 2003, H. Sahli, unpublished data). The fact that *H. assimulans* was absent from the best remaining potential habitat on Oahu strongly suggests that it has been extirpated from that island.

Hylaesus assimulans was also absent from additional coastal sites with suitable habitat. K. Magnacca searched coastal habitat at Makapuu and Barber's Point, which contain vegetation similar to Kaena Point but in a more degraded condition, in 1999 and 2002 respectively, but did not find any *Hylaesus* species (K. Magnacca, pers. comm., July 2008). Magnacca observed that historic localities for *H. assimulans* in and around the coastal Honolulu and Waianae areas have been lost to development, and that other former *Hylaesus* habitat has been built upon or overcome with invasive vegetation (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., July 2008).

3. Lanai (see Figure 1 and Appendix 1c)

Hylaesus assimulans is extremely rare on Lanai, and remains only in small pockets of native vegetation (K. Magnacca, pers. comm., July 2008). Seven sites on Lanai with suitable habitat for *H. assimulans* have been searched recently, and *H. assimulans* was found at only 2 of these locations. In 1999, two specimens were collected from lowland dry habitats near Polihua Road (300 m/1000 ft), and one specimen was collected from Manele Road (180 m/600 ft). *Hylaesus assimulans* was absent from 5 other sites with suitable habitat on Lanai searched by K. Magnacca between 1998 and 2006. Two of these sites were historic collection sites for this species: lowland habitat on Mt. Koele on the main part of Lanai Mountain, and coastal habitat at Awalua on the western edge of Shipwreck Beach in northwestern Lanai (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Between 1999 and 2001 Magnacca searched similar habitats nearby these historic collecting sites (Mt. Koele on the Munro Trail and Kaiholena (732 m/2400 ft); Shipwreck Beach near Awalua), but did not find *H. assimulans*. *Hylaesus assimulans* was also absent in searches for *Hylaesus* species between 1999 and 2001 in lowland dry forest at two elevations in the Kahue Unit of the Kanepuu Preserve (427 m/1400 ft and 490m/1600 ft) in northern Lanai, and at the Garden of the Gods (430 m/1400 ft). Other rare *Hylaesus* species were present in recent collection efforts at Kahue and Shipwreck Beach.

4. Kahoolawe (see Figure 1 and Appendix 1d)

A population of *H. assimulans* was discovered in 1997 in coastal habitat on Kahoolawe at Kamohio. *Hylaesus assimulans* was previously unknown from Kahoolawe (Daly and Magnacca 2003, K. Magnacca, pers. comm., Jan. 2008, July 2008). It was absent from one other site where other *Hylaesus* species were collected: lowland habitat on the east coast at Pali o Kalapakea.

5. Molokai (see Figure 1 and Appendix 1e)

Hylaesus assimulans has never been collected from Molokai, although it probably occurred there since almost all *Hylaesus* species that are found on Lanai, Oahu and Maui also occurred on Molokai (K. Magnacca, pers. comm., July 2008). Recent search efforts have been made in 5 sites on Molokai, but *H. assimulans* was not present at any of the sites. Other rare *Hylaesus* species were recently collected at 4 of these sites (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Figure 1. Historic and recent collections, and recent search effort for *Hylaeus assimulans*.

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.

	SITE	ELEVATION	Perkins' historic <i>H. assimulans</i> collections (1892-1906)	Recent <i>H. assimulans</i> searches and collections (1997-2006)	Other native <i>Hylaeus</i> spp. recently collected from the same site?
Oahu	"Oahu"		x		
	"w. coast, near sea level"***	Coast	x		
	Kaala Mtns	150 m/500 ft	x		
	Waianae	Coast	x	o	o
	Waianae Mountains	lowland	x		
	Honolulu	Coast	x	o	o
	Kaena Point NAR	Coast		o	x
	Makapuu	Coast		o	o
	Barber's Point	Coast		o	o
Maui	"Maui"		x		
	Wailuku Sand Hills (Waiehu Dune)	30 m/100 ft	x	o	x
	Wailuku Sand Hills - Kahului Section	30 m/100 ft	x	o	
	Waikapu	120 m/394 ft		x	x
	Kanaio NAR	600 m/2000 ft		o	x
	Manawainui Gulch	coast		o	x
	Lahainaluna (West Maui NAR)	550 m/1800 ft		x	x
Lanai	Awalua/Shipwreck Beach	coast	x	o	x
	Kanepuu Preserve, Kahue Unit	1600 ft		o	x
	Garden of the Gods	1400 ft		o	x
	Mts. Koele/Munro Trail/Kaiholena	600 m/2000 ft	x	o	x
	Manele	180 m/600 ft		x	o
	Polihua Road	300 m/1000 ft		x	x
	Kahue	430 m/1400 ft		o	x
Molokai	Moomomi Preserve	coast		o	x
	Northwest Molokai dunes	coast		o	o
	Hoolehua Beach	coast		o	x
	Kaupikiawa	coast		o	x
	Kuololimu Point	coast		o	x

Kahoolawe	Kamohio	coast		x	o
	Pali o Kalapakea	300 m/1000 ft		o	x

VI. HABITAT REQUIREMENTS

A. Overview

Hylaeus assimulans is endemic to the Hawaiian Islands of Oahu, Lanai, Maui, Kahoolawe, and has narrow habitat requirements. It likely existed historically on Molokai, although it has not been collected there recently. It depends largely on coastal strand, lowland dry forest and shrubland habitats, which are increasingly degraded, rare and patchily distributed (Cuddihy and Stone 1990, Liebherr 2005, Magnacca 2005, Magnacca 2007, Sakai *et al.* 2002).

1. Habitat distribution

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), *Jaquemontia ovata* (pau o Hiiaka), and *Sesuvium portulacastrum* (akulikuli or sea purslane).

Lowland dry forests on the Hawaiian Islands occur on leeward slopes up to 500 to 1000 m (1640-3280 ft) elevation and receive up to 1250 mm (50 in) rainfall annually (Cuddihy and Stone 1990). They are typically dominated by *Diospyros sandwicensis* (lama) or *Metrosideros polymorpha* (ohia lehua), and a diversity of native shrubs grows in the understory (Cuddihy and Stone 1990, Wagner *et al.* 1999).

Dry shrubland habitats on the Hawaiian Islands occur up to 610 m (2000 ft) elevation, and 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), *Wikstroemia* species (akia), *Chenopodium oahuense* (aweoweo), *Bidens menziesii* (kookoolau), *Styphelia tameiameia* (pukiawe), *Psydrax odoratum* (alahee), and low-growing *Metrosideros polymorpha* (ohia). Dry shrubland is usually characterized by mixed stands with one or two of these species as dominant. Adventive grasses are abundant in dry shrublands (Cuddihy and Stone 1990).

2. Relationships with plants

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

Hylaeus assimulans has been observed visiting the flowers of *Sida fallax* (ilima) and *Lipochaeta lobata* (shrubland nehe). *Sida fallax* is its probable primary food plant (K. Magnacca, pers. comm. Sept.

2008). *Hylaeus assimulans* is seemingly more closely associated with *Sida* species than other *Hylaeus* species, and may be common where this plant is abundant (Daly and Magnacca 2003, Magnacca 2005, Magnacca 2007, K. Magnacca, pers. comm., July 2008). In recent collections, *Hylaeus assimulans* seems to be less restricted to coastal strand habitat and more common in dry forest at relatively higher elevation, which may be related to the abundance of *Sida* in the understory in much of this habitat (Magnacca 2005).

Hawaiian *Hylaeus* species are highly dependent on relatively few species of native Hawaiian plants, and probably require a mix of native species (Daly and Magnacca 2003). In addition to its known flower records, it is likely that *H. assimulans* visits 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* (koa), *Metrosideros polymorpha* (ohia), *Styphelia tameiameia* (pukiawe), *Scaevola* species (naupaka), and *Chamaesyce* species (akoko). In coastal sites, the most important pollen sources for *Hylaeus* species are *Scaevola* spp., *Chamaesyce* spp., *Myoporum sandwicense*, *Tournefortia argentea* (non-native, tree heliotrope), *Jacquemontia ovata*, and *Sida fallax* (K. Magnacca, unpub. data). In dry shrubland habitats, *Hylaeus* species collect approximately 70% of pollen from four genera: *Styphelia*, *Dodonaea*, *Metrosideros* and *Sophora* (K. Magnacca, pers. comm., Aug 2008). Several larger genera of native plants serve as secondary host plants for many *Hylaeus* species (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

Hylaeus assimulans' nesting habits are unknown, but it probably nests in the ground like related species (Magnacca 2005). Nest site availability is an important habitat requirement for *Hylaeus* populations; ground-nesters need relatively dry conditions (Zimmerman 1972, Daly and Magnacca 2003).

B. Diet

1. Larvae

Larvae of *H. assimulans* are unknown. In other species of *Hylaeus*, and likely in *H. assimulans*, 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. assimulans* is known to visit *Lipochaeta lobata* (shrubland nehe) and *Sida fallax* (ilima) (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

C. Life Cycle

The egg, pupa, larva and nests of *H. assimulans* are unknown. Other *Hylaeus* species make solitary nests in pre-existing cavities in hollow stems, wood, crevices, or under bark, 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 *Hylaeus* deposits eggs in brood cells that she constructs in the nest. She lines her brood cells with a self-secreted cellophane-like material. *Hylaeus* species 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. assimulans* on protected land besides those in Lahainaluna in the West Maui Natural Area Preserve on Maui, Kamohio on Kahoolawe, and one population in a very small remnant of native vegetation in Waikapu Valley on Maui (Magnacca 2005, Appendices 1c,e). 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, invasive invertebrates and the replacement of native vegetation by invasive plants (Magnacca 2007).

Hylaeus assimulans depends largely on coastal strand and dry lowland habitats, which are increasingly rare and patchily distributed (Magnacca 2005 a, b; Cuddihy and Stone 1990). Lowland dry forest and shrubland have been all but eliminated on most of the Hawaiian Islands; less than 1% of these habitats remain on Oahu, Molokai and Lanai, less than 2% remains on Maui, and less than 17% remains on Hawaii (Sakai *et al.* 2002). Across all the Hawaiian Islands, more than 90% of dry forests in Hawaii have been destroyed (Mehrhoff 1993, Bruegmann 1996). The loss of coastal and dry lowland habitats since human occupation on Oahu is illustrated in the maps in Appendix 2a-b. Coastal strand habitat has similarly been lost to development or overtaken by invasive vegetation: 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 (K. Magnacca, pers. comm., July 2008). Almost all of the coastal and lowland collection sites where Perkins collected *Hylaeus* species between 1892 and 1906 have changed drastically (Liebherr and Polhemus 1997).

In general, the main Hawaiian Islands are more heavily vegetated now than they were during the period when Perkins collected, although much of that vegetation is non-native. 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 by Perkins and other naturalist collectors. Grazing by feral ungulates has since decreased and invasive 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 habitat status of all historic and recent collection sites for *Hylaeus assimulans* are discussed in detail below, with the exception of three unknown sites labeled by Perkins as “Oahu,” “w. coast, near sea level” and “Maui.”

1. Maui

Habitat in most of Perkins' collection sites on Maui has been lost to development (Liebherr and Polhemus 1997). *Hylaeus assimulans* is extremely rare here, and remains in very small pockets of native lowland vegetation (K. Magnacca, pers. comm., July 2008). See Figure 1 for a table of collection sites, and Appendix 1a for a map of collection sites.

a. Wailuku sand hills (Waiehu dunes) & Wailuku Sand Hills - Kahului Section

The Wailuku sand hills were Perkins' primary collection site for *Hylaeus* on Maui (Magnacca 2007). All that remains of this native habitat is a very small (less than 1 ha) remnant of sand dune coastal habitat on state lands at Waiehu near a golf course. 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 the rare *H. longiceps* from the Waiehu dunes in 1999 and 2001, but *H. assimulans*, as well as several other species once collected there by Perkins, were absent (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

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

b. Lahainaluna

K. Magnacca collected *H. assimulans* at this dry lowland forest at 550 m (1800 ft) on the western side of Maui in 1999. This site is in the West Maui Natural Area Reserve, which is protected by the state (DLNR 1989). The management plan for the Reserve calls for the control and removal of feral ungulates, and the control of selected priority invasive plant species (DLNR 1989).

c. Waikapu

This locality where *H. assimulans* currently exists is at 120 m (400 ft) in Waikapu Valley, to the south of Iao Valley on the eastern side of West Maui. It is on private property maintained by the Native Hawaiian Plant Society (NHPS). The site is approximately 10,000 ft² and is surrounded by an enclosure fence. The enclosure and adjacent area are dominated by *Dodonaea viscosa* (aalii), an indigenous Hawaiian plant with a cosmopolitan distribution (Wagner *et al.* 1999). The fence was built in the mid-1980s by the NHPS, and they currently maintain the enclosure by inspecting the fence, weeding, and collecting seeds of native species. Threats include a nearby population of axis deer (*Axis axis*) and fire. There have been two major fires in the past five years in the vicinity of the enclosure, although neither fire has burned the enclosed area (H. Oppenheimer, pers. comm., July 2008). The site is mistakenly noted as "Kaohonua" in Daly and Magnacca (2003) (K. Magnacca, pers. comm., July 2008).

2. Oahu

Hylaeus assimulans is likely extirpated from Oahu. A map of collection sites on Oahu is in Appendix 1b. Maps of habitat loss on Oahu since human occupation are in Appendix 2.

a. Honolulu

Perkins collected *H. assimulans* in 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 Appendix 2, the Honolulu area was once characterized by a mix of lowland dry forest, shrubland and grassland, but these ecosystems have been eliminated from the area. In Perkins' time, the valleys behind Honolulu were open ranch and farmland, but have since been replaced with urban development (Leibherr and Polhemus 1997). Habitat has been converted for tourism or other urban development, and covered with roads, structures, and alien vegetation, or intentionally afforested 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 (Leibherr 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. Kaala

Perkins (1899) collected *H. assimulans* on the ridges of the north side of Kaala above Waialua. Dry lowland habitats were once much more expansive in these mountains, as illustrated in Appendix 2a-b. This area of habitat is not currently protected.

c. Waianae Mountains

Perkins (1899) collected *H. assimulans* in the Waianae Mountains, upland from Waianae. Dry lowland habitats were once much more expansive in these mountains, as illustrated in Appendix 2a-b. This area of habitat is protected within the state Waianae-Kaala Forest Reserve but is not intensively managed for native species.

d. Waianae

Perkins (1899) collected *H. assimulans* in coastal habitat in 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. This historic collection site is not protected, and there is abundant suburban development. The site where Perkins collected has been developed with housing that extends up into Waianae Valley. Much of the native vegetation was destroyed by brush fires (Liebherr and Polhemus 1997). Habitat loss in this area is illustrated in the maps in Appendix 2a-b.

3. Lanai

Hylaeus assimulans is extremely rare on Lanai, and remains only in very small pockets of native lowland vegetation; coastal habitat is less common on Lanai than on Maui. All of Lanai is privately owned. A map of collection sites on Lanai is in Appendix 1c.

a. Awalua

Perkins (1899) collected *H. assimulans* in coastal habitat at Awalua, on the northern coast of Lanai. The area was uninhabited at the time Perkins collected, and bees and wasps were abundant on the “usual coast flowers” (Evenhuis 2007). This area is currently not managed for conservation of native species. Magnacca searched similar habitat nearby at Shipwreck Beach in 2001 and *H. assimulans* was not present; Perkins’ Awalua collection site has not been searched recently (Daly and Magnacca 2003).

b. Mts. Koele

Perkins collected *H. assimulans* from “Mts. Koele,” at 610 m (2000 ft) in the main part of the Lanai Mountain, east of Lanai City. He made many collecting trips up to the highest peaks of the Koele Mountains (Perkins 1899, Evenhuis 2007). This area is currently not managed for conservation of native species. K. Magnacca recently searched this site along the Munro Trail and at Kaiholena and did not find *H. assimulans*.

c. Polihua Road

K. Magnacca collected *H. assimulans* in lowland dry forest along Polihua Road (300 m/1000 ft), in central Lanai in 1999. This area is not managed for conservation of native species.

d. Manele Road

K. Magnacca collected *H. assimulans* in 1999 in lowland dry forest along Manele Road (180 m/600 ft), north of Manele Beach in southern Lanai. He observed on this visit that the canopy was dominated by (invasive) kiawe trees, and the understory had a dense stand of ilima (*Sida fallax*), the probable preferred food plant for *H. assimulans* (K. Magnacca, pers. comm., Sept. 2008). However, with the exception of a few stunted plants at the roadside where moisture had accumulated, the rest of the stand of ilima had senesced or possibly died. K. Magnacca observed that native vegetation at this site was prone to drought and probably did not provide consistent habitat for *Hylaeus* throughout the year (Magnacca 2007, K. Magnacca, pers. comm. Oct 2008). This area is not managed for conservation of native species.

4. Kahoolawe

See Figure 1 for a table and Appendix 1d for a map of collection sites on Kahoolawe.

a. Kamohio

David Foote collected *H. assimulans* at Kamohio, near the high cliffs of Kamohio Bay in the center of the southern coast of Kahoolawe (Daly and Magnacca 2003). This is one of the three known remaining populations of *H. assimulans* on land that is protected from development (Magnacca 2005). The island is uninhabited. Erosion of soil caused by grazing has resulted in the loss of much of the native coastal strand and lowland habitat on Kahoolawe (Warren 2004, Magnacca 2005). Kahoolawe was used by the U.S. military since 1941 for military practice, including the testing of bombs and target practice. In 1993 Congress ended military use on Kahoolawe, and the Kahoolawe Island Reserve Commission (KIRC) was created to manage land use and restoration of natural resources on the entire island of Kahoolawe (the Kahoolawe Island Reserve). In 1994 the island was signed over to the people of Hawaii and can only be used for Native Hawaiian activities, fishing, environmental restoration, historic preservation, and education; commercial uses are prohibited (Warren 2004).

E. Current Conservation Efforts

The federal and state governments have not developed any conservation plans for *Hylaeus assimulans*, 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. assimulans* are the loss of its habitat and the encroachment into this habitat of invasive plant species that are displacing native plant communities (Cuddihy and Stone 1990, Daly and Magnacca 2003, Magnacca 2005). Coastal and lowland habitats have been most heavily impacted by human occupation. More than 75% of the recognized coastal and lowland habitat types in Hawaii are rare, and as of 1987, a third of these coastal and lowland sites were not protected from development (Nature Conservancy of Hawaii 1987). Almost all of the coastal and lowland collection sites where Perkins collected *Hylaeus* species between 1892 and 1906 would be unrecognizable to him now (Liebherr and Polhemus 1997). Two maps in Appendix 2 illustrate the extent of habitat loss to development on the island of Oahu.

1. Habitat loss

a. 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 assimulans was once widespread and the decline in the number of its populations has paralleled the loss of coastal habitat (Magnacca 2005). It is now restricted to a portion of the remaining few localities of coastal strand habitat and dry lowland forest (Daly and Magnacca 2003). *Hylaeus assimulans* is now absent from many of Perkins' historic collection localities, which have been developed or taken over by invasive plant species. These areas include the Waianae area and Honolulu on Oahu, the Wailuku sand hills on Maui, and Awalua on Lanai (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.

b. The loss of lowland dry forest and lowland dry shrubland

Dry lowland forest and shrubland were once abundant and considered some of the most diverse of all Hawaiian habitat types but are now very rare (Magnacca 2007). 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). Less than 1% of these two habitat types remains on Oahu, Molokai and Lanai, less than 2% remains on Maui, and less than 17% remains on Hawaii (Sakai *et al.* 2002). The loss of dry lowland forest has been greatest on the middle islands of Maui Nui (Maui, Lanai and Molokai) and Oahu (Gagne 1988, Magnacca 2005). Loss of lowland dry habitats is due to conversion for other uses, or the influx of non-native plant species that out compete native species. 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).

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 coastal strand and dry lowland habitats (Cuddihy and Stone 1990, Mascaro *et al.* 2008). 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. assimulans* 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 assimulans* is limited to coastal and lowland elevations (up to 610 m/2000 ft) (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).

Native coastal vegetation in many sites is threatened by *Prosopis pallida* (kiawe), an invasive deciduous thorny tree. Other invasive plant species abundant in coastal habitats include *Melinis minutiflora* (molasses grass), *Leucaena leucephala* (koa haole), and *Cenchrus ciliaris* (buffelgrass). Species that commonly invade lowland dry forest include *Lantana camara* (lantana), koa haole, molasses grass, *Pennisetum clandestinum* (kikuyu grass), *Psidium guajava* (guava), and *Schinus terebinthifolius* (Christmas berry). Lowland dry shrubland is commonly invaded by molasses grass, koa haole, kiawe, buffelgrass, and *Cynodon dactylon* (Bermuda grass) (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 assimulans* 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 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 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 replaced by non-native pollinators, and that *Hylaeus* are very important for the reproduction of native plants. The loss of populations of *H. assimulans* 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). 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 Hawaiian plants that occur on multiple islands (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 *Chamaesyce* species (akoko), *Scaevola* species (naupaka), and *Sesbania tomentosa* (ohai). *Hylaeus assimulans* has been observed visiting flowers of

Lipochaeta lobata on Maui. A variety of this plant species that only occurs on Oahu, *Lipochaeta lobata* var. *leptophylla* (nehe), is federally listed as an endangered species. It is possible that former populations of *Hylaeus assimulans* on Oahu pollinated this plant.

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. assimulans* (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* 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).

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

1. Collection

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. assimulans*, which is rare and has small populations, the collecting of a small number of individuals could significantly reduce the 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 1990). The native Hawaiian invertebrate fauna evolved in the absence of all social insects (Zimmerman 1948, Wilson and Taylor 1967, Howarth 1985), and the native species are not adapted to defend themselves against 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 invasive ant species in Hawaii, *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. assimulans*. *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* occurs from sea level to 800 m and has been found up to 1200 m (Medeiros *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 invasive vegetation (Reimer 1994). *Pheidole megacephala* and *A. gracilipes* are generalist predators and are very abundant and aggressive (Holway *et al.* 2002).

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 preying on seeds of native plants (Bond and Slingsby 1984). Invasive ants' largest ecosystem-level effect has been to negatively affect pollination, partially due to direct predation on the larvae of *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 assimulans* likely nests in the ground like related *Hylaeus* species, and thus its brood would 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 besides the native *Hylaeus* species (Snelling 2003), including two non-native *Hylaeus* species. Most non-native bees inhabit areas dominated by invasive vegetation and thus are not competing with natives (Daly and Magnacca 2003). *Apis mellifera* (the European honeybee) is a major exception; this social species is often very abundant in areas with native vegetation, and aggressively competes with *Hylaeus* species 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* species (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* spp., *Hylaeus albonitens*, and *Lasioglossum impavidum* (Magnacca 2007). These may have a significant impact on *H. assimulans* through competition for pollen, because they are more similar in size and probably visit similar flowers. The impact of these species on *Hylaeus* species has not been studied (Magnacca 2007).

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

Vespula pensylvanica (the western yellow jacket wasp) is a social wasp native to North America. It was first reported on Oahu in the 1930s (Sherley 2000), and an aggressive race had become established by 1977 (Gambino *et al.* 1987). In temperate climates, *V. pensylvanica* has an annual life cycle, but in Hawaii's tropical climate, populations of individuals of this species persist through a second year, allowing them to have larger numbers of individuals in colonies (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), but they can be found down to sea level (Gambino *et al.* 1990). *Vespula pensylvanica* is an aggressive opportunist generalist predator, and predated on *Hylaeus*, although *Hylaeus* is not its primary prey source (Gambino *et al.* 1987). Because of the rarity of *H. assimulans*, 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 apply to *Hylaeus assimulans*. Only three known populations of *H. assimulans* are on land that is protected from development: in Kamohio on Kahoolawe (Appendix 1d), in Lahainluna in the West Maui Natural Area Reserve (Appendix 1a), and in a native plant enclosure at Waikapu on Maui (Appendix 1a) (Magnacca 2005, K. Magnacca, pers. comm., July 2008).

It is important to note that even in areas 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. assimulans* will likely require active management of protected areas, which can include exclusion and removal of feral ungulates, control and removal of invasive plant and insect species, and the restoration of native vegetation. Existing regulatory mechanisms are inadequate to provide the necessary active management to protect *Hylaeus assimulans*.

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

2. Global climate change

Global climate change may threaten *H. assimulans*. 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 assimulans* 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. assimulans* with changes in rainfall patterns, since this species inhabits dry areas, some 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. assimulans*. 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. assimulans* 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 assimulans is endemic to the Hawaiian Islands of Oahu, Lanai, Maui, Kahoolawe, and probably once occurred on 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. assimulans*, 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).

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 if associated with narrow habitat specificity (Sakai *et al.* 2002) as is *H. assimulans* (Daly and Magnacca 2003). Furthermore, the close interdependence of Hawaiian endemic flora and their endemic pollinators (Sakai *et al.* 1995, Cox and Elmqvist 2000) makes them vulnerable to reciprocal decline and extinction (Cox and Elmqvist 2000).

VIII. CONCLUSION

Hylaeus assimulans is a rare bee endemic to the Hawaiian Islands that is in imminent danger of going extinct. *Hylaeus assimulans* is endemic to the Hawaiian islands of Oahu, Maui, Kahoolawe and Lanai, and it likely used to inhabit Molokai. There is strong evidence of significant decline of *H. assimulans* (Magnacca 2005, Magnacca 2007). It is largely restricted to extremely rare native lowland dry forest and shrubland, and coastal strand habitat (Daly & Magnacca 2003, Magnacca 2005, Magnacca 2007). Species numbers have declined precipitously with the concurrent loss and degradation of these habitats. It was absent from many of its historic localities that were revisited by Karl Magnacca between 1998 and 2005, and from many sites with suitable habitat where other *Hylaeus* species have been recently collected (Daly & Magnacca 2003, K. Magnacca, pers. comm. July 2008).

The primary threats to *H. assimulans* 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 that they depend on 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. assimulans* 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 assimulans* is threatened with extinction and must be given protection under the Endangered Species Act.

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Personal Communication

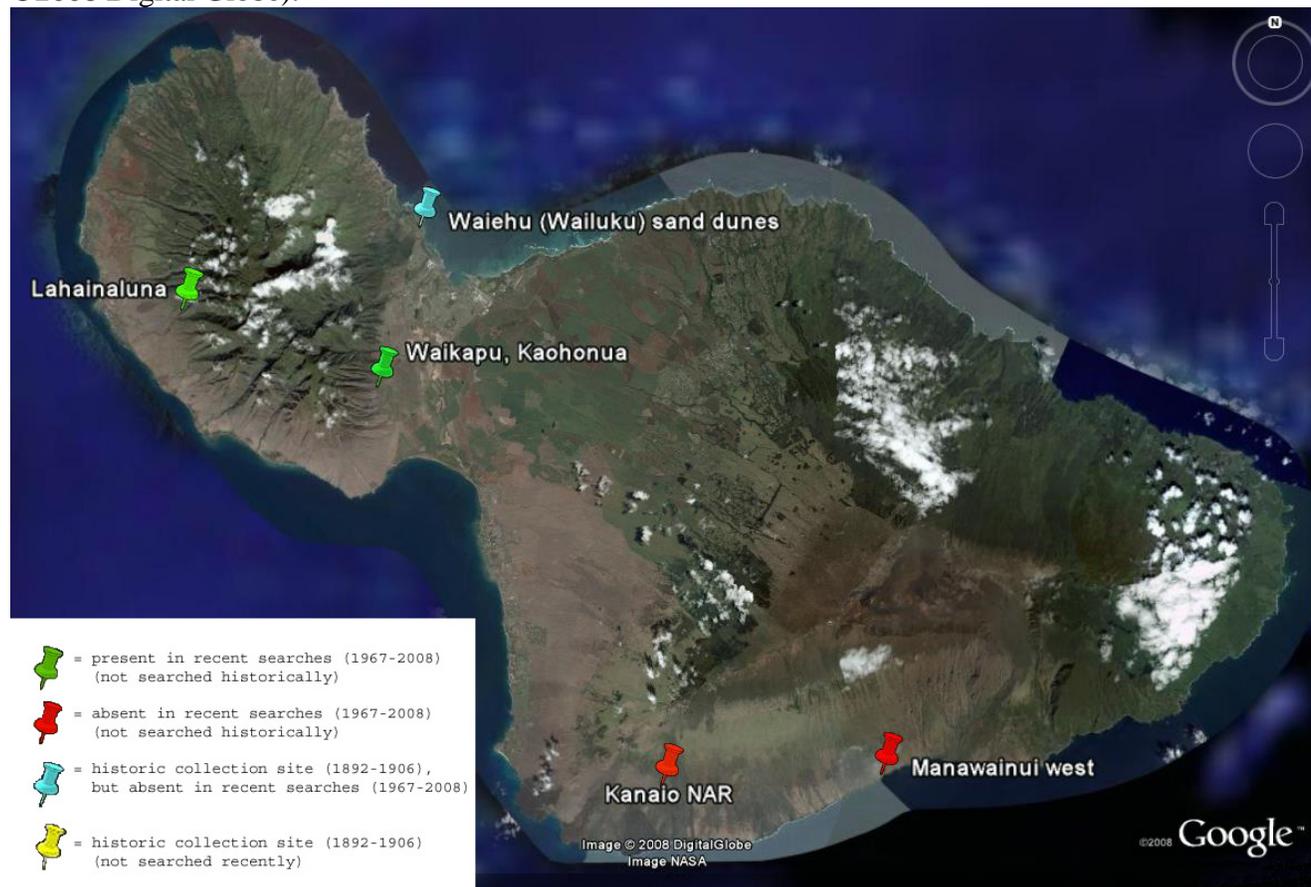
- K. Magnacca, Jan., July, Aug., Sept., Oct. 2008
H. Oppenheimer, July 2008
S. Plentovich, Oct. 2008

Unpublished data

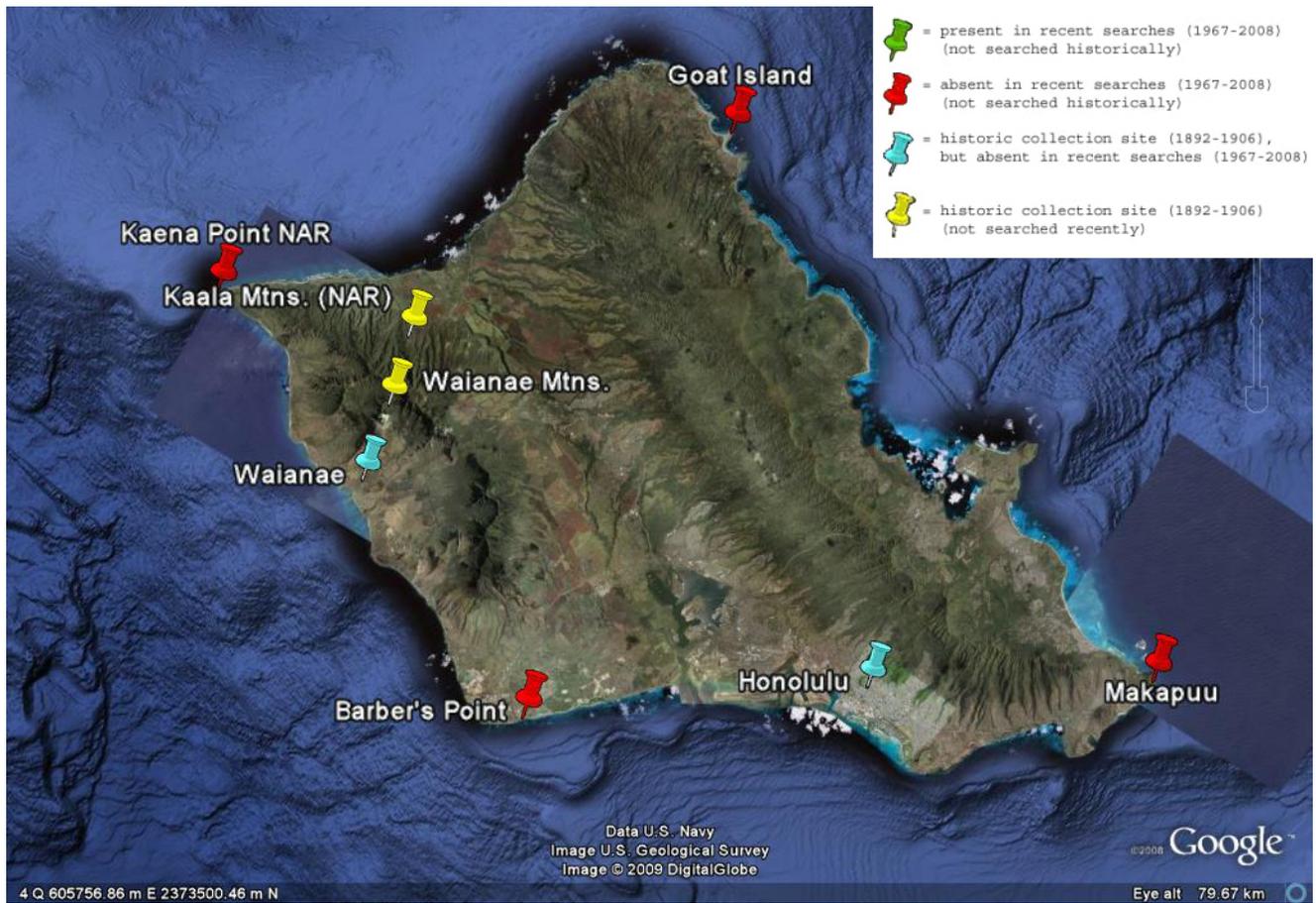
- K. Magnacca
H. Sahli

X. APPENDIX IA-E. Locations of recorded specimens of *Hylaeus assimulans*.

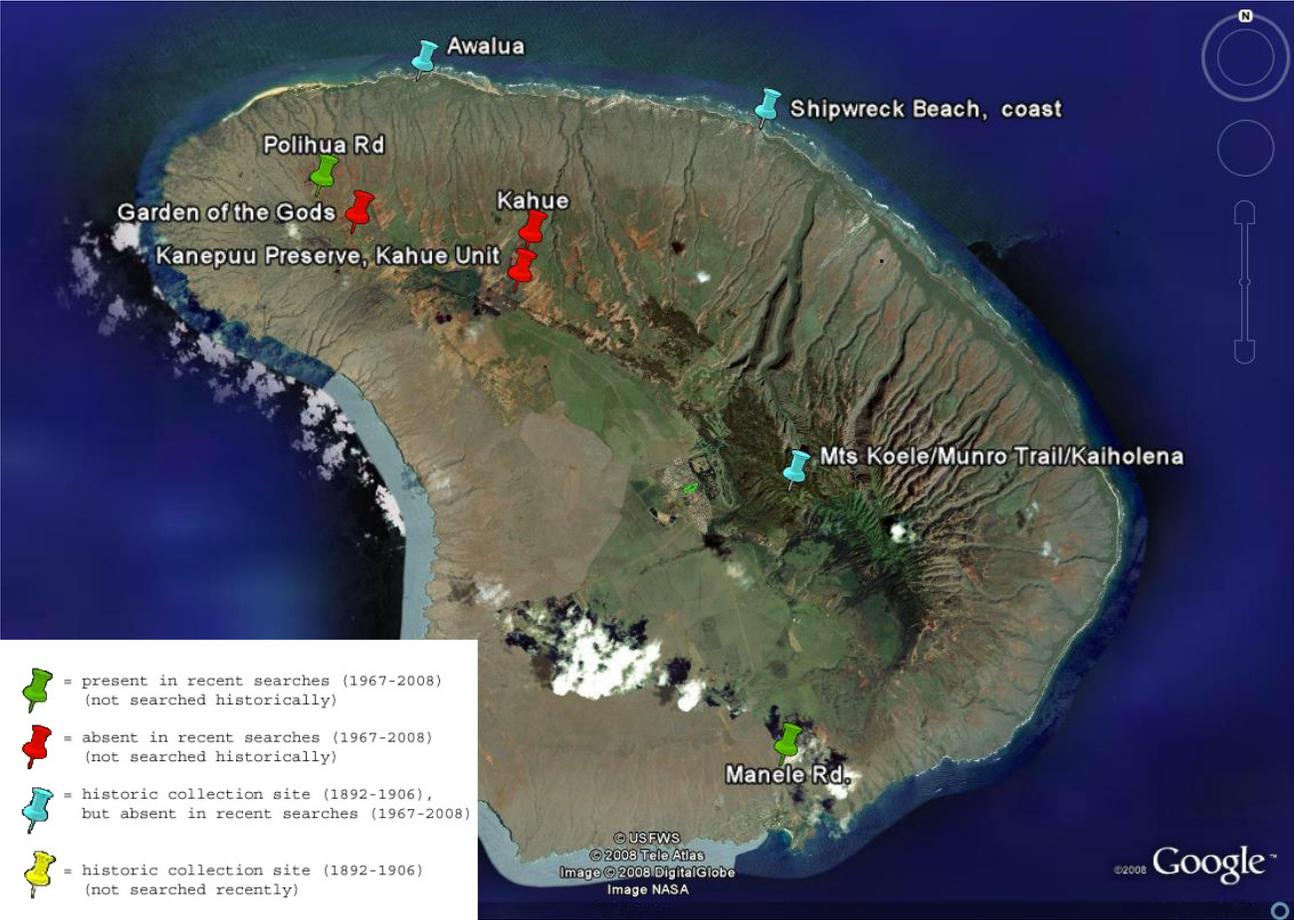
Appendix IA. Map of Maui showing recent and historic collection sites for *Hylaeus assimulans* (map ©2008 Digital Globe).



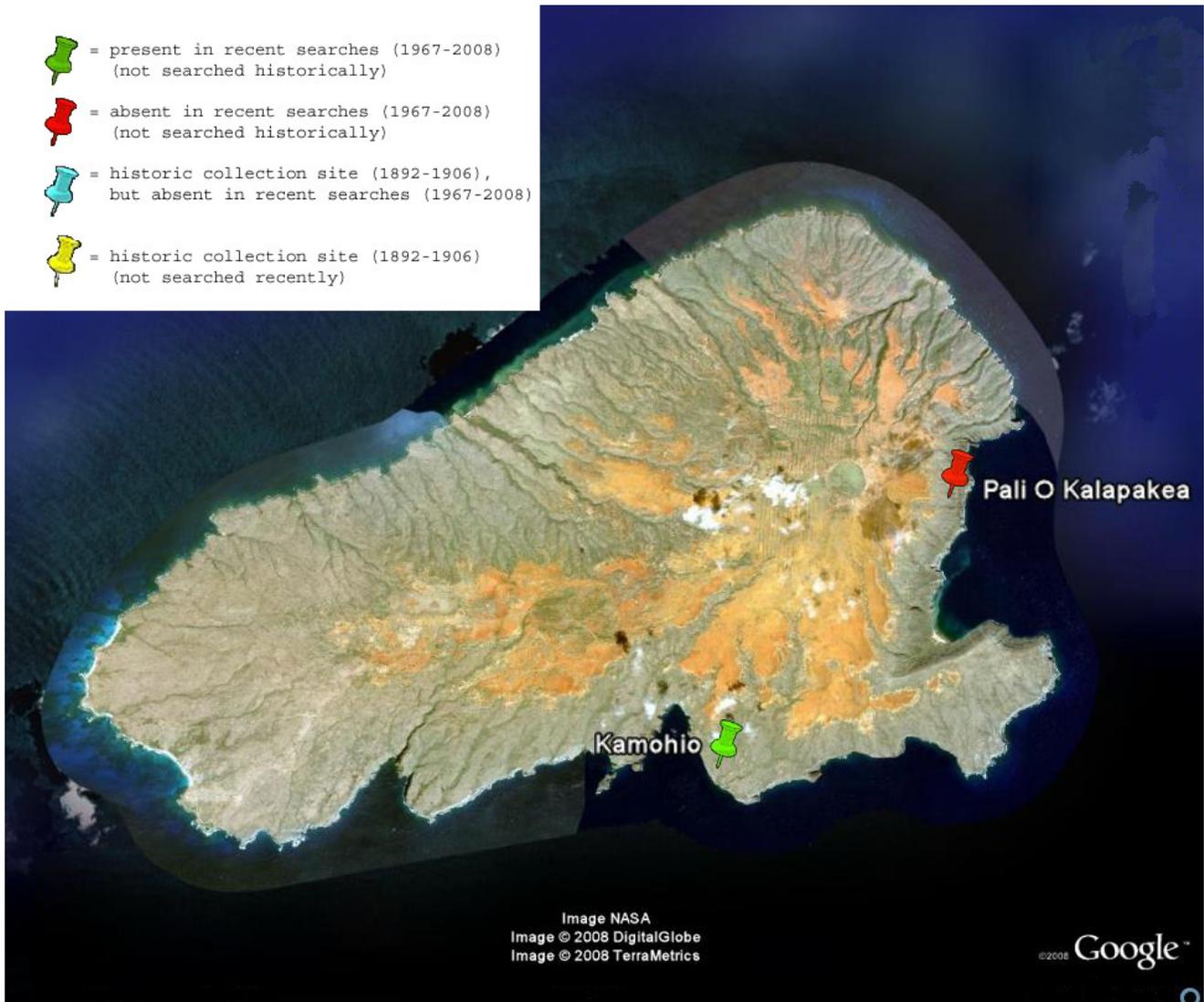
Appendix IB. Map of Oahu with recent and historic collection sites for *Hylaes assimulans* (map ©2008 Digital Globe).



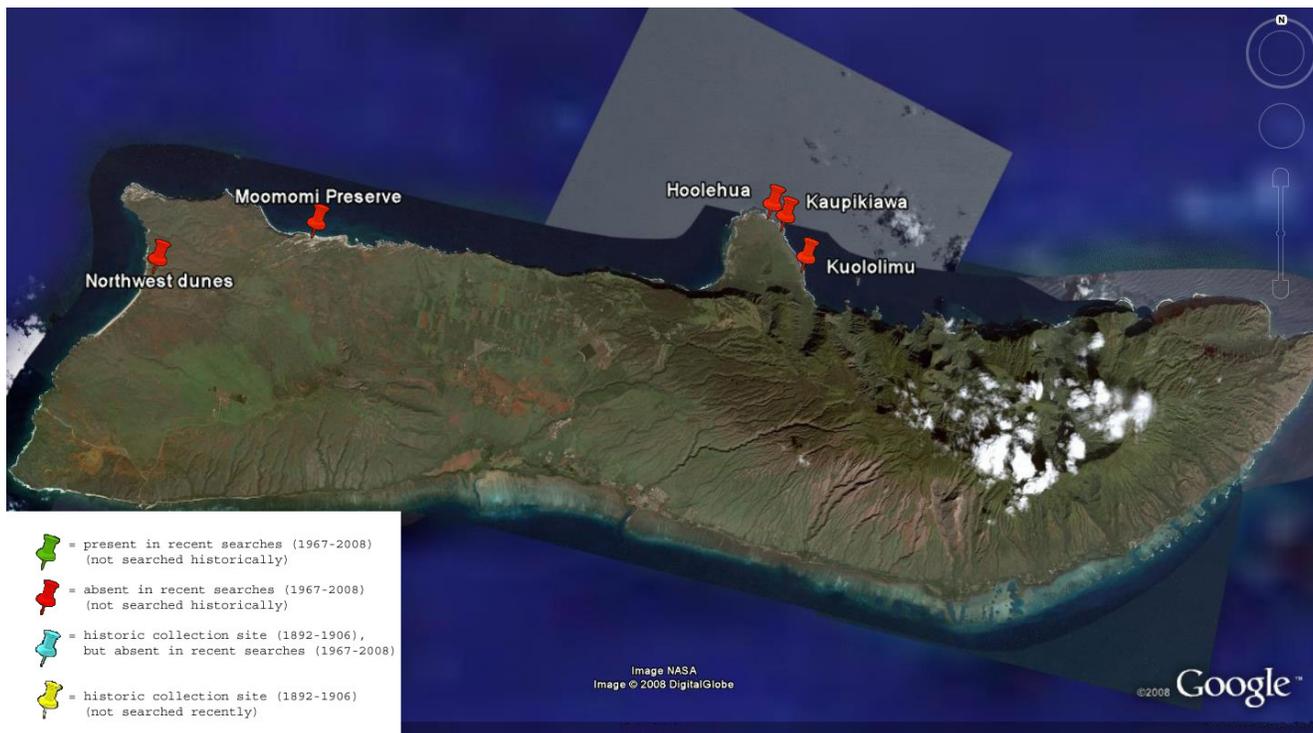
Appendix IC. Map of Lanai with historic and recent collection sites for *Hylaes assimulans* (map ©2008 Digital Globe)



Appendix ID. Map of Kahoolawe showing recent collection sites for *Hylaes assimulans* (map ©2008 Digital Globe).

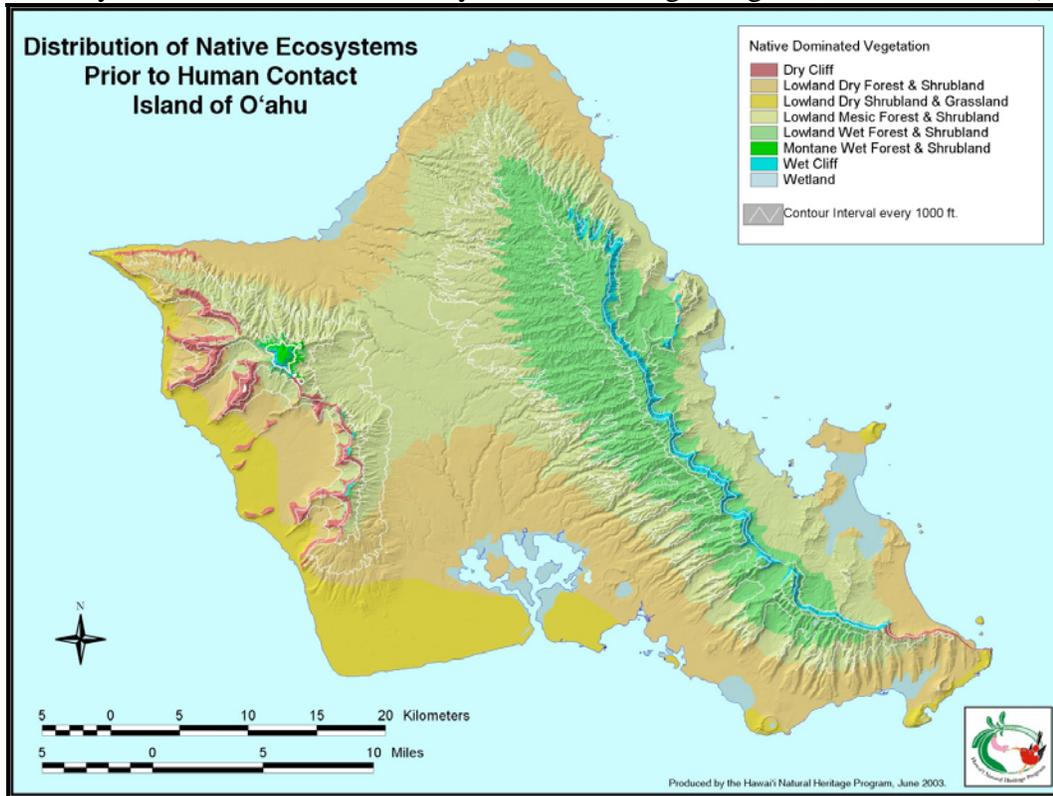


Appendix IE. Map of Molokai showing all sites where *Hylaes assimulans* was searched for but not found (map ©2008 Digital Globe).



XI. APPENDIX IIA-B: Distribution of native ecosystems (a) prior to human contact and (b) currently on the island of Oahu.

Appendix IIA. Distribution of native ecosystems prior to human contact on the island of Oahu (map courtesy of The Nature Conservancy Natural Heritage Program, from HCA 2003).



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

