U.S. Fish & Wildlife Service

Recovery Outline for 12 Hawaiian Picture-wing Flies

August 2006

Threatened: ***Drosophila mulli***

Endangered: ***D. aglaia, D. differens, D. hemipeza, D. heteroneura, D. montgomeryi, D. musaphilia, D. neoclavisetae, D. obatai, D. ochrobasis, D. substenoptera, D. tarphytrichia.***

Drosophila heteroneura. Photo courtesy Kevin Kaneshiro ©, used with permission.

Common Names	Hawaiian picture-wing fly (12 species)
Scientific Names	*Drosophila aglaia, D. differens, D. hemipeza, D. heteroneura, D. montgomeryi, D. mulli, D. musaphilia, D. neoclavisetae, D. obatai, D. ochrobasis, D. substenoptera,* and *D. tarphytrichia*.
Listing Status and Date	Threatened, *Drosophila mulli* only; Endangered, all others. May 9, 2006 (71 Federal Register 26835)
Lead Agency/Region	U.S. Fish and Wildlife Service, Region 1
Lead Field Office	Pacific Islands Fish and Wildlife Office 300 Ala Moana Boulevard, Room 3-122, Box 50088 Honolulu, Hawaii 96850 Telephone: 808-792-9400

Purpose of the Recovery Outline: This document describes a preliminary course of action for the survival and recovery for twelve species of Hawaiian picture-wing flies. It is meant to serve as interim guidance to direct recovery efforts and inform consultation and permitting activities until a comprehensive draft recovery plan has been completed. Recovery outlines are intended primarily for internal use by the U.S. Fish and Wildlife Service, and formal public participation will be invited upon the release of the draft recovery plan. However, we will consider any new information or comments that members of the public may wish to offer in response to this outline during the recovery planning process. For more information on Federal survival and recovery efforts for the

Hawaiian picture-wing flies, or to provide additional comments, interested parties may contact the lead field office for these species at the above address and telephone number.

Scope of Recovery and Available Information: The scope of this effort is for multiple species. Many aspects of Hawaiian *Drosophila* biology have been researched, including their internal and external morphology, behavior, ecology, physiology, biochemistry, banding structure of chromosomes, and the structure of their DNA. A large number of sites across the Hawaiian Islands have been surveyed since the 1960s providing researchers with a good understanding of the distribution of *Drosophila* species and how it has changed over time. In addition, the habitat needs and threats to the species were reviewed by a scientific panel of Hawaiian *Drosophila* experts hosted by the Service in 2005 (referenced in this outline as Science Panel 2005). Uncertainties associated with the specific habitat needs and biology of the Hawaiian picture-wing flies will be resolved to the extent possible through the course of the recovery process and will likely result in modifications to the recovery program over time.

I. Overview

A. BIOLOGICAL ASSESSMENT

1. Species Description and Life History

The Hawaiian picture-wing group (genus *Drosophila*, family Drosophilidae) consists of 106 known species, most of which are relatively large with elaborate markings on the otherwise clear wings of both sexes, the pattern of which varies among species (Hardy and Kaneshiro 1981; Carson 1992). The picture-wing *Drosophila* have been referred to as the "birds of paradise" of the insect world because of their relatively large size (4.32 to 6.35 millimeters [0.17 to 0.25 inches), colorful wing patterns, and the males' elaborate courtship displays and territorial defense behaviors.

Each species of Hawaiian picture-wing fly described is found only on a single island, and the larvae of each are dependent upon only a single or a few related species of native host plants (see Table 1).

The general life cycle of Hawaiian *Drosophila* is typical of that of most flies: after mating, females lay eggs from which larvae (immature stage) hatch; as larvae grow they molt (shed their skin) through three successive stages (instars); when fully grown, the larvae change into pupae (a transitional form) in which they metamorphose and emerge as adults. Breeding generally occurs year-round, but egg laying and larval development increase following the rainy season as the availability of decaying matter, upon which the flies feed, increases in response to the heavy rains (K. Kaneshiro, *in litt*., 2005b). In general, Hawaiian *Drosophila* lay between 50 and 200 eggs in a single clutch.

Table 1. Distribution of 12 Hawaiian picture-wing flies by island, general habitat type, and primary host plant(s).

Species	Island	Habitat type	Primary host plant(s)
Dropsophila aglaia	Oahu	mesic forest	*Urera glabra*
D. hemipeza	Oahu	mesic forest	*Cyanea* spp., *Lobelia* spp., *Urera kaalae*
D. montgomeryi	Oahu	mesic forest	*Urera kaalae*
D. obatai	Oahu	dry to mesic forest	*Pleomele aurea, Pleomele forbesii*
D. substenoptera	Oahu	wet forest	*Cheirodendron* spp., *Tetraplasandra* spp.
D. tarphytrichia	Oahu	mesic forest	*Charpentiera* spp.
D. heteroneura	Hawaii	mesic to wet forest	*Cheirodendron* spp., *Clermontia* spp., *Delissea* spp.
D. mulli	Hawaii	wet forest	*Pritchardia beccariana*
D. ochrobasis	Hawaii	mesic to wet forest	*Clermontia* spp., *Marattia* spp., *Myrsine* spp.
D. differens	Molokai	wet forest	*Clermontia* spp.
D. musaphilia	Kauai	mesic forest	*Acacia koa*
D. neoclavisetae	Maui	wet forest	*Cyanea* spp.

Eggs develop into adults in about a month, and adults generally become sexually mature 1 month later. Adults generally live for 1 to 2 months.

While the larval stages of most species are saprophytic (feeding on decaying vegetation, such as rotting leaves, bark, flowers, and fruits), some have become highly specialized, being carnivorous on egg masses of spiders, or feeding on green algae growing underwater on boulders in streams (Kaneshiro and Kaneshiro 1995).

The distribution of the12 Hawaiian picture-wing flies varies by island, from the native dry *Diospyros* spp. (lama) and *Metrosideros polymorpha* (ohia) forests to mesic and wet native *Acacia koa* (koa) and ohia communities. Native host plant species used by picture-wing flies and found within these communities include*: Clermontia clermontioides (*`oha wai), *Urera glabra* (opuhe), *Urera kaalae* (opuhe), *Cheirodendron trigynum* (`olapa), *Pritchardia beccariana* (loulu), *Cyanea* spp. (haha), *Acacia koa*, *Charpentiera* spp. (papala), *Tetraplasandra* spp. (`ohe), *Marattia* spp. (pala), *Myrsine* spp. (kolea), *Pleomele forbesii* (hala pepe), and *Delissea* spp. (delissea).

2. Historical and Current Population Status

Flies in the Drosophilidae family are distributed throughout the higher, main Hawaiian Islands (*i.e*., Hawaii, Maui, Oahu, Kauai, Molokai, and Lanai), and each species is typically found on a single island (Carson and Yoon 1982). Genetic studies of

Hawaiian picture-wing *Drosophila* revealed a 5 million-year-old evolutionary history rooted to species on the island of Kauai (Carson 1992). This work on the evolutionary history of Hawaiian *Drosophila* augments an extensive systematic treatment of the genus (Hardy 1965; Kaneshiro 1976).

As a group, Hawaiian Drosophilidae can be found in most of the natural communities in Hawaii. They have developed and adapted ecologically to a tremendous diversity of ecosystems ranging from desert-like habitats, to rain forests, to swampland (Kaneshiro and Kaneshiro 1995).

The primary dataset used to document observations of the picture-wing flies spans from 1965 to 1999 (K. Kaneshiro, *in litt*., 2005a). Additional data were obtained from individuals familiar with particular species and locations. Many sites were surveyed infrequently or have not been surveyed recently while others have relatively complete records from 1966 to 1999. Because a large number of sites across the Hawaiian Islands have been surveyed since the 1960s using bait stations that are not species-specific, researchers have a relatively good understanding of the distribution of *Drosophila* species within natural forest communities and how that distribution has changed over time. Biologists have observed a general decline of the Hawaiian Drosophilidae, including the picture-wing flies, along with other components of the native ecosystem.

Native vegetation on all the main Hawaiian Islands has undergone extreme alteration because of past and present land management practices, including ranching, introduction of nonnative plants and animals, and agricultural development (Cuddihy and Stone 1990).

Each species of Hawaiian picture-wing fly described in this document is found only on a single island, and the larvae of each are dependent upon only a single or a few related species of plants. Host plant species are threatened by a variety of factors, including their direct destruction by pigs (*Sus scrofa*), goats (*Capra hircus*), cattle (*Bos taurus*), and rats (*Rattus* spp.), competition with nonnative plants, and the indirect effects of soil disturbance which further promotes the spread of nonnative species. In addition to habitat degradation, the picture-wing flies are threatened by a variety of introduced predatory species, including yellow jacket wasps (*Vespula pensylvanica*) and several ant species (family Formicidae). See Appendix I for maps showing the distribution of each species by island.

Population status by island and species:

Island of Oahu – *Drosophila aglaia, D. hemipeza, D. montgomeryi, D. obatai, D. substenoptera,* and *D. tarphytrichia*

Drosophila aglaia

Drosophila aglaia is historically known from five mesic native forest localities in the Waianae Mountains of Oahu between 427 and 853 meters (1,400 and 2,800 feet) above sea level. The last observation of this species occurred in 1997 during the last

survey of the Palikea site. The species has not been observed at the other four historical sites since 1970 or 1971 despite subsequent surveys. However, three of the sites (Makaleha Valley, Peacock Flats, and Puu Kaua) have not been surveyed since the 1970s and the fourth site, Puu Pane, was surveyed only once again in 1991 (K. Kaneshiro, *in litt*., 2005a).

Drosophila hemipeza

Drosophila hemipeza is restricted to the island of Oahu where it is historically known from seven mesic native forest localities between 488 and 853 meters (1,600 and 2,800 feet) above sea level (not including the Pupukea site of discovery, which is now considered an extirpated population). The species has been documented from seven sites, with survey history at these sites as follows: (1) the species was documented in 1969 but not in subsequent surveys spanning until 1972 in the Makaleha Valley; (2) individuals were detected at Puu Kaua in 1971 but not in subsequent surveys as recently as 1999; (3) at Kaluaa Gulch, the species was observed in 1971 but not in 1972; (4) in Makaha Valley, the species was detected in 1971 and no surveys have been conducted since; (5) at Palikea the last observation occurred in 1997, also the date of the last survey; (6) the species has not been detected at the Mauna Kapu site since 1975 despite subsequent surveys spanning until 1983; and (7) the species was detected at Pauoa Flats in the Koolau Range that was surveyed three times between 1973 and 1974, with one observation of one individual during the last survey in 1974 (K. Kaneshiro, *in litt.*, 2005a).

Drosophila montgomeryi

Drosophila montgomeryi is historically known from three mesic native forest localities in the Waianae Mountains on western Oahu between 610 and 853 meters (2,000 and 2,800 feet) above sea level. The best available information concerning the status of the species at these sites is as follows: (1) one individual was recorded from Kaluaa Gulch during the last survey in 1972; (2) at Palikea, one individual was observed on the last survey date in March 1997; and (3) at Puu Kaua, historically the site with the highest number of total individuals observed, the species was last detected in 1971 despite five subsequent surveys between 1997 and 1999 (K. Kaneshiro, *in litt*., 2005a).

Drosophila obatai

Drosophila obatai is historically known from two dry to mesic native forest localities between 457 to 670 meters (1,500 to 2,200 feet) in elevation on the island of Oahu. Nine individuals were recorded during 10 surveys between 1970 and 1991 (K. Kaneshiro, *in litt*., 2005a). Individuals of the species were detected in November 1971 at the time of the last survey at Wailupe Gulch. The second site (Puu Pane) has been surveyed eight times between 1970 and 1991 with the last detection occurring in March 1971 (K. Kaneshiro, *in litt*., 2005a).

Drosophila substenoptera

Drosophila substenoptera is historically known from seven localities in the wet native forest of the Koolau and Waianae Mountains on Oahu at elevations between 396 to 1,189 meters (1,300 to 3,900 feet) above sea level. *Drosophila substenoptera* is now

only known to occur on the summit of Mt. Kaala, where historically it was most consistently observed. *Drosophila* researchers have devoted intensive efforts to relocating this species at other sites because the species is considered important for genetic studies of the *D. planitibia* phylogeny group; unfortunately, these efforts have failed to relocate this species at other sites (Kaneshiro and Kaneshiro 1995; Science Panel 2005).

Drosophila tarphytrichia

Historically, *Drosophila tarphytrichia* was known from both the Koolau and the Waianae Mountains between 610 and 853 meters (2,000 and 2,800 feet) above sea level. The species is now considered to be extirpated from the Koolau range where it was originally discovered near Manoa Falls on Oahu. *Drosophila tarphytrichia*'s four mesic forest habitat sites in the Waianae Mountains include Puu Kaua, Mauna Kapu, Kaluaa Gulch, and Palikea, the latter two of which were occupied during the last surveys there in 1972 and 1997, respectively (Kaneshiro and Kaneshiro 1995; K. Kaneshiro, *in litt*. 2005a). At the 4 Waianae habitat sites, a total of 31 *D. tarphytrichia* individuals were recorded on 36 different survey dates between 1965 and 1999 (K. Kaneshiro, *in litt*. 2005a).

Island of Hawaii – *Drosophila heteroneura, D. mulli,* and *D. ochrobasis*

Drosophila heteroneura

Drosophila heteroneura has been recorded from 24 localities on 4 of the island's 5 volcanoes (Hualalai, Mauna Kea, Mauna Loa, and Kilauea) in 5 different mesic to wet montane environments (Kaneshiro and Kaneshiro 1995; K. Kaneshiro, *in litt.* 2005a). Based on the relatively extensive survey data, the population decline of *Drosophila heteroneura* has been demonstrated clearly. For example, *D. heteroneura* was recorded 760 times during surveys between 1975 and 1979. In the early 1980s, the first disappearance of a *D. heteroneura* population was recorded from the Olaa Forest site in Hawaii Volcanoes National Park (Carson 1986; Foote and Carson 1995). Subsequently, the absence of the species was noted in several other locations in southern and western parts of the island where *D. heteroneura* had previously been relatively common. By the late 1980s, *D. heteroneura* was believed to be extinct until an extremely small population was discovered on private land at Hualalai Volcano in 1993 (Kaneshiro and Kaneshiro 1995). The species was not observed again until 1998 when Foote (2000) recorded six specimens of *D. heteroneura* inhabiting a site at approximately 1,352 meters (4,436 feet) above sea level near a host plant species, *Clermontia clermontioides*. *Drosphila heteroneura* was last observed in 2001 at the Kona Unit of the Hakalau Forest National Wildlife Refuge (D. Foote, U.S. Geological Survey, *in litt*. 2005).

Drosophila mulli

Drosophila mulli is restricted to the island of Hawaii and is historically known from two locations between 985 and 1,220 meters (3,200 and 4,000 feet) above sea level. The site of discovery for *Drosophila mulli* is located within a State-owned montane wet ohia forest at Olaa Forest Reserve at approximately 985 meters (3,200 feet) above sea level. This site was surveyed at least 62 times between 1965 and 2001, with fewer than

10 individuals observed on 4 different dates. The last recorded observation at this site occurred in 2001 (K. Kaneshiro, *in litt*. 2005a; D. Foote, *in litt*. 2006). A second locality was discovered in 1999, approximately 15 kilometers (9.3 miles) from the original site within a State-owned montane wet ohia forest site at Upper Waiakea Reserve at approximately 1,219 meters (4,000 feet) above sea level (Science Panel 2005; S. Montgomery, Montane Matters, *in litt*. 2005a).

Drosophila ochrobasis

Drosophila ochrobasis was widely distributed between 1,189 to 1,615 meters (3,900 and 5,300 feet) in mesic to wet forest areas on the island of Hawaii. *Drosophila ochrobasis* has been recorded from 10 localities on 4 of the island's 5 volcanoes (Hualalai, Mauna Kea, Mauna Loa, and the Kohala mountains). Recorded almost every year from 1967 to 1975, sometimes in relatively large numbers (135 occurrences in the period between 1970 and 1974), *D. ochrobasis* is now largely absent from its historical localities. A single individual of *D. ochrobasis* was last observed at the 1855 lava flow (Kipuka 9 and Kipuka 14) in 1986 (Kaneshiro and Kaneshiro 1995; K. Kaneshiro, *in litt*. 2005a). Several surveys between 1995 and 1997 failed to locate the species at many of its historical sites (K. Kaneshiro, *in litt*. 2005a).

Island of Molokai – *Drosophila differens*

Drosophila differens

Drosophila differens is historically known from three sites on private land between 1,158 to 1,372 meters (3,800 to 4,500 feet) elevation on the island of Molokai, within montane wet ohia forest (K. Kaneshiro, *in litt.* 2005a). Only one of the originally surveyed populations was still present during a survey conducted in 1999 (K. Kaneshiro, *in litt.* 2005a).

Island of Kauai – *Drosophila musaphilia*

Drosophila musaphilia

Drosophila musaphilia is historically known from only four mesic native forest sites on Kauai, one at 579 meters (1,900 feet) above sea level, and four sites between 792 and 1,067 meters (2,600 and 3,500 feet) above sea level. The species has been observed a total of 11 times during 52 different survey dates since its discovery (Kaneshiro and Kaneshiro 1995; K. Kaneshiro, *in litt*. 2005a). Researchers estimate that 75 percent of *D. musaphilia*'s total potential habitat has been surveyed (K. Kaneshiro, pers. comm. 2006). The best available information concerning the status of the species at these sites is as follows: (1) a single observation of *D. musaphilia* was recorded from one lowland, wet ohia forest site at Wahiawa (Alexander Reservoir) in 1968 (this population is believed to be extirpated); (2) at the Halemanu site, the species was observed in 1970 and last observed in 1972 but not in subsequent surveys as recent as 1996; (3) one individual was observed in 1968 at the Kokee (Nualolo Trail) site and not again during numerous surveys through 1999; and (4) individuals were last observed in 1992 along the Waimea Canyon Road at an elevation of 792 meters (2,600 feet) (K. Kaneshiro, *in litt*. 2005a).

Island of Maui – *Drosophila neoclavisetae*

Drosophila neoclavisetae

Drosophila neoclavisetae is known historically from two populations located in wet native forest on Maui. Populations were found historically along the Puu Kukui Trail within montane wet ohia forests on State land in West Maui. One habitat site was found in 1969 at 1,353 meters (4,440 feet) and the other in 1975 at 1,067 meters (3,500 feet) above sea level (Kaneshiro and Kaneshiro 1995; K. Kaneshiro, *in litt*. 2005a). Researchers estimate that between 90 and 95 percent of *D. neoclavisetae*'s total potential range has been surveyed (K. Kaneshiro, pers. comm. 2006).

3. Habitat Description and Landownership

The 12 Hawaiian picture-wing flies are known from native forest communities on Federal, State, and private lands where host plant populations exist. Known host plants for the 12 picture-wing flies include: *Clermontia clermontioides*, *Urera glabra*, *Urera kaalae*, *Cheirodendron trigynum*, *Pritchardia beccariana*, *Cyanea* spp., *Acacia koa*, *Charpentiera* spp., *Tetraplasandra* spp., *Marattia* spp., *Myrsine* spp., *Pleomele forbesii*, and *Delissea* spp.

4. Summary Biological Assessment

It is difficult to say whether the current known population status of these species will be conducive to strategies that could lead to their long-term persistence in the wild. Demographics will likely be influenced by native forest habitat protection and host plant availability as well as by predatory wasp populations and other insects competing for use of host plants. Further systematic surveys into new localities are needed, as well as repeat surveys of sites with known historical populations. Use of remote sensing and data from plant and insect surveys may help to develop models of host plant distribution, which in turn may be used for targeting potential survey locales. If extant populations are fenced and feral ungulates are removed from the area it is likely that Hawaiian picture-wing fly habitat quality will improve. For example, Foote and Carson (1995) found that pig exclosures on the Big Island supported significantly higher relative frequencies of picture-wing flies compared to other native and nonnative *Drosophila* species (7 percent of all observations outside of the exclosure and 18 percent of all observations inside the exclosure), as well as their native host plants. Loope *et al*. (1991) showed that native plant cover increased from 6 to 95 percent after excluding pigs from a montane bog on northeastern Haleakala, Maui, for a period of 6 years. Control strategies will need to be developed and implemented to manage alien weed populations which may occur in or adjacent to key picture-wing fly habitat. In summary, the experts present at the 2005 science panel stated that the most significant step to recovery for these 12 picture-wing flies would involve the conservation of the host plant habitat for the species (Science Panel 2005). Understanding the full extent of each species' remaining habitat and the threats facing those areas will be a first step in recovering these picture-wing flies.

B. THREATS ASSESSMENT

1. Listing Factors/Primary Threats to the Species

As identified in the final listing rule for these species, published May 9, 2006 (USFWS 2006) and the results of the associated science panel conducted in 2005 (Science Panel 2005), the primary threats to these 12 picture-wing flies are habitat degradation by introduced ungulates and rats, predation by nonnative wasps and ants, competition with nonnative arthropods within limited host plant material, and host plant habitat displacement and alteration by nonnative plants and wildfire stimulated by alien grass species.

A description of each of these threats is presented below; each is classified according to the five listing/delisting factors identified in section 4(a)(1) of the Endangered Species Act ("Act"; 16 USC 1531 *et seq*.).

(a) The present or threatened destruction, modification, or curtailment of its habitat or range (Factor A)

Native vegetation on all of the main Hawaiian Islands has undergone extreme alteration because of past and present land management practices, including ranching, introduction of nonnative plants and animals, and agricultural development (Cuddihy and Stone 1990). The primary threat facing the 12 picture-wing fly species is the ongoing loss of habitat caused by feral animals, nonnative plants, and wildfire facilitated by the introduction and spread of nonnative grasses.

Feral ungulates have devastated native vegetation in many areas of the Hawaiian Islands (Cuddihy and Stone 1990). Because the endemic Hawaiian flora evolved without the presence of browsing and grazing ungulates, many plant groups have lost their adaptive defenses such as spines, thorns, stinging hairs, and defensive chemicals (University of Hawaii Department of Geography 1998), and cattle, goats, pigs, domestic sheep (*Ovis aries*), mouflon sheep (*Ovis musimon*), axis deer (*Axis axis*), and black-tailed deer (*Odocoileus hemionus*) readily eat these plants as well as disturbing the soil and distributing nonnative plant seeds that alter the ecosystem. In addition to the damage these nonnative herbivores cause by browsing and grazing, goats, pigs, and other ungulates that inhabit steep and remote terrain cause severe erosion of whole watersheds due to their foraging and trampling behaviors (Cuddihy and Stone 1990).

The invasion of several nonnative plants, including species such as *Psidium cattleianum* (waiawī `ula `ula or strawberry guava), *Lantana camara* (la'au kalakala or lantana), *Melinis minutiflora* (molasses grass), *Pennisetum setaceum* (fountain grass) *Schinus terebinthifolius* (Christmas berry), and *Clidemia hirta* (Koster's curse), further contributes to the degradation of native forests and the host plants of picture-wing flies (Kaneshiro and Kaneshiro 1995; Wagner *et al.* 1999; Science Panel 2005). *Psidium cattleianum*, *Lantana camara*, *Melinis minutiflora*, and *Schinus terebinthifolius* form dense stands, thickets, or mats that shade or outcompete native plants. *Melinis minutiflora* and *P. setaceum* are grasses that increase fire risk and tend to replace native

plants following fires, (Smith 1985; Cuddihy and Stone 1990; Wagner *et al*. 1999), and *Lantana camara* produces chemicals that inhibit the growth of other plant species (Smith 1985; Wagner et al. 1999). *Passiflora mollissima* (banana poka) is a vine that causes damage or death to native trees by overloading the branches and also shades out native plants beneath its dense canopy cover (Wagner *et al*. 1999).

Fire threatens species of Hawaiian picture-wing flies living in dry to mesic grassland, shrubland, and forests on both the islands of Hawaii and Oahu. A large factor in the alteration of Hawaiian dry and mesic regions in the past 200 years has been the increase in fire frequency, a condition to which the native flora is not adapted. The invasion of fires-adapted alien plants, especially *Melinis minutiflora* on Oahu and *Pennisetum setaceum* on Hawaii, facilitated by ungulate disturbance, has increased the susceptibility of native areas to wildfire and increased fire frequency. The impact of an altered fire regime is a serious and immediate threat to the dry and mesic habitats that support over one-third of Hawaii's threatened and endangered species, as well as the picture-wing flies and their host plants (Hughes *et al*. 1991; Kaneshiro and Kaneshiro 1995; Blackmore and Vitousek 2000).

(b) Overutilization for commercial, recreational, scientific, or educational purposes (Factor B)

Overutilization is not known to be a threat to any of these species.

(c) Disease or predation (Factor C)

Disease is not known to be a threat to any of the Hawaiian picture-wing flies. However, predation by nonnative insects and other arthropods is a serious threat to these species. Commercial shipping and air cargo to Hawaii have resulted in the establishment of over 3,372 species of nonnative insects, 387 of which were purposely introduced, sometimes with the specific intent of reducing populations of native Hawaiian insects (Funasaki *et al*. 1988; Lai 1988; Staples and Cowie 2001). The continuing rate of establishment is estimated to be between 20 and 30 new species a year (Beardsley 1962, 1979; Staples and Cowie 2001). Nonnative arthropods pose a grave threat to Hawaii's native *Drosophila*, both through direct predation or parasitism as well as competition for food or space (Howarth and Medeiros 1989; Howarth and Ramsay 1991; Kaneshiro and Kaneshiro 1995; Staples and Cowie 2001).

Due to their large colony sizes and systematic foraging habits, nonnative species of social Hymenoptera (ants and some wasps) pose the greatest predation threat to the Hawaiian picture-wing flies (Carson 1982; Gambino *et al*. 1987; Kaneshiro and Kaneshiro 1995). Several alien ant species have been implicated in the extinction or local loss of many native species, including much of the lowland Hawaiian insect fauna (Howarth and Medeiros 1989). As Kaneshiro and Kaneshiro (1995) described, many of Hawaii's native species evolved in the absence of predators and do not have the adaptive traits to compete with alien species. Therefore, when alien insects such as yellow jacket

wasps and various species of ants were introduced, many native insects including the Hawaiian *Drosophila* were decimated.

(d) The inadequacy of existing regulatory mechanisms (Factor D)

Although the 12 Hawaiian picture-wing flies and at least 1 known host plant species are listed as endangered, regulatory mechanisms remain inadequate for thorough protection of the species, particularly regulations pertaining to the augmentation and introduction of biological control agents in Hawaii.

Release of Biological Controls

As discussed in the Disease and Predation section above, regulatory mechanisms designed to prevent the establishment of nonnative insects are inadequate given that 3,372 species of nonnative insects have become established in Hawaii (Howarth 1990; Howarth *et al*. 1995; Staples and Cowie 2001), with an estimated 20 to 30 new species added each year (Beardsley 1962, 1979; Staples and Cowie 2001).

Under Hawaii's Plant Quarantine Law (Hawaii Revised Statues Chapter 150A), the State of Hawaii requires that introductions of biological controls be reviewed by the Board of Agriculture before release. The U.S. Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) regulates the importation and release of biological controls through the Plant Protection Act of 2000 (7 USC 7701 *et seq*.). APHIS requires a risk analysis for each species proposed for release. In order for a species to be approved for releases, the risk analysis must ensure that introduced biological control agents are limited in host range and do not pose a threat to listed species or native plants, or crops. Nevertheless, some nonnative wasp species have been introduced by Federal and State agencies for biological control of pest flies to the possible detriment of Hawaiian picture-wing flies. Because the post-release biology and host range are difficult to predict from laboratory studies done prior to release (Gonzalez and Gilstrap 1992; Roderick 1992), the purposeful release or augmentation of any dipteran (fly) predator or parasitoid is a potential threat to all picture-wing flies (Kaneshiro and Kaneshiro 1995; Simberloff 1992).

Endangered Species Act Protections for Host Plants

One of the host plants used by 2 of the 12 picture-wing flies, (*Urera kaalae*, the only known host plant for *Drosophila montgomeryi* and a host plant for *D. hemipeza*) is federally listed as endangered. Under Hawaii State law, Federal listing automatically invokes State listing (HRS § 195D-4(a)). Furthermore, critical habitat has also been designated for this species. As such, this plant and its habitats are afforded certain protections under sections 7 and 9 of the Endangered Species Act (Act) and under section 13-107-3 of the Hawaii Administrative Rules.

Under section 7 of the Act, all Federal agencies must ensure, in consultation with the Service, that any action they authorize, fund, or carry out is not likely to jeopardize

the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This protection does not apply to activities conducted on non-Federal land that do not involve Federal permitting or funding. *Drosophila aglaia*, *D. obatai*, and *D. heteroneura* are the only three species addressed in this outline that have been recorded on federally-owned land. *Drosophila aglaia* and *D. obatai*'s host plants are not listed as threatened or endangered, and *D. heteroneura* is currently known from only two locations, one area on Federal land and one adjacent area on private land. In addition, none of the 12 species occur in areas likely to require a section 404 Clean Water Act permit from the U.S. Army Corps of Engineers.

Under section 9 of the Act, endangered plants cannot be removed, reduced to possession, or maliciously damaged or destroyed from areas under Federal jurisdiction. Endangered plants outside of Federal jurisdiction cannot be cut, dug up, damaged, or destroyed in knowing violation of any State law or regulation. They are also protected under section 13-107-3 of the Hawaii Administrative Rules which prohibits the take (i.e., to cut, collect, uproot, destroy, injure, or possess) and sale of native endangered or threatened plants on all lands in the State of Hawaii. However, these State regulations are difficult to enforce because of limited State funding and personnel.

e) Other natural or manmade factors affecting its continued existence (Factor E)

The Hawaiian Islands now support several established species of nonnative tipulid flies (crane flies, family Tipulidae), and the larvae of some species within this group feed within the decomposing bark of some of the host plants utilized by picture-wing flies, including *Charpentiera*, *Cheirodendron*, *Clermontia*, and *Pleomele* spp. (Science Panel 2005; K. Magnacca, U.S. Geological Survey, *in litt.*2005; S. Montgomery, *in litt.* 2005a). Therefore, all of the picture-wing flies addressed in this rule, except for *Drosophila mulli* and *D. musaphilia*, face larval-stage competition from nonnative tipulid flies. The tipulid larvae feed within the same portion of the decomposing host plant area normally occupied by the picture-wing fly larvae. The likely effect of this competition is a reduction in available host plant material for picture-wing fly larvae (Science Panel 2005). In laboratory studies, Grimaldi and Jaenike (1984) demonstrated that competition between *Drosophila* spp. larvae and other fly larvae can exhaust food resources, which affects both the probability of larval survival and the body size of adults, resulting in reduced adult fitness, fecundity, and lifespan.

The Hawaiian picture-wing flies evolved in isolated habitats, resulting in their tremendous speciation (Williamson 1981); as a result, small population size may be less of a threat than small habitat size (Science Panel 2005). Many of these picture-wing flies are now reduced to just a few populations within localized patches of their host plants, compounding the effects of numerous other factors contributing to their decline. The destruction of native plants and host plants within their habitat exacerbates the opening of niches for additional, introduced nonnative plant species. Once nonnative species are established, it is difficult for native plants, including the host plants for the picture-wing flies, to recover (Kaneshiro and Kaneshiro 1995; Science Panel 2005). Irrespective of the threats of predation and competition, the 2005 science panel members expressed

agreement in identifying the need to protect host plant habitat as the most important conservation and recovery goal for the 12 Hawaiian picture-wing flies (Science Panel 2005).

2. Summary Threats Assessment

Island of Oahu – *Drosophila aglaia, D. hemipeza, D. montgomeryi, D. obatai, D. substenoptera,* and *D. tarphytrichia*

The major threats to *Drosophila aglaia*, *D. hemipeza*, *D. montgomeryi*, *D. obatai*, *D. substenoptera*, and *D. tarphytrichia* include current and future degradation and modification to their limited remaining habitat from feral ungulates, such as pigs and goats; nonnative plants, particularly *Psidium cattleianum* and *Clidemia hirta*; and fire (Cuddihy and Stone 1995; Kaneshiro and Kaneshiro 1995; Science Panel 2005). The picture-wing flies on Oahu continue to experience a significant amount of habitat loss and degradation throughout their range. Furthermore, the host plant species for *D. aglaia*, *D. hemipeza*, *D. montgomeryi*, and *D. obatai* are rare or sparsely distributed and threatened by ongoing habitat degradation.

Additionally, *Drosophila aglaia*, *D. hemipeza*, *D. montgomeryi*, *D. obatai*, *D. substenoptera*, and *D. tarphytrichia* face competition at the larval stage from nonnative tipulid flies, and all life stages face substantial predation pressure from nonnative insects such as ants and yellow jacket wasps (Kaneshiro and Kaneshiro 1995; Science Panel 2005). Currently, existing regulations offer inadequate protection to these species from the introduction of nonnative insects and the loss of their host plants.

Island of Hawaii – *Drosophila heteroneura, D. mulli,* and *D. ochrobasis*

Drosophila heteroneura and *D. ochrobasis* were historically widely distributed across the Big Island, known from 24 sites and 10 sites, respectively. However, these species have not been recently observed at many of these sites and may now be limited to as few as two areas each (Kaneshiro and Kaneshiro 1995; K. Kaneshiro, *in litt*. 2005a; Science Panel 2005). *D. mulli* was historically known from two sites, both of which were still occupied as of the last survey.

The major threats to *Drosophila heteroneura* and *D. ochrobasis* include current and future degradation and modification to their limited remaining habitat from feral ungulates, such as pigs; nonnative plants, particularly *Psidium cattleianum* and *Pennisetum setaceum*; and fire (Cuddihy and Stone 1995; Kaneshiro and Kaneshiro 1995; Science Panel 2005). Feral pigs and goats have dramatically altered the native vegetation (Kaneshiro and Kaneshiro 1995; D. Foote, *in litt*. 2005; Science Panel 2005). These feral ungulates destroy host plant seedlings and habitat by the trampling action of their hooves and through the spread of seeds of nonnative plants (Cuddihy and Stone 1995; D. Foote, *in litt*. 2005). Goats, pigs, and rats directly feed upon *D. heteroneura* and *D. ochrobasis* host plants. Cattle also feed on *D. ochrobasis* host plants. Rats directly feed upon the

seeds produced by *D. mulli* host plants (K. Magnacca, *in litt.* 2005; S. Montgomery, *in litt.* 2005b), and feral cattle and goats contribute to erosion on some steeper slopes where *D. heteroneura* and *D. ochrobasis* host plants occur.

The Hawaiian Islands now support several species of nonnative beetles (family Scolytidae, genus *Coccotrypes*), a few of which bore into and feed on the nuts produced by certain native plant species including *Pritchardia beccariana*, the host plant of *Drosophila mulli*. Affected *Pritchardia* spp., including *P. beccariana*, drop their fruit before the nuts reach maturity due to the boring action of the scolytid beetles. Little natural regeneration of this host plant species has been observed in the wild since the arrival of this scolytid beetle (K. Magnacca, *in litt.* 2005; Science Panel 2005). Compared to the host plants of the other picture-wing flies, *P. beccariana* is long lived (up to 100 years), but over time scolytid beetles may have a significant impact on the availability of habitat for *D. mulli.*

The invasion of several nonnative plants, particularly *Psidium cattleianum*, *Rubus ellipticus* (yellow Himalayan raspberry), *Passiflora mollissima*, and *Pennisetum setaceum*, contributes to the degradation of picture-wing host plant habitat on the island of Hawaii (Kaneshiro and Kaneshiro 1995; Wagner *et al*. 1999; Science Panel 2005). Jacobi and Warshauer (1992) reported that nonnative plants, including *Passiflora mollissima*, *Pennisetum setaceum*, and *Psidium cattleianum*, were found in 72 percent of 64 vegetation types sampled in a 5,000 square kilometer (1,930 square mile) study area on the island of Hawaii. *Psidium cattleianum* and *Rubus ellipticus* form dense stands that exclude other plant species (Cuddihy and Stone 1990; Wagner *et al*. 1999), and the vine *Passiflora mollissima* overloads the branches of native trees and shades out native plants below (Wagner *et al*. 1999). The grass *Pennisetum setaceum* has greatly increased fire risk in some regions, especially on the dry slopes of Hualalai, Kilauea, and Mauna Loa Volcanoes on the island of Hawaii (Wagner *et al*. 1999). This species quickly reestablishes itself after fires, unlike its native Hawaiian plant counterparts (Wagner *et al*. 1999).

Additionally, these species face competition at the larval stage from nonnative tipulid flies within the host plant, and all stages face substantial predation pressure from nonnative insects such as long-legged ants (*Anoplolepis longipes)* and yellow jacket wasps (Kaneshiro and Kaneshiro 1995; Science Panel 2005).

Drosophila mulli faces similar threats but its host plant is long-lived, and management efforts in Hawaii Volcanoes National Park (in forest adjacent to a known *D. mulli* site) are being undertaken to reduce the severity of those threats to its host plant. As a result of these actions, some regeneration of the host plant has been observed (K. Magnacca, pers. comm. 2006). Within *D. mulli*'s second habitat site in the Upper Waikea Reserve area, pig fencing is expected to reduce the effects of browsing pigs upon the host plant population (K. Magnacca, pers.comm. 2006). Because of ongoing management efforts benefiting *D. mulli*, and because its host plant can live for 100 years, *D. mulli* is not immediately at risk of extinction.

Island of Molokai – *Drosophila differens*

Drosophila differens is historically known from only three sites. It is threatened by pigs, axis deer, rats, nonnative plants, tipulid competition, and by predation from yellow jacket wasps. The primary threats to this species' habitat are from feral pigs and the nonnative weed, *Psidium cattleianum*, in a manner similar to picture-wing fly habitat on Oahu and Hawaii (see above). In addition, axis deer are present on Molokai, and they continue to degrade native forest habitat by trampling and overgrazing vegetation, which removes ground cover and exposes the soil to erosion. Although goats were described as a threat to at least one population of *D. differens* at Pu'u Kolekole in the proposed rule to list the species (USFWS 2006), we have subsequently learned that they may not be present in this area (K. Kaneshiro, pers. comm. 2006). Nonnative predatory and parasitic insects are considered significant factors contributing to the reduction in range and abundance of the Hawaiian picture-wing flies, and, in combination with habitat loss, are threats to their continued existence (Science Panel 2005).

These threats, considered in the context of the small number of individuals of the species (as inferred from the lack of positive survey results, despite extensive, focused efforts to relocate this species), are magnified and place *D. differens* in danger of extinction.

Island of Kauai – *Drosophila musaphilia*

Drosophila musaphilia is historically known from four sites, and has only been observed twice since 1972, most recently in 1992 along the Waimea Canyon Road at an elevation of 792 meters (2,600 feet). This species and its habitat remain threatened by pigs, goats, black-tailed deer, nonnative plants, nonnative ants, yellow jacket predation, and wildfire. Degradation and modification of *Drosophila musaphilia* habitat, particularly from the effects of feral ungulates and the nonnative weed *Psidium cattleianum*, have occurred and are likely to continue into the future (Kaneshiro and Kaneshiro 1995; Science Panel 2005). In addition to pigs and goats (see Oahu and Hawaii species for a discussion of the effects of these ungulates on picture-wing fly habitat), *D. musaphilia* habitat is threatened by black-tailed deer, which feed on a variety of alien and native plants, including the host plant, *Acacia koa* (van Riper and van Riper 1982). Of the three feral ungulates, pigs are the most serious threat, followed by goats, then black-tailed deer. All three will readily feed upon *Acacia koa* seedlings, but pigs and goats are easier to hunt and control, while black- tailed deer are difficult to hunt and control due to their excellent hearing (S. Perlman, Kauai National Tropical Botanical Garden, pers. comm. 2006).

The invasion of several nonnative plants, particularly *Psidium cattleianum*, *Lantana camara*, *Melinis minutiflora*, *Rubus argutus* (prickly Florida blackberry), *Clidemia hirta*, and *Passiflora mollissima*, further contributes to the degradation of native forests and the host plants of *D. musaphilia* (Kaneshiro and Kaneshiro 1995; Wagner *et al*. 1999; Science Panel 2005). In addition, fire and the resultant invasion by alien species remains a significant threat to the mesic forests that *Drosophila musaphilia*

inhabits on Kauai (Science Panel 2005). *M. minutiflora* is a grass that burns readily, often grows at the border of forests, and tends to carry fire into areas with woody native plants (Smith 1985; Cuddihy and Stone 1990). It is able to spread prolifically after a fire and effectively outcompete less fire-adapted native plant species, ultimately creating a stand of nonnative grass where forest once stood.

Drosophila musaphilia is known to be inherently rare since the larvae feed within slime fluxes, which develop on *Acacia koa* trees and are also rare. Yet, while threats from feral ungulates and nonnative weeds are affecting the regeneration of *Acacia koa*, the adult trees within this area remain relatively stable (Science Panel 2005).

These threats, considered in the context of the small number of individuals of the species (as inferred from the lack of positive survey results, despite substantial survey effort within potential habitat for the species), are magnified and place *Drosophila musaphilia* in danger of extinction. Nonnative predatory and parasitic insects are considered significant factors contributing to the reduction in range and abundance of the Hawaiian picture-wing flies and, in combination with habitat loss, threaten their continued existence (Science Panel 2005).

Island of Maui – *Drosophila neoclavisetae*

Drosophila neoclavisetae has only been observed twice in one area of west Maui. This species and its habitat remains threatened by nonnative plants, tipulid competition, and predation by yellow jacket wasps. *Drosophila neoclavisetae* is limited to the highlands of West Maui, where degradation and modification of its habitat, particularly from the effects of feral pigs, have occurred (Kaneshiro and Kaneshiro 1995; Science Panel 2005). Rats are also a significant factor threatening *D. neoclavisetae* habitat and are abundant in the areas where *D. neoclavisetae* has been observed (Science Panel 2005). Yellow jacket wasps are believed to be a significant threat to this species, and in combination with habitat loss, threaten its continued existence (Science Panel 2005). These threats, considered in the context of the small number of individuals of the species (as inferred from the lack of positive survey results, despite extensive, focused efforts to relocate this species), are magnified and place *D. neoclavisetae* in danger of extinction.

C. CONSERVATION ASSESSMENT

1. Conservation Efforts

Unlike numerous Hawaiian insects known only from their original taxonomic descriptions, many aspects of Hawaiian *Drosophila* and picture-wing fly biology have been researched, including their internal and external morphology, behavior, ecology, physiology, biochemistry, the banding sequence of giant chromosomes, and the structure of their DNA (Kaneshiro and Kaneshiro 1995). More than 80 research scientists and over 350 undergraduates, graduate students, and postdoctoral fellows have participated in research on many species of the Hawaiian Drosophilidae, resulting in over 600 scientific publications. While some research has been conducted to assess the impacts of feral

ungulates or the foraging habits of yellow jacket wasps in certain areas, for example, no specific research on the topic of this group's conservation has taken place. Furthermore, to date no on-the-ground conservation or management has been specifically implemented for the picture-wing flies. However, several of the historical and currently occupied habitat sites for all of the 12 species fall within larger managed areas or preserves, where some management activities such as fencing and feral ungulate and nonnative weed removal or control likely benefit the flies and their host plant habitat.

The threats facing Hawaiian picture-wing flies have been known for many years, and as a result of that knowledge, we classified 10 of the 12 *Drosophila* addressed here as candidates for listing (as threatened or endangered species) in the February 28, 1996, Notice of Review of Plant and Animal Taxa That Are Candidates for Listing as Endangered or Threatened Species (Notice of Review) (61 Federal Register 7596). The remaining two species, *Drosophila differens* and *D. ochrobasis*, were classified as candidates for listing in the Notice of Review dated September 19, 1997 (62 Federal Register 49398).

On January 17, 2001, we published a proposed rule to list as endangered the 12 species of Hawaiian picture-wing flies (66 Federal Register 3964), which included a detailed history of Federal actions completed prior to the publication of the proposal. At that time, we did not propose critical habitat for the 12 picture-wing flies. In the proposed rule and associated notifications, we requested that all interested parties submit comments, data, or other information that might contribute to the development of a final rule.

During the listing process, we convened a panel of three scientists from outside the Service with expertise in Hawaiian *Drosophila* to help review and address uncertainties in the scientific information available for these 12 picture-wing flies, particularly threats to their existence (Science Panel 2005). A second panel composed of four Service managers and a State manager participated in related policy discussions and considered the available information including assessment of status, threats, and extinction risks. Both panels reviewed the available information and participated in a combined panel meeting in November 2005, prior to the close of the final comment period for the final listing rule, which was published on May 9, 2006. We determined that the designation of critical habitat is prudent for the 12 species of picture-wing flies.

2. Summary Conservation Assessment

A significant amount of research has been conducted on the morphology, biology, genetics, and evolution of the Hawaiian *Drosophila*, however, no specific conservation or management activities for this group have occurred. However, some sites are being managed to exclude ungulates. These species remain endangered or threatened by one or more of the following: habitat degradation by pigs, goats, deer, rats, cattle, nonnative insects, and nonnative plants, all of which reduce the quality of habitat; direct host plant loss and host plant habitat loss from fire; direct predation by ants and nonnative wasps; and competition with nonnative insects.

II. Preliminary Recovery Strategy

A. RECOVERY PRIORITY NUMBER

All 12 of the listed Hawaiian picture-wing flies are assigned a recovery priority number of 5 on a scale of 1C (highest) to 18 (lowest; the "C" indicates the potential for conflict with human economic activities), based on the high degree of threat, a low potential for recovery, and their status as full species (USFWS 1983a,b). There is no perceived potential for conflict with human economic activities.

B. RECOVERY GOAL AND OBJECTIVES

The goal of the recovery program is to establish a framework within which recovery actions are undertaken to ensure the long-term survival of the Hawaiian picture-wing flies included in this outline, and to control or reduce the threats to the individual species to the extent that each no longer requires the protections afforded by the Endangered Species Act and therefore warrants delisting. Although subject to change, full recovery of the 12 Hawaiian picture-wing flies is currently envisioned as follows: viable populations of each listed Hawaiian picture-wing species will persist on protected and managed habitat throughout most of the species' historical range on their islands of origin. Threats to the 12 species, primarily habitat loss and degradation and predation by nonnative insect species, will be sufficiently abated to ensure the high probability of survival for each listed species of Hawaiian picture-wing fly for at least 100 years.

C. INITIAL ACTION PLAN

The goal of the initial phase of recovery is to arrest and reverse the general population declines and increase the occupied range of the 12 species of Hawaiian picture-wing flies. The primary objectives of the initial phase of recovery will be to:

1. Protect habitat and control threats (overview)

    1.1 Identify and survey remaining extant populations for all 12 species of the Hawaiian picture-wing flies

    1.2 Identify recovery emphasis areas and management units

    1.3 Ensure long-term protection of habitat (see below)

    1.4 Identify and control threats to all 12 species of the Hawaiian picture-wing flies and their host plants

        1.4.1 Within identified management units, construct and maintain fencing around those areas containing picture-wing fly host plants; remove ungulates

1.4.2 Control particularly invasive nonnative weeds

1.4.3 Provide wildfire protection as necessary

1.4.4 Protect management units from human disturbance as necessary

1.4.5 Control and manage purposeful and accidental introduction of potential predators and parasites

1.4.6 Control other threats as appropriate

2. Expand existing wild *Drosophila* host plant populations as necessary

2.1 Select current populations for augmentation or sites for establishment of new populations of host plants

2.2 Prepare sites within management units and out-plant listed and rare species of *Drosophila* host plants

3. Conduct additional research essential to recover the 12 Hawaiian picture-wing flies

3.1 Conduct research to confirm the larval stage host plants for *Drosophila mulli* and *D. neoclavisetae*

3.2 Study the natural recruitment, range, and fecundity of *Drosophila* host plants

3.3 For each of the 12 species of picture-wing flies, determine annual life history cycle and investigate impacts of nonnative insect predators, parasites, and competitors

3.4 Conduct studies on the range, demography, and dispersal of each species

3.5 For *Drosophila musaphilia*, conduct studies on the range, density, and life cycle of suitable slime fluxes on *Acacia koa* trees

3.6 Evaluate research results and implement adaptive management as necessary

4. Develop and implement a detailed monitoring plan for each species

5. Investigate need for and feasibility of picture-wing translocations into unoccupied historical habitat

6. Develop and initiate a public information program for the 12 picture-wing flies

7. Develop downlisting and delisting criteria as necessary to validate recovery objectives

These objectives will be accomplished by using the full range of protection tools available (*e.g.* critical habitat identification and determination, section 7 consultations, incidental take permits, partnerships, etc.) and will be based on our current understanding of the ecological requirements of these species and what is needed to fully protect their habitats. Heightened public awareness through information and incentive programs may play a role in generating voluntary protection actions (*e.g.* grants for habitat restoration and protection, Safe Harbor Agreements, etc.).

D. SUMMARY OF RECOVERY ACTIONS

The recovery effort should build upon ongoing conservation and monitoring efforts described above. Specific actions that should be undertaken early in the process include the following:

- Protect all remaining extant populations of the 12 Hawaiian picture-wing flies. Re-establish some host plant species into their habitat.

- Conduct systematic, island-wide surveys for additional populations of Hawaiian *Drosophila* spp. and their host plant species. Make use of landscape modeling, spatial analysis, remote sensing technology, and existing survey data to better understand host plant distributions and priority areas for targeting future *Drosophila* surveys.

- Prioritize research studies that provide information and tools which will aid in the mitigation of known threats and limiting factors of the Hawaiian *Drosophila*.

- Increase outreach effort and coordination with State agencies and private landowners regarding Hawaiian *Drosophila* conservation. Promote opportunities to assist in the recovery of these species through Habitat Conservation Plans, Safe Harbor Agreements, and through various conservation partnerships funded by State and Federal agencies and private organizations.

III. Preplanning Decisions

A. PLANNING APPROACH

A recovery plan for the 12 Hawaiian picture-wing flies will be prepared pursuant to section 4 (f) of the Endangered Species Act. Plan preparation will be conducted by the Pacific Islands Fish and Wildlife Office.

The species do not, at this time, warrant the appointment of a recovery team. Our lead biologist will coordinate recovery efforts within an informal network of experts and involved parties. Periodically, meetings among these parties may be convened with the purpose of sharing information and ideas about advancing the recovery of the Hawaiian picture-wing flies. Plans for stakeholder involvement are addressed below.

B. INFORMATION MANAGEMENT

All information relevant to the recovery of the 12 Hawaiian picture-wing flies will be housed in the Pacific Islands Fish and Wildlife Office's administrative files. Our lead biologist will be responsible for maintaining a full administrative record for the recovery planning and implementation process for the species.

C. RECOVERY PLAN SCHEDULE

Regional Office Review Draft	December 2007
Public Review Draft	March 2008
Public Comment Period	60 days
Final Recovery Plan	December 2008

D. STAKEHOLDER INVOLVEMENT

Key stakeholders:

- Private landowners that own lands occupied currently or historically by any of the 12 Hawaiian picture-wing flies
- Local entities and State and Federal agencies that own and/or manage lands occupied currently or historically by any of the 12 Hawaiian picture-wing flies
- Native Hawaiian groups
- Conservation organizations
- The University of Hawaii, *Drosophila* Project researchers
- The Nature Conservancy of Hawaii
- U.S. Geological Survey, Biological Resources Discipline
- State of Hawaii Department of Lands and Natural Resources, Division of Forestry and Wildlife

E. STAKEHOLDER INVOLVEMENT STRATEGY

The implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, states, local jurisdictions, non-governmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (*e.g.*, restoration of vegetation), research, captive propagation and reintroduction, and outreach and information. Because many of the current and historical populations of the 12 picture-wing flies occur or occurred on non-federal lands, recovery of these species cannot be accomplished solely on Federal lands. To achieve recovery of these species requires cooperative conservation efforts with State and local governments as well as private landowners. We anticipate identifying these non-federal landowners and coordinating with them to determine their ability and willingness to assist in recovery actions for Hawaiian picture-wing flies.

Stakeholders will be invited to participate in meetings as warranted, and will be given an opportunity to review and comment on a draft of the recovery plan prior to its finalization. Stakeholders will also be invited to contribute directly in developing and implementing recovery strategies and actions.

A mailing list of stakeholders will be maintained and the Pacific Islands Fish and Wildlife Office will attempt to foster open and ongoing communications with all interested parties. Field biologists working with the Hawaiian picture-wing flies and other natural resource issues in the Hawaiian Islands will attempt to develop strong one-on-one working relationships with interested parties over time to achieve the collaborative recovery of the Hawaiian picture-wing flies.

Approved:

Acting David Wesley

Regional Director, Region 1
U.S. Fish and Wildlife Service

8/2/06
Date

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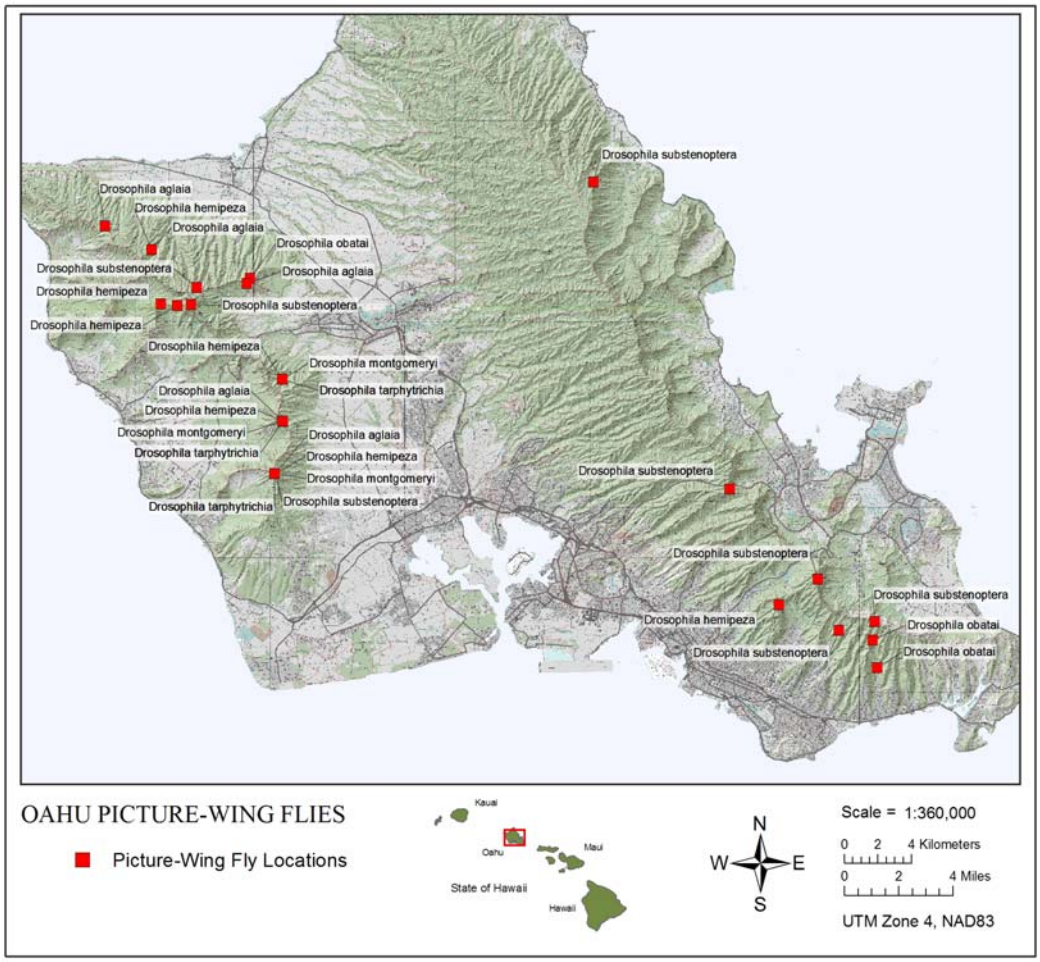
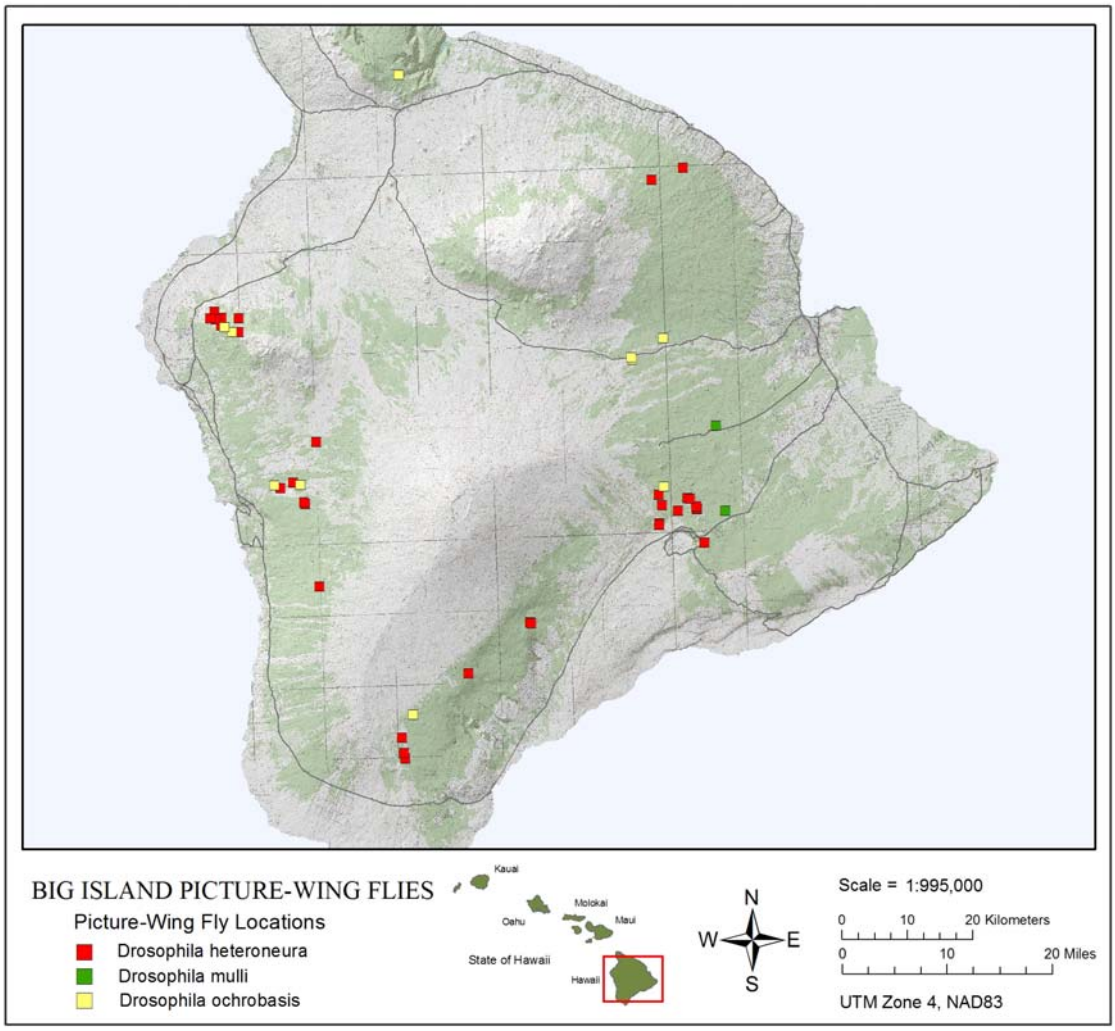
APPENDIX I.

Maps 1 through 5, showing the distribution of each of the 12 Picture-wing flies by island, as discussed in the final listing rule (USFWS 2006).

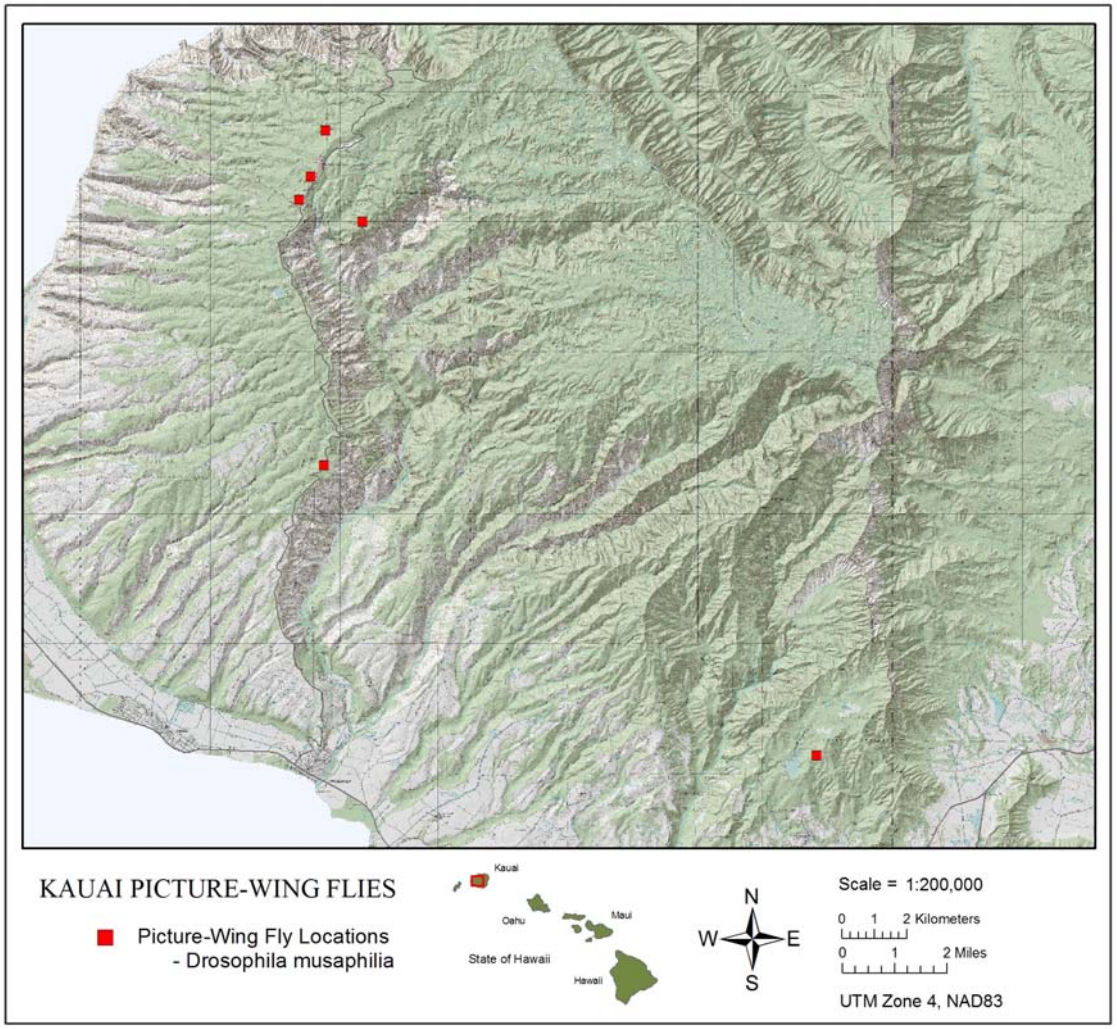
Map 1. Island of Oahu: Current and historical distribution of *Drosophila aglaia*, *D. hemipeza*, *D. montgomeryi*, *D. obatai*, *D. substenoptera*, and *D. tarphytrichia.*



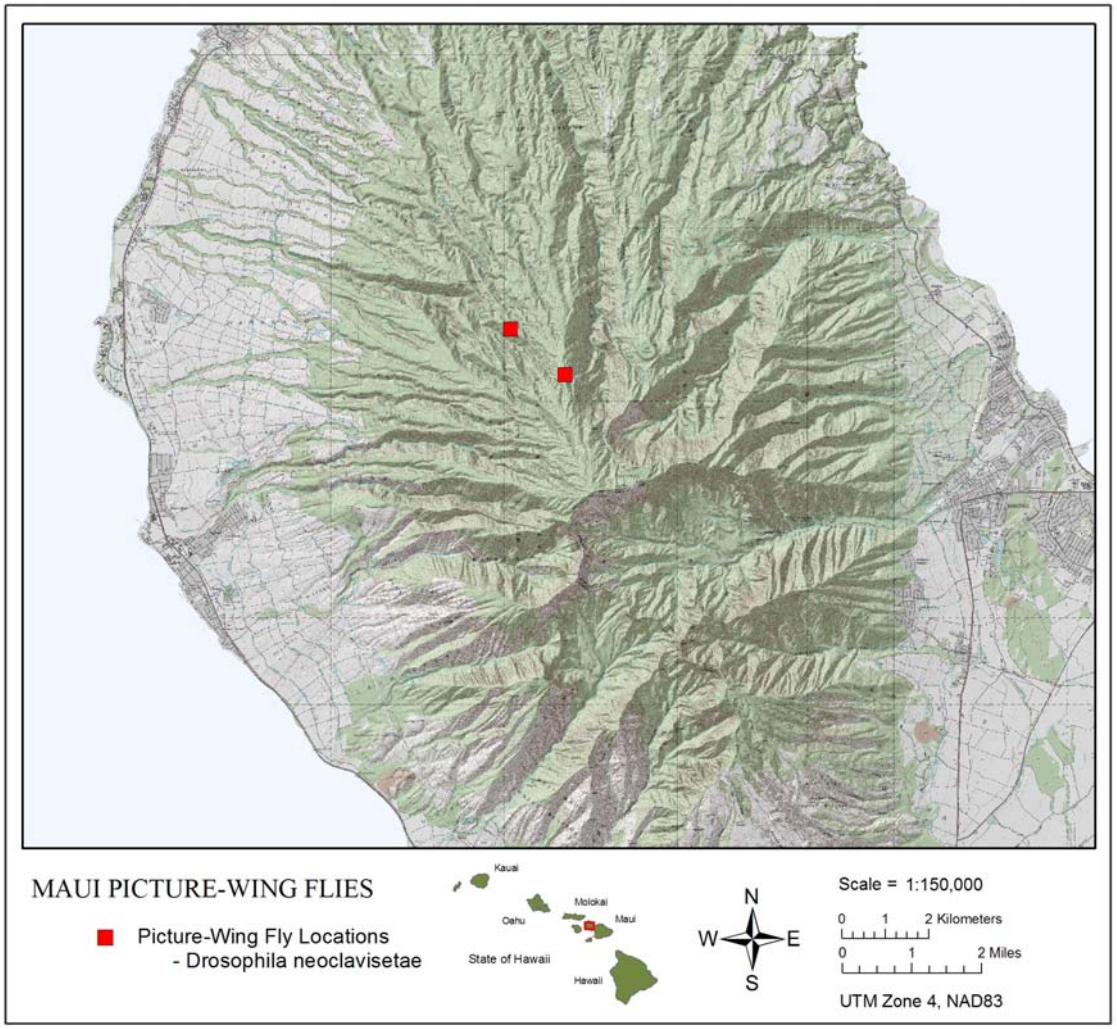
Map 2. Island of Hawaii: Current and historical distribution of *Drosophila heteroneura*, *D. mulli*, and *D. ochrobasis.*



Map 3. Island of Kauai: Current and historical distribution of *Drosophila musaphilia.*



Map 4. Island of Maui: Current and historical distribution of *Drosophila neoclavisetae.*



Map 5. Island of Molokai: Current and historical distribution of *Drosophila differens.*