PETITION TO LIST
TWO SPECIES OF HAWAIIAN YELLOW-FACED BEES
Hylaeus anthracinus and *Hylaeus longiceps*
AS ENDANGERED UNDER THE U.S. ENDANGERED SPECIES ACT

Prepared by

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Submitted by

The Xerces Society for Invertebrate Conservation

March 23, 2009

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

Dear Mr. Salazar:

The Xerces Society hereby formally petitions to list the Hawaiian yellow-faced bees *Hylaeus anthracinus* and *Hylaeus longiceps* 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 anthracinus* and *Hylaeus longiceps* are threatened with extinction and must be given protection under the Endangered Species Act.

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

Sincerely,

Scott Hoffman Black, Executive Director
Xerces Society
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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 anthracinus and *Hylaeus longiceps* are two rare Hawaiian yellow faced bees endemic to the Hawaiian Islands that are in imminent danger of going extinct. There is strong evidence of significant decline of *H. anthracinus* and *H. longiceps*, and they are two of the most highly endangered native Hawaiian *Hylaeus* species (Magnacca 2007a). 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). However, recent surveys indicate that most *Hylaeus* species are in decline, many are extremely rare, and several are possibly extinct (Daly and Magnacca 2003, Magnacca 2007a). *Hylaeus anthracinus* and *Hylaeus longiceps* were abundant in Perkins' time, but the continued loss of their habitat puts them at risk of extinction. *Hylaeus anthracinus* has disappeared from all its historic localities that were recently searched, and *H. longiceps* was only present at one (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Because remnant populations of *H. anthracinus* and *H. longiceps* are small and isolated, they are especially vulnerable to habitat loss, predation, stochastic events, and other changes to their habitat (Magnacca 2005a, b). They depend primarily on coastal strand and lowland dry habitats, which are increasingly rare and patchily distributed (Magnacca 2005a,b, Cuddihy and Stone 1990). Although some of the remnant populations of *H. anthracinus* and *H. longiceps* are on lands that are protected from development (Daly and Magnacca 2003, Magnacca 2005a,b; K. Magnacca, pers. comm., July 2008), these 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 2007a).

Conservation of *H. anthracinus* and *H. longiceps* 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. anthracinus* and *H. longiceps* and may cause their extinction if habitat is not managed for conservation of these species (Magnacca 2007a).

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 2008). *Hylaeus* might be important to the recovery of some threatened and endangered Hawaiian plants.

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

II. CANDIDATE BACKGROUND, STATUS, AND LISTING HISTORY

Hylaeus anthracinus and *H. longiceps* have Global Heritage Status Ranks of GNR, meaning that their ranks have not yet been assessed. Both species are listed as Critically Imperiled on the Xerces Society for Invertebrate Conservation's Red List of Pollinator Insects (Magnacca 2005a, b).

Hylaeus anthracinus and *H. longiceps* were listed by the United States federal government as "Category 2" Candidate Species in 1984 based on the recognition that all 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," respectively (USFWS 1996, Magnacca 2005a, b).

III. TAXONOMY

The taxonomy of *H. anthracinus* and *H. longiceps* is uncontested. *Hylaeus anthracinus* and *H. longiceps* are small bees 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 2007a). 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).

The most recent taxonomic treatment for both *H. anthracinus* and *H. longiceps* is Daly and Magnacca (2003).

Hylaeus anthracinus was described as *Prosopis anthracina* by F. Smith (1853), and then moved to the new genus *Nesoprosopis* by Perkins (1899). *Hylaeus longiceps* was described as *Nesoprosopis longiceps* by Perkins (1899). *Nesoprosopis* was reduced to a subgenus of *Hylaeus* by Meade-Waldo (1923). Although the distinctness of these species is unquestioned, recent genetic evidence (Magnacca and Brown, submitted) suggests that *H. anthracinus* may be composed of three cryptic species, representing the Hawaii, (Maui + Kahoolawe), and (Molokai + Oahu) populations, making conservation of all populations especially important.

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 their plumose hairs (Michener 2000).

Hylaeus anthracinus is a medium-sized black bee with clear to smoky wings and black legs. The male has a single large yellow spot on his face; the lower face is entirely yellow below the antennal sockets. The female is entirely black. *Hylaeus anthracinus* commonly occurs alongside *H. longiceps* or *H. flavipes*. The *H. anthracinus* female can be distinguished from them by the black hairs on the end of the abdomen and the unusual mandible with three teeth, which is a character that is only shared with its sister species on Kauai, *H. flavifrons* (Daly and Magnacca 2003, Magnacca 2005a).

Hylaeus longiceps is a medium-sized black bee with clear to slightly smoky wings. Its distinguishing characteristics are its long head and the male's facial marks. The male's lower face is entirely yellow, and the yellow area is extended at the sides in a broad stripe above the antennal sockets. The area above the clypeus is very long and narrow, and the scape is twice as long as it is wide. The female is entirely black and unmarked, with distinct punctation on the front of her head (Daly and Magnacca 2003, Magnacca 2005b).

B. Immature

Egg, larva, pupa, and nest of *H. anthracinus* and *H. longiceps* are unknown (Magnacca 2005a, b).

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 petition are from this collecting period. Perkins collected on all of the higher islands with the exception of Kahoolawe and Niihau (Hawaii, Oahu, Kauai, Maui, Lanai and Molokai) (Liebherr and Polhemus 1997). He called the *Hylaeus* "almost the most ubiquitous of any Hawaiian insects" (Perkins 1913), but more recent surveys (Daly and Magnacca 2003) indicate that most *Hylaeus* species are in decline, many are extremely rare, and several are possibly extinct (Daly and Magnacca 2003, Magnacca 2007a). *Hylaeus anthracinus* and *H. longiceps* are among the most endangered of Hawaiian *Hylaeus* species, and have not been found in recent searches of many of their historic collection localities, as detailed below under "current distribution" (see Figure 1 for a table of historic and recent collections of these species).

Hylaeus anthracinus is historically known from numerous coastal strand and dry lowland forest locations up to 610 m (2000 ft) elevation on the Hawaiian Islands of Oahu, Molokai, Kahoolawe, Maui, Hawaii and Lanai. It is also, but very rarely, found at higher elevations in dry forest. Historic collections made by Perkins indicate that *H. anthracinus* was once widespread and abundant in coastal habitat (Magnacca 2005a). Perkins noted that *H. anthracinus* was especially abundant in coastal and lowland habitats on Maui, Molokai and Lanai (Daly, H. V., unpub. data). On Hawaii, Perkins collected *H. anthracinus* from Kealakekua Bay and Kona. On Maui he collected it at the Wailuku sand hills (Waiehu dunes), with additional specimens labeled "Maui" and "Maui coast." On Lanai he collected *H. anthracinus* at Manele. On Oahu, he collected this species in Honolulu, Waialua, Waianae, in the Waianae Mountains, in Waikiki, and at unspecified coastal sites and one higher elevation site labeled "mts." On Molokai, Perkins collected *H. anthracinus* at Kauluwai (spelled "Kaulawai" on labels) and two unknown sites, one in the lower slopes of the mountains and the second in the "Molokai plains" (Perkins 1899, Daly and Magnacca 2003). See Appendix 1 for maps of Perkin's collection sites for *H. anthracinus.*

Hylaeus longiceps is historically known from numerous coastal strand and dry lowland shrubland locations up to 610 m (2000 ft) on the Hawaiian Islands of Oahu, Molokai, Lanai, and Maui. On Maui, Perkins (1899) collected *H. longiceps* from the Wailuku sand hills (Waiehu dunes) and Haleakala (2000ft), with additional specimens labeled "Maui." On Lanai he collected it in Manele, and unspecified localities (labeled "Lanai"). On Molokai Perkins collected *H. longiceps* at Kaunakakai, the "Molokai coast and plains", the "west end" of the island, and the "Molokai Mountains." Lastly, on Oahu, Perkins collected this species in coastal habitat in Waianae. See Appendix 2 for maps of Perkin's collection sites for *H. longiceps*.

Hylaeus anthracinus and *H. longiceps* probably occurred historically throughout much of the leeward and lowland areas on Maui Nui and Oahu, since their host plants, ilima (*Sida fallax*), akoko (*Chamaesyce* spp.), naupaka (*Scaevola* spp.), and pau o Hiiaka (*Jacquemontia ovata*) extended throughout this range. Nearly the entire habitat in this area has been either developed or degraded and is no longer suitable for *H. anthracinus* and *H. longiceps* (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., Sept 08).

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. K. Magnacca attempted to search for *Hylaeus* species at historic sites and in all habitats where they were likely to occur, but could not access some sites because of restricted access, weather, and time (Magnacca 2007a). Additional collection efforts were made between 1975 and 1997 by other researchers (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008), and between 2000 and 2008 by Heather Sahli, Patrick Aldrich, and Sheldon Plentovich (H. Sahli, P. Aldrich & S. Plentovich, pers. comm., July-Sept 2008).

Hylaeus anthracinus

There is strong evidence of significant decline of *H. anthracinus*. Although this species was once abundant in coastal and lowland habitats, degradation and loss of habitat have decreased its range significantly. It is now restricted to small populations in a few small patches of coastal and dry lowland habitat and also occurs very rarely at higher elevations (Magnacca 2005a), as seen in the maps in Appendix 1. *Hylaeus anthracinus* was absent from all of its historical sites that were recently searched (1997 - 2008). 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).

Recent search efforts for *Hylaeus* species have been made in 43 sites that were either historic collecting localities for *H. anthracinus* or contained suitable habitat for this species at the time of search effort. *Hylaeus anthracinus* was found at only 14 of these 43 sites, and has disappeared from all 9 of the historic localities that were searched. Several of these historical collection sites, such as Honolulu, Waikiki, and Kealakekua Bay, no longer contain *Hylaeus* habitat, which has been replaced by urban development or overcome with non-native vegetation (Perkins 1899, Liebherr and Polhemus 1997, Daly and Magnacca 2003). *Hylaeus anthracinus* was absent from 17 sites with suitable habitat from which other *Hylaeus* species were collected (Figure 1; Daly and Magnacca 2003, K. Magnacca, pers. comm., Jan 2008). No recent collections of *H. anthracinus* have been made on Lanai, and it has probably been extirpated from that island. It is extremely rare on Oahu, and was only found at one site. Researchers recently found this species for the first time on Mokuauia, a small islet offshore of Oahu, and on Kahoolawe.

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

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

Hylaeus anthracinus has declined significantly on Maui; Perkins described it as abundant in coastal and lowland habitats on this island (Perkins 1899), but it was not found in search efforts of many sites by K. Magnacca in 1999 and 2001. Seven sites on Maui were recently searched for *Hylaeus* species. One of these sites, the Wailuku sand hills, was a historical collection site for *H. anthracinus*. What was once a large expanse of coastal dune habitat where Perkins collected many *Hylaeus* species is now divided into small remnants, only one of which contains suitable habitat for *Hylaeus*, with intact native vegetation. *Hylaeus anthracinus* was notably absent from both the more northern patch of habitat that still has native vegetation (where *H. longiceps* was present), and from the southern portion at Kahului, which is dominated by invasive plant species (Daly and Magnacca 2003, K. Magnacca pers. comm., Jan 2008, Oct. 2008). *Hylaeus anthracinus* was found in only 2 sites on Maui, both in 1999: dry forest in Kanaio Natural Area Reserve (610 m/2000 ft, 1 specimen), and coastal habitat at Manawainui Gulch on Maui (7 specimens) (Daly and Magnacca 2003).

2. Oahu (see Figure 1 and Appendix 1b)
Hylaeus anthracinus has declined precipitously since Perkins' collecting period on Oahu. It is extremely rare on the island, and there is only 1 known remaining population. K. Magnacca recently searched for *Hylaeus* species in 8 sites on Oahu, including 5 historic collection sites for this species. *Hylaeus anthracinus* was absent from all 5 of its historic collection sites that were searched; several of these sites no longer contain suitable habitat for *Hylaeus* species, and have been developed or overcome with invasive vegetation. These areas include Honolulu, Waikiki, the Honolulu mountains (Evenhuis 2007), Waialua, and Waianae (K. Magnacca, pers. comm., July 2008, P. Aldrich, pers. comm., Aug 2008). *Hylaeus anthracinus* was only present at one site, Kaena Point Natural Area Reserve (NAR) (18 specimens collected). Kaena Point NAR contains the best remaining coastal habitat for *Hylaeus* species on Oahu (Magnacca 2007a).

Hylaeus anthracinus was also absent from additional coastal sites on Oahu 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 *Hylaeus* species (K. Magnacca, pers. comm., July 2008). *Hylaeus anthracinus* was found for the first time recently on Mokuauia, an islet off the shore of Oahu (S. Plentovich, pers. comm., July 2008). This and other islets were not historically searched for *Hylaeus* species.

3. Hawaii (see Figure 1 and Appendix 1c)
Populations of *H. anthracinus* have declined significantly throughout its historic range on the Kona Coast of Hawaii. Perkins (1899) collected *H. anthracinus* on the Kona coast at Kealakekua Bay (site of the Captain Cook Monument). K. Magnacca spent a large amount of time in Kealakekua Bay, and Keei, to the south, in the 1990s and 2000s, and searched thoroughly for *Hylaeus* species. He did not find any *Hylaeus* species and observed that most of the area was dominated by invasive vegetation such as *Leucaena leucephala* (koa haole) or lacking vegetation entirely (K. Magnacca, pers. comm., July 2008). *Hylaeus anthracinus* has been found recently on Hawaii at only six sites, all on the leeward side: Kohanaiki (near Puhili Point, 15 specimens), just south of Kohanaiki in Kaloko-Honokohau National Historic Park (P. Aldrich, unpublished data), Kaulana Bay near South Point (16 specimens, Daly and Magnacca 2003), Makalawena beach, and the Mahaiula section of Kona Coast State Park (P. Aldrich, unpublished data), and one high-elevation record from the Pohakuloa Training Area (1 specimen, E. Wascher). *Hylaeus anthracinus* was absent from several sites near South Point where other *Hylaeus* species were collected: Kalu, Ka Lae, Kaalualu, and Mahana, indicating that the South Point population is highly localized and that the species may have more stringent habitat requirements than those taken nearby (*H. difficilis* and *H. flavipes*)..

4. Molokai (see Figure 1 and Appendix 1d)
K. Magnacca recently searched 5 sites on Molokai for *Hylaeus anthracinus*. He collected *H. anthracinus* from 3 sites: the Moomomi Preserve, and at Hoolehua Beach and Kaupikiawa, both on the Kalaupapa Peninsula. *Hylaeus anthracinus* was not collected in recent searches of several sites with suitable habitat on Molokai. Magnacca searched sand dune habitat in the northwest corner of Molokai nearby the Kaluakoi resort and did not find any *Hylaeus* species (K. Magnacca, pers. comm., July 2008).

5. Lanai (see Figure 1 and Appendix 1e)
Hylaeus anthracinus has not been collected recently on Lanai and may be extirpated from that island. It was absent from all 8 sites on Lanai that were recently searched for *Hylaeus* species, including its historic collection locality at Manele Bay. Other *Hylaeus* species were collected at 7 of these locations (Daly and Magnacca 2003).

6. Kahoolawe (see Figure 1 and Appendix 1f)
A population of *H. anthracinus* was discovered in 2002 in lowland habitat on Kahoolawe at Pali o Kalapakea. Four specimens were collected. *Hylaeus anthracinus* 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 *Hylaeus* species were collected: coastal habitat at Kamohio, on the southeast coast.

Figure 1. Historic and recent collections, and recent search effort for *Hylaeus anthracinus.* 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. anthracinus* (1892-1906)	Recent searches and collections of *H. anthracinus* (1997-2006)	Other native *Hylaeus* species recently collected from the same site?
Oahu				
"coast" (a)	coast	x		
"coast" (b)	coast	x		
Honolulu	Coast	x	o	o
Waialua	Coast	x	o	o
Waianae	Coast	x	o	o
Waikiki/Queen's Beach	Coast	x	o	o
Kaena Point NAR	Coast		x	x
Barber's Point	Coast		o	o
Makapuu	Coast		o	o
Honolulu Mtns	250 - 500 m/ 800-1600 ft	x	o	x
Mokuauia (Goat Island), offshore Oahu	Coast		x	o
Hawaii				
"Kona"	Coast	x		
Kealakeakua Bay	Coast	x	o	o
Kohanaiki (nr. Puhili Point)	Coast		x	o
Kaloko-Honokohau National Historic Park	Coast		x	x
Kekaha Kai (Kona Coast) State Park, Mahaiula Section	Coast		x	x
Pohakuloa Training Area	1590-1650 m/ 5200-5400 ft		x	x
Ka Lae (South Point)	Coast		o	x
Kalu	Coast		o	x
Kaulana Bay	Coast		x	x
Kaalualu	Coast		o	x
Makalawena	Coast		x	o

Keei	Coast		o	o
Mahana	Coast		o	x
Maui				
"Maui"		x		
"Maui coast"	Coast	x		
Wailuku Sand Hills (Waiehu Dunes)	30 m/100 ft	x	o	x
Wailuku Sand Hills – Kahului Section	30 m/100 ft	x	o	o
Haleakala 2K	610 m/2000 ft		o	o
Waikapu, Kaohonua	120 m/394 ft		o	x
Kanaio NAR	610 m/2000 ft		x	o
Manawainui Gulch	Coast		x	o
Lahainaluna (West Maui NAR)	549 m/1800 ft		o	x
Lanai				
Manele	Coast	x	o	o
Manele Road	180 m/600 ft		o	x
Kahue	430 m/1400 ft		o	x
Kanepuu Preserve, Kahue Unit	490 m/1600 ft		o	x
Garden of the Gods	430 m/1400 ft		o	x
Polihua Road	300 m/1000 ft		o	x
Awalua/Shipwreck Beach	Coast		o	x
Mts. Koele/Munro Trail/Kaiholena	610 m/2000 ft		o	x
Molokai				
Kauluwai	430 m/1400 ft	x		
lower slopes of the mountains	500 m/1640 ft	x		
Molokai plains	lowland	x		
Molokai mountains	500 m/1640 ft	x		
Moomomi	Coast		x	x
Northwest Molokai dunes	Coast		o	o
above Hoolehua Beach	Coast		x	o
Kaupikiawa	Coast		x	o
Kuololimu Point	Coast		o	x
Kahoolawe				
Kamohio	Coast		o	x
Pali o Kalapakea	300 m/1000 ft		x	o

Hylaeus longiceps

There is strong evidence of decline of *H. longiceps*. Although this species was once common in coastal and lowland habitats, degradation and loss of habitat have decreased its range significantly (Magnacca 2005b; see map of Oahu in Appendix 3b). Remaining populations of this species are

restricted to small populations in small patches of habitat (Magnacca 2005b). *Hylaeus longiceps* was absent from all but one of its historical sites that were recently searched (1997-2008). It was also absent from many additional sites with suitable habitat, many from which other native *Hylaeus* species have been recently collected (Figure 2; Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Twenty-five sites that were either historic collecting localities or contained suitable habitat were recently searched, and populations of *H. longiceps* were found in only 6 of these locations. Five of the sites that were visited were historic collection sites for *H. longiceps*; it was absent from all but one of these sites. Two of its historic collection sites, Waianae and Kaunakakai, no longer contain *Hylaeus* habitat, and it has been replaced by urban development or overcome with non-native vegetation (Perkins 1899, Liebherr and Polhemus 1997, Daly and Magnacca 2003).

1. Maui (see Figure 2 and Appendix 2a)
Hylaeus longiceps is extremely rare on Maui. There is only one known remaining population, at the historic collection site of the Wailuku sand hills (Waiehu dune). Seven specimens were collected at this site (Daly and Magnacca 2003). The Wailuku sand hills was once a much larger expanse of coastal dune habitat where Perkins collected many *Hylaeus* species, but it now remains in a few remnants, only one of which contains suitable habitat for *Hylaeus* species with intact native vegetation. *Hylaeus longiceps* was collected in the northern patch of habitat at Waiehu where native vegetation is still present, but was absent from the southern portion at Kahului, which is dominated by invasive plant species (Daly and Magnacca 2003, K. Magnacca pers. comm., Jan 2008, Oct. 2008).

Hylaeus longiceps was absent from five other sites on Maui that were recently visited. One historical site, dry forest on the slopes of Haleakala, is devoid of suitable vegetation for *Hylaeus* species, and has been developed and overgrown with invasive vegetation (K. Magnacca, pers. comm., Sept. 2008). *Hylaeus longiceps* was also absent from four sites with suitable habitat where other *Hylaeus* species with similar habitat requirements were recently collected: the Kanaio NAR, Lahainaluna, Manawainui Gulch, and Waikapu, Kaohonua.

2. Oahu (see Figure 2 and Appendix 2b)
Hylaeus longiceps, like *H. anthracinus*, is extremely rare on Oahu. There is only one known remaining population of this species on this island, at Kaena Point NAR. Kaena Point NAR contains the best remaining coastal habitat for *Hylaeus* species on Oahu (Magnacca 2007a). Four additional sites were recently visited in search of this species. One, Waianae, is a historic collection locality for *H. longiceps*, but all former habitat has been built upon or overcome with invasive vegetation (K. Magnacca, pers. comm., July 2008). *Hylaeus longiceps* was also absent from sites that presently contain suitable habitat.

Hylaeus anthracinus was also absent from additional coastal sites on Oahu 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 *Hylaeus* species (K. Magnacca, pers. comm., July 2008).

3. Molokai (see Figure 2 and Appendix 2c)
Six sites on Molokai were recently searched for *H. longiceps*. *Hylaeus longiceps* was only found at one of these sites, the Moomomi Reserve, in 1999 (8 specimens). K. Magnacca looked for *Hylaeus* habitat at one of this species' historic collection sites, Kaunakakai, and observed that former *Hylaeus*

habitat had been built upon or overgrown with invasive vegetation (K. Magnacca, pers. comm., July 2008).

Hylaeus longiceps was also absent from several sites with suitable habitat, some from which other rare *Hylaeus* species were recently collected. Magnacca searched sand dune habitat in the northwest corner of Molokai nearby the Kaluakoi resort and did not find any *Hylaeus* species (K. Magnacca, pers. comm., July 2008). *Hylaeus longiceps* was also absent from three sites on the Kalaupapa Peninsula where other rare *Hylaeus* species had been recently collected: Kuololimu Point, Hoolehua Beach, and Kaupikiawa (Daly and Magnacca 2003).

4. Lanai (see Figure 2 and Appendix 2d)
Seven sites on Lanai have been recently searched for *Hylaeus* species, and *H. longiceps* was found in only 3 of these sites: lowland habitat at Kahue (3 specimens) and Polihua Road (12 specimens), and coastal habitat at Shipwreck Beach (2 specimens). It was absent from its historic collecting locality at Manele Bay, although other rare *Hylaeus* species have been collected there recently (Daly and Magnacca 2003). It was also absent from three other sites with suitable dry lowland habitat: the Kahue Unit of the Kanepuu Preserve, Garden of the Gods, and the Munro Trail/Kaiholena area of the Koele Mountains (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Figure 2. Historic and recent collections, and recent search effort for *Hylaeus longiceps.*
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. longiceps* (1892-1906)	Recent searches and collections of *H. longiceps* (1997-2008)	Other native *Hylaeus* species recently collected from the same site?
Oahu				
Waianae	coast	x	o	o
Kaena Point NAR	coast		x	x
Barber's Point	coast		o	o
Makapuu	coast		o	o
Honolulu Mtns	430 m/1400 ft		o	x
Maui				
"Maui"		x		
Wailuku Sand Hills (Waiehu Dune)	30 m/100 ft	x	x	o
Wailuku Sand Hills - Kahului Section	30 m/100 ft	x	o	o
Haleakala 2K	610 m/2000 ft	x	o	o
Waikapu, Kaohonua	120 m/394 ft		o	x
Kanaio Natural Area Reserve	610 m/2000 ft		o	x
Manawainui Gulch	coast		o	x
Lahainaluna (West Maui NAR)	549 m/1800 ft		o	x

Lanai				
"Lanai"		x		
Manele	180 m/600 ft	x	o	x
Kahue	430 m/1400 ft		x	x
Kanepuu Preserve, Kahue Unit	490 m/1600 ft		o	x
Garden of the Gods	430 m/1400 ft		o	x
Polihua Road	300 m/1000 ft		x	x
Awalua/Shipwreck Beach	coast		x	o
Mts. Koele/Munro Trail/Kaiholena	610 m/2000 ft		o	x
Molokai				
Kaunakakai [urban center]	coast	x	o	o
Molokai plains	lowland	x		
Molokai coast	coast	x		
Molokai mountains	500 m/1640 ft	x		
west end of Molokai	?	x		
Moomomi	coast		x	x
Northwest Molokai dunes	coast		o	o
above Hoolehua Beach	coast		o	x
Kaupikiawa	coast		o	x
Kuololimu Point	coast		o	x

VI. HABITAT REQUIREMENTS

A. Overview

Hylaeus anthracinus and *H. longiceps* are endemic to the Hawaiian Islands and have narrow habitat requirements. *Hylaeus anthracinus* is endemic to Hawaii, Oahu, Maui, Lanai, Kahoolawe, and Molokai; *H. longiceps* to Oahu, Maui, Lanai and Molokai. The two species depend almost exclusively on increasingly rare and patchily distributed habitats (Magnacca 2005 a,b; Cuddihy and Stone 1990, Appendix 3). Both species are found primarily in coastal strand habitat. However, *H. anthracinus* can occasionally be found in lowland dry forest, and very rarely, in higher elevation dry forest, and *H. longiceps* also occurs in lowland dry shrublands (Magnacca 2005 a,b).

1. Habitat description

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).

Although it most often occurs in coastal habitat, *Hylaeus anthracinus* has been collected in lowland dry forests. 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); a diversity of native shrubs grows in the understory (Cuddihy and Stone 1990, Wagner *et al.* 1999).

Although it primarily occurs in coastal habitat, *H. longiceps* has been collected in dry shrubland habitat. Dry shrubland habitats on the Hawaiian Islands occur up to 610 m (2000 ft) elevation, and receive up to 1250 mm (50 in) of 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* (aali), *Wikstroemia* species (akia), *Chenopodium oahuense* (aweoweo), *Bidens menziesii* (kookoolau), *Styphelia tameiameiae* (pukiawe), *Psydrax odoratum* (alahee), and low-growing *Metrosideros polymorpha* (ohia) (USFWS 1999). Dry shrubland is usually characterized by mixed stands with one or two of the aforementioned species as dominant. Invasive grasses are abundant in dry shrublands.

Hylaeus anthracinus and *H. longiceps* very rarely occur at higher elevations in dry forests. Montane dry forests occur on the leeward sides of the islands of Maui and Hawaii (Cuddihy and Stone 1990). Most historical higher elevation dry forests have been lost, with the exception of the island of Hawaii, and to a lesser extent, on the slopes of Haleakala on Maui. Montane dry forests are dominated by some combination of koa (*Acacia koa*), *mamane Sophora chrysophylla*), ohia (*Metrosideros polymorpha*), and rarely, akoko (*Chamaesyce olowaluana*) (Cuddihy and Stone 1990). These habitats, especially those in the Saddle area of Hawaii, are similar in some respects to coastal strand habitats inhabited by these species, in that the climate is dry enough that soils do not get too moist to inhibit nesting.

2. Relationships with plants

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

Hylaeus longiceps has been observed visiting the flowers of a wide variety of plants, including *Scaevola coriacea* (dwarf naupaka), *Sida fallax* (ilima), *Scaevola sericea* (naupaka kahakai), *Sesbania tomentosa* (ohai), *Myoporum sandwicense* (naio), *Santalum ellipticum* (iliahialoe, coast sandalwood), *Chamaesyce degeneri* (akoko), and *Vitex rotundifolia* (pohinahina). *Hylaeus anthracinus* has been observed visiting the flowers of *Sesbania tomentosa*, *Scaevola sericea*, *Sida fallax*, *Tournefortia argentea* (tree heliotrope, alien species), *Argemone glauca* (pua kala) (Maui), *Chamaesyce celastroides*, *Chamaesyce degeneri*, *Heliotropium anomalum*, and *Myoporum sandwicense*. It has also been collected from inside the fruit capsule of *Hedyotis coriacea* (kioele) (Daly and Magnacca 2003, Magnacca 2005a,b; Magnacca 2007a, K. Magnacca, pers. comm., Jan 2008). Although Hawaiian *Hylaeus* species almost exclusively visit native Hawaiian plants, one alien species is an exception;

some *Hylaeus* species, including *H. anthracinus,* have been observed visiting *Tournefortia argentea* for nectar and pollen (Daly and Magnacca 2003, Magnacca 2007a).

Hawaiian *Hylaeus* species are highly dependent on relatively few species of native Hawaiian plants, and probably require a mix of native species (Daly & Magnacca 2003). In addition to its known flower records, it is likely that *H. anthracinus* and *H. longiceps* visit species in several taxa that other *Hylaeus* species are known to frequently visit. In coastal sites, the most important pollen sources for *Hylaeus* species are *Scaevola* spp., *Chamaesyce* spp., *Myoporum*, *Tournefortia, Jacquemontia,* and *Sida* (K. Magnacca, unpub. data).

3. Nesting requirements

Nest site availability is an important habitat requirement for *Hylaeus* populations; ground-nesters need relatively dry conditions and wood-nesters tend to live in wetter areas (Zimmerman 1972, Daly and Magnacca 2003). Although the nesting habits of *H. anthracinus* and *H. longiceps* are unknown, they likely nest like closely related species; *H. anthracinus* in the stems of coastal shrubs (Magnacca 2005a), and *H. longiceps* in the ground (Magnacca 2005b).

B. Diet

1. Larvae

Larvae of *H. anthracinus* and *H. longiceps* are unknown. In other species of *Hylaeus*, and likely in *H. anthracinus* and *H. longiceps*, 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 their crop. The food is provided in liquid form to the young (Michener 2000).

2. Adult

Adult *Hylaeus* consume nectar and pollen of various plants for energy; both species visit a wide variety of plants, listed above.

C. Life Cycle

The egg, pupa, larva and nests of *H. anthracinus* and *H. longiceps* are unknown. *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

Many of *H. anthracinus'* and *H. longiceps'* current localities are unprotected and/or threatened by the encroachment of invasive vegetation and other habitat degradation (*i.e.* Kohanaiki, Kahue, Polihua Road, and Shipwreck Beach) (Magnacca 2007a). Some of their historic and current collection localities are protected from development by federal or state agencies (*i.e.* Kekaha Kai (Kona Coast) State Park, Kaena Point, Kaloko-Honokohau National Historic Park, Kanaio State Natural Area Reserve, Kalaupapa National Historic Park), or The Nature Conservancy (*i.e.* Moomomi Reserve). Other locations, such as South Point, Waiehu dune, and Manawainui gulch, are managed by

government agencies but access is largely unregulated (Magnacca 2007a). Even if their habitat is 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 (Cuddihy and Stone 1990, Magnacca 2007a). Conservation of *H. anthracinus* and *H. longiceps* 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, control of fires, and the restoration of native vegetation.

1. Oahu

Oahu is the most developed of the Hawaiian Islands. When considering *Hylaeus* species endemic to multiple islands, the Oahu populations are invariably the most endangered (K. Magnacca, pers. comm., Jan. 2008). Maps of collection sites on Oahu are in Appendix 1 for *H. anthracinus* and Appendix 2 for *H. longiceps*.

a. Honolulu

Perkins collected *H. anthracinus* 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 3, the Honolulu area was once characterized by coastal strand and various lowland habitats, 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 (Liebherr and Polhemus 1997). Habitat has been converted for tourism or other urban development, covered with roads, overcome by non-native vegetation, or intentionally planted with non-native tree species (Wester 1983, Liebherr and Polhemus 1997, Magnacca 2005a,b). 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 habitat for native Hawaiian *Hylaeus* species remaining in Honolulu (K. Magnacca, pers. comm., July 2008).

b. Honolulu Mountains

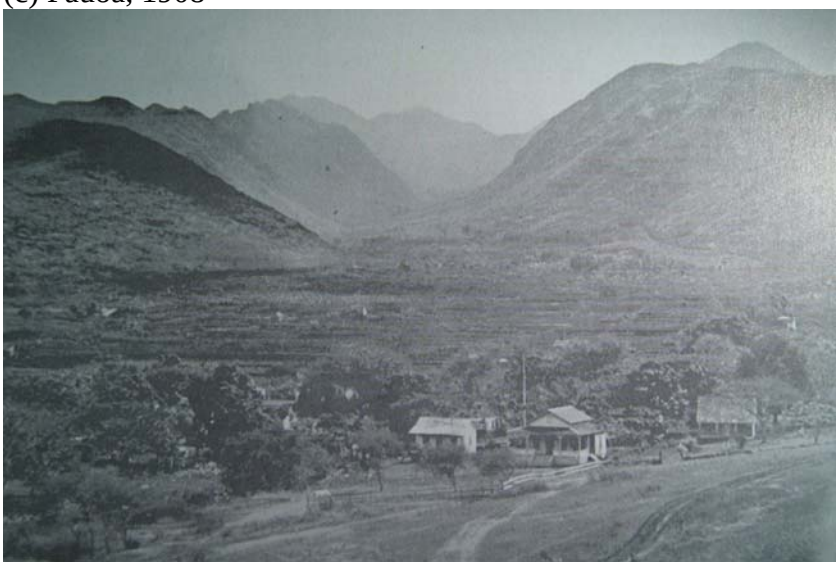
Perkins collected *Hylaeus anthracinus* from the mountains above Honolulu. The exact location of his collection is unknown, although Evenhuis (2007) indicates that he did general collecting at Tantalus, the Nuuanu Valley, Waiolani Ridge, and the Lanihuli Ridge, all between approximately 400 and 700 m (1300 and 2300 ft) elevation. Magnacca recently collected just east of this area on the Lanipo Trail (460 m/1500 ft) and Wiliwilinui Trail (610 m/2000 ft). *Hylaeus anthracinus* and *H. longiceps* were absent, but two common and relatively secure *Hylaeus* species were collected on the Wiliwilinui Trail, and *H. connectens*, which occurs in a much broader expanse of habitats than do *H. anthracinus* and *H. longiceps*, was collected on the Lanipo Trail (Daly and Magnacca 2003). Habitat in Perkins' historic collecting area in the Honolulu Mountains has very little native vegetation left. When Perkins collected at these sites, the area was largely used for grazing and agriculture, and native habitat remained in small isolated patches. The area is much more heavily vegetated than in Perkins' time, most agricultural operations in the area have been abandoned, and invasive plant species have come to dominate the landscape (Liebherr and Polhemus 1997, K. Magnacca, pers. comm., Aug. 2008). This change in the character of the landscape is illustrated in recent and historic photos of two sites from this area Nuuanu (Figure 3) (1889 and 1996), and Pauoa (1908 and 1996). The dry and barren terrain at the time may have led to the normally coastal plants favored by *H. anthracinus* growing in areas that they currently cannot tolerate, as the area has revegetated and soil moisture has increased.

Figure 3. 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). These photos are adapted from Liebherr and Polhemus (1997).

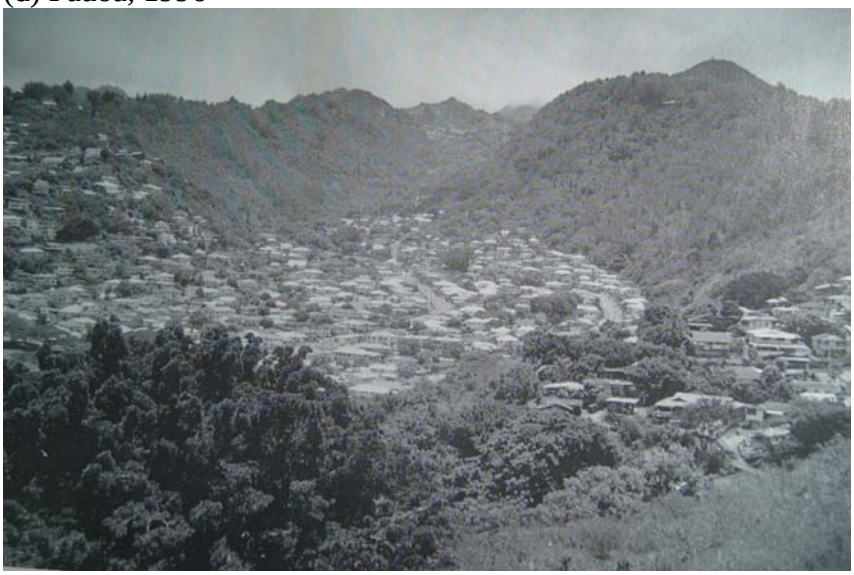
(a) Nuuanu, 1889

(b) Nuuanu, 1996

(c) Pauoa, 1908



(d) Pauoa, 1996



c. Waialua

Waialua is a town on the north shore of Oahu. *Hylaeus anthracinus* was collected here by Perkins (1899). Waialua was a center of sugar production since the late 1860s but the sugar mill shut down in 1996 and its former site currently serves as an industrial park (Dorrance and Morgan 2000). During the period of Perkins' collecting, much of this area on Oahu was occupied by feral goats and cattle, and largely denuded of vegetation. Perkins probably focused his collecting in remnant patches of native vegetation. Although the area is presently more vegetated, the vegetation is largely alien and remnant patches of native vegetation that may harbor *Hylaeus* species are difficult to locate (K. Magnacca, pers. comm., July 2008). The area is not protected.

d. Waianae

Waianae is on the southwest coast of Oahu. Perkins (1899) collected *H. anthracinus* and *H. longiceps* here. As in Waialua, during the period of Perkins' collecting, much of this area on

Oahu was occupied by feral goats and cattle, and largely denuded of vegetation. Perkins probably focused his collecting in remnant patches of native vegetation. Although the area is presently more vegetated, the vegetation is largely alien and remnant patches of native vegetation that may harbor *Hylaeus* species are difficult to locate (K. Magnacca, pers. comm., July 2008). The area is not protected.

e. Waikiki

Waikiki is heavily developed for tourism, and almost all *Hylaeus* habitat has been lost (K. Magnacca, pers. comm., July 2008). Perkins (1899) collected *H. anthracinus* in Waikiki.

f. Kaena Point Natural Area Reserve

Kaena Point is a State Natural Area Reserve in the westernmost corner of Oahu. It is the only locality on Oahu where *H. anthracinus* and *H. longiceps* have recently been collected (1998-2008) (Daly and Magnacca 2003, H. Sahli, pers. comm., Oct. 2008). Kaena Point contains the best preserved coastal ecosystem on Oahu (K. Magnacca, pers. comm., July 2008). The primary activities there are recreation, hiking, nature study, education, and the observation of wildlife (HI DLNR 2007). Illegal off-road driving was once a concern, but the road has been blocked off and native vegetation is regenerating and being actively restored by the Kaena Point Ecosystem Restoration Project (HI DLNR 2007, Magnacca 2007a). Access to Kaena Point is largely unregulated, so recreational impacts may be difficult to regulate. Native vegetation is threatened by the presence of alien vertebrates such as rats, mice, mongoose, cats, and dogs. The Hawaii Department of Land and Natural Resources (HI DLNR) plans to build a predator-proof fence to prevent these invasive species from entering 59 acres of coastal habitat within Kaena Point Natural Area Reserve (HI DLNR 2007).

g. Goat Island (Mokuauia)

Mokuauia is an islet offshore of Oahu in Laie Bay. It encompasses 13 acres and reaches a maximum elevation of 15 feet. The entire islet is a State Seabird Sanctuary, and it is managed by the Hawaii Department of Forestry and Wildlife (HI DOFAW). As a State Seabird Sanctuary, regulations restrict human activities on the islet, and federal law protects birds and other species federally listed as threatened or endangered. Critical habitat for the endangered plant *Sesbania tomentosa* (ohai) was established here in 2003, and the DOFAW is actively managing the islet for restoration of native vegetation and control of alien species. Mokuauia is a popular islet for visitors, and is heavily visited, especially on weekends. Threats to Mokuauia include the introduction of alien species by visitors, foot traffic, and visitors' dogs (OIRC 2008).

2. Hawaii

Hylaeus longiceps is not known from the island of Hawaii.

a. Kealakekua Bay and "Kona"

Perkins (1899) collected *H. anthracinus* on the Kona coast at Kealakekua Bay (site of the Captain Cook Monument). Magnacca searched for habitat suitable for *Hylaeus* species in Kealakekua Bay and Keei, to the south in the 1990s and 2000s. He did not find any *Hylaeus* species and observed that most of the area was dominated by invasive vegetation such as *Leucaena leucephala* (koa haole) or lacking vegetation entirely (K. Magnacca, pers. comm., July 2008).

b. Kohanaiki (near Puhili Point)

Hylaeus anthracinus was collected by K. Magnacca in 2003 at Kohanaiki (near Puhili Point) (K. Magnacca, pers. comm., Jan. 2008). Kohanaiki is an area of land that was granted to indigenous Hawaiians in 1995 (Kohanaiki Ohana 1995). This site is not protected from development (Kohanaiki Ohana 1995, Magnacca 2007a). *Hylaeus anthracinus* was collected on tree heliotrope (*Tournefortia argentea*) at Kohanaiki.

c. Kaloko-Honokohau National Historic Park

P. Aldrich collected *H. anthracinus* in Kaloko-Honokohau National Historic Park, which is just south of Kohanaiki (P. Aldrich, pers. comm., July 2008, K. Magnacca, pers. comm., Aug. 2008). Kaloko-Honokohau is protected from development as a National Historic Park and is managed by the National Park Service (NPS). The NPS actively manages the park to suppress fire (NPS 2008). The invasive aggressive ant *Anoplolepis gracilipes* (the long-legged ant) is present in this area (K. Magnacca, pers. comm., July 2008) and may pose a threat to *H. anthracinus.*

d. Makalawena Beach

Makalawena Beach is in southern Kona area, and it is inaccessible by motor vehicle. Visitors must hike in on a trail that begins inside Kekaha Kai (Kona Coast) State Park. P. Aldrich collected *H. anthracinus* here (P. Aldrich, pers. comm., July 2008). Although it is difficult to access, visitation to Makalawena Beach is largely unregulated, and recreational impacts thus hard to regulate. Makalawena Beach is on land managed by the Kamehameha Schools/Bishop Estate.

e. Kekaha Kai (Kona Coast) State Park, Mahaiula Section

P. Aldrich collected *H. anthracinus* in the Mahaiula section of Kona Coast State Park. This park is managed by the Hawaii Department of Land and Natural Resources' Division of Forestry and Wildlife. Access to this park is largely unregulated, so recreational impacts may be difficult to regulate.

f. South Point (Kaulana Bay)

The area near South Point, at the southernmost tip of the island of Hawaii, is the best coastal habitat for *Hylaeus* on the island of Hawaii. The South Point area is registered as a National Historic Landmark District (CTE). A large portion of the area is managed by the Department of Hawaii Homelands, and some of it is privately owned. However, access is for the most part unregulated, and there is frequent recreational activity. Remaining populations of *H. anthracinus* may be negatively impacted by damage to vegetation by visitors (Magnacca 2005a). *Hylaeus anthracinus* appears to be restricted to an area of newer lava flows east of the point at Kaulana Bay where it was collected in 1999 and 2002 (Magnacca 2007a). Other *Hylaeus* species were collected there as well as at South Point proper (Ka Lae) and several points east along the coast.

g. Pohakuloa Training Area

The Pohakuloa Training Area is on the southern slopes of Mauna Kea and is managed by the U.S. Army. One male *H. anthracinus* was collected in higher elevation dry forest in the Pohakuloa Training Area in 2004 at a site about 1590-1650 m (5200-5400 ft), but a stable population there has not yet been confirmed (Magnacca 2007a). The specimen was collected from inside the fruit capsule of a very rare and federally listed endangered plant, kioele (*Hedyotis coriacea*) (K. Magnacca, pers. comm., Jan. 2008). This area may be subject to

impacts from military activity, such as loss of native vegetation to fires set by ordnance, and compaction by army vehicles.

3. Maui

Habitat in most of Perkins' collection sites on Maui has been lost to development (Liebherr and Polhemus 1997). *Hylaeus anthracinus* and *H. longiceps* are extremely rare here, and remain in small pockets of native vegetation (K. Magnacca, pers. comm., July 2008). See Figure 1 for a table of collection sites, and Appendices 1a & 2a for maps of collection sites.

a. Haleakala (610 m/2000 ft)

Perkins (1899) collected *H. longiceps* in dry forest on Haleakala at 610 m/2000 ft elevation. This collection site was probably on the northwest slope near the towns of Pukalani or Makawao, where Perkins stopped on his way to Wailuku (K. Magnacca, pers. comm., July 2008). Dry forests that supported populations of *Hylaeus* species were once abundant at Perkins' collection site and up to 6000 ft elevation on Haleakala. This dry forest habitat is now almost completely gone except for a few patches on the southwest slopes such as Puu o Kali and Kanaio.

b. Kanaio Natural Area Reserve

Hylaeus anthracinus was collected at this dry forest site on the lower southern slopes of Haleakala at 610 m/2000 ft elevation in 1999. It is a State Natural Area Reserve (NAR) of 876 acres, and contains a remnant of native dryland forest and native shrublands. Threats to native vegetation in this reserve include disturbance by ungulates, the presence of *Pheidole megacephala* (the big-headed ant), and the loss of native pollinators and seed dispersers. The NAR plans to rehabilitate habitat in the Kanaio NAR by excluding feral ungulates with fencing, managing weeds, and planting native species (Medeiros *et al.* 1993).

c. Manawainui Gulch

Hylaeus anthracinus was collected in 1999 at this coastal site on land managed by the Department of Hawaiian Home Lands, just east of Kahikinui where the highway first reaches the coast (K. Magnacca, pers. comm., July 2008). This site should not be confused with the larger Manawainui Valley east of Kaupo, or Manawainui Gulch at Ukumehame on West Maui.

d. Wailuku sand hills (Waiehu & Kahului)

The Wailuku sand hills were Perkins' primary collection site for *Hylaeus* on Maui (Magnacca 2007a). 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. 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. anthracinus*, 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 2007a).

4. Lanai

All of Lanai is privately owned. There have been no recent collections of *H. anthracinus* from Lanai, and it has probably been extirpated from that island (Daly and Magnacca 2003, Magnacca 2007a, K. Magnacca, pers. comm., Jan 2008). *Hylaeus longiceps* is rare here, and remains only in very small pockets of native vegetation; coastal habitat is even less common on Lanai than on Maui. *Hylaeus longiceps* was collected between 1999 and 2001 from three sites, described below.

a. Kahue

K. Magnacca collected *H. longiceps* in dry forest at Kahue (427 m/1400 ft) in 1999 (Daly and Magnacca 2003). The Kahue site is just south of the Kanepuu Preserve, which is an area of land protected by the Nature Conservancy (K. Magnacca, pers. comm., July 2008). K. Magnacca searched in the Kanepuu Preserve for *H. anthracinus* and *H. longiceps* and did not find them.

b. Polihua Road

K. Magnacca collected *H. longiceps* 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.

c. Shipwreck Beach

K. Magnacca collected *H. longiceps* in native coastal habitat at Shipwreck Beach in 2001. This site is close to Awalua, where Perkins made historical collections of other *Hylaeus* species. Shipwreck Beach is a popular tourist site on Lanai, and vegetation might be impacted by foot traffic or collection.

5. Molokai

a. Kaunakakai

Hylaeus longiceps was collected by Perkins (1899) from this locality. Kaunakakai is the primary urban area on Molokai, and all former *Hylaeus* habitat has been lost to urban development (K. Magnacca, pers. comm., July 2008).

b. West end of Molokai.

Hylaeus longiceps was collected by Perkins (1899) from this locality. Most coastal habitat on the western end of Molokai, with the exception of the Moomomi Reserve, has been degraded and taken over by invasive vegetation (K. Magnacca, pers. comm., July 2008).

c. Kauluwai

Hylaeus anthracinus was collected by Perkins (1899) here. In Daly and Magnacca (2003) Kauluwai is mistakenly noted as a site on Maui (and spelled as "Kaulawai" on Perkins' label), but is actually on Molokai, in the center of the island near Kalae. It is unlikely that any native habitat remains in the area.

d. Moomomi Reserve

The Moomomi Coast is protected as a preserve by The Nature Conservancy. It contains an intact community of native beach flora backed by an area dominated by non-native trees. Both *H. anthracinus* and *H. longiceps* were found in recent collections between 1999 and 2001 (Magnacca 2007a). Many of the dunes in the TNC Moomomi Reserve are dominated by alien vegetation; Magnacca collected *H. anthracinus* and *H. longiceps* from an area of native vegetation.

e. Hoolehua Beach and Kaupikiawa, Kalaupapa National Historic Park

Kalaupapa National Historic Park is on the northern coast of Molokai on the Kalaupapa peninsula. The east side of the peninsula is more rocky and barren than the remainder but contains scattered native coastal vegetation similar to South Point on the island of Hawaii (Magnacca 2007a). 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). *Hylaeus anthracinus* was collected here in 2005 at a coastal site above Hoolehua Beach near the tip of the peninsula, and at Kaupikiawa, just to the east (Magnacca 2007b).

6. Kahoolawe

a. Pali o Kalapakea

K. Wood collected *Hylaeus anthracinus* from dry habitats at 300 m/1000 ft elevation from Pali o Kalapakea on Kahoolawe in 2002. This island is uninhabited. Erosion of soil caused by grazing has resulted in the loss of much of the coastal strand habitat on Kahoolawe (Warren 2004, Magnacca 2005a). 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). *Hylaeus longiceps* is not known from the island of Kahoolawe.

E. Current Conservation Efforts

The federal and state governments have not developed any conservation plans for *H. anthracinus* and *H. longiceps*, nor have they made any targeted efforts to preserve or restore habitat for these 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. anthracinus* and *H. longiceps* are the loss of their 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 2005a,b). Coastal and lowland habitats have been most heavily impacted by human occupation. More than 75% of the recognized coastal and lowland habitat types 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 sites where Perkins collected *Hylaeus* species between 1892 and 1906 would be unrecognizable to him now (Liebherr and Polhemus 1997). Four maps in Appendix 3 illustrate the extent of habitat loss on the islands of Oahu and Hawaii both before and after human settlement.

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 2007a). 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 2007a). 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 anthracinus and *H. longiceps* were once widespread and their decline has paralleled the loss of coastal habitat (Magnacca 2005a,b). They are now restricted to a portion of the remaining few localities of relatively intact native coastal strand habitat and dry forest habitats on each island (Daly and Magnacca 2003). *Hylaeus anthracinus* and *H. longiceps* are now absent from many of Perkins' historical collection localities, which have been developed or taken over by invasive plant species. These areas include Honolulu and Waikiki on Oahu, Kealakekua Bay and Keei, the urban area near Kona on Hawaii, and the northwest dunes and Kaunakakai areas on Molokai (Cuddihy and Stone 1990, Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

Magnacca (2007a) 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 shrubland and lowland dry forest

Lowland dry forest and lowland dry shrubland were once abundant and considered some of the most diverse of all Hawaiian habitat types but are now very rare (Magnacca 2007a). 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 2005a, b).

Historic land use practices reduced the range of lowland dry forests long ago; many lowland forests were converted for agricultural use, logged, or used for ranching. Nineteenth century ranching practices on Oahu destroyed almost all of the native forests between 210 and 550 m elevation (Cuddihy and Stone 1990). However, development is currently not the primary threat to *Hylaeus* species. Rather, the 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 2007a).

Lowland dry shrublands only remain in areas that were not altered by intensive agriculture or grazing. 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). Invasive grasses are also abundant in dry shrublands.

c. The loss of higher elevation dry forest

Most of the higher elevation dry forests on the Hawaiian islands have been lost to development or other habitat degradation. Most remaining higher elevation dry forests are on the island of Hawaii, and some remain on the slopes of Haleakala on Maui at Auwahi (Cuddihy and Stone 1990). At one point dry forests were likely expansive on the slopes of Haleakala (Medeiros *et al.* 1986). Remaining higher elevation dry forests are threatened by the encroachment of invasive plants, damage by feral ungulates, and fire (Cuddihy and Stone 1990).

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 forest habitats (Cuddihy and Stone 1990, Mascaro *et al.* 2008). 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), these native plant species are often important 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. anthracinus* and *H. longiceps* because *Hylaeus* species depend on native vegetation for nectar and pollen and are almost entirely absent from habitats dominated by invasive vegetation (Daly and Magnacca 2003). *Hylaeus anthracinus* and *H. longiceps* are largely 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 this same habitats; 25% of listed plant species are from dry forest and shrubland alone (Sakai *et al.* 2002). It is suspected that dry lowland habitats once supported a more diverse *Hylaeus* community than it now does, because many *Hylaeus* foraging plants are now extirpated (Magnacca 2007a). About one-fifth of the plant taxa native to dry lowland shrubland are extinct (Sakai *et al.* 2002). Most of the coastline of the major Hawaiian Islands does not have significant amounts of native foraging plants besides *Scaevola sericea* (naupaka kahakai), which alone does not provide for the survival of *Hylaeus*.

Native coastal vegetation in many sites is threatened by *Prosopis pallida* (kiawe), an invasive deciduous thorny tree. *Cynodon dactylon* (Bermuda grass) threatens a population of *Sesbania tomentosa* (ohai) at Moomomi on Molokai. Other invasive plant species abundant in coastal habitats include *Melinus 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). Higher elevation dry forests are commonly invaded by *Aleurites moluccana* (kukui), *Clidemia hirta* (Koster's curse) and *Psidium cattleianum* (strawberry guava).

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 spread easily by self-pollination or vegetative means, whereas many invasive species have these capabilities (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 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. anthracinus* and *H. longiceps* may exacerbate the decline of dependent plant species (Cox and Elmqvist 2000).

Many taxa of native plants that serve as foraging resources for numerous *Hylaeus* species are in decline (Daly and Magnacca 2003, USFWS 2008) and may exist in only very small populations (Cox and Elmqvist 2000). Four native Hawaiian plant taxa from coastal strand habitat, three from coastal dry shrubland, and seventeen from lowland dry or mesic forest are federally listed as endangered species and included in the USFWS recovery plan for Hawaiian plants that occur on multiple islands (USFWS 1999). *Hylaeus longiceps* and *H. anthracinus* have been observed visiting flowers of several of these endangered taxa, and likely visit additional endangered species. *Hylaeus anthracinus* has been collected from inside the fruit capsule of *Hedyotis coriacea* (kioele), a dry forest species that is listed as endangered. There are less than 20 known individuals of this plant remaining, all of which are on Hawaii with the exception of one individual plant on Maui (NatureServe 2008). *Hylaeus longiceps* is known to forage on both *Scaevola coriacea* (dwarf naupaka) and *Sesbania tomentosa* (ohai); *Scaevola coriacea* is possibly extirpated from Oahu (USFWS 1999, Daly and Magnacca 2003, USFWS 2008). *Sesbania tomentosa* is also visited by *H. anthracinus* (Daly and Magnacca 2003). *Sesbania tomentosa* is threatened by lack of adequate pollination (USFWS 1999) due at least in part to the decline of *Hylaeus* species in its habitat. Both species also visit the endangered *Chamaesyce celastroides* var. *kaenana* (akoko) (Daly and Magnacca 2003), which is endemic to coastal dry shrubland on Oahu and has Critical Habitat designated for it there.

3. Habitat disturbance by feral ungulates

Feral ungulates have contributed to the decline of native Hawaiian plant communities (Stone and Loope 1987), 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 *H. anthracinus* or *H. longiceps* (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).

Research on pomace flies (*Drosophila* spp.), which are endemic Hawaiian invertebrates that also depend closely on native vegetation has shown that pig-inflicted damage to native vegetation can negatively impact invertebrate populations. Several species of rare and endemic Hawaiian *Drosophila* (pomace flies) are federally listed as endangered species under the Endangered Species Act (USFWS 2006). Foote and Carson (1995) showed that excluding pigs from *Drosophila* habitat increased populations of these rare *Drosophila* species. Active management that controls 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 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). *Hylaeus anthracinus* was found in the Pohakuloa Training Area on the island of Hawai'i, and ordnance-induced fires may threaten *H. anthracinus*' habitat there.

5. Recreation

Some of the best habitat for *H. anthracinus* and *H. longiceps*, such as Kaena Point on Oahu, Kona Coast State Park, Makalawena, Mokuauia, and South Point on Hawaii, are popular recreational sites. Some of these sites have largely unregulated access. Human impacts at these sites may include removal or trampling of vegetation on or nearby trails and the compaction of vegetation by off-road vehicles.

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. Although geographically restricted and vulnerable to stochastic events such as fire or drought, some populations of *H. anthracinus* and *H. longiceps*, such as those at Kaena Point, Moomomi, and the Kona coast of Hawaii, are moderately large in numbers of individuals and therefore unlikely to be threatened by collection. Others, such as those at Waiehu and Manawainui, appear to be much smaller and may be vulnerable to over collection.

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 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. anthracinus* and *H. longiceps*. *Pheidole megacephala* is primarily restricted to dry lowland habitats below 1000 m (3289 ft) and is almost always the dominant ant in its habitat (Reimer 1994). *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 (Cole *et al.* 1992, Medeiros *et al.* 1986, Stone and Loope 1987, 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 longiceps* likely nests in the ground like related *Hylaeus* species, and thus its brood might be especially susceptible to ant predation (Magnacca 2005b).

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, including two non-native *Hylaeus* species (Snelling 2003). Most invasive bees inhabit areas dominated by invasive 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 absent, 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 2007a). 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 invasive bee species present in areas of native vegetation include *Ceratina* spp., *Hylaeus albonitens*, and *Lasioglossum impavidum* (Magnacca 2007a). These may have an impact on *H. anthracinus* and *H. longiceps* through competition for pollen, because they are similar in size and probably visit similar flowers. The impact of these species on *Hylaeus* species has not been studied (Magnacca 2007a).

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

Vespula pensylvanica (the western yellowjacket wasp) is a social wasp native to North America. It was first reported on 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, 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 predates on *Hylaeus*, although *Hylaeus* is not its primary prey source (Gambino *et al.* 1987). Because of the rarity of *H. anthracinus* and *H. longiceps*, 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 anthracinus* or *Hylaeus longiceps*.

Many of *H. anthracinus* and *H. longiceps*' current localities are unprotected and/or threatened by development (*i.e.*, Puhili Point, Kahue, Pohakuloa Training Area, Polihua Road, and Shipwreck Beach). Other locations are owned by government agencies but access is largely unregulated and natural resource management is minimal (South Point, Manawainui Gulch, Waiehu dune). Some historic and current collection localities are protected from development by federal or state agencies (*i.e.*, Kaena Point, Kanaio State Natural Area Reserve, and Kalaupapa National Historic Park) or The Nature Conservancy (*i.e.*, Moomomi).

However, it is important to note that even in areas 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 2007a). Conservation of *H. anthracinus* and *H. longiceps* 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 anthracinus* and *Hylaeus longiceps*.

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. *H. anthracinus* and *H. longiceps* 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). Both *H. anthracinus* and *H. longiceps* are rare and have very small populations, and they are likely more vulnerable to habitat change and stochastic events due to low genetic variability. Stochastic events on the Hawaiian Islands that might affect *Hylaeus* populations are tsunamis, droughts, fires, and on the island of Hawaii, lava flows.

2. Global climate change

Global climate change could threaten *H. anthracinus* and *H. longiceps*. A changing climate may cause shifts in the range of 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 anthracinus* and *H. longiceps* are restricted to habitat patches where host species are present, and are not likely to disperse far to find new habitat. Thus, the ecology of these species, combined with the patchy distribution of their 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. anthracinus* and *H. longiceps* with changes in rainfall patterns, since these species inhabit dry areas, 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. anthracinus* and *H. longiceps.* 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. anthracinus* and *H. longiceps* do 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 they inhabit, and some coastal habitat will likely be lost.

3. The vulnerability of island endemics

Hylaeus anthracinus is endemic to the Hawaiian Islands of Oahu, Hawaii, Maui, Lanai, Molokai, and Kahoolawe. *Hylaeus longiceps* is endemic to Oahu, Maui, Lanai, 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. anthracinus* and *H. longiceps*, 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 2007a).

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 are *H. anthracinus* and *H. longiceps* (Daly and Magnacca 2003). Furthermore, the close interdependence of Hawaiian endemic flora and their endemic pollinators (Cox and Elmqvist 2000, Sakai *et al.* 1995) makes them vulnerable to reciprocal decline and extinction (Cox and Elmqvist 2000).

VIII. CONCLUSION

Hylaeus anthracinus and *Hylaeus longiceps* are rare bees endemic to the Hawaiian Islands that are in imminent danger of going extinct. *Hylaeus anthracinus* is endemic to the islands of Oahu, Molokai, Kahoolawe, Maui, Hawaii, and formerly Lanai. *Hylaeus longiceps* is endemic to the islands of Oahu,

Molokai, Lanai, and Maui. There is strong evidence of the decline of these two species (Magnacca 2005a,b, Magnacca 2007a). *Hylaeus anthracinus* and *H. longiceps* are largely restricted to extremely rare native coastal strand habitat (Daly and Magnacca 2003, Magnacca 2005a, b, Magnacca 2007a), and their numbers have declined precipitously with the concurrent loss of this habitat. They were absent from many historical localities that were revisited between 1998 and 2005, and from many sites with suitable habitat, many from which other *Hylaeus* species have been recently collected (Daly and Magnacca 2003, K. Magnacca, pers. comm., July 2008).

The primary factors threatening *H. anthracinus* and *H. longiceps* are:

1. Scarcity of habitat, and habitat loss due to development or land conversion (Cuddihy and Stone 1990, Magnacca 2007a)
2. The displacement and decline of these species habitat 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 *Pheidolemegacephala* (the big-headed ant) (Cole *et al.* 1992, Daly and Magnacca 2003).
4. Competition for resources with non-native honey bees (*Apis mellifera*) (Daly and Magnacca 2003, Magnacca 2007a).
5. Predation by *Vespula pensylvanica* (the western yellow-jacket wasp (Gambino *et al.* 1987).

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

IX. REFERENCES

Alpha, C. G., D. R. Drake, and G. Goldstein. 1996. Morphological and physical responses of *Scaevola sericea* (Goodeniaceae) seedlings to salt spray and substrate salinity. American Journal of Botany 83(1): 86-92.

Baker, J. D., C. L. Littnan and D. W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 4:1-10.

Blackmore, M. and P. M. Vitousek 2000. Cattle grazing, forest loss and fuel loading in a dry forest ecosystem at Pu'u Wa'aWa'a Ranch, Hawai'i. Biotropica 32(4a): 625-632.

Bond, W. and P. Slingsby. 1984. Collapse of an ant-plant mutualism: the Argentine Ant (*Iridomyrmex humilis*) and myrmecochorous Proteaceae. Ecology 65:1031-1037.

Bruegmann, M. M. 1996. Hawaii's dry forests. Endangered Species Bulletin. 11, 26-27.

Cabin, R. J., S. G. Weller, D. H. Lorence, T. W. Flynn, A. K. Sakai, D. Sanquist, L. J. Hadway. 2000. Effects of long-term ungulate exclusion and recent alien species control on the preservation and restoration of a Hawaiian tropical dry forest. Conservation Biology. 14, 439-453.

Cole , F. R., A. C. Medeiros, L. L. Loope, and W. W. Zuehlke. 1992. Effects of the Argentine ant on arthropod fauna of Hawaiian high-elevation shrubland. Ecology 73:1313 – 1322 .

Cox, P. A. and T. Elmqvist. 2000. Pollinator extinction in the Pacific Islands. Conservation Biology 14(5): 1237-1239.

Cuddihy, L. W. and C. P. Stone. 1990. *Alteration of Native Hawaiian Vegetation: Effects of Humans, Their Activities and Introductions*. Honolulu: University of Hawaii Cooperative National Park Resources Studies Unit.

D'Antonio, C. M., J. T. Tunison, and R. Loh. 2000. Variation in impact of exotic grass fueled fires on species composition across an elevation gradient in Hawaii. Austral Ecology 25: 507-522.

Daly, H. V. and K. N. Magnacca. 2003. *Insects of Hawaii: Volume 17: Hawaiian Hylaeus (Nesoprosopis) Bees (Hymenoptera: Apoidea).* Honolulu: University of Hawaii Press.

Dorrance, W. H. and F. S. Morgan. 2000. *Sugar Islands: The 165-year Story of Sugar in Hawai'i.* Mutual Publishing: Honolulu.

Evenhuis, N. L., Ed. 2007. Barefoot on Lava: The Journals and Correspondence of Naturalist R. C. L. Perkins in Hawaii, 1892-1901. Bishop Museum Press: Honolulu.

Foote, D. and H. L. Carson. 1995. Drosophila as monitors of change in Hawaiian ecosystems. *In* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (Eds.) *Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems*. U.S. Department of Interior, National Biological Service, Washington D.C.

Gagne, W. C. 1979. Canopy-associated arthropods in *Acacia koa* and *Metrosideros* tree communities along an altitudinal transect on Hawaii Island. Pacific Insects 21:56-82.

Gagne, W. C. 1981. Status of Hawaii's endangered species: insects and land snails. 'Elepaio 42(4):31-36.

Gagne, W. C. 1988. Conservation priorities in Hawaiian natural systems. Bioscience 38(4):264-270.

Gagne, W. C. and L. W. Cuddihy. 1999. Vegetation. *In* W.L. Wagner, D. R. Herbst and S. H. Sohmer. *Manual of the Flowering Plants of Hawaii.* Bishop Museum and University of Hawaii Press.

Gambino, P., A. C. Medeiros and L. L. Loope. 1987. Introduced vespids *Paravespula pensylvanica* prey on Mau's endemic arthropod fauna. Journal of Tropical Ecology 3(2): 169-170.

Gambino, P., A. C. Medeiros and L. L. Loope. 1990. Invasion and colonization of upper elevations on East Maui (Hawaii) by *Paravespula pennsylvanica* (Hymenoptera: Vespidae). Annals of the Entomological Society of America 83: 1088-1095.

Hawaii Department of Land and Natural Resources (HI DLNR). Division of Forestry and Wildlife. 2007. Draft Environmental Assessment: Ka'ena Point Ecosystem Restoration Project. Wai'anae and Waialua Districts, Island of O'ahu.

Holway, D. A., L. Lach, A. V. Suarez, N. D. Tsutsui, and T. J. Case. 2002. The causes and consequences of ant invasions. Ann. Rev. Syst. 33: 181-233.

Howarth, F. G. 1985. Impacts of invasive land arthropods and mollusks on native plants and animals in Hawaii, pp. 149-179 *In* Stone, C. P. and J. M. Scott (Eds.) *Hawaii's Terrestrial Ecosystems: Preservation and Management.* Honolulu: University of Hawaii Press.

Kohanaiki Ohana. 1995. http://www.kohanaiki.org/. Accessed July 15 2008.

Krushelnycky, P. D., L. L. Loope and N. J. Reimer. 2005. The ecology, policy and management of ants in Hawaii. Proceedings of the Hawaiian Entomological Society. 37.

Lach, L. 2008. Floral visitation patterns of two invasive ant species and their effects on other Hymenopteran visitors. Ecological Entomology 33(1): 155-160.

Liebherr, J. K. and D. A. Polhemus. 1997. R. C. L. Perkins: 100 years of Hawaiian entomology. Pacific Science 51(4):343-355.

Liebherr, J. K. 2005. Patterns of endangerment or pathways to enlightenment? Reconstructing the *Fauna Hawaiiensis*. Systematics and Biodiversity 2(2): 175-189.

Magnacca, K. 2005a. Species Profile: *Hylaeus anthracinus. In* Shepherd, M.D., D.M. Vaughan, and S. H. Black (Eds.). *Red List of Pollinator Insects of North America.* CD-ROM Version 1 (May 2005). Portland, OR: The Xerces Society for Invertebrate Conservation.

Magnacca, K. 2005b. Species Profile: *Hylaeus longiceps. In* Shepherd, M.D., D.M. Vaughan, and S. H. Black (Eds.). *Red List of Pollinator Insects of North America.* CD-ROM Version 1 (May 2005). Portland, OR: The Xerces Society for Invertebrate Conservation.

Magnacca, K. N. and B. C. Danforth. 2006. Evolution and biogeography of native Hawaiian Hylaeus bees (Hymenoptera: Colletidae). Cladistics 22 (5), 393–411.

Magnacca, K. N. and B. C. Danforth. 2007. Low nuclear DNA variation supports a recent origin of Hawaiian *Hylaeus* bees (Hymenoptera: Colletidae). Molecular Phylogenetics and Evolution 43(3): 908-915.

Magnacca, K. M. 2007a. Conservation status of the endemic bees of Hawaii, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, K. M. 2007b. New records of *Hylaeus (Nesoprosopis)* and *Ceratina* bees in Hawai'i. Bishop Museum Occasional Papers 96: 44-45.

Mascaro, J., K. K. Becklund, R. F. Hughes, and S. A. Schnitzer. 2008. Limited native plant regeneration in novel, exotic-dominated forests on Hawaii. Forest Ecology and Management 256(4): 593-606.

Meade-Waldo, G. 1923. Hymenoptera, fam. Apidae, subfam. Prosopidae, fasc. 181. pp.1-45 *In* P. Wystman (Ed.), *Genera Insectorum.* L. Desmet-Verteneuil, Brussels.

Medeiros, A. C., L. L. Loope, F. R. Cole. 1986. Distribution of ants and their effects on endemic biota of Haleakala and Hawaii Volcanoes National Park: a preliminary assessment. Pp. 39-52. Proc. 6th Conf. Nat. Sci., Hawaii Volcanoes National Park.

Medeiros, A. C., L. L. Loope and C. G. Chimera. 1993. Kanaio Natural Area Reserve Biological Inventory and Management Recommendations. Natural Area Reserve System, State of Hawaii.

Mehrhoff, L. 1993. Rare plants of Hawaii: a status report. Plant Conservation. 7, 1-2.

Michener, C. D. 1974. The Social Behavior of Bees. Cambridge: Harvard University Press.

Michener, C. D. 2000. *The Bees of the World*. The Johns Hopkins University Press: Baltimore and London.

National Park Service. 2006. Kalaupapa National Historical Park. Accessed July 11, 2008. http://www.nps.gov/kala/index.htm

National Park Service. 2008. Kaloko-Honokohau National Historic Park Fire Management Plan. Accessed October 21, 2008. http://www.nps.gov/kaho/

National Research Council: Committee on the Status of Pollinators in North America. 2007. *Status of Pollinators in North America*. The National Academies Press: Washington, D.C.

NatureServe. 2008. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.0. NatureServe, Arlington, Virginia. Accessed October 21, 2008. http://www.natureserve.org/explorer.

Nature Conservancy of Hawaii. 1987. *Biological overview of Hawaii's Natural Area Reserves System.* Hawaii Heritage Program. Prepared for Hawaii State Department of Land and Natural Resources. Honolulu.

Offshore Islet Restoration Committee (OIRC). Islets: Oahu: Mokuauia. Accessed October 22, 2008. http://www.hawaiioirc.org/OIRC-ISLETS-Oahu/OIRC-ISLETS-Oahu-Mokuauia.htm

O'Toole, C. and A. Raw. 1999. *Bees of the World*. London: Blandford.

Perkins, R. C. L. 1899. Hymenoptera, Aculeata, pp. 1-115, Pls. 1-2. *In* D. Sharp (Ed.), *Fauna Hawaiiensis.* Vol. 1. Cambridge University Press, Cambridge, United Kingdom.

Perkins, R. C. L. 1913. Introduction. Pages i–ccxxvii *In* D. Sharp (Ed.) *Fauna Hawaiiensis*. Vol. 1. Cambridge University Press, London.

Ramadan, M. M. 2007. Trouble in paradise - First varroa mites found in Hawaii. American Bee Journal 147:465-465.

Reimer, N. J., J. W. Beardsley, and G. Jahn. 1990. Pest ants in the Hawaiian Islands. Pp. 40-50 *In* R. K. Vander Meer, K. Jaffe, and A. Cedeno (Eds.) *Applied Myrmecology: A world perspective.* Westview Press, Boulder, CO.

Reimer, N. J. 1994. Distribution of invasive ants in vulnerable Hawaiian ecosystems. *In* David F. Williams (Ed.) *Exotic Ants: Biology, Impact and Control of Introduced Species.* Boulder, Colorado: Westview Press.

Richmond, T. de A. and D. Mueller-Dombois. 1972. Coastline ecosystems on Oahu, Hawaii. Vegetation 25: 367-400.

Ronck, R. 1984. *Panorama Hawaii – Scenic views of the Hawaiian Islands*. Mutual Publ. Co., Honolulu.

Sahli, H., D. Drake, A. Taylor, T. Fukami and E. Stacy. 2008. Changes in pollination across an elevation gradient on the island of Hawaii. Abstract, 93rd ESA Annual Meeting, Milwaukee, Wisconsin, Aug 3 – Aug 8, 2008. http://eco.confex.com/eco/2008/techprogram/P12618.HTM. Accessed July 29, 2008.

Sakai, A. K., W. L. Wagner, D. M. Ferguson. 1995. Origins of dioecy in the Hawaiian flora. Ecology 76:2517-2529.

Sakai, A. K., W. L. Wagner and L. A. Mehrhoff. 2002. Patterns of endangerment in the Hawaiian flora. Systematic Biology 51:276–302.

Sherley, G. (Ed.). 2000. Invasive species in the Pacific: A technical review and draft regional strategy. Apia, Samoa: South Pacific Regional Environment Programme.

Schmitt, R. C. 1977. *Historical statistics of Hawaii.* Univ. Press Hawaii, Honolulu.

Scott, E. B. 1968. *Saga of the Sandwich Islands, Vol. 1*. Sierra-Tahoe Publ. Co., Lake Tahoe, Nevada.

Simberloff, D. and B. Von Holle. 1999. Positive interactions of nonindigenous species: invasional meltdown? Biological Invasions 1:21-32.

Smith, F. 1853. Catalogue of hymenopterous insects in the collection of the British Museum. Part 1. Andrenidae and Apidae. Printed by order of the Trustees, London.

Smith, C. W. and J. T. Tunison. 1992. Fire and invasive plants in Hawai'i: research and management implications for native ecosystems. *In* C. P. Stone and J. M. Scott (Eds.). *Hawai'i's terrestrial ecosystems: preservation and management*. Pp. 394-408. Cooperative National Park Resources Study Unit, University of Hawai'i. Honolulu. Hawaii.

Snelling, R. R. 2003. Bees of the Hawaiian Islands, exclusive of *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Apoidea). Journal of the Kansas Entomological Society 76**:**342 – 356.

Stone, C. P. and S. J. Anderson. 1988. Introduced animals in Hawaii's natural areas. Vertebrate Pest Conference Proceedings Collection: Proceedings of the 13th Vertebrate Pest Conference. University of Nebraska, Lincoln.

Stone, C. P. 1985. Invasive animals in Hawaii's native ecosystems: toward controlling the adverse effects of introduced vertebrates. pp. 251-288 *In* C.P. Stone and J. M. Scott (Eds.) *Hawaii's*

Terrestrial Ecosystems: Preservation and Management. Cooperative National Park Resources Study Unit. Honolulu: University of Hawaii.

Stone, C. P. and L. L. Loope. 1987. Reducing negative effects of introduced animals on native biotas in Hawaii: What is being done, what needs doing, and the role of national parks. Environmental Conservation 14:245-258.

Stone, C. P. and J. M. Scott (Eds.). 1985. *Hawaii's Terrestrial Ecosystems: Preservation and Management*. Proceedings of a Symposium held June 5-6, 1984 at Hawaii Volcanoes National Park. Cooperative National Park Resources Studies Unit: University of Hawaii, Honolulu.

USFWS. 1984. Endangered and threatened wildlife and plants: Review of invertebrate wildlife for listing as endangered or threatened species. Federal Register. 49:21664-21673.

USFWS. 1996. Endangered and threatened wildlife and plants: Review of plant and animal taxa that are candidate for listing as endangered or threatened species. Federal Register 61:7596-7613.

USFWS. 1999. Recovery Plan for the Multi-Island Plants. U.S. Fish and Wildlife Service: Portland, Oregon.

USFWS. 2006. Endangered and threatened wildlife and plants: Determination of status for 12 species of Picture-Wing Flies from the Hawaiian Islands. Federal Register. Vol. 71 No. 89.. Rules and Regulations. Accessed July 2008. http://www.fws.gov/pacificislands/CHRules/picturewings.pdf

USFWS. 2008. Threatened and Endangered Species System. Kioele (*Hedyotis coriacea*). Accessed October 21, 2008. http://ecos.fws.gov/speciesProfile/SpeciesReport.do?spcode=Q1WZ

Wagner, W. L., D. R. Herbst and R. S. N. Yee. 1985. Status of the native flowering plants of the Hawaiian Islands. *In* C. P. Stone and J. M. Scott (Eds.) *Hawaii's Terrestrial Ecosystems: Preservation and Management.* Cooperative National Park Resources Study Unit. Honolulu: University of Hawaii.

Wagner, W. L., D. R. Herbst and S. H. Sohmer. 1999. *Manual of the Flowering Plants of Hawaii.* Honolulu: University of Hawaii Press.

Warren, S. D. 2004. Degradation and recovery of vegetation on Kahoolawe Island, Hawaii: A photographic journey. Pacific Science 58(3):461-495.

Wester, L. 1983. Vegetation. *In* J. R. Morgan (Ed.), *Hawaii, a Geography.* Westview Press: Boulder.

Wilson, E. O. and R. W. Taylor. 1967. The ants of Polynesia. Pacific Insects Monograph 14.

Zimmerman, E. C. 1948. *Insects of Hawaii*. Vol. 1. Introduction. xv. Univ. of Hawaii Press, Honolulu.

Zimmerman, E. C. 1972. Adaptive radiation in Hawaii with special reference to insects. pp.528-534 *In* A. Key (Ed.) *A Natural History of The Hawaiian Islands.* Honolulu: University Press of Hawaii.

Personal Communication:

P. Aldrich, July and August 2008

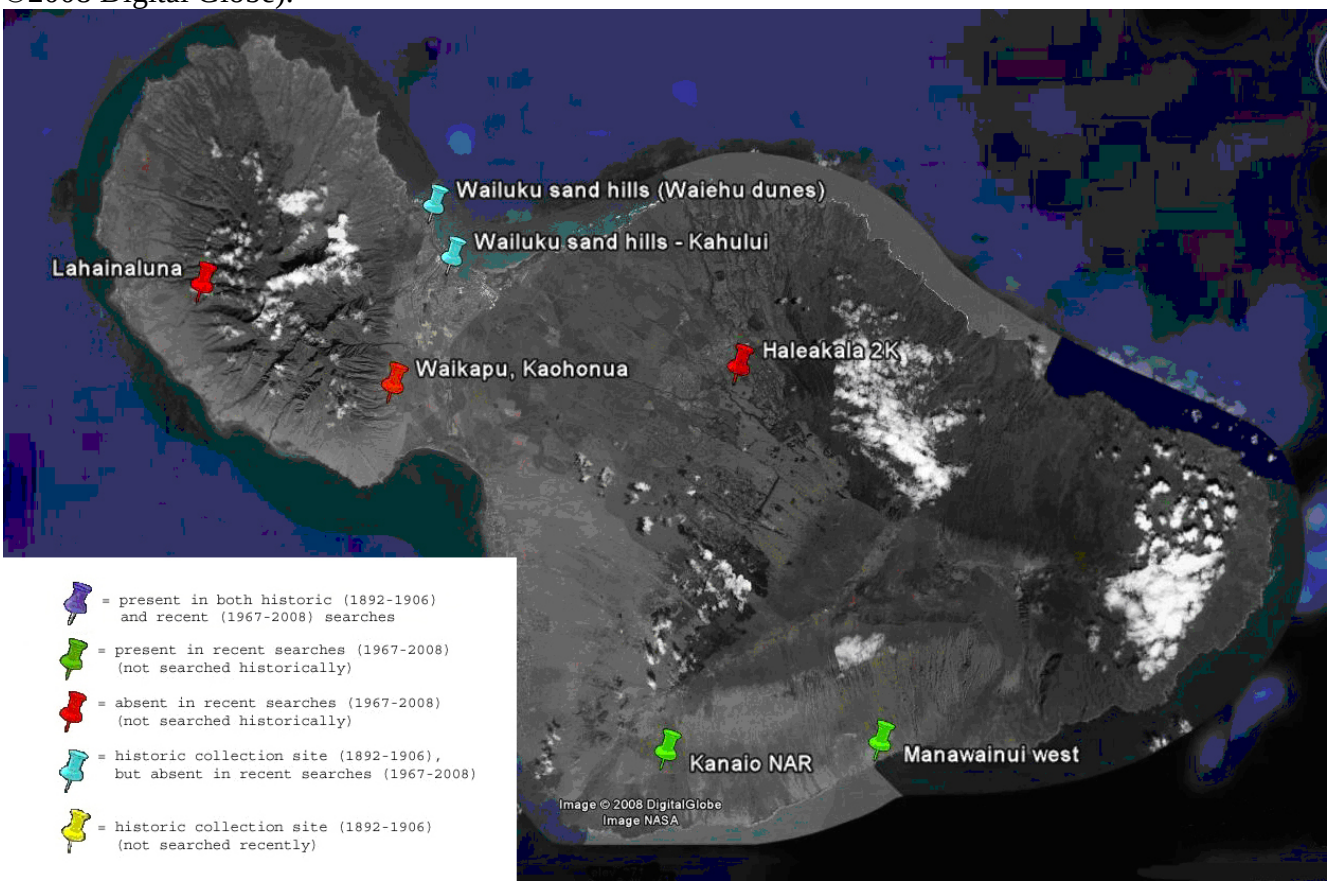
K. Magnacca, January, July, August, September, and October, 2008

S. Plentovich, July 2008

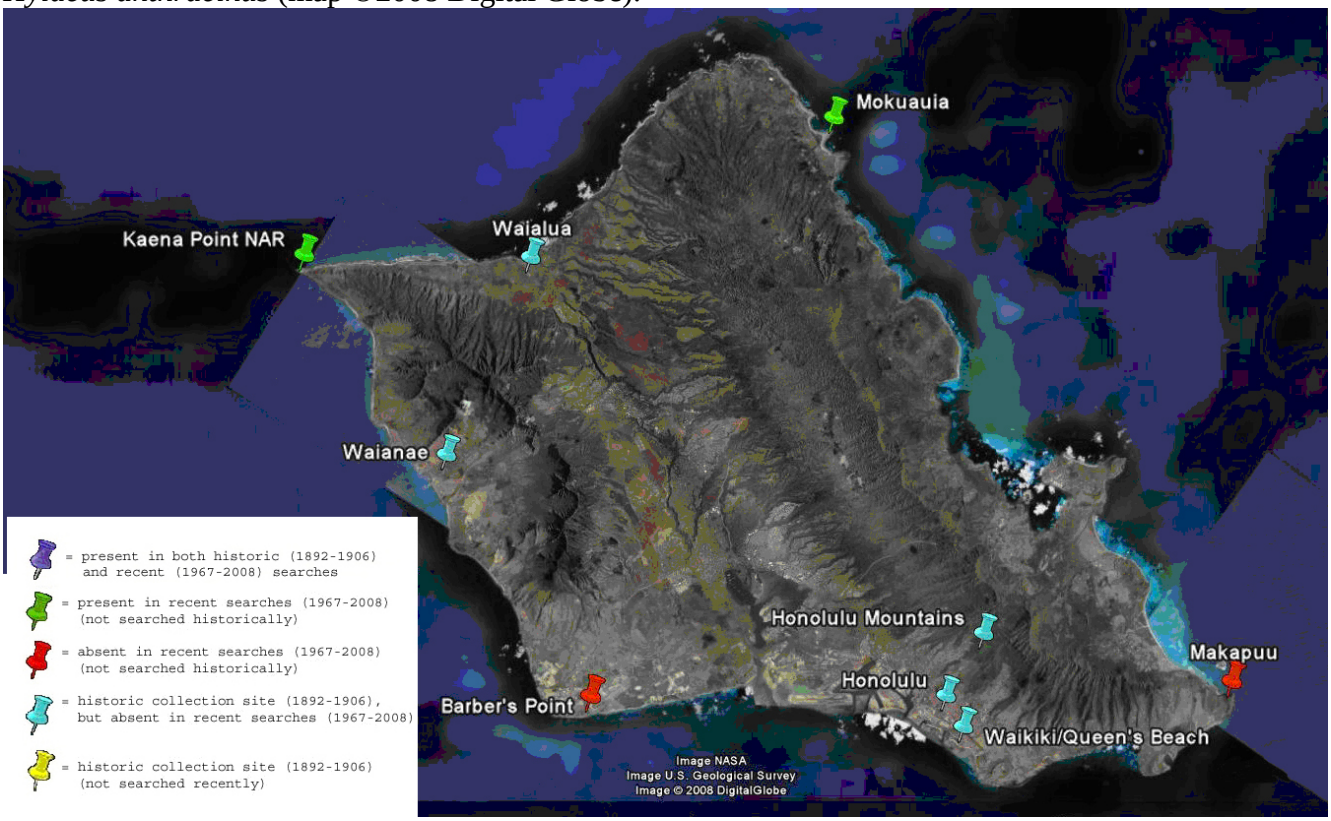
H. Sahli, October 2008

APPENDIX 1a-f. LOCATION OF RECORDED POPULATIONS OF *Hylaeus anthracinus*

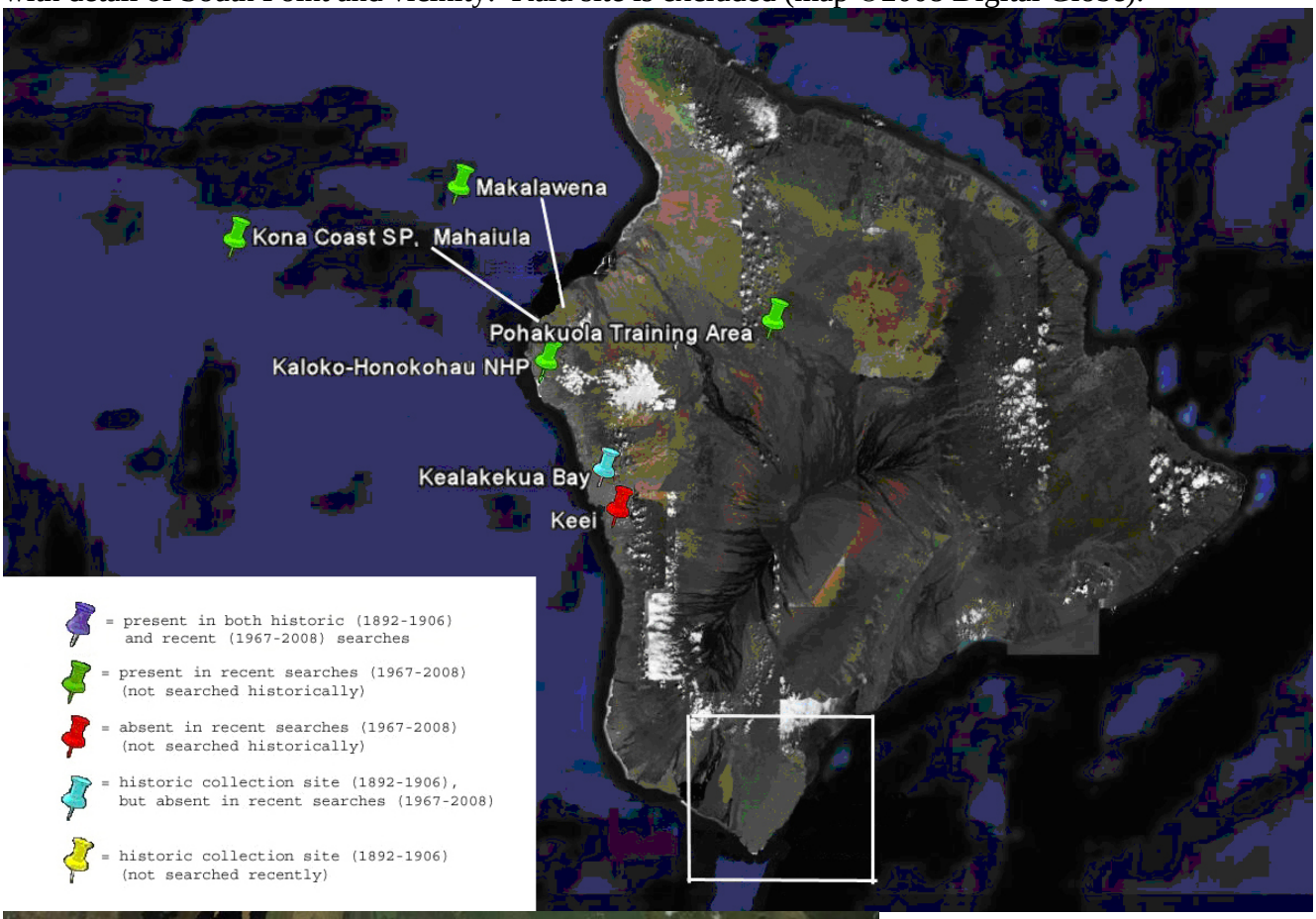
Appendix 1a. Map of Maui showing recent and historic collection sites for *Hylaeus anthracinus* (map ©2008 Digital Globe).

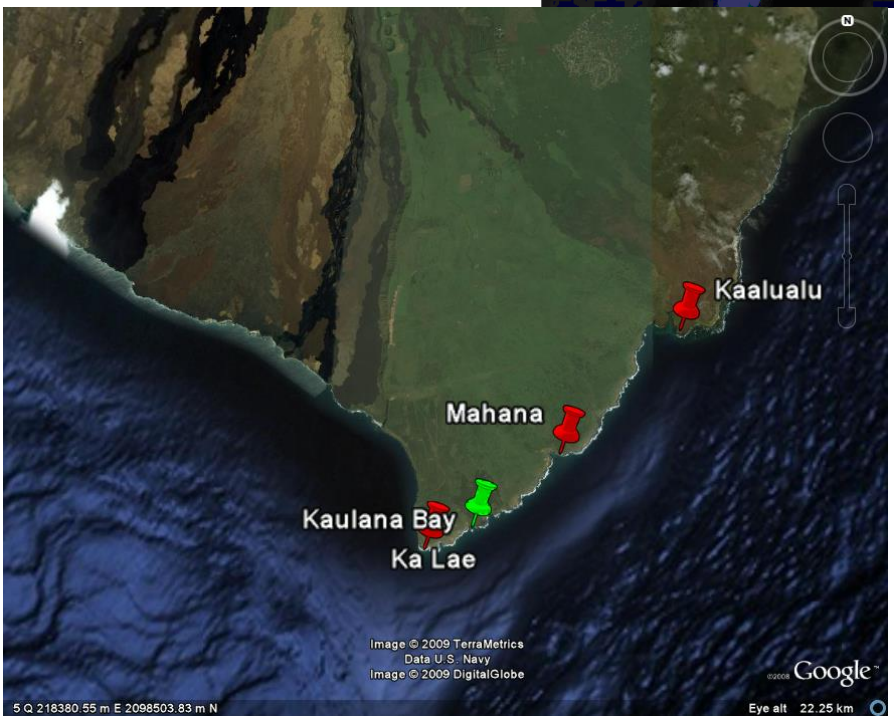


Appendix 1b. Map of Oahu, including Mokuauia, showing recent and historic collection sites for *Hylaeus anthracinus* (map ©2008 Digital Globe).

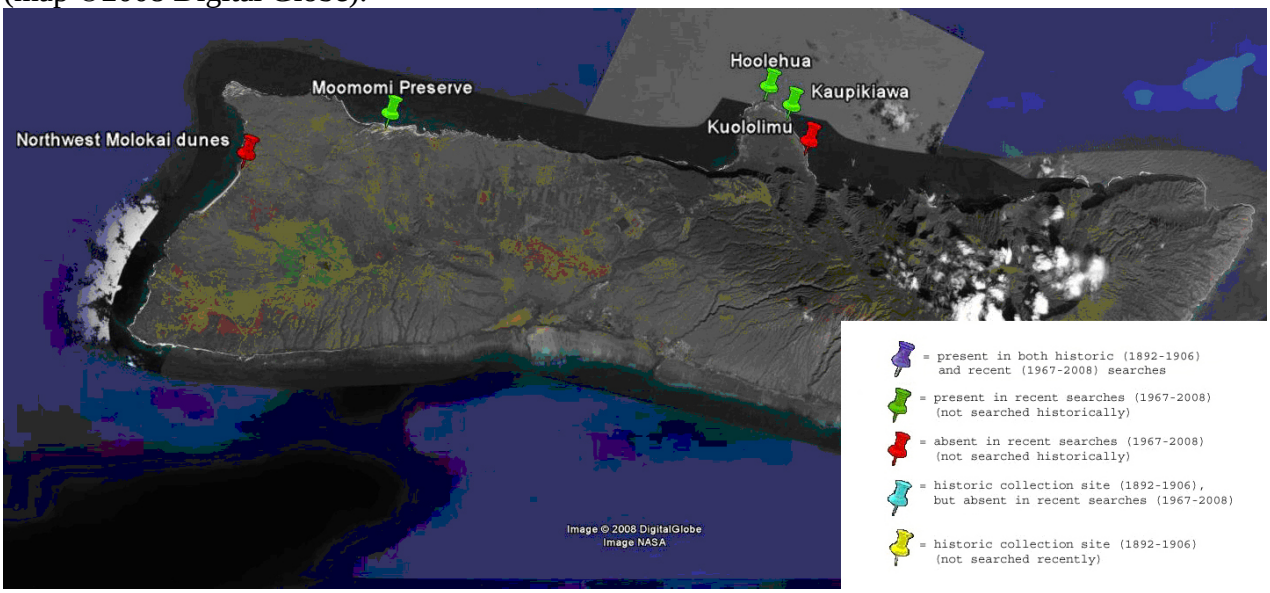


Appendix 1c. Map of Hawaii showing recent and historic collection sites for *Hylaeus anthracinus*, with detail of South Point and vicinity. Kalu site is excluded (map ©2008 Digital Globe).

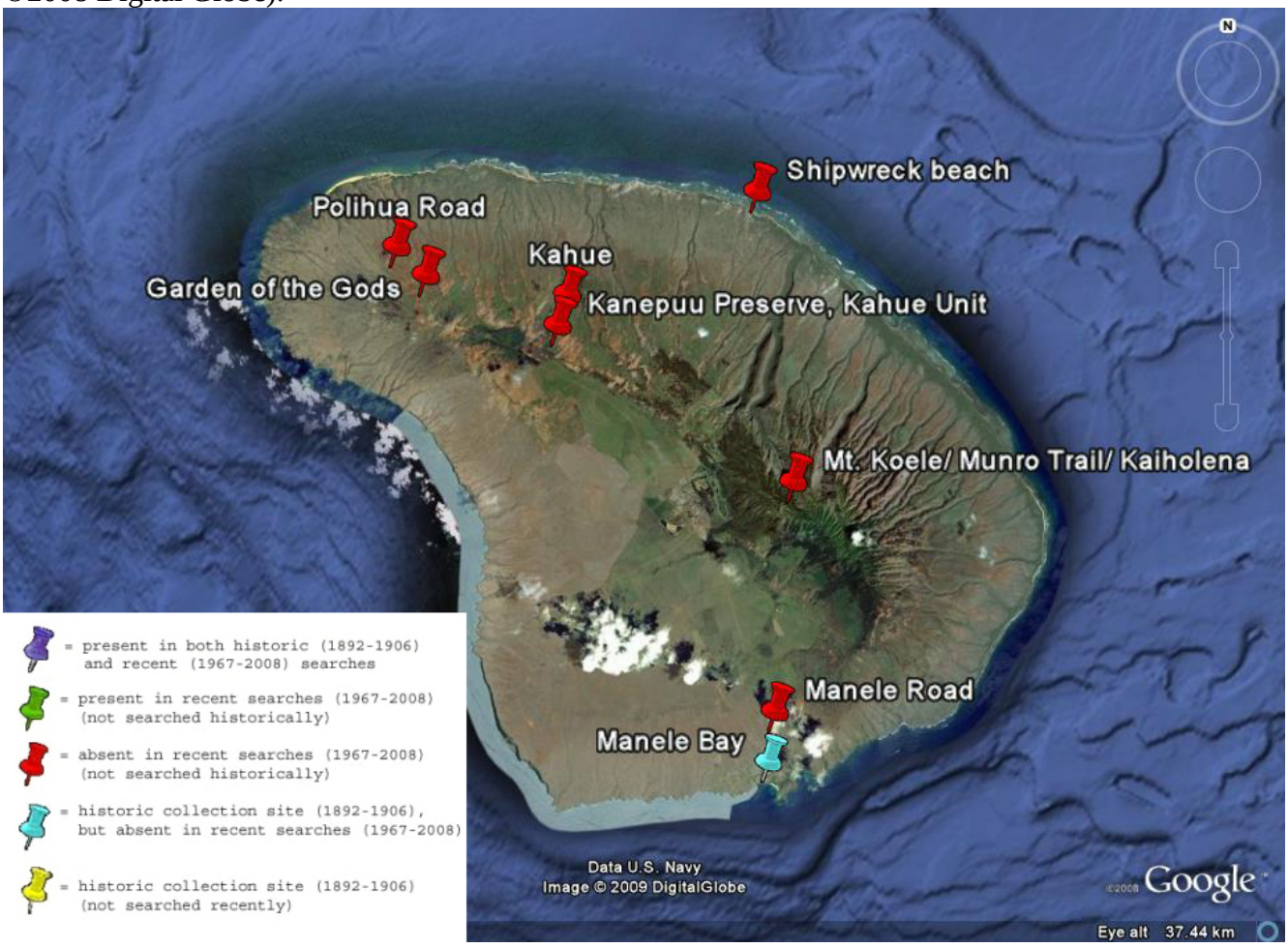




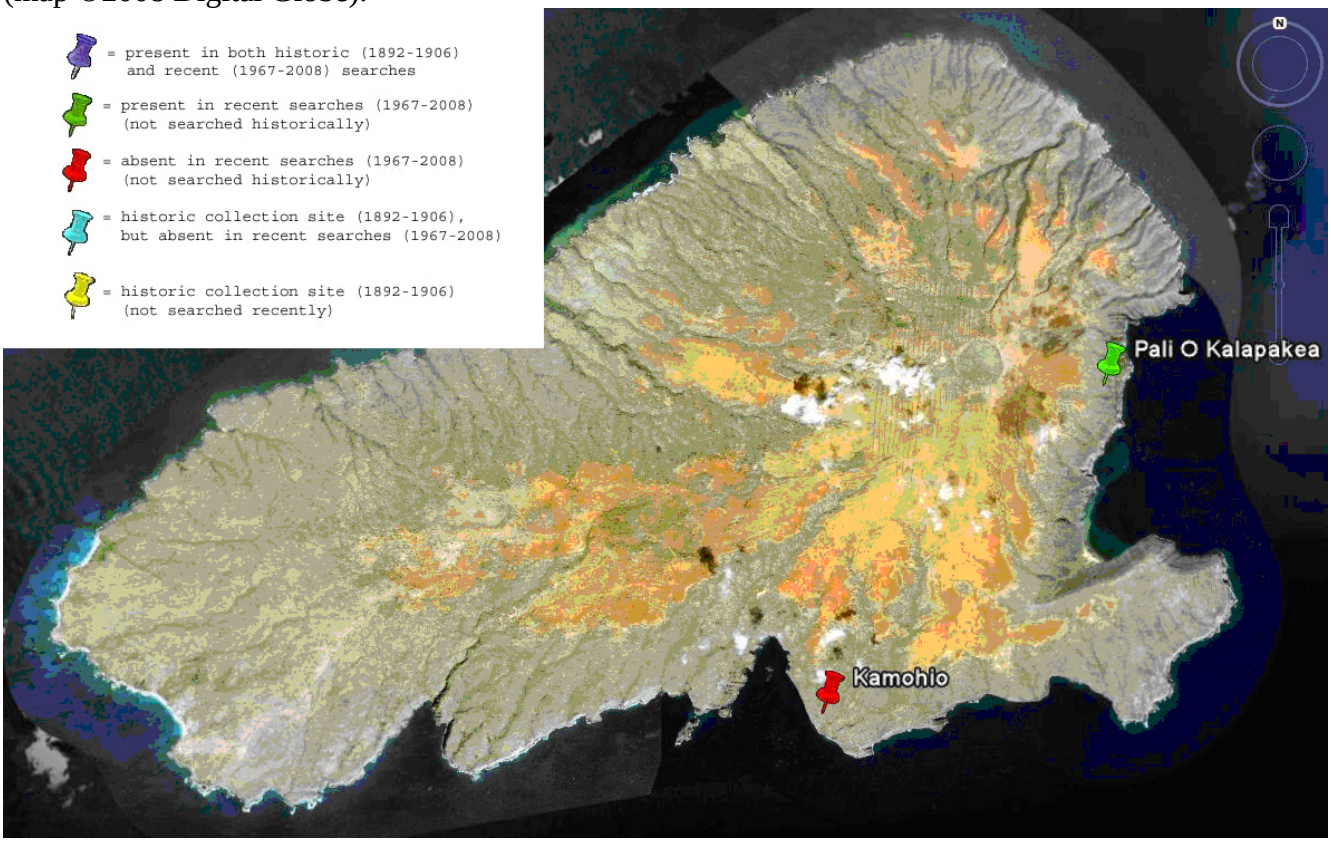
Appendix 1d. Map of Molokai showing recent and historic collection sites for *Hylaeus anthracinus* (map ©2008 Digital Globe).



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

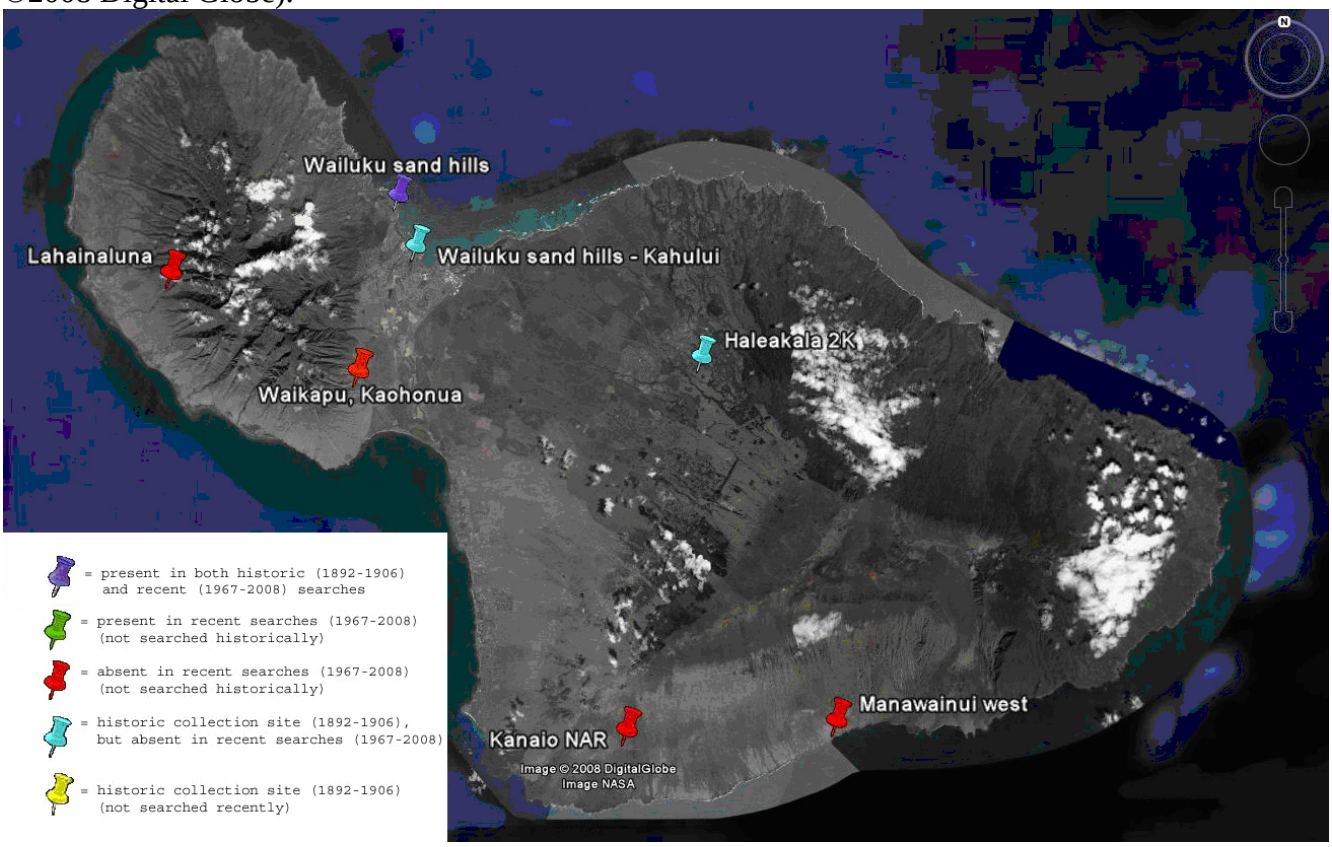


Appendix 1f. Map of Kahoolawe showing recent and historic collection sites for *Hylaeus anthracinus* (map ©2008 Digital Globe).

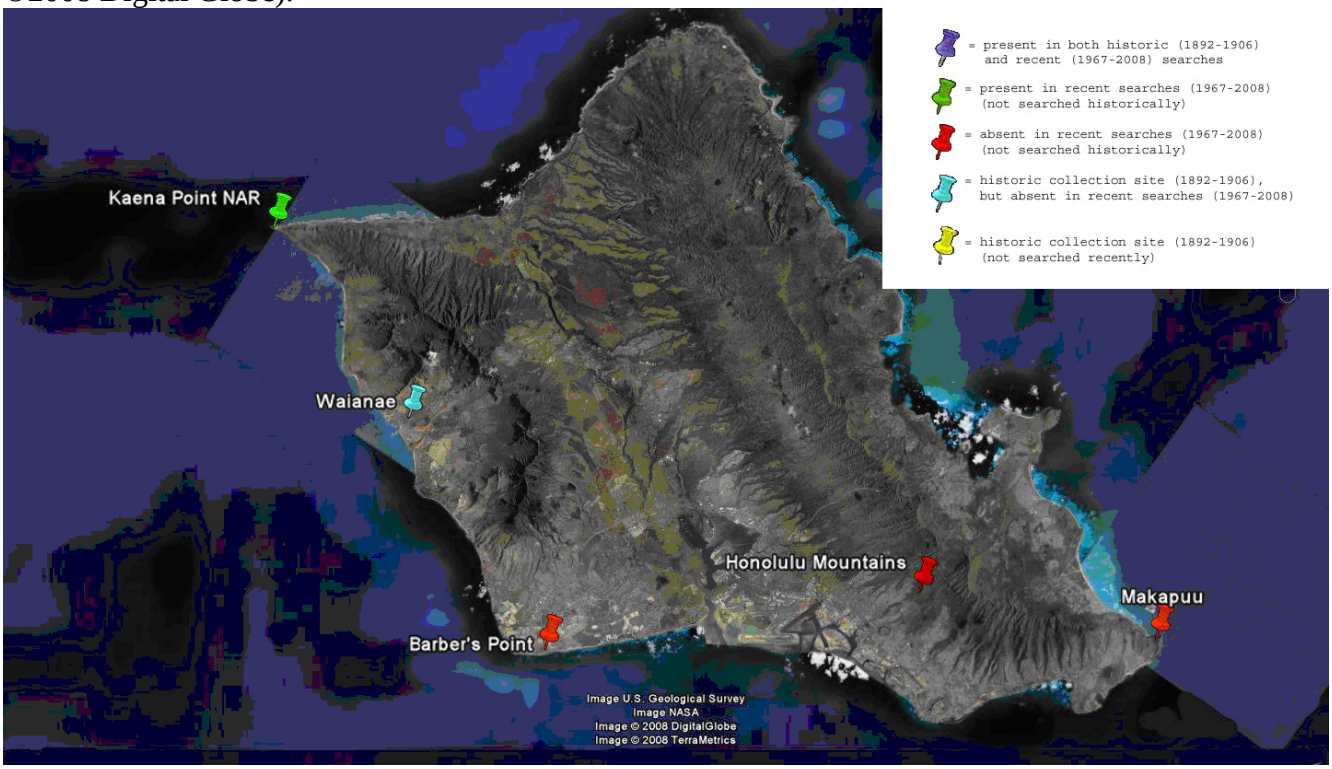


APPENDIX 2 a-d. LOCATION OF RECORDED POPULATIONS OF *Hylaeus longiceps*

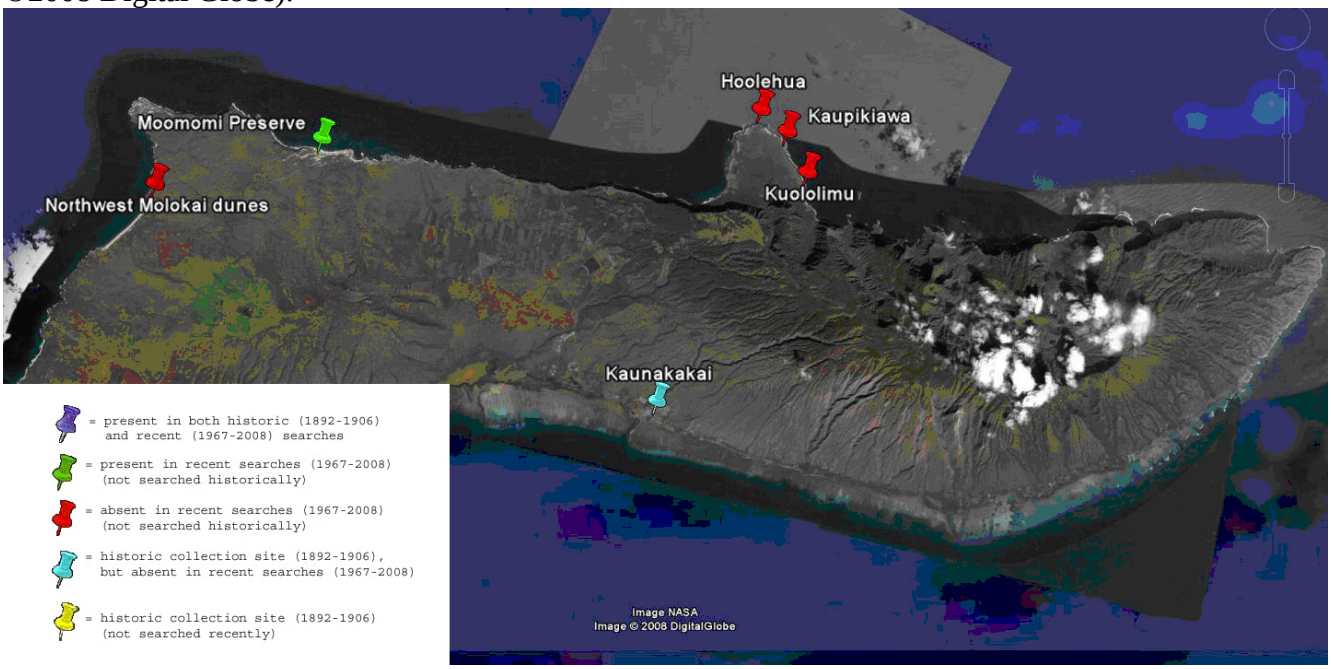
Appendix 2a. Map of Maui showing recent and historic collection sites for *Hylaeus longiceps* (map ©2008 Digital Globe).



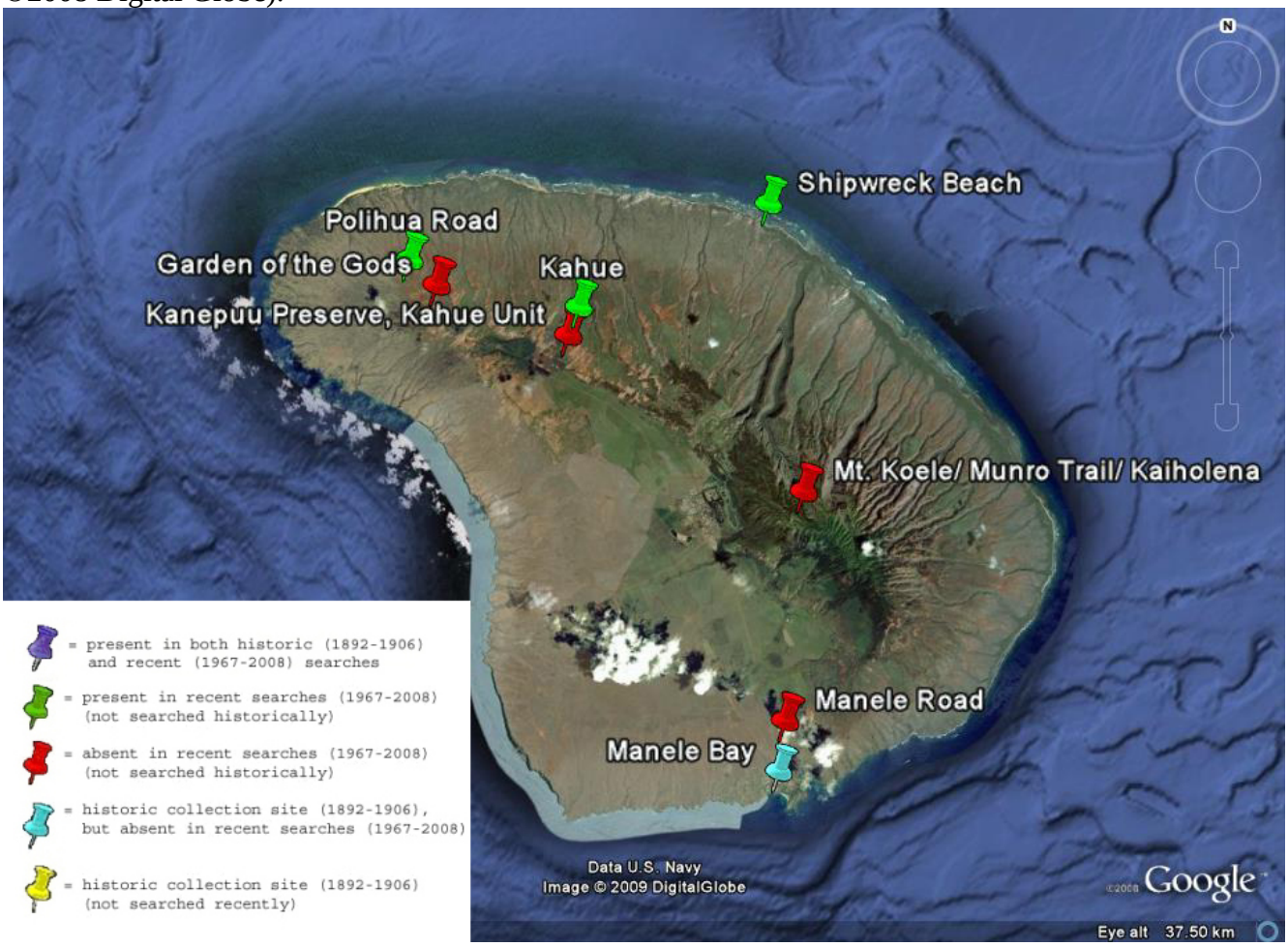
Appendix 2b. Map of Oahu showing recent and historic collection sites for *Hylaeus longiceps* (map ©2008 Digital Globe).



Appendix 2c. Map of Molokai showing recent and historic collection sites for *Hylaeus longiceps* (map ©2008 Digital Globe).

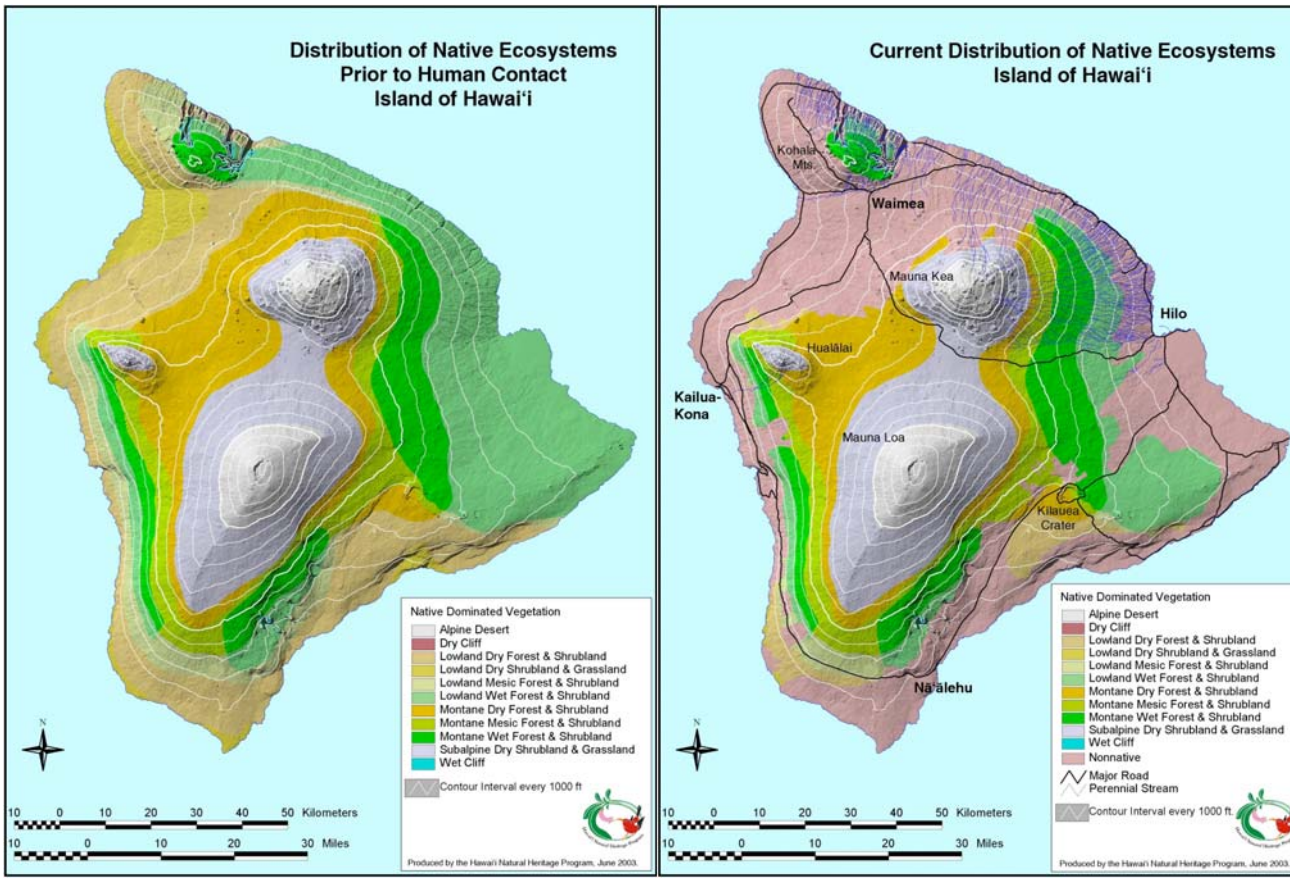


Appendix 2d. Map of Lanai showing recent and historic collection sites for *Hylaeus longiceps* (map ©2008 Digital Globe).



APPENDIX 3a-b. Maps of habitat loss since human colonization on the islands of Hawaii and Oahu.

Appendix 3a. Habitat loss since human colonization on the island of Hawaii



Appendix 3b. Habitat loss since human colonization on the island of Oahu