U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Hylaeus assimulans

Common Name:

Assimulans yellow-faced bee

Lead region:

Region 1 (Pacific Region)

Information current as of:

06/01/2013

Status/Action

___ Funding provided for a proposed rule. Assessment not updated.

___ Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

___ New Candidate

_X_ Continuing Candidate

___ Candidate Removal

> ___ Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status
>
> ___ Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species
>
> ___ Range is no longer a U.S. territory
>
> ___ Insufficient information exists on biological vulnerability and threats to support listing
>
> ___ Taxon mistakenly included in past notice of review
>
> ___ Taxon does not meet the definition of "species"
>
> ___ Taxon believed to be extinct
>
> ___ Conservation efforts have removed or reduced threats

___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

___ Non-Petitioned

_X_ Petitioned - Date petition received: 03/23/2009

90-Day Positive:06/16/2010

12 Month Positive:09/06/2011

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing? **Yes**

Explanation of why precluded:

We find that the immediate issuance of a proposed rule and timely promulgation of a final rule for this species has been, for the preceding 12 months, and continues to be, precluded by higher priority listing actions (including candidate species with lower LPNs). During the past 12 months, the majority our entire national listing budget has been consumed by work on various listing actions to comply with court orders and court-approved settlement agreements; meeting statutory deadlines for petition findings or listing determinations; emergency listing evaluations and determinations; and essential litigation-related administrative and program management tasks. We will continue to monitor the status of this species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures. For information on listing actions taken over the past 12 months, see the discussion of Progress on Revising the Lists, in the current CNOR which can be viewed on our Internet website (http://endangered.fws.gov/).

Historical States/Territories/Countries of Occurrence:

- **States/US Territories**: Hawaii
- **US Counties**: Honolulu, HI, Maui, HI
- **Countries**: United States

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories**: Hawaii
- **US Counties**: Maui, HI
- **Countries**: United States

Land Ownership:

Hylaeus assimulans is known from a total of five populations on the islands of Kahoolawe, Lanai, and Maui: three on private land and two on State land (Daly and Magnacca 2003, p. 217; Magnacca 2005a, p. 2;

Magnacca 2007b, p. 44).

Lead Region Contact:

ARD-ECOL SVCS, Jesse D'Elia, 5032312349, jesse_delia@fws.gov

Lead Field Office Contact:

PACIFIC ISLANDS FISH AND WILDL OFC, Kristi Young, 503 231-6845, kristi_young@fws.gov

Biological Information

Species Description:

Hylaeus assimulans is similar in structure to other hymenopterans (bees, wasps, and ants) in that adults have three main body parts-a head, thorax, and abdomen. One pair of antennae arises from the front of the head, between the eyes. Two pairs of wings and three pairs of legs are attached to the thorax. The abdomen is composed of multiple segments (Borror et al. 1989, pp. 665-666).

The *Hylaeus* genus, which includes H. assimulans, are commonly known as yellow-faced bees or masked bees for their yellow-to-white facial markings. All of the *Hylaeus* species roughly resemble small wasps in appearance, due to their slender bodies and their seeming lack of setae (sensory hairs). However, *Hylaeus* bees have plumose (branched) hairs on the body that are longest on the sides of the thorax. To a discerning eye, it is these plumose setae that readily distinguish them from wasps (Michener 2000, p. 55).

H. assimulans is distinguished by its large size relative to other coastal *Hylaeus* species and slightly smoky to smoky-colored wings. The male is black with yellow face marks, with an almost entirely yellow clypeus (lower face region) with additional marks on the sides that narrow dorsally (towards the top). The male also has brown appressed (flattened) hairs on the tip of the abdomen. The female is entirely black, large-bodied, and has no distinct punctuation on the abdomen (Daly and Magnacca 2003, p. 56).

Taxonomy:

Hylaeus assimulans was first described as *Nesoprosopis assimulans* (Perkins 1899, pp. 75, 101-102); *Nesoprosopis* was reduced to a subgenus of *Hylaeus* in 1923 (Meade-Waldo 1923, p. 1). The species was most recently described as *H. assimulans* by Daly and Magnacca in 2003 (pp. 55-56).

Habitat/Life History:

The general life cycle of *Hylaeus assimulans* is typical of most solitary bees: after mating, females create a nest in which to lay eggs that will hatch and develop into larvae (immature stage); as larvae grow, they molt (shed their skin) through three successive stages (instars); when fully grown, the larvae change into pupae (a resting form) in which they metamorphose and emerge as adults (Borror et al. 1989, p. 665).

Hawaiian *Hylaeus* species are grouped within two categories: ground-nesting species that require relatively dry conditions, and stem-nesting species that are often found within wetter areas (Zimmerman 1972, p. 533; Daly and Magnacca 2003, p. 11). *H. assimulans* is a ground-nesting species currently known from the islands of Kahoolawe, Lanai, and Maui. Nests of *H. assimulans* are usually constructed opportunistically within existing burrows, or other similarly small natural cavities under bark or rocks that they suit to their own needs. This is unlike the nest construction of many other bee species, which are purposefully excavated or constructed underground. All *Hylaeus* spp., including the Hawaiian *Hylaeus* species, lack strong mandibles and other adaptations for digging and often use nest burrows abandoned by other insect species (Daly and

Magnacca 2003, p. 9). The female *H. assimulans* lays eggs in brood cells she constructs in the nest and lines with a self-secreted, cellophane-like material. Prior to sealing the nest, the female provides her young with a mass of semiliquid nectar and pollen left alongside her eggs. Upon hatching, the grub-like larvae eat the provisions left for them, grow and molt through three instar stages, pupate, and eventually emerge as adults (Michener 2000, p. 24). The adult male and female bees feed upon flower nectar for nourishment. *H. assimulans*, like most *Hylaeus* species, lack an external structure for carrying pollen, called a scopa, and instead internally transport collected pollen, often mixed with nectar, within their crop (stomach).

The exact diet of the larval stage of *H. assimulans* is unknown, although the larvae are presumed to feed on stores of pollen and nectar collected and deposited in the nest by the adult female. Likewise, the exact nesting habits of *H. assimulans* are not known, but the species is thought to nest within the ground or in other natural cavities within patches of native coastal shrub species (Magnacca 2005a, p. 2).

H. assimulans adults have been observed visiting the flowers of its likely primary nesting host plant, *Sida fallax* (ilima), as well as the flowers of *Lipochaeta lobata* (nehe) (Daly and Magnacca 2003, p. 58). *H. assimulans* appears to be closely associated with plants in the genus *Sida*, and studies thus far suggest this yellow-faced bee species may be more common where this plant is abundant (Daly and Magnacca 2003, pp. 58, 217; Magnacca 2007a, p. 183). In recent survey efforts, *H. assimulans* seems to be more common in dry forest at relatively higher elevations, which may be related to the abundance of *Sida* in the understory (Magnacca 2005b, p. 2). *Sida* species were less often found in coastal habitat. It is likely *H. assimulans* visits several other native plants, including *Acacia koa* (koa), *Metrosideros polymorpha* (ohia), *Styphelia tameiameiae* (pukiawe), and species of *Scaevola* (naupaka) and *Chamaesyce* (akoko), which are frequented by other *Hylaeus* species as well (Magnacca 2005b, pers. comm.).

Recent studies of visitation records of Hawaiian *Hylaeus* bees, including *H. assimulans*, to native flowers (Daly and Magnacca 2003, p. 11) and pollination studies of native plants (Sakai et al. 1995, pp. 2,524-2,528; Cox and Elmqvist 2000, p. 1,238; Sahli et al. 2008, p. 1) have demonstrated Hawaiian *Hylaeus* species almost exclusively visit native plants to collect nectar and pollen, pollinating those plants in the process. *Hylaeus* bees are very rarely found visiting nonnative plants for nectar and pollen (Magnacca 2007a, pp. 186, 188) and are almost completely absent from habitats dominated by nonnative plant species (Daly and Magnacca 2003, p. 11). Sahli et al. (2008, p. 1) quantified pollinator visitation rates to all of the flowering plant species in communities on a Hawaiian lava flow dating from 1855 to understand how pollination webs and the integration of native and nonnative species changes with elevation. In that study, eight flowering plants were observed at six sites, which ranged in elevation from approximately 2,900 to 7,900 feet (ft) (approximately 880 to 2,400 meters (m)). The study also found the proportion of native pollinators changed along the elevation gradient; at least 40 to 50 percent of visits were from nonnative pollinators at low elevation, as opposed to 4 to 20 percent of visits by nonnative pollinators at mid to high elevations. *Hylaeus* bees were less abundant at lower elevations, and there were lower visitation rates of any pollinators to native plants at lower elevations, which suggests *Hylaeus* may not be easily replaceable by nonnative pollinators (Sahli et al. 2008, p. 1).

Historical Range/Distribution:

Historically, *Hylaeus assimulans* was known from numerous coastal and lowland dry forest habitats up to 2,000 ft (610 m) in elevation on the islands of Lanai, Maui, and Oahu. There are no collections from Molokai although it is likely *H. assimulans* also occurred there because all other species of *Hylaeus* known from Maui, Lanai, and Oahu also occurred on Molokai (Daly and Magnacca 2003, pp. 217-229). Between 1997 and 2008, surveys for Hawaiian *Hylaeus* were conducted in 25 sites on Kahoolawe, Lanai, Maui, Molokai, and Oahu. *H. assimulans* was absent from six of its historical localities on Lanai, Maui, and Oahu (Xerces Society 2009b, p. 4). *H. assimulans* was not observed at 19 other sites with potentially suitable habitat on Lanai, Maui, Molokai, and Oahu, including several sites from which other native *Hylaeus* species have been recently collected (Daly and Magnacca 2003, pp. 56, 217; Magnacca 2005b, p. 2; Magnacca 2007a, pp. 177, 181, 183).

Current Range Distribution:

Currently, *Hylaeus assimulans* is known from five small patches of coastal and lowland dry forest habitat: one location on Kahoolawe; two locations on Lanai; and two locations on Maui (Daly and Magnacca 2003, p. 58; Magnacca 2005, p. 2). This species has likely been extirpated from Oahu because it has not been observed since Perkins 1899 surveys and was not found during recent surveys of potentially suitable coastal habitat at Kaena Point, Makapuu, and Kalaeloa (Daly and Magnacca 2003, p. 217; Magnacca 2005, p. 2; Sahli, unpublished data).

The lands on which *H. assimulans* occurs are under a variety of jurisdictions, including private and State (e.g., Division of Forestry and Wildlife (DOFAW), Natural Areas Reserves (NARs), and the Kahoolawe Island Reserve Commission (KIRC)). Presented below is more specific information regarding the populations found on each island.

<u>Kahoolawe</u>

Although not historically known from Kahaoolawe (Daly and Magnacca 2003, p. 217), *Hylaeus assimulans* was discovered in 1997 near the high cliffs of Kamohio Bay in the center of the southern coast of the island (Daly and Magnacca 2003, p 217). The species was absent from one other site on the island in lowland habitat on the east coast at Pali o Kalapakea where other *Hylaeus* species were collected (Daly and Magnacca 2003, pp. 217-229). Overgrazing by introduced cattle and goats, and bombing and target practice by the U.S. military, have led to soil erosion resulting in the loss of almost all of the coastal and lowland dry forest habitat on this island (Warren 2004, p. 461). In 1993, Congress ended military use on Kahoolawe, and the Kahoolawe Island Reserve Commission (KIRC) was created to manage land use and restore Kahoolawes natural resources (Dept. of Defense, p. 1). Access to the island is limited and controlled by KIRC, and activities conducted on the island include fishing, habitat restoration, historical preservation, and education. Commercial enterprises are currently prohibited on the island (Warren 2004, p. 1).

<u>Lanai</u>

On Lanai, Perkins found *Hylaeus assimulans* in low numbers within uninhabited coastal habitat at Awalua in northwest Lanai, and in the Koele mountains at an elevation of 2,000 ft (610 m) (Perkins 1899, p. 102). Between 1998 and 2006, seven sites with potentially suitable habitat on private land, including Mt. Koele and Awalua, were surveyed, and *H. assimulans* was found only near Manele Road and Polihua Road in small pockets of native vegetation (Magnacca, pers. comm. 2008b). Descriptions of these sites follow:

(A) Manele Road: In 1999, *Hylaeus assimulans* was collected in lowland dry forest along Manele Road at 600 ft (180 m) in elevation, north of Manele Beach in southern Lanai (Daly and Magnacca 2003, p. 217). Researchers observed the canopy was dominated by invasive *Prosopis pallida* trees and the understory had a dense stand of *Sida fallax*, the likely primary host plant of *H. assimulans* (Magnacca, pers. comm. 2005b). However, with the exception of a few stunted plants at the roadside where moisture had accumulated, the rest of the stand of *Sida fallax* had senesced (reached maturity) or possibly died. Native plants at this site appeared to be drought-intolerant and probably did not provide consistent habitat for *Hylaeus* throughout the year (Magnacca 2007a, p. 183; Magnacca, pers. comm. 2008a).

(B) Polihua Road: In 1999, two specimens of *H. assimulans* were collected in lowland dry forest along Polihua Road at 1,000 ft in elevation (300 m) in central Lanai (Daly and Magnacca 2003, p. 58). Both sites are on private land, and we are unaware of any recent or current land management in these areas.

<u>Maui</u>

Perkins collected *Hylaeus assimulans* from coastal habitat at the Wailuku sand hills, and from an unknown site labeled Maui (Daly and Magnacca 2003, p. 58). Although other rare *Hylaeus* spp. were collected from the Waiehu dunes area during surveys conducted in 1999 and 2001, *H. assimulans*, as well as several other species once collected there by Perkins, were not found (Daly and Magnacca 2003, pp. 217-229). Between 1998 and 2006, researchers surveyed six potentially suitable habitat locations island-wide, and *H. assimulans* was found within small pockets of native plants in only two of these sites (Daly and Magnacca 200 3, p. 217). However, researchers believe *H. assimulans* may exist in potentially suitable habitat in rugged and inaccessible portions of west Maui (Magnacca, in litt. 2010, p. 1). Descriptions of these two sites follow:

(A) Lahainaluna: In 1999, *H. assimulans* was collected in dry lowland forest at 1,800 ft (550 m) in elevation on the west side of Maui. The site is with the States West Maui Natural Area Reserve (NAR). Established in 1986, the NARs management plan calls for the control and removal of feral ungulates, and the control of selected priority invasive plant species (http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/west-maui).

(B) Waikapu: In 2000, researchers collected *H. assimulans* in lowland dry shrubland dominated by the native shrub, *Dodonaea viscosa* (aalii) at 400 ft (120 m) elevation in Waikapu Valley, which is south of Iao Valley on the east side of west Maui (Daly and Magnacca 2003, p. 217). The 10,000-square ft (.09-square-hectare) site is privately-owned and surrounded by a fence to exclude nonnative axis deer (*Axis axis*). The fence was built in the mid-1980s by the Native Hawaiian Plant Society, and is currently managed by inspecting the fence for breaks; removing nonnative, invasive weeds; and collecting seeds of native plants for propagation. There have been two major fires in the past 5 years in the vicinity of the fenced area, although neither fire has burned within the enclosed area (Oppenheimer 2008, pers. comm.).

Between 1997 and 2007, *H. assimulans* was not collected during surveys of potentially suitable habitat at other locations on Maui where other rare *Hylaeus* species were collected, including lowland dry forest habitat in Kanaio NAR and coastal habitat at Manawainui Gulch (Daly and Magnacca 2003, pp. 217-229; Magnacca 2008a, pers. comm.).

<u>Oahu</u>

Perkins found *Hylaeus assimulans* to be widespread but not relatively abundant on Oahu (Perkins 1899, pp. 75, 101-102). His Oahu collection sites included Honolulu (Perkins 1899, pp. 75, 101-102), the Kaala Mountains, the Waianae Mountains, and the Waianae coast (Perkins 1899, p. 102; Daly and Magnacca 2003, p. 58). There are also specimens collected by Perkins from unknown locations labeled Oahu and w. coast, near sea level (Perkins 1899, p. 102; Daly and Magnacca 2003, p. 58).

H. assimulans was not found during surveys conducted between 1998 and 2008, including surveys at one historical location (Daly and Magnacca 2003, pp. 58, 217). Although *H. assimulans* was recently found on Mokuania (see *Hylaeus assimulans* Range and Distribution), *H. assimulans* was not found during surveys of potentially suitable habitat on this off-shore islet (Plentovich 2008, pers. comm.). The absence of *H. assimulans* from potentially suitable coastal habitat on Oahu suggests it has likely been extirpated from this island (Daly and Magnacca 2003, p. 58; Sahli et al. 2008).

Population Estimates/Status:

Hylaeus assimulans is currently known from five small patches of coastal and lowland dry forest habitat (Magnacca 2005a, p. 2): one location on Kahoolawe; two locations on Lanai; and two locations on Maui. The lands on which *H. assimulans* occurs are private and State (DOFAW and KIRC) ownership (Daly and Magnacca 2003, p. 217; Magnacca 2007b, p. 44). These five locations supported small populations of *H. assimulans*, but the number of individual bees is unknown. Table 1, below, summarizes information about the current population sites for this species.

Table 1. Occupied population sites and habitat conservation status of *Hylaeus assimulans* on the islands of Kahoolawe, Lanai, and Maui.

				Last Year	Approx.	Habitat

	Population Site	Island	Land Owner	Observed (or surveyed)	Size in Acres	Conservation Status & Threats
1	Kamohio Bay	Kahoolawe	State (KIRC)	1997	Unknown	Conserved
2	Manele Road	Lanai	Private	1999	Unknown	Not conserved
3	Polihua Road	Lanai	Private	1999	Unknown	Not conserved
4	Lahainaluna	Maui	State (NAR)	1999	Unknown	Conserved
5	Waikapu	Maui	Private	2000	0.25 acres	Conserved

Threats

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

Degradation and loss of coastal and lowland habitat used by *Hylaeus* bees on all of the main Hawaiian Islands is the primary threat to *Hylaeus assimulans* (Cuddihy and Stone 1990, pp. 60-61; Daly and Magnacca 2003, pp. 55, 173; Magnacca 2007a, p. 188). Coastal and lowland habitats have been severely altered and degraded, partly because of past and present land management practices, including agriculture, grazing, and urban development; the deliberate and accidental introductions of nonnative animals and plants; and recreational activities. In addition, fire is a potential threat to the habitat of *H. assimulans* in some locations.

<u>Habitat Destruction and Modification by Urbanization and Land Use Conversion</u>

Destruction and modification of *Hylaeus* bee habitat by urbanization and land use conversion leads to the direct loss and fragmentation of foraging and nesting habitat of *H. assimulans*. In particular, because native host plant species are known to be essential to *H. assimulans* for foraging of nectar and pollen, any further loss of this habitat may endanger its long-term chances for conservation and recovery. Additionally, conversion and modification of suitable habitat for *H. assimulans* is also likely to further exacerbate the introduction and spread of nonnative plants into and within these areas (see Habitat Destruction and Modification by Nonnative Plants section below).

<u>Coastal Habitat</u>

Native coastal habitat is one of the rarest habitats on the main Hawaiian Islands (Hawaii, Kahoolawe, Kauai, Lanai, Maui, Molokai, and Oahu) (Wagner et al. 1999, pp. 45, 54; Cuddihy and Stone 1990, pp. 94-95; Magnacca 2007, p. 180). Coastal habitat is highly valued for development, popular for recreation, typically dry on both the windward and leeward sides of the islands, vulnerable to fire, and especially susceptible to invasion by nonnative plants. Increased access to coastal areas, and resulting habitat disturbance, has been facilitated by development, road-building, and past agricultural activities (Cuddihy and Stone 1990, pp. 94-95). The native coastal 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, pp. 94-95) (see Habitat Destruction and Modification by Nonnative Plants section below). Most of the coastal areas of the main Hawaiian Islands now lack significant amounts of native plants suitable for foraging by *Hylaeus*, other than *Scaevola sericea*, which alone cannot support *Hylaeus* populations (Magnacca 2007a, p. 187). The restricted and isolated nature of coastal habitat places species that depend on these areas even more at risk for a variety of reasons, including but not limited to their increased susceptibility to random and stochastic events such as hurricanes and wildfire, the reduced range of native plants including host plants, and the reduced number of suitable sites for species to expand their range (Sakai et al. 2002, p. 291).

Five species of candidate Hawaiian yellow-faced bees (*Hylaeus anthracinus*, *H. assimulans*, *H. facilis*, *H. hilaris*, and *H. longiceps*) were once widespread and common in coastal habitat (Perkins 1912, p. 688) throughout the main Hawaiian Islands, with the exception of Kauai. These five species are now absent from all of Perkins coastal collection localities: Kealakekua Bay and Keei and the urban area near Kona on the island of Hawaii; the Awalua area on Lanai; the Wailuku sand hills area on Maui; the northwest dunes and Kaunakakai areas on Molokai; Waikiki, the Waianae area, and the Honolulu mountains on Oahu (Daly and Magnacca 2003, pp. 217-229). However, they have recently been collected in disparate coastal habitat on one or more of the islands of Hawaii, Kahoolawe, Lanai, Maui, Molokai, and Oahu (Daly and Magnacca 2003, pp. 217-229).

Lowland Dry Habitat

Lowland dry forests and shrublands have also been heavily impacted by urbanization and conversion to agriculture or pasture throughout the Hawaiian Islands, with the estimated loss of more than 90 percent of dry forests and shrublands (Bruegmann 1996, p. 26; Juvik and Juvik 1998, p. 124). Less than 1 percent of lowland dry forest and shrubland remains on Oahu, Molokai, and Lanai; less than 2 percent remains on Maui; and less than 17 percent remains on Hawaii Island (Sakai et al. 2002, p. 296). Without greater conservation and restoration efforts, we believe the remaining lowland dry forest and shrublands, which were once abundant and perhaps the most diverse of all Hawaiian habitat types (Medeiros et al. 2006, p. 1), could completely disappear due to continued development and other land use conversion, compounded by the effects of nonnative species, wild fire, and other random and stochastic events (see the following sections on Habitat Destruction and Modification by Nonnative Plants; by Nonnative Ungulates; by Fire; by Recreational Activities; by Hurricanes and Drought; and by Climate Change) (Cabin et al. 2000, p. 449).

Four species of candidate yellow-faced bees (*H. anthracinus*, *H. assimulans*, *H. facilis*, and *H. longiceps*) were once widespread (i.e., there were several populations across two or more islands) and found within lowland dry habitat on several islands, including Hawaii, Lanai, Maui, Molokai, and Oahu. However, these species have not been observed during recent surveys from their historical population sites on these islands (Magnacca 2005a, b, c, f, pp. 1-2). Five of the seven candidate *Hylaeus* bee species (*H. assimulans*, *H. facilis* , *H. kuakea*, *H. longiceps*, and *H. mana*) are most often found in dry and mesic forest (see discussion below) and shrubland habitat (Daly and Magnacca 2003, p. 11), and the greatest proportion of endangered or at-risk Hawaiian plant species are also limited to these same habitats; 25 percent of Hawaiian listed plant species are from dry forest and shrubland alone (Sakai et al. 2002, pp. 276, 291, 292). According to Magnacca (2007, pp. 186-187), lowland dry and mesic forests now support less-diverse *Hylaeus* communities because many native plants used for foraging are extirpated from these habitats.

In summary, destruction and modification by urbanization and land use conversion of the coastal and lowland habitat of *H. assimulans* is continuing, and is expected to continue reducing and fragmenting the remaining habitat available to this species in the future, endangering the species long-term chances for conservation and recovery. Because of the decreased amount of suitable native coastal and lowland habitat remaining in the Hawaiian Islands and the continued conversion of these native habitats by development, road building, or agriculture, we conclude the ongoing habitat loss and land modification is a significant ongoing threat to *H. assimulans*.

Habitat Destruction and Modification by Nonnative Plants

Native vegetation on all of the main Hawaiian Islands has undergone extreme alteration because of past and present land management practices, including ranching, agricultural development, and the deliberate introduction of nonnative plants and animals (Cuddihy and Stone 1990, pp. 27, 58). The original native flora of Hawaii (species that were present before humans arrived) consisted of about 1,000 taxa, 89 percent of which were endemic (species that occur only in the Hawaiian Islands). Over 800 plant taxa have been introduced from elsewhere, and nearly 100 of these have become pests (e.g., injurious plants) in Hawaii

(Smith 1985, p. 180; Cuddihy and Stone 1990, p. 73; Gagne and Cuddihy 1999, p. 45). Some of these plants were brought to Hawaii by various groups of people, including the Polynesians, for food or cultural reasons. Beginning in the early 1900s, plantation owners (and the territorial government of Hawaii), alarmed at the reduction of water resources for their crops caused by the destruction of native forest cover by grazing feral and domestic animals, introduced nonnative trees for reforestation and continued the practice through the late 1930s (The Nature Conservancy (TNC) 2003, p. 19). Ranchers intentionally introduced pasture grasses and other nonnative plants for agriculture, and sometimes inadvertently introduced weed seeds as well. Other plants were brought to Hawaii for their potential horticultural value (Scott et al. 1986, pp. 361-363; Cuddihy and Stone 1990, p. 73).

Nonnative plants adversely impact native Hawaiian habitat, including that of *H. assimulans*, by modifying the availability of light, altering soil-water regimes, modifying nutrient cycling, and altering fire characteristics of native plant communities. A major concern is that successive fires burn farther and farther into native habitat, destroy native plants, and remove habitat for native species by altering microclimatic conditions to favor nonnative species), and ultimately converting native dominated plant communities to nonnative plant communities (Smith 1985, pp. 180-181; Cuddihy and Stone 1990, p. 74; DAntonio and Vitousek 1992, p. 73; Vitousek et al. 1997, p. 6). Nonnative plants directly and indirectly affect *H. assimulans* by modifying or destroying its coastal and lowland forest habitat and reducing food sources.

The spread of nonnative plant species is one of the primary causes of decline of *Hylaeus assimulans*, and a current threat to its existing populations because the species depends closely on native vegetation for nectar and pollen. *Hylaeus* bees in general are almost entirely absent from habitat dominated by invasive, nonnative vegetation (Sakai et al. 2002, pp. 276, 291; Daly and Magnacca 2003, p. 11; Liebherr 2005, p. 186). The native flora within most of lowland habitat in the Hawaiian Islands is being replaced by aggressive, nonnative plant species (Cuddihy and Stone 1990, pp. 73-74; Wagner et al. 1999, p. 52). Many native plant species communities that have been replaced by often monotypic communities of nonnative plants were once foraging resources for numerous species of Hylaeus bees including *H. assimulans* (Cox and Elmqvist 2000, p. 1238; Daly and Magnacca 2003, p. 11; USFWS 1999, pp. 145, 163, 171, 180; USFWS 2008b, pp. 7, 9).

Many of the native plants that currently serve as foraging resources for *Hylaeus assimulans* are declining due to a lack of pollinators and competition with nonnative plants (Daly and Magnacca 2003, p. 11; USFWS 2008b, pp. 7, 9; Smith 1985, pp. 180-181; Cuddihy and Stone, 1990, p. 74; DAntonio and Vitousek 1992, p. 73; Vitousek et al. 1997, p. 6) and are found only in very small populations (USFWS 1999, pp. 145, 163, 171, 180; Cox and Elmqvist 2000, p. 1,238). Several other widespread nonnative plant species threaten coastal habitats of H. assimulans known from these areas. Understory and sub-canopy species include *Asystasia gangetica* (Chinese violet), *Atriplex semibaccata* (Australian saltbush), *Leucana leucocephala* (koa haole), *Pluchea indica* (Indian fleabane), *Pluchea symphytifolia* (sourbush), and *Verbesina encelioides* (golden crown-beard) (DOFAW 2007, pp. 20-22, 54-58; HBMP 2008). Nonnative canopy species include *Prosopis pallida* (kiawe) (DOFAW 2007, pp. 20-22, 54-58; HBMP 2008), an invasive, nonnative, deciduous thorny tree (TNC 2009, p. 8). In addition, several nonnative grasses such as *Cenchrus ciliaris* (buffelgrass), *Chloris barbata* (swollen fingergrass), *Digitaria insularis* (sourgrass), and *Panicum maximum* (guinea grass) threaten the coastal habitats in which these native species are known to occur (DOFAW 2007, pp. 20-22, 54-58; HBMP 2008).

As noted in the Life History section, above, *Hylaeus* species almost exclusively visit native plants to collect nectar and pollen (Daly and Magnacca 2003, p. 11), pollinating those plants in the process (Sakai et al. 1995, pp. 2,524-2,528; Cox and Elmqvist 2000, p. 1,238; Sahli et al. 2008, p. 1). *Hylaeus* bees are very rarely found visiting nonnative plants for nectar and pollen (Magnacca 2007a, pp. 186, 188). Unpublished data on *Hylaeus* spp. pollen use (Magnacca, in litt. 2011, p. 65) suggest only approximately three percent of pollen collected by yellow-faced bees in general is from nonnative plant sources. These data do not include observations regarding yellow-faced bee use of *Tournefortia argentea* (tree heliotrope), which is a naturalized and relatively recent arrival to the Hawaiian Islands, as a pollen resource (Magnacca, in litt. 2011, p. 65) (see additional information on this species below). Other than *Scaevola sericea*, native vegetation is lacking along most of the coastline of the main Hawaiian Islands. As Hylaeus spp. have not been observed at coastal sites where *Scaevola sericea* represents the only native plant species occurrence, researchers believe yellow-faced bees, including *H. assimulans*, are unable to survive on this species alone (Magnacca 2007, p. 187; Magnacca, in litt. 2011, p. 65).

In summary, the spread of nonnative plants throughout the coastal and lowland habitat of *Hylaeus assimulans* represents a serious and ongoing threat to this species. Many of the native plant species being replaced by invasive, nonnative plants provide foraging resources (e.g. pollen, nectar) for *Hylaeus* bees, including *H. assimulans*. The best available information indicates *H. assimulans* does not characteristically forage on nonnative plants (Daly and Magnacca 2003, p. 13). Only 14 of 820 recent (1998 to 2010) *Hylaeus* spp. observations were on flowers of nonnative plant species; however, none of those observations involved *H. assimulans*. Therefore, we conclude that the ongoing spread of nonnative plants into the habitats of *H. assimulans* remains a significant threat due to manner in which nonnative plants alter and fragment habitat, increase the likelihood of fire, and attract nonnative insect species. This threat further endangers the species long-term chances for conservation and recovery.

Habitat Destruction and Modification by Nonnative Ungulates

The presence of nonnative mammals, such as feral pigs (*Sus scrofa*), cattle (*Bos taurus*), goats (*Capra hircus*), and axis deer (*Axis axis*), is considered one of the primary factors underlying the alteration and degradation of native vegetation and habitat in the Hawaiian Islands (Stone 1985, pp. 262-263; Cuddihy and Stone 1990, pp. 60-66; 73 FR 73801). Beyond the direct effects of trampling and consuming native plants, nonnative ungulates contribute significantly to increased erosion, and their behavior (i.e., rooting and moving across large areas) facilitates the spread and establishment of competing, invasive, nonnative plant species (Cuddihy and Stone 1990, p. 65). Feral pigs occur on all of the main Hawaiian Islands except Kahoolawe and Lanai (Hawaii Ecosystems at Risk Project (HEAR) 1998; Kessler 2011, pers. comm.); goats are found on all of the main Hawaiian Islands except Lanai (HEAR 1998); feral cattle are found on Hawaii and Maui (HEAR 1998); Mouflon sheep and hybrids are found on Hawaii and Lanai (Hawaii Conservation Alliance (HCA) 2007); and axis deer are found on Hawaii, Lanai, Maui, and Molokai (HCA 2007). At least one endangered coastal and lowland plant species, *Sesbania tomentosa* (ohai), threatened by the browsing, trampling, and digging activities of nonnative ungulates (e.g., axis deer, goats, and cattle), is a possible foraging source for *H. assimulans* (USFWS 1999, pp. 145, 163, 171, 180; Daly and Magnacca 2003, pp. 11, 13).

The State of Hawaii provides game mammal (e.g., feral pigs, goats, and deer) hunting opportunities on State-designated public hunting areas on the islands of Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu (Hawaii Administrative Rules § 13-123-14-13-123-20; Department of Land and Natural Resources (DLNR) 1999). The States management objectives for game animals ranges from maximizing public hunting opportunities (e.g., sustained yield) in some areas to removal by State staff, or their designees, in other areas (Hawaii Administrative Rules § 13-123). *H. assimulans* has populations in or adjacent to areas where terrestrial habitat may be manipulated for game enhancement and where game populations are maintained at certain levels for public hunting (Hawaii Administrative Rules § 13-123). Public hunting areas are predominantly not fenced, and game mammals have unrestricted access to most areas across the landscape, regardless of underlying land use designation. While fences are sometimes built to provide protection from game mammals to the natural resources within the fenced area, the current number and locations of fences are not adequate to prevent habitat destruction and degradation of the terrestrial habitat of *H. assimulans*.

In summary, feral pigs, cattle, goats, and axis deer continue to alter and degrade native vegetation within *H. assimulans* habitat in the Hawaiian Islands. We believe these ungulates represent a significant and ongoing threat to the continued existence of *H. assimulans*, endangering the species long-term chances for conservation and recovery. Ungulates directly trample and consume native plants, including plants used for foraging by *H. assimulans*. The best available information indicates that *H. assimulans* does not use nonnative plants for foraging (Daly and Magnacca 2003, p. 13). While some specific areas throughout the State, including some *H. assimulans* habitat sites, are managed to exclude the presence of or control ungulates, we are unaware of any plans to entirely eradicate or eliminate ungulates from the Hawaiian Islands. In addition, public hunting areas maintain populations of nonnative ungulates and often do not provide adequate fencing to prevent nonnative ungulates from negatively impacting the habitat of *H. assimulans*. Therefore, the ongoing alteration and degradation of many of the native coastal and lowland habitat where *H. assimulans* occurs by ungulates is expected to further impact this species foraging and nesting habitat through the direct consumption and trampling of native plants, introduction and spread of nonnative plants, and increased erosion.

Habitat Destruction and Modification by Fire

Fire is a relatively new, human-exacerbated threat to native species and natural vegetation in Hawaii. The historical fire regime in Hawaii was characterized by infrequent, low severity fires, as few natural ignition sources existed (Cuddihy and Stone 1990, p. 91; Smith and Tunison 1992, pp. 395-397). Natural fuel beds were often discontinuous, with moderate to high rainfall in many areas on most islands. Fires inadvertently or intentionally ignited by the original Polynesians in Hawaii probably contributed to the initial decline of native vegetation in the drier plains and foothills. These early settlers practiced slash-and-burn agriculture that created open lowland areas suitable for the later colonization of nonnative, fire-adapted grasses (Kirch 1982, pp. 5-6, 8; Cuddihy and Stone 1990, pp. 30-31). Beginning in the late 18th century, Europeans and Americans introduced plants and animals that further degraded native Hawaiian ecosystems. Pasture areas and ranching, in particular, created highly fire-prone areas of nonnative grasses and shrubs (DAntonio and Vitousek 1992, p. 67). Fires of all intensities, seasons, and sources are destructive to native Hawaiian ecosystems (Brown and Smith 2000, p. 172), and a single grass-fueled fire can kill most native trees and shrubs in the burned area (DAntonio and Vitousek 1992, p. 74). Although Vogl (1969) (in Cuddihy and Stone 1990, p. 91) suggests naturally occurring fires, primarily from lightning strikes, have been important in the development of the original Hawaiian flora, and many Hawaiian plants might be fire-adapted, Mueller-Dombois (1981) (in Cuddihy and Stone 1990, p. 91) points out most natural vegetation types of Hawaii would not carry fire before the introduction of nonnative grasses. Smith and Tunison (in Cuddihy and Stone 1990, p. 91) state that native plant fuels typically have low flammability.

Fire represents a threat to *H. assimulans* in coastal and lowland dry habitat. Fire threatens *H. assimulans* by destroying the native plant species and communities on which the species depend and opening up habitat for increased invasion by nonnative plants. Fire can destroy dormant seeds of native plants as well as the plants themselves. Successive fires that burn farther and farther into native habitat destroy native plants and remove habitat for native plant and animal species by altering microclimate conditions favorable to nonnative plants. Nonnative plant species most likely to be spread as a consequence of fire are those that (1) produce a high fuel load; (2) are adapted to survive and regenerate after fire; and (3) establish rapidly in newly burned areas. Grasses (particularly those that produce mats of dry material or retain a mass of standing dead leaves) that invade native forests and shrublands provide fuels that allow fire to burn areas that would not otherwise easily burn, including even the edges of wetter forests (Fujioka and Fujii 1980, in Cuddihy and Stone 1990, p. 93; DAntonio and Vitousek 1992, pp. 70, 73-74; Tunison et al. 2002, p. 122). Native woody plants may recover from fire to some degree, but fire tips the competitive balance toward nonnative species (National Park Service 1989, in Cuddihy and Stone 1990, p. 93).

For example, on a post-burn survey at Puuwaawaa on the island of Hawaii, an area of native *Diospyros* forest with undergrowth of the nonnative grass *Pennisetum setaceum* (fountain grass), Takeuchi noted no regeneration of native canopy is occurring within the Puuwaawaa burn area (Takeuchi 1991, p. 2). Takeuchi also stated, Burn events served to accelerate a decline process already in place, compressing into days a sequence which would ordinarily have taken decades (Takeuchi 1991, p. 4). The author concluded that in addition to increasing the number of fires, the nonnative *P. setaceum* acted to suppress establishment of native plants after a fire (Takeuchi 1991, p. 6).

There have been several recent fires on Oahu that have impacted rare or endangered species in coastal, lowland dry, and mesic habitats. Between 2004 and 2005, wildfires burned more than 360 acre (ac) (146 ha) of mesic habitat in Honouliuli Preserve, home to more than 90 rare and endangered plants and animals and located along the windward side of the Waianae Mountains (TNC, in litt. 2005). In 2006, a fire at Kaena Point State Park burned 60 ac (24 ha) and encroached on endangered plants in Makua Military Reservation Army Training Area. In 2007, there was a significant fire in lowland dry and mesic habitat at Kaukonahua that crossed 12 gulches, eventually encompassing 5,655 ac (2,289 ha), negatively impacting seven endangered plant species. Occurrences of several native species were extirpated as a result of the fire. The Kaukonahua fire also provided pathways for nonnative ungulates (cattle, goats, and pigs) to access previously undisturbed areas. This fire opened gaps in previously densely vegetated areas allowing the growth of the invasive grass *Panicum maximum* (guinea grass), which is also used as a food source by cattle and goats. An area infested by *P. maximum* burned, and the grass resprouted blades over two feet in length only two weeks after the fire (U.S. Army Garrison 2007, p. 3). In 2009, there were two smaller fires which burned 200 ac (81 ha) at Manini Pali (Kaena Point State Park) and 3.8 ac (1.5 ha) at Makua Cave (at the mouth of Makua Valley). These examples of recent fires illustrate nonnative grass invasion leads to grass/fire cycles that convert native vegetation to grassland (DAntonio and Vitousek 1992, p. 77).

Several areas in the State of Hawaii, including some areas containing *Hylaeus* spp. habitat sites, are currently loosely addressed under fire management plans. For example, in 2003, the Army completed an Integrated Wildland Fire Management Plan (WFMP) for all of its Oahu training installations. This plan is currently being updated (U.S. Army 2009, pp. 4-73). The goal of the WFMP is to reduce the threat of wildfire that adversely affects listed and other rare species. Although no candidate yellow-faced bees are known from military land on Oahu, at least one species, *H. kuakea*, occurs on land roughly adjacent to military land along the Schofield Barracks East Range and could be impacted by fires caused by military activities, or conversely, could benefit from activities to suppress and control origination of fires either on or adjacent to military land.

Additionally, DOFAW maintains a fire management program tasked with fire suppression activities targeted toward the protection of watershed areas, forest reserves, public hunting areas, wildlife and plant sanctuaries, and NARS. Their activities include the maintenance of firebreak roads, signage, and helicopter dip tanks; active fire control during fire outbreak; controlled burns when and where deemed necessary; fire training efforts, including education; and maintenance of a State fire management program website (http://www.state.hi.us/dlnr/dofaw/fmp). According to their website, DOFAW is involved in the protection of 3,360,000 ac statewide, which is approximately 81 percent of the State's land area.

In summary, while we are aware of fire management in some areas of the State, including some *H. assimulans* habitat sites, there is evidence that the repeated outbreak of fire within Hawaiis native coastal, lowland dry, and lowland mesic forests often leads to the irrevocable conversion of native to nonnative habitat (i.e., nonnative plant species). These nonnative habitats are unsuitable for nesting and foraging by *H. assimulans*. Therefore, we conclude fire is a significant ongoing threat to the habitat of *H. assimulans* in coastal and lowland dry habitat.

<u>Habitat Destruction and Modification by Recreational Activities</u>

Some of the best habitat areas for the seven candidate *Hylaeus* species, including *H. assimulans*, are also popular recreational sites, particularly those areas located within coastal habitat (Magnacca 2007a, p. 180). Suitable remaining habitat for *H. assimulans* is also popular for hiking, including coastal sites such as Kaena Point (on Oahu). Human impacts at recreational sites can include removal or trampling of vegetation on or near trails and the compaction of vegetation by off-road vehicles (Magnacca 2007a, p. 180). However, we are not aware that any of these areas are actually being impacted by recreational activities.

In summary, while trampling and compaction of vegetation from human activities may negatively impact the habitat of some populations of *H. assimulans*, we have no basis to conclude these impacts would be at a scale that represents a threat to the species. While some areas, particularly coastal sites, are undoubtedly popular recreational sites, we believe this is a local rather than a range-wide problem for *H. assimulans*. Therefore, we conclude that recreational activities are not a threat to this species at this time.

Habitat Destruction and Modification by Hurricanes and Drought

Stochastic (random, naturally occurring) events, such as hurricanes and drought, can alter or degrade the habitat of *H. assimulans* directly by modifying and destroying native coastal and lowland dry (e.g., by mechanical damage to vegetation). Indirect effects include creating disturbed areas conducive to invasion by nonnative plants, which outcompete the native plants used by *H. assimulans* for foraging of nectar and pollen. We presume these events also alter microclimatic conditions (e.g., opening the tree canopy leading to an increase in habitat temperature, soil erosion, and decreasing soil moisture) so that the habitat no longer supports the native host plants necessary to *H. assimulans* for nectar and pollen foraging, as well as nesting.

Hurricanes affecting Hawaii were only rarely reported from ships in the area from the 1800s until 1949. Between 1950 and 1997, 22 hurricanes passed near or over the Hawaiian Islands, 5 of which caused serious damage (Businger 1998, pp. 1-2). In November 1982, Hurricane Iwa struck the Hawaiian Islands, with wind gusts exceeding 100 miles per hour (mph) (161 kilometers per hour (kph)), causing extensive damage, especially on the islands of Niihau, Kauai, and Oahu (Businger 1998, pp. 2, 6). Many forest trees were destroyed (Perlman 1992, pp. 1-9), which opened the canopy and facilitated the invasion of nonnative plants (Kitayama and Mueller-Dombois 1995, p. 671). Habitat alteration and degradation by nonnative plants is a threat to the habitat of *H. assimulans*, as described in the Habitat Destruction and Modification by Nonnative Plants section above. In September 1992, Hurricane Iniki, a category 4 hurricane with maximum sustained wind speeds recorded at 140 mph (225 kph), passed directly over the island of Kauai and close to the island of Oahu, causing significant damage to areas along Oahus southwestern coast (Barbers Point or Kalaeloa, through Kaena) (Blake et al. 2007, p. 20). Damage by future hurricanes could further decrease the remaining native-plant-dominated habitat areas that support this species (Bellingham et al. 2005, p. 681).

H. assimulans may also be affected by temporary habitat loss (e.g., desiccation of habitats, die-off of host plants) associated with droughts, which are not uncommon on the Hawaiian Islands. Between 1860 and 2002, the Hawaiian Islands were affected by approximately 49 periods of drought (Giambelluca et al. 1991, pp. 3-4; Hawaii Commission on Water Resource Management 2009a and 2009b). These drought events lead to an increase in the number of forest and brush fires (Giambelluca et al. 1991, p. v), causing a reduction of native plant cover and habitat (DAntonio and Vitousek 1992, pp. 77-79). With populations that have already been severely reduced in both abundance and geographic distribution, even such a temporary loss of habitat can have a severe negative impact on *H. assimulans* if, for example, the host plants for nectar and pollen foraging are lost for one or more seasons. Because small populations are demographically vulnerable to extinction caused by random fluctuations in population size and sex ratio, stochastic events such as hurricanes pose the threat of immediate extinction of a species with a very small and geographically restricted distribution such as *H. assimulans* (Lande 1988, p. 1,455).

In summary, natural disasters, such as hurricanes and drought, represent a significant threat to coastal and lowland dry habitats and *H. assimulans*, endangering its chance for conservation and recovery. These types of events are known to cause significant habitat damage, and because the species now persists in low numbers within a restricted range, it is more vulnerable to these events and less resilient to such habitat disturbances. Hurricanes and drought, even though unpredictable, have been and are expected to continue to be threats to the *H. assimulans*, and they therefore pose immediate and ongoing threats to the species and its habitat.

Habitat Destruction and Modification by Climate Change

Climate change will be a particular challenge for biodiversity because the interaction of additional stressors may push species beyond their ability to survive (Lovejoy et al. 2005, pp. 325-326). The synergistic implications of climate change and habitat fragmentation are the most threatening facet of climate change for biodiversity (Lovejoy et al. 2005, p. 4). The magnitude and intensity of the impacts of global climate change and increasing temperatures on native Hawaiian ecosystems are unknown; we are not aware of climate change studies specifically related to the coastal and lowland habitat areas occupied by *H. assimulans*, or to other *Hylaeus* bee species. Based on the best available information, climate change impacts could include the loss of native plant species that comprise the habitats in which *H. assimulans* occurs (Pounds et al. 1999, pp. 611-612; Still et al. 1999, p. 610; Benning et al. 2002, pp. 14,246,14,248); however, because no climate change studies have looked at the effects to coastal and lowland habitat, we have no way of predicting the amount or extent of any such possible habitat loss. Because the host plant habitat of *H. assimulans* is outside of the tidal and immediate near shore zone, we do not expect any direct effects to its habitat from sea level rise itself.

In addition, *H. assimulans* may be vulnerable to changes in precipitation caused by global climate change. However, future changes in precipitation are uncertain because they depend in part on how El NiÃ±o (a disruption of the ocean atmospheric system in the tropical Pacific having important global consequences for weather and climate) might change, and reliable projections of changes in El NiÃ±o have yet to be made (Benning et al. 2002, pp. 14,248-14,249). Oki (2004, p. 4) has noted long-term evidence of decreased precipitation and stream flow in the Hawaiian Islands, based upon evidence collected by stream gauging stations. This long-term drying trend, coupled with periodic El NiÃ±o-caused drying events, has created a pattern of severe and persistent stream dewatering events (Polhemus, in litt 2008, p. 26). Future changes in precipitation and the forecast of those changes are highly uncertain because they depend, in part, on how the El NiÃ±o-La NiÃ±a (a different disruptive extreme weather and climate pattern that can alternate with El NiÃ±o) weather cycle might change (Hawaii Climate Change Action Plan 1998, pp. 2-10).

If precipitation is significantly reduced, *H. assimulans* may be among the species most vulnerable to extinction, with possible impacts expected to include habitat loss and alteration or changes in disturbance regimes (e.g., storms and hurricanes), in addition to possible direct physiological stress of an unknown nature, which could potentially cause the species to seek out less suitable habitats as its preferred habitats become degraded. The probability of a species going extinct as a result of these factors increases when ranges are restricted, habitat decreases, and population numbers decline (Intergovernmental Panel on Climate Change 2007, p. 8). Such is the case for *H. assimulans*, which is characterized by a limited climatic range and restricted habitat requirements, small population size, and low number of individuals. However, without reliable predictions of the amount and extent of anticipated precipitation change, we are unable to determine whether precipitation changes would result in negative impacts to *H. assimulans* at this time.

In summary, *H. assimulans*, like most insects, is presumed to have limited environmental tolerances. This species also has a limited range and restricted habitat requirements (Daly and Magnacca 2003, p. 11). The projected effects of global climate change and increasing temperatures on *H. assimulans* would likely be related to changes in microclimatic conditions in its habitats. These changes may also lead to the loss of native plant species due to direct physiological stress, the loss or alteration of habitat, increased competition from nonnative bee species, and changes in disturbance regimes (e.g., fire, storms, and hurricanes). Therefore, we believe *H. assimulans* will be exposed to projected environmental impacts that may result from changes in climate, and subsequent impacts to its habitats (Pounds et al. 1999, pp. 611-612; Still et al. 1999, p. 610; Benning et al. 2002, pp. 14,246, 14,248), and we do not anticipate a reduction in this ongoing threat any time in the near future. However, because the specific and cumulative effects of climate change on this species are presently unknown, we are not able to determine the magnitude of this potential threat with confidence or precision.

<u>Summary of Factor A</u> - The present or threatened destruction, modification, or curtailment of its habitat or range

H. assimulans is dependent upon the persistence of native Hawaiian plants and their increasingly rare associated habitat types, particularly coastal and lowland dry areas. As identified above in our Factor A analysis, the native habitats on which *H. assimulans* depend have been drastically directly altered during the last century, with many areas either converted for development or agriculture, or indirectly altered due to the effects of nonnative ungulates, nonnative plants, and fire. Habitat conversion and loss of host plants, and other stochastic events (e.g., hurricanes and drought), are all contributing factors to the present and threatened destruction, modification, and curtailment of the habitat and range of *H. assimulans*.

Land conversion and fragmentation of remaining coastal and lowland dry habitat is continuing throughout this species known range, particularly due to the effects of feral ungulates, fire, and nonnative plants. We anticipate habitat conversion and fragmentation to continue, and likely increase, throughout its known range. As discussed above, *H. assimulans* has experienced significant habitat losses. As more habitats become unsuitable, we expect its population declines to continue or accelerate.

We have evaluated the best scientific and commercial information available regarding the present or threatened destruction, modification, or curtailment of *H. assimulans* habitat or range. Based on the current and ongoing habitat issues identified, their synergistic effects, and their likely continuation, we have determined this factor poses a significant threat to *H. assimulans*.

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

We are unaware of any collections of *Hylaeus assimulans* by recreational or insect enthusiast collectors. However, insect collecting is a valuable component of research, including taxonomic work, and is often necessary to document the existence of populations and population trends. Based on comments received in response to the 90-day finding for this species, *H. assimulans* is not believed to be particularly threatened by over-collection.

C. Disease or predation:

<u>Disease</u>

We are not aware of any information indicating disease presents a threat to *Hylaeus assimulans*.

<u>Predation</u>

<u>Predation by Nonnative Ants</u>

Ants are known to prey upon *Hylaeus* species (Medeiros et al. 1986, pp. 45-46; Reimer 1994, p. 17), thereby directly eliminating them from specific areas. In one particular study, nests of *Nesoprosopis* sp., an endemic ground-nesting bee, could not be found in ant-infested plots but were commonly encountered in ant-free sites of the same habitat. *Nesoprosopis* was reduced to a subgenus of *Hylaeus* in 1923 (Meade-Waldo 1923, p. 1). Ants are not a natural component of Hawaii's arthropod fauna, and the native *Hylaeus* species of the islands evolved in the absence of predation pressure from ants. Ants can be particularly destructive predators because of their high densities, recruitment behavior, aggressiveness, and broad range of diet (Reimer 1993, pp. 17-18). The threat of ant predation on *H. assimulans* is amplified by the fact that most ant species have winged reproductive adults (Borror et al. 1989, p. 738) and can quickly establish new colonies in suitable habitats (Staples and Cowie 2001, p. 55). In addition, these attributes allow some ants to destroy otherwise geographically isolated populations of native arthropods (Nafus 1993, pp. 19, 22-23). Ants have not been observed preying upon *H. assimulans*. However, at least one or more of the most aggressive and widespread species (discussed below) occur in every known population site of *H. assimulans* and are presumed to be a serious threat due to the impact of predation.

At least 47 species of ants are known to be established in the Hawaiian Islands (Hawaii Ants 2008, pp. 1-11). Native insect fauna, likely including *H. assimulans* (Zimmerman 1948, p. 173; Reimer et al. 1990, pp. 40-43; HEAR 2005, pp. 1-2), have been severely impacted by at least four particularly aggressive ant species:

Pheidole megacephala (big-headed ant), *Anoplolepis gracilipes* (long-legged ant or yellow crazy ant), *Solenopsis papuana* (no common name), and *Solenopsis geminata* (no common name). Numerous other species of ants are recognized as threats to Hawaiis native invertebrates, and an unknown number of new species of ants are established every few years (Staples and Cowie 2001, p. 53). Due to their preference for drier habitat sites, ants are more likely to occur in high densities in the coastal and dry habitat currently occupied by *H. assimulans* (Reimer 1994, p. 12).

Pheidole megacephala originated in central Africa (Krushelnycky et al. 2005, p. 24) and was first reported in Hawaii in 1879 (Krushelnycky et al. 2005, p. 24). This species is considered one of the most invasive and widely distributed ants in the world (Krushelnycky et al. 2005, p. 5). In Hawaii, this species is the most ubiquitous ant species found, from coastal to mesic habitat up to 4,000 ft (1,219 m) in elevation, including within the habitat areas of *H. assimulans*. With few exceptions, native insects have been eliminated in habitats where *P. megacephala* is present (Perkins 1913, p. xxxix; Gagne 1979, p. 81; Gillespie and Reimer 1993, p. 22). Consequently, *P. megacephala* represents a threat to populations of *H. assimulans* in coastal to dry areas Hawaii, Lanai, Maui, and Oahu (Reimer 1993, p. 14; Reimer 1994, p. 17; Daly and Magnacca 2003, pp. 9-10).

Anoplolepis gracilipes appeared in Hawaii in 1952, and now occurs on Hawaii, Kauai, Maui, and Oahu (Reimer et al. 1990, Antweb 2011). It inhabits low- to mid-elevation (less than 2,000 ft (600 m)) rocky areas of moderate rainfall (less than 100 in (250 cm) annually) (Reimer et al. 1990, p. 42). Although surveys have not been conducted to ascertain this species presence in each of the known habitat sites occupied by *H. assimulans*, we may presume that it likely occurs within some of the identified population sites based upon anecdotal evidence of their expanding range and their preference (as indicated where the species is most commonly collected) for coastal and dry forest habitats (Antweb 2011). Direct observations indicate Hawaiian arthropods are susceptible to predation by this species; Gillespie and Reimer (1993, p. 21) and Hardy (1979, pp. 37-38) documented the complete extirpation of several native insects within the Kipahulu area on Maui after this area was invaded by *A. gracilipes*. Lester and Tavite (2004, p. 391) found that *A. gracilipes* in the Tokelau Atolls (New Zealand) can form very high densities in a relatively short period of time with locally serious consequences for invertebrate diversity. Densities of 3,600 individuals collected in pitfall traps within a 24-hour period were observed, as well as predation upon invertebrates ranging from crabs to other ant species. On Christmas Island in the Indian Ocean, numerous studies have documented the range of impacts to native invertebrates, including *Gecarcoidea natalis* (red land crab), as a result of predation by supercolonies of the *A. gracilipes* (Abbott 2006, p. 102). *A. gracilipes* colonies have the potential as predators to profoundly affect the endemic insect fauna in territories they occupy. Studies comparing insect populations at otherwise similar ant-infested and ant-free sites found extremely low numbers of large endemic noctuid moth larvae (*Agrostis* spp. and *Peridroma* spp.) in ant-infested areas. Nests of ground-nesting cottelid bees (*Nesoprosopis* spp.) were eliminated from ant-infested sites (Reimer et al. 1990, p. 42). Although only cursory observations exist in Hawaii (Reimer et al. 1990, p. 42), we believe these ants are a threat to populations of *H. assimulans*, in dry areas within its elevation range.

Solenopsis papuana is the only abundant, aggressive ant that has invaded intact mesic to wet forest, as well as coastal and lowland dry habitats. This species occurs from sea level to over 2,000 ft (600 m) on all of the main Hawaiian Islands, and is still expanding its range (Reimer 1993, p. 14). Although surveys have not been conducted to ascertain the presence of *S. papuana* in each of the known habitat sites occupied by *H. assimulans*, because of the expanding range of this species and its widespread occurrence in coastal and dry lowland habitats, it is a possible threat to all known populations of *H. assimulans* (Reimer et al. 1990, p. 42; Reimer 1993, p. 14).

Like *Solenopsis papuana*, *S. geminata* is also considered a significant threat to native invertebrates (Gillespie and Reimer 1993) and occurs on all the main Hawaiian Islands (Reimer et al. 1990; Nishida 1997). Found in drier areas of the Hawaiian Islands, it has displaced *P. megacephala* as the dominant ant in some localities (Wong and Wong 1988, p. 175). Known to be a voracious nonnative predator in many areas to where it has spread, the species was documented to significantly increase fruit fly mortality in field studies in Hawaii

(Wong and Wong 1988, p. 175). In addition to predation, *S. geminata* workers tend honeydew-producing members of the Homoptera suborder, especially mealybugs, which can impact plants directly and indirectly through the spread of disease (Manaaki Whenua Landcare Research 2011).

Solenopsis geminata was included among the eight species ranked as having the highest potential risk to New Zealand in a detailed pest risk assessment for the country (Global Invasive Species Database 2011) and is included as one of five ant species listed among the 100 of the Worlds Worst invaders (Manaaki Whenua Landcare Research 2011).

Although surveys have not been conducted to ascertain the presence of *S. geminata* in each of the known habitat sites occupied by *H. assimulans*, because of the expanding range of this species and its widespread occurrence in coastal and dry lowland habitats, it is a possible threat to all known populations of *H. assimulans* (Wong and Wong 1988, p. 175).

The *Hylaeus* egg, larvae, and pupal stages are more vulnerable to attack by ants than the mobile adult bees (Daly and Magnacca 2003, p. 10). Invasive ants have severely impacted ground-nesting *Hylaeus* species in particular (Cole et al. 1992, pp. 1317, 1320; Medeiros et al. 1986, pp. 45-46), because their nests are easily accessible and in or near the ground. Because *H. assimulans* is believed to be ground-nesting species, they may also be more susceptible to ant predation (Magnacca 2005g, p. 2).

Hylaeus populations are known to be drastically reduced in ant-infested areas (Medeiros et al. 1986, pp. 45-46; Stone and Loope 1987, p. 251; Cole et al. 1992, pp. 1313, 1317, 1320; Reimer 1994, p. 17). The presence of ants in nearly all of the low-elevation habitat sites historically and currently occupied by *H. assimulans* may increase the uncertainty of this species recovery within some of these areas (Reimer 1994, pp. 17-18; Daly and Magnacca 2003, pp. 9-10). Although the primary impact of ants on the native invertebrate fauna is via predation (Reimer 1994, p. 17), they also compete for nectar (Howarth 1985, p. 155; Hopper et al. 1996, p. 9; Holway et al. 2002, pp. 188, 209; Daly and Magnacca 2003, p. 9; Lach 2008, p. 155) and nest sites (Krushelnycky et al. 2005, pp. 6-7). Some ant species may impact *H. assimulans* indirectly as well, by consuming seeds of native plants, thereby reducing the plants recruitment and fecundity (Bond and Slingsby 1984, p. 1,031). Several studies (Krushelnycky 2005, p. 9; Lach 2008, p. 155) suggest a serious ecosystem-level effect of invasive ants on pollination. Where ranges overlap, ants compete with native pollinators such as *Hylaeus* bees and preclude them from pollinating native plants. For example, *P. megacephala* is known to actively rob nectar from flowers without pollinating them (Howarth 1985, p. 157). Lach (2008, p. 155) found that *Hylaeus* bees that regularly consume pollen from flowers of *Metrosideros polymorpha* were entirely absent from trees with flowers exposed to foraging by *P. megacephala* individuals.

The rarity or disappearance of native *Hylaeus* species, including *H. assimulans*, from historically documented localities over the past 100 years is due to a variety of factors. Although we have no direct information that conclusively correlates the decrease in populations of *H. assimulans* due to the establishment of nonnative ants, severe predation of other *Hylaeus* species by ants has been documented, resulting in clear reductions in populations. We expect similar predation impacts to *H. assimulans* to continue as a result of the widespread presence of ants throughout the Hawaiian Islands, their highly efficient and non-specific predatory behavior, and their ability to quickly disperse and establish new colonies. Therefore, we conclude that predation by nonnative ants represents a serious threat to the continued existence of *H. assimulans*, now and into the future.

Predation by Nonnative Western Yellow Jacket Wasps

Vespula pensylvanica (the western yellow jacket wasp) is a potentially serious threat to *H. assimulans* (Gambino et al. 1987, p. 170; Wilson et al. 2009, pp. 1-5). V. pensylvanica is a social wasp species native to the mainland of North America. It was first reported from Oahu in the 1930s (Sherley 2000, p. 121), and an aggressive race became established in 1977 (Gambino et al. 1987, p. 170). In temperate climates, *V. pensylvanica* has an annual life cycle, but in Hawaiis tropical climate, colonies of this species persist through a second year, allowing them to have larger numbers of individuals (Gambino et al. 1987, p. 170) and thus a greater impact on prey populations. Most colonies are found between approximately 2,000 and 3,500 ft (approximately 600 and 1,050 m) in elevation (Gambino et al. 1990, p. 1,088), although they can also occur at sea level. *V. pensylvanica* is known to be an aggressive, generalist predator (Gambino et al. 1987, p. 170), and has been documented preying upon Hawaiian *Hylaeus* species (although not specifically upon *H. assimulans*) (Wilson et al. 2009, p. 2). However, predation *V. pensylvanica* is a potentially significant threat to *H. assimulans* because of the wasps presence in habitat occupied by the species combined with its small population sizes. It has been suggested that *V. pensylvanica* may compete for nectar with *Hylaeus* species, but we have no information to suggest this represents a threat to *H. assimulans*.

<u>Summary of Factor C - Disease or predation</u>

We do not find evidence that disease is currently impacting H. assimulans, nor do we have information to indicate disease outbreaks will occur in the future. Although we have no direct information that conclusively correlates the decrease in populations of this species due to the establishment of V. pensylvanica, severe predation of other Hylaeus species by yellow jacket wasps has been documented, resulting in clear reductions in populations. We expect similar predation impacts to *H. assimulans* to continue as a result of the widespread presence of yellow jacket wasps in many areas throughout the Hawaiian Islands, their highly efficient and non-specific predatory behavior, and their ability to quickly disperse and establish new colonies.

The presence of nonnative ants in nearly all lowland habitat historically and currently occupied by *H. assimulans*, combined with the near extirpation of native insects in these areas, suggest predation by nonnative ants is a serious threat to the species. Observations and reports have documented that ants are particularly destructive predators because of their high densities, broad ranges of diet, and ability to establish new colonies in otherwise geographically isolated locations because the reproductive adult ants are able to fly. Because the ranges of *Pheidole megacephala*, *Anoplolepis gracilipes*, *Solenopsis geminata*, and *Solenopsis papuana* overlap the ranges of *H. assimulans*, and based on their observed predatory behavior at other locations where they occur, these nonnative predators represent an imminent and serious threat to *H. assimulans*. Unless these aggressive, nonnative ant predators are eliminated or controlled, we expect this threat to continue or increase. Furthermore, a decrease in the amount and distribution of suitable host plants for foraging could indirectly impact *H. assimulans* by forcing the species to seek less optimal, but predator-free, foraging sites.

D. The inadequacy of existing regulatory mechanisms:

Currently, there are no Federal, State, or local laws, treaties, or regulations that specifically conserve or protect *H. assimulans* from the numerous threats facing this species. However, there are some regulations that potentially address the threats posed by introduced, nonnative species; these are discussed below.

<u>Inadequate Protection from Nonnative Ungulates</u>

Nonnative ungulates pose a major ongoing threat to *Hylaeus assimulans* through destruction and degradation of its habitat. Although some public hunting areas are fenced to prevent the movement of nonnative ungulates to other areas, there are currently no Federal, State, or local laws, treaties, or regulations that adequately address the threats from nonnative ungulates to *H. assimulans* habitat. The absence of regulatory mechanisms exacerbates the threats discussed under Factor A.

<u>Inadequate Protection from Introduction of Nonnative Species</u>

The Hawaii Department of Agriculture (HDOA) is the lead State agency in protecting Hawaiis agricultural and horticultural industries, animal and public health, natural resources, and environment from the introduction of nonnative, invasive species (DLNR 2003, p. 3-10). While there are several State agencies (HDOA, DLNR, Hawaii Department of Health) authorized to prevent the entry of pest species into the State, the existing regulations are inadequate for the reasons discussed in the sections below.

In 1995, a partnership called the Coordinating Group on Alien Pest Species (CGAPS), comprised primarily of managers from every major Federal, State, county, and private agency and organization involved in invasive species work in Hawaii, was formed in an effort to influence policy and funding decisions, improve communication, increase collaboration, and promote public awareness (CGAPS 2009). This group facilitated the formation of the Hawaii Invasive Species Council (HISC), which was created by gubernatorial executive order in 2002 to coordinate local initiatives for the prevention and control of invasive species by providing policy-level direction and planning for the State departments responsible for invasive species issues. In 2003, the governor signed into law Act 85, which conveys statutory authority to the HISC to coordinate approaches among the various State and Federal agencies, and international and local initiatives, for the prevention and control of invasive species (HDLNR 2003, p. 3-15; HISC 2009; Haw. Rev. Stat. section 194-2(a)). Some of the recent priorities for the HISC include interagency efforts to control nonnative species such as the plants *Miconia calvescens* (miconia) and *Cortaderia* sp. (pampas grass), coqui frogs (*Eleutherodactylus coqui*), and ants (HISC 2009). However, in October 2009, HISC approved a 2010 budget that, due to a tighter economy in Hawaii and anticipated budget cuts in State funding support, resulted in a 50 percent reduction in funding with an anticipated setback in conservation achievements and the loss of experienced, highly trained staff (HISC 2009).

Inadequate Regulatory Control of Nonnative Invertebrate Species

As noted above (see Factor C, Disease and Predation), predation by nonnative ants and the nonnative yellow jacket wasp is a potentially significant threat to *H. assimulans*. Commercial shipping and air cargo, as well as biological introductions to Hawaii, have resulted in the establishment of over 3,372 species of nonnative insects (Howarth 1990, p. 18; Staples and Cowie 2001, p. 52), with an estimated continuing establishment rate of 20 to 30 new species per year (Beardsley 1962, p. 101; Beardsley 1979, p. 36; Staples and Cowie 2001, p. 52). The prevention and control of introduced pest species in Hawaii is the responsibility of Hawaii State government and Federal agencies, along with a few private organizations. Even though these agencies have regulations and some controls in place, complete control of introduced pest species is difficult to achieve. Consequently, the introduction and movement of nonnative invertebrate pest species, including nonnative ants and yellow jacket wasps, between islands and from one watershed to the next, continues.

Inadequate Regulatory Control of Nonnative Plant Species

Nonnative plants destroy and modify habitat throughout the range of *Hylaeus assimulans*. As such, they represent a significant and immediate threat to this species. In addition, nonnative plants have been shown to outcompete native plants and convert native-dominated plant communities to nonnative plant communities (see Factor A, Habitat Destruction and Modification by Nonnative Plants). The HDOA regulates the import of plants into the State from domestic origins under Hawaii State law (Haw. Rev. Stat. Ch. 150A). While all plants require inspection upon entry into the State and must be apparently free of insects and diseases, not all plants require import permits. Parcels brought into the State by mail or cargo must be clearly labeled as Plant Materials or Agricultural Commodities, but, given budget constraints and an insufficient number of personnel, it is unlikely that all of these parcels are inspected or monitored prior to delivery in Hawaii. Shipments of plant material into Hawaii must be accompanied by an invoice or packing manifest listing the contents and quantities of the items imported, although it is unclear if all of these shipments are inspected or monitored prior to delivery (HDOA 2009). There are only 12 plant crops regulated (H.A.R. chapter 4-70) to some degree: sugarcane and grasses, pineapple and other bromeliads, coffee, cruciferous vegetables, orchids, banana, passion fruit, pine, coconut, palms, and any host plants that harbor either European corn borer or the Caribbean fruit fly (HDLNR 2003, p. 3-11). The HDOA also maintains the State list of noxious weeds, and these plants are restricted from entry into the State except by permit from the HDOAs Plant Quarantine Branch.

Although the State has general guidelines for the importation of plants, and regulations are in place regarding the plant crops mentioned above, the intentional or inadvertent introduction of nonnative plants outside the regulatory process and movement of species between islands and from one watershed to the next continues, which represents a threat to native flora and fauna for the reasons described above. In addition, government funding is inadequate to provide for sufficient inspection services and monitoring. One study concluded plant importation laws virtually ensure new invasive plants will be introduced via the nursery and ornamental trade, and outreach efforts cannot keep up with the multitude of new invasive plants being distributed. The author states the only thing wide-scale public outreach can do in this regard is to let the public know new invasive plants are still being sold, and suggest that people should ask for noninvasive or native plants instead (Martin, in litt. 2007, p. 9).

On the basis of the above information, existing regulatory mechanisms do not adequately protect *H. assimulans* from the threat of new introductions of nonnative species, and the continued expansion of nonnative species populations on and between islands and watersheds. Nonnative species may directly compete with, consume, prey upon, or modify or destroy the habitat of H. assimulans for food, space, and other necessary resources. Because current Federal, State, and local laws, treaties, and regulations are inadequate to prevent the introduction and spread of nonnative species from outside the State of Hawaii, as well as between islands and watersheds, the threats from these introduced species remain immediate and significant due to an inadequacy of existing regulatory mechanisms.

<u>Summary of Factor D</u> - The inadequacy of existing regulatory mechanisms

Existing regulatory mechanisms and agency policies do not address the primary threats to *H. assimulans* and its habitat from nonnative species including ungulates, plants, and arthropods, and the States current management of nonnative game mammals does not prevent the degradation and destruction of habitat of *H. assimulans*. (see discussion under Factor A).

We consider the threat from inadequate regulatory mechanisms to be immediate and significant for the following reasons:

(1) Existing State and Federal regulatory mechanisms are not preventing the introduction and spread of nonnative species between islands and watersheds; and

(2) Habitat-altering nonnative plant species (Factor A) and predation by nonnative animal species (Factor C) pose major ongoing threats to *H. assimulans*. Because existing regulatory mechanisms are inadequate to maintain habitat for *H. assimulans* and to prevent the spread of nonnative species, the inadequacy of existing regulatory mechanisms is considered to be a significant and immediate threat to *H. assimulans*.

E. Other natural or manmade factors affecting its continued existence:

Species endemic to single islands or known from few, widely dispersed locations are inherently more vulnerable to extinction than widespread species because of the higher risks from genetic bottlenecks, random demographic fluctuations, climate change, and localized catastrophes such as hurricanes, landslides, and drought (Lande 1988, p. 1,455; Mangel and Tier 1994, p. 607; Pimm et al. 1988, p. 757). These problems can be further magnified when populations are few and restricted to a limited geographic area, and the number of individuals is very small. Populations with these characteristics face an increased likelihood of stochastic extinction due to changes in demography, the environment, genetics, or other factors, in a process described as an extinction vortex (Gilpin and SoulÃ© 1986, pp. 24-25). Small, isolated populations often exhibit a reduced level of genetic variability or genetic depression due to inbreeding, which diminishes a species capacity to adapt and respond to environmental changes, thereby lessening the probability of long-term persistence (Frankham 2003, pp. S22-S29; SoulÃ© 1986, pp. 31-34). The negative impacts associated with small population size and vulnerability to random demographic fluctuations or natural catastrophes can be further magnified by synergistic interactions with other threats.

Hylaeus assimulans very small populations are likely more vulnerable to habitat change and stochastic events due to low genetic variability (Daly and Magnacca 2003, p. 3; Magnacca 2007, p. 173). According to Magnacca (2007, p. 3), *H. assimulans* has not been collected recently from Oahu, where it was historically known to occur, and it is restricted to rare habitat. Additionally, the small number of populations known for this species increases its risk of extinction due to stochastic events such as hurricanes, wildfires, or prolonged drought (Jones et al. 1984, p. 209; Smith and Tunison 1992, p. 398).

The recurrence intervals for stochastic events (e.g., wildfires, prolonged drought, and hurricanes) cannot be predicted, which introduces some uncertainty regarding potential effects to *H. assimulans*. The fact that a species is potentially vulnerable to stochastic processes does not necessarily mean it is reasonably likely to experience or have its status affected by a given stochastic process within timescales meaningful under the Act. Because of its small number of populations, negative impacts to *H. assimulans* from hurricanes, wildfires, and drought would be likely if these events occur. Because these events have been documented on Oahu and other Hawaiian islands in the past, we believe that they represent an ongoing threat to this species, although the specific timing, location, or magnitude is unknown. The threat from fire is unpredictable, but omnipresent in habitats that have been invaded by nonnative, fire-prone grasses. Hurricanes and drought conditions present an ongoing and ever-present threat, because they can occur at any time, although the incidence and magnitude of specific events is not predictable.

<u>Competition with Nonnative Insects</u>

There are 15 known species of nonnative bees in Hawaii (Snelling 2003, p. 342), including two nonnative *Hylaeus* species (Magnacca 2007, p. 188). Most nonnative bees inhabit areas dominated by nonnative vegetation and do not compete with native Hawaiian bees for foraging resources (Daly and Magnacca 2003, p. 13). *Apis mellifera,* the European honey bee, is an exception; this social species is often very abundant in areas with native vegetation and aggressively competes with Hylaeus for nectar and pollen (Hopper et al. 1996, p. 9; Daly and Magnacca 2003, p. 13; Snelling 2003, p. 345).

Apis mellifera was first introduced to the Hawaiian Islands in 1875 and currently inhabits areas from sea level to the upper tree line boundary (Howarth 1985, p. 156). *A. mellifera* individuals have been observed foraging on *Hylaeus* host plants such as *Scaevola* spp. and *Sesbania tomentosa* (Hopper et al. 1996, p. 9; Daly and Magnacca 2003, p. 13; Snelling 2003, p. 345). Although we lack information indicating Hawaiian *Hylaeus* populations have declined because of competition with *A. mellifera* for nectar and pollen, *A. mellifera* does forage in *Hylaeus* spp. habitat and may exclude *Hylaeus* spp. (Magnacca 2007, p. 188; Lach 2008, p. 155). *Hylaeus* species do not occur in native habitat where there are large numbers of *A. mellifera* individuals, but the impact of smaller, more moderate populations is not known (Magnacca 2007, p. 188). Nonnative, invasive bees are widely documented to decrease nectar volumes and usurp native pollinators (Lach 2008, p. 155). There are also indications that populations of *A. mellifera* are not as vulnerable as *Hylaeus* bees to predation by nonnative ant species (see Factor C, Disease and Predation). Lach (2008, p. 155) observed that *Hylaeus* bees that regularly collect pollen from the flowers of *Metrosideros polymorpha* trees were entirely absent from trees with flowers visited by *Pheidole megacephal a*, while visits by *A. mellifera* were not affected. As a result, *A. mellifera* may have a competitive advantage over *Hylaeus* spp., as it is not excluded by *P. megacephala* (Lach 2008, p. 155).

Other nonnative bees found in areas of native vegetation include *Ceratina* spp. (carpenter bees), *Hylaeus albonitens* (Australian colletid bees), and *Lasioglossum impavidum* (no common name) (Magnacca 2007, p. 188). While it has been suggested these nonnative bees may impact native *Hylaeus* bees through competition for pollen based on their similar size and flower preferences, there is no information that demonstrates these nonnative bees forage on *Hylaeus* host plants (Magnacca 2007, p. 188). It has also been suggested parasitoid wasps may compete for nectar with native *Hylaeus* species (Daly and Magnacca 2003, p. 10); however, information demonstrating nonnative parasitoid wasps forage on the same host plants as *H. assimulans* is unavailable.

We acknowledge the potential for negative impacts on *H. assimulans* from competition with *A. mellifera* for nectar and pollen (Magnacca 2007, p. 188). In addition, one study in Hawaii suggests *A. mellifera* may have an additional advantage for collecting pollen and nectar because it may not be negatively affected by the presence of predatory *P. megacephala* individuals on native vegetation (Lach 2008, p. 155). Competition with *A. mellifera* may be a potential threat to *H. assimulans* because: (1) A. mellifera forage on *Hylaeus* host plant species; (2) they may exclude *Hylaeus* spp. from those resources (*Hylaeus* spp. are never found foraging in the presence of *A. mellifera* bees); and (3) *A. mellifera* may have a competitive advantage over Hawaiian *Hylaeus* sp., as one study suggests honey bees are not negatively affected by the presence of *P. megacephala* individuals on native vegetation to the extent the *Hylaeus* species may be. *A. mellifera* bees have been known to exclude other *Hylaeus* species, and it is well-documented that they forage in native plant areas. However, the best available scientific information indicates that competition with *A. mellifera* may represent a threat to *H. assimulans*, but the threat is of unknown magnitude, and additional research would be helpful to better understand this interaction.

We have no information indicating other species of nonnative bees or parasitoid wasps negatively impact populations of *H. assimulans* due to competition for nectar and pollen, and have, therefore, determined that competition with other species of nonnative bees or parasitoid wasps is not a threat.

<u>Summary of Factor E</u> - Other natural or manmade factors affecting its continued existence

The small number of populations of *H. assimulans* and its inherently small gene pool increases its risk of extinction due to stochastic events such as hurricanes, wildfires, and drought, which although unpredictable, represent an ongoing and significant threat to the species. We have no information indicating other nonnative bees or parasitoid wasps compete for nectar and pollen on *Hylaeus* host plants. Therefore, we have determined that competition with these species does not present a significant threat to *H. assimulans*. While A. *mellifera* bees forage in native plant areas and have been known to exclude other *Hylaeus* species, the best available information does not indicate competition between *A. mellifera* and *H. assimulans* is a significantly quantifiable threat.

Conservation Measures Planned or Implemented :

Some *Hylaeus assimulans* current collection localities are protected from development, urbanization, and conversion to agriculture by State or private agencies: one *H. assimulans* population occurs on the island of Kahoolawe, which is joint managed by the State and KIRC as a preserve; and the two populations of *H. assimulans* occurring on Maui are afforded protection: one being managed as a NAR by the State, and the private parcel is managed as a rare plant reserve and is fenced to prevent access by axis deer. These areas are actively managed to restore native habitat and to reduce or eliminate many of the common threats to the native plant communities found there, including feral ungulates and wildfire. However, existing regulatory mechanisms are inadequate to provide the necessary active management needed to protect the habitat of the populations outside of these protected TNC, NHP or NAR areas (see discussion under Factor D, above). Conservation of *H. assimulans* will require active management of its known population sites, involving exclusion and removal of feral ungulates, control and removal of nonnative plant and insect species, and the restoration of native vegetation (Magnacca 2007, p. 185).

Summary of Threats :

Hylaeus assimulans was originally known from numerous coastal and lowland dry forest habitats on four different main Hawaiian Islands. Now reduced to five populations across three islands (now extirpated from Oahu), the species remains threatened by habitat degradation from nonnative feral ungulates, nonnative plants, fire, stochastic events, inadequate regulatory protection, and climate change. The species itself is at risk from inadequate regulatory protection, small population size, and predation by and competition with nonnative insect species. We conclude there is sufficient information to develop a proposed rule for *H. assimulans*, and we find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

Because existing regulatory mechanisms are inadequate to provide the necessary active management to protect *Hylaeus assimulans*, conservation of the species will require the active control and management of natural areas where populations are known to exist. This active management will involve exclusion and removal of feral ungulates, control and removal of nonnative plant and insect species, improved and increased wild fire management and control, and the restoration of native vegetation. The continued impact of development, fire, feral ungulates, invasive ants, and the loss of native vegetation to invasive plant species will undoubtedly have a negative impact on the remaining populations of *H. assimulans* and may cause their extinction if habitat is not managed for conservation of this species (Magnacca 2007, p. 185). Necessary management actions should include:

- Protecting host plant populations from feral ungulates including pigs, goats, deer, and cattle;
- Researching and implementing methods to control nonnative plant species, particularly *Asystasia gangetica* (Chinese violet), *Atriplex semibaccata* (Australian saltbush), *Cenchrus ciliaris* (buffelgrass), *Chloris barbata* (swollen fingergrass), *Digitaria insularis* (sourgrass), *Leucana leucocephala* (koa haole), *Panicum maximum* (guinea grass), *Pluchea indica* (Indian fleabane), *P. symphytifolia* (sourbush), *Prosopis pallida* (kiawe), and *Verbesina encelioides* (golden crown-beard);
- Researching and implementing control methods, such as poison baiting, for nonnative social insect species including ants;
- Further research into the effects of *A. mellifera* on native *Hylaeus* spp.; and
- Conducting field surveys at known locations and in suitable habitat.

Priority Table

<table>
<tr><td>Magnitude</td><td>Immediacy</td><td>Taxonomy</td><td>Priority</td></tr>
<tr><td rowspan="6">High</td><td rowspan="3">Imminent</td><td>Monotypic genus</td><td>1</td></tr>
<tr><td>Species</td><td>2</td></tr>
<tr><td>Subspecies/Population</td><td>3</td></tr>
<tr><td rowspan="3">Non-imminent</td><td>Monotypic genus</td><td>4</td></tr>
<tr><td>Species</td><td>5</td></tr>
<tr><td>Subspecies/Population</td><td>6</td></tr>
<tr><td rowspan="6">Moderate to Low</td><td rowspan="3">Imminent</td><td>Monotype genus</td><td>7</td></tr>
<tr><td>Species</td><td>8</td></tr>
<tr><td>Subspecies/Population</td><td>9</td></tr>
<tr><td rowspan="3">Non-Imminent</td><td>Monotype genus</td><td>10</td></tr>
<tr><td>Species</td><td>11</td></tr>
<tr><td>Subspecies/Population</td><td>12</td></tr>
</table>

Rationale for Change in Listing Priority Number:

Magnitude:

This species is highly threatened by feral ungulates that degrade and destroy host plant habitat and nonnative plants that degrade habitat and compete with native host plants for light, space, and nutrients. Predation by nonnative social insects is also a serious threat. Threats to the native forest habitat of *Hylaeus assimulans*, and to individuals of this species, occur throughout its range and are expected to continue or increase without their control or eradication. No known conservation measures have been taken to date to specifically address these threats.

Imminence :

Threats to *Hylaeus assimulans* host plant habitat from feral ungulates and nonnative plants and direct predation by nonnative social insects are considered imminent because they are ongoing.

__Yes__ Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

__No__ Is Emergency Listing Warranted?

The species does not appear to be appropriate for emergency listing at this time because the immediacy of the threats is not so great as to imperil a significant proportion of the taxon within the time frame of the routine listing process. If it becomes apparent that the routine listing process is not sufficient to prevent large losses that may result in this species' extinction, then the emergency rule process for this species will be initiated. We will continue to monitor the status of the species as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures.

Description of Monitoring:

Much of the information in this form is based upon five petitions we received and dated March 23, 2009, from Scott Hoffman Black, Executive Director of the Xerces Society. The five petitions requested that seven species of Hawaiian yellow-faced bees (including *Hylaeus assimulans*) be listed as Endangered under the Act and critical habitat be designated. Each petition contained information regarding the species taxonomy and ecology, historical and current distribution, present status, and current and potential threats. We acknowledged the receipt of the petitions in a letter to Mr. Black, dated May 8, 2009. In that letter we also stated that issuing an emergency regulation temporarily listing the species under section 4(b)(7) of the Act was not warranted at that time. We published the 90-day finding in the Federal Register on June 16, 2010 (75 FR 34077). On September 6, 2011, we published a 12-month finding in the Federal Register (76 FR 55170), which determined that listing was warranted but precluded.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

none

Indicate which State(s) did not provide any information or comment:

Hawaii

State Coordination:

On February 20, 2013, we provided the Hawaii Division of Forestry and Wildlife with copies of our most recent candidate assessments for their review and comment. No additional information or comments on this species were received from the State.

Literature Cited:

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.

Antweb. 2011 Species: *Anoplolepis gracilipes*. http://www.antweb.org/description.do?rank=species&name=gracilipes&genus=anoplolepis&project=tokelauan accessed 2011.

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

Borror, D.J., C.A. Triplehorn, and N.F. Johnson. 1989. Introduction to the Study of Insects, Sixth Ed. Saunders College Publishing, Philadelphia.

Brown, J.K., and J.K. Smith. 2000. Wildland fire in ecosystems: effects of fire on flora. General Technical Report RMRS-GTR-42-vol.2, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden. 257 pp.

Bruegmann, M.M. 1996. Hawaiis 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, and 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.

Cane, J.H., and V.J. Tepedino. 2001. Causes and extent of declines among native North American invertebrate pollinators: detection, evidence, and consequences. Conservation Ecology 5(1):1. URL:

http://www.consecol.org/vol5/iss1/art1/, accessed June 23, 2008.

(CGAPS) Coordinating Group on Invasive Pest Species. 2009. CGAPS Vision and Action Plan, December 2009. 14 pp.

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., and P.M. Vitousek. 1992. Biological invasions by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics 23:63-87.

Daly, H.V. Unpublished data. *Hylaeus* (Nesoprosopis) species recorded from Hawaii sorted by site of collection.

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

(DLNR) Department of Land and Natural Resources. 2011 -https://hawaiitrails.ehawaii.gov/trail.php?TrailID=OA+08+007). Re: Poamoho Trail & Army lease.

Frankham, R. 2003. Genetics and conservation biology. C. R. Biologies. 326:S22-S29.

Fullaway, D.T. 1918. Notes on Hawaiian Prosopidae. Proceedings of the Hawaiian Entomological Society 3:393-398.

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., and L.W. Cuddihy. 1999. Vegetation. In Wagner, W.L., D.R. Herbst, and S.H. Sohmer (eds.), 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 Maus 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.

Gilpin, M., and M.E. Soule. 1986. Minimum viable populations. In Soule, M.E. (ed), Conservation Biology: The Science of Scarcity and Diversity, Sinauer Associates, Inc, Sunderland. Pp. 24-25.

Gillespie, R.G., and N. Reimer. 1993. The effect of alien predatory ants (Hymenoptera: Formicidae) on Hawaiian endemic spiders (Araneae: Tetragnathidae). Pacific Science 47:21-33.

Global Invasive Species Database. 2011. (Regarding invasive ant species status). http://www.issg.org/database/species/ecology.asp?si=169&fr=1&sts=&lang=EN, accessed July 29, 2011.

Hardy, D.E. 1979. An ecological survey of Puaaluu Stream. Part III. Report on a preliminary entomological survey of Puaaluu Stream, Maui. Cooperative National Park Resources Study Unit. University of Hawaii. Technical Report 27:34-39.

(HDLNR) Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife. 2007. Draft Environmental Assessment: Kaena Point Ecosystem Restoration Project. Waianae and Waialua Districts, Island of Oahu. http://www.state.hi.us/dlnr/dofaw/kaena/index.htm

(HDLNR) Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife. 2000. Na Ala Hele Trail and Access System. Oahu: Poamoho Ridge Trail and Poamoho Hele Loa Access Road. http://www.hawaiitrails.org/trail.php?TrailID=OA+08+007, accessed October 29, 2008.

(HDLNR) Hawaii Department of Land and Natural Resources. 2008. Natural Area Reserves System: Mount Kaala. http://hawaii.gov/dlnr/dofaw/nars/reserves/oahu/mountkaala, accessed October 29, 2008.

(HDLNR) Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife. 2005. Hawaiis Comprehensive Wildlife Conservation Strategy. http://www.state.hi.us/dlnr/dofaw/cwcs/index.html, accessed June 27, 2008.

(HDLNR) Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, Na Ala Hele Trail and Access Program. 2007. Report to the Twenty-Fourth Legislature Session of 2008: Hawaii Statewide Trail and Access System Na Ala Hele. Honolulu, Hawaii.

(HDLNR) Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, NARS Program. Information about Kanaio NAR management. http://hawaii.gov/dlnr/dofaw/rpc/projects-on-maui, accessed December 2, 2010.

(HDLNR) Hawaii Department of Land and Natural Resources, Division of State Parks. 2010. Information about Kekaha Kai State Park. http://www.hawaiistateparks.org/parks/hawaii/index.cfmpark_id=47, accessed December 2, 2010.

(HDLNR) Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, NARS Program. Information about West Maui NAR management. http://hawaii.gov/dlnr/dofaw/nars/reserves/maui/west-maui.

(HEAR) Hawaii Ecosystems at Risk Project. 2005. Pest Ants in Hawaii. http://www.hear.org/AlienSpeciesInHawaii/ants/index.html

(HISC) Hawaii Invasive Species Council. 2009. HISC eNews, Vol. 3, No. 6. October 2009. 1 p.

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.

Hopper, D., A. Asquith, and M. Bruegmann. 1996. Hawaiis Birds and Bees. Endangered Species Bulletin 11(6):8-10.

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.), Hawaiis Terrestrial Ecosystems: Preservation and Management. Honolulu: University of Hawaii Press.

Jones, B.L., S.S.W. Chin, and J.C. Brice. 1984. Olokele rock avalance, island of Kauai, Hawaii. Geology 12:209-211.

Juvik, S.P., and J.O. Juvik (eds.). 1998. Atlas of Hawaii, 3rd Edition. University of Hawaii Press. 333 pp.

Kirch, P.V. 1982. The impact of the prehistoric Polynesians on the Hawaiian ecosystem. Pacific Science 36:1-14.

Kohanaiki Ohana. 1995. Information concerning cultural and recreational preservation and pursuits at Kohanaiki. http://www.kohanaiki.org/, accessed July 15 2008.

Kremen, C., N.M. Williams, M.A. Aizen, B. Gemmill-Herren, G. LeBuhn, R. Minckley, L. Packer, S.G. Potts, T. Roulston, I. Steffan-Dewenter, D.P. Vazquez, R. Winfree, L. Adams, E.E. Crone, S.S. Greenleaf, T.H. Keitt, A.M. Klein, J. Regetz, T.H. Ricketts. 2007. Pollination and other ecosystem services produced by mobile organisms: a conceptual framework for the effects of land-use change. Ecology Letters 10:299-314.

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.

Lande, R. 1988. Genetics and demography in biological conservation. Science 241:1455-1460.

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.N. 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.N. 2005b. Species Profile: *Hylaeus assimulans*. 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. 2005c. Species Profile: *Hylaeus facilis*. 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. 2005d. Species Profile: *Hylaeus hilaris*. 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. 2005e. Species Profile: *Hylaeus kuakea*. 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. 2005f. 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. 2005g. Species Profile: *Hylaeus mana*. 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.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 Hawaii. Bishop Museum Occasional Papers 96:44-45.

Magnacca, K.M. 2011. Email correspondence between Mike Richardson, U.S. Fish and Wildlife, PIFWO Biologist and Karl Magnacca, post-doctoral fellow at the University of Hawaii at Hilo, regarding the status of the seven *Hylaeus* bees and his formal comments on the 90-day finding for the species.

Manaaki Whenua Landcare Research. 2011. (Regarding invasive ant species status). http://www.landcareresearch.co.nz/research/biocons/invertebrates/Ants/invasive_ants/solgem_info.asp, accessed July 29, 2011.

Mangel, M., and C. Tier. 1994. Four facts every conservation biologist should know about persistence. Ecology 75:607-614.

Martin, C. 2007. Coordinating Group on Alien Pest Species, Report to the legislature on efficacy of public outreach on invasive species, August 16, 2007.

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

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

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

Nafus, D.M. 1993. Extinction, biological control, and insect conservation on islands. In Gaston, K.J., T.R. New, and M.J. Samways (eds.), Perspectives on Insect Conservation, Intercept Ltd., Andover. Pp. 139-154.

National Park Service. 2006. Kalaupapa National Historical Park. (Regarding Kalaupapa National Park management). http://www.nps.gov/kala/index.html, accessed July 11, 2008.

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.

Natural Resources Conservation Service. 1978. Tantalus Series. National Soil Survey Center: National Cooperative Soil Survey. http.://ortho.ftw.nrcs.usda.gov/osd/dat/T/TANTALUS.html, accessed August 15, 2008.

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

Nishida, G.M. (ed.). 1997. Hawaiian Terrestrial Arthropod Checklist. 3rd ed. Bishop Museum Technical Report No. 12. 263 pgs.

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

Perkins, R.C.L. 1912. The colour-groups of the Hawaiian wasps, etc. Trans. Entomol. Soc. Lond. 1912:677-701.

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

Pimm, S., H. Lee Jones, and J. Diamond. 1988. On the risk of extinction. American Naturalist 132:757-785.

Reimer, N.J. 1993. Distribution and impact of alien ants in vulnerable Hawaiian ecosystems. In Williams, D. F. (ed.), Exotic Ants: Biology, Impact, and Control of Introduced Species, Westview Press, Boulder. Pp. 11-22.

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

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

Rock, J.F. 1913. The indigenous trees of the Hawaiian Islands. Pac. Trop. Bot. Garden, Lawai, Kauai, Hawaii, and Charles E.Tuttle Co., Rutland, Vermont and Tokyo, Japan.

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, and 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.

Smith, C.W. 1985. Impact of non-native plants on Hawaiis native biota. In Stone, C.P., and J.M. Scott (eds.), Hawaiis terrestrial ecosystems: preservation and management. Pp. 180-250. Cooperative National Park Resources Study Unit, University of Hawaii, Honolulu, Hawaii.

Smith, C.W., and J.T. Tunison. 1992. Fire and invasive plants in Hawaii: research and management implications for native ecosystems. In Stone, C.P., and J.M. Scott (eds.), Hawaiis terrestrial ecosystems: preservation and management. Pp. 394-408. Cooperative National Park Resources Study Unit, University of Hawaii. 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.

SoulÃ©, M.E. 1986. Minimum viable populations: Processes of Species Extinction. Pp.19-34. In SoulÃ©, M. E. (ed.), Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Inc., Sunderland, Massachusetts, U.S.A.

Staples, G.W., and R.H. Cowie (eds.). 2001. Hawaiis Invasive Species. Mutual Publishing and Bishop Museum Press. Honolulu. 111 pp.

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

Takeuchi, W. 1991. Botanical survey of Puuwaawaa, final report. Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu. 69 pp.

The Nature Conservancy Natural Heritage Program. 2003. In The Hawaiian Conservation Alliance: Conservation of Biological Resources in Hawaii. http://hawaiiconservation.org/_library/documents/statusreport.pdf, accessed August 20, 2008.

(TNC) The Nature Conservancy. 2000. Honouliuli Reserve Master Plan. http://www.nature.org/wherewework/northamerica/states/hawaii/files/finalmp.pdf, accessed July 4, 2008.

(TNC) The Nature Conservancy. 2003. Last Stand, The Vanishing Hawaiian Forest. 24 pp.

(TNC) The Nature Conservancy. 2005. South Ekahanui Fence and Restoration Project at Honouliuli Preserve, Phases 1 and 3: Final Report, pp 16-17.

(TNC) The Nature Conservancy. 2006a. Coastal vegetation. Hawaiian High Islands Ecoregion Plan, http://www.hawaiiecoregionplan.info/coastalsystem.html, accessed December 1, 2009.

(TNC) The Nature Conservancy. 2006b. Lowland dry system. Hawaiian High Islands Ecoregion Plan, http://www.hawaiiecoregionplan.info/LDsystem.html, http://www.hawaiiecoregionplan.info/home.html, accessed April 22, 2008.

(TNC) The Nature Conservancy. 2006c. Lowland mesic system. Hawaiian High Islands Ecoregion Plan, http://www.hawaiiecoregionplan.info/LMsystem.html, http://www.hawaiiecoregionplan.info/home.html, accessed December 11, 2007.

(TNC) The Nature Conservancy. 2006d. Lowland wet system. Hawaiian High Islands Ecoregion Plan, http://www.hawaiiecoregionplan.info/LWsystem.html, http://www.hawaiiecoregionplan.info/home.html, accessed December 11, 2007.

(TNC) The Nature Conservancy. 2006e. Montane wet system. Hawaiian High Islands Ecoregion Plan, http://www.hawaiiecoregionplan.info/MWsystem.html, http://www.hawaiiecoregionplan.info/home.html, accessed December 11, 2007.

(TNC) The Nature Conservancy. 2009. Moomomi Preserve Molokai, Hawaii. FY2010 Operational Plan and FY2009 Final Progress Report. Submitted to the Department of Land & Natural Resources Natural Area Partnership Program August 2009. 21 pp.

U.S. Army Garrison 2007. Ecosystem management in Kaena Point. 2007 Status Report for Makua Implementation Plan and the Draft Oahu Implementation Plan, Directorate of Public Works, Environmental Division, Schofield Barracks. Fire appendices.

U.S. Army Garrison 2009. Ecosystem management in Kaena Point. 2009 Status Report for Makua Implementation Plan and the Draft Oahu Implementation Plan, Directorate of Public Works, Environmental Division, Schofield Barracks. Fire appendices.

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

(USFWS) U.S. Fish and Wildlife Service. 2004. Biological Opinion of the U.S. Fish and Wildlife Service for routine military training and transformation of the 2nd Brigade 25th Infantry Division (Light) U.S. Army Installations of Hawaii. 217 pp.

(USFWS) U.S. Fish and Wildlife Service. 2008. Hawaiian Islands Plants: Listed species, as designated under the U.S. Endangered Species Act. http://www.fws.gov/pacificislands/wesa/HIlistingplants.pdf, accessed June 23, 2008.

Vitousek, P.M., C.M. DAntonio, L.L. Loope, M. Rejmanek, and R. Westerbrooks. 1997. Introduced species: a significant component of human-caused global change. New Zealand Journal of Ecology 21:1-16.

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.

Wilson, E.E., L.M. Mullen, and D.A. Holway. 2009. Life history plasticity magnifies the ecological effects of a social wasp invasion. Proceedings of the National Academy of Science. USA. 5 pp.

Wong, M.A., and T.T.Y. Wong. 1988. Predation of the Mediterranean fruit fly and oriental fruit fly (Diptera: Tephritidae) by the fire ant (Hymenoptera: Formicidae) in Hawaii. Proceedings of the Hawaiian Entomological Society 28:169-177.

Xerces Society for Invertebrate Conservation. 2009a. Petition to list two species of Hawaiian yellow-faced bees (*Hylaeus anthracinus* and *Hylaeus longiceps*) as endangered under the U.S. Endangered Species Act. 49 pp.

Xerces Society for Invertebrate Conservation. 2009b. Petition to list one species of Hawaiian yellow-faced bees (*Hylaeus assimulans*) as endangered under the U.S. Endangered Species Act. 34 pp.

Xerces Society for Invertebrate Conservation. 2009c. Petition to list one species of Hawaiian yellow-faced bees (*Hylaeus facilis*) as endangered under the U.S. Endangered Species Act. 38 pp.

Xerces Society for Invertebrate Conservation. 2009d. Petition to list one species of Hawaiian yellow-faced bees (*Hylaeus hilaris*) as endangered under the U.S. Endangered Species Act. 23 pp.

Xerces Society for Invertebrate Conservation. 2009e. Petition to list two species of Hawaiian yellow-faced bees (*Hylaeus mana* and *Hylaeus kuakea*) as endangered under the U.S. Endangered Species Act. 24 pp.

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 Key, A. (ed.), A Natural History of The Hawaiian Islands. Honolulu: University Press of Hawaii.

Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve: 06/13/2013
Date

Concur: 10/28/2013
Date

Did not concur: ____________________ ____________
Date

Director's Remarks: