

**Arthropod Survey of the Waiākea 1942 Lava  
Flow Natural Area Reserve and Selected Kīpuka  
Within the Mauna Loa Kīpuka Mosaic, Hawai‘i**

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## INTRODUCTION

The insects and related arthropods (jointed legged animals such as spiders, mites, and isopods) are the dominant animals in most terrestrial ecosystems both in terms of numbers of species and numbers of individuals (Preston *et al.*, 1995). There are 8963 arthropod species recorded from the Hawaiian Islands (Nishida, 1997). More than 1700 of native insects have been recorded from the Island of Hawai‘i (Howarth *et al.*, 1995). In the past there has been little attempt to develop a comprehensive listing of arthropod species present in any of the state’s Natural Area Reserves (Preston *et al.*, 1995). While there have been a few inventories for selected groups of arthropods, most of these studies have not addressed complex relationships between arthropod species, nor has much work been done to determine what role these arthropods may play as important food resources for other animals, especially native birds. The present project was a preliminary survey, and as such no attempt was made to capture data beyond a listing of identifiable taxa. A complete listing of the insects and related arthropods was well beyond the scope of this study. Therefore this two-week survey serves only to demonstrate some effective methods for sampling arthropods and related organisms, and to provide a partial profile of invertebrate diversity in the Mauna Loa Kīpuka Mosaic area. This report gives a limited overview of the arthropod fauna collected the Mauna Loa Kīpuka Mosaic area along the Saddle Road, Hawai‘i. Identifications of species were done on the bases of available expertise. The information contained in this report will be used to help resource managers in making decisions regarding the possible expansion of the Waiākea 1942 Lava Flow Natural Area Reserve. It will also aid in the development of management strategies regarding the protection of rare and sensitive species located near the existing NAR and in areas along the Saddle Road where many unique species occur especially within the *kīpuka*.

## METHODS

Sampling was conducted at selected sites along Tree Planting Road, selected *kīpuka* along Saddle Road, and at several sites along Power Line Road. Table 1 lists the collection sites and Table 2 lists the species collected during this survey and recent past surveys. Time did not allow for any night collecting during this survey. However, light trapping using an ultraviolet light hung near a white sheet would be the preferred method for collecting night flying insects. In most instances, moths would be the target group. Using this method of collecting yields specimens with as little damage as possible, making their identification easier. An extensive list of Lepidoptera collected from past surveys is found in Table 2. Arthropod specimens were collected using primarily pyrethrum fogging, sweep nets, hand aspirators, and host searching. The technique of using a water-based pyrethroid to disturb and dislodge insects and related arthropods from selected substrates is very effective. This fogging technique utilizes a white plastic sheet, which is spread out under a mossy log or other habitat, and the selected log is fogged with the parathyroid. The arthropods become irritated, dazed, and finally dislodged from the substrate, and fall or jump down onto the sheet where they are either aspirated into a vile or picked up individually with forceps. Drosophilidae (pomace flies) were collected using mushroom and banana baits. Yellow pan traps were used to collect flying insects (mostly flies) and other insects attracted to the color yellow and the water used in the trap. Some species were observed only and not collected, these are noted in Table 2. Specimens were stored in vials containing 95% ethyl alcohol and taken to Bishop Museum for processing and analysis by specialists. Additional records were added from the literature, as were data from previous surveys of the area and from historic collections at the museum. The status of the species identified was checked using literature and known host ranges. This report is divided into two parts.

The first part lists the arthropod species collected and authoritatively identified to date. Some species belong to groups for which there are no specialists available, and these had to be excluded from the report. The second part contains a synopsis of the more interesting or notable species collected.

## SURVEY AREA

The survey area is located in the South Hilo district of the Island of Hawai'i. It is bordered on four sides by the Stainback Highway, at Tree Planting road up to Powerline road, and the Saddle road. The Waiākea 1942 Lava Flow Natural Area Reserve was accessed from Tree Planting road at about the 3400 ft. elevation. During the time we were there, the Waiākea 1942 Lava Flow NAR was very dry with an open canopy of 'ōhia, tropical ash, an under story of tree ferns, a'ali'i, and mixed lower stature plants. We set our upper elevation boundary at Pu'u Huluhulu at about 7000 ft. elevation. The study area was so large that sites were selected on the basis of habitat type and the experience of the collectors. Collection methods were limited due the large size of the study area. General collecting (leaf litter, rotten logs, and substrates with special habitat) were sampled only when time allowed. We wanted a wide diversity of species, therefore sites ranged from lava fields, dry to mesic forest, and, cloud forest. Various *kīpuka* were accessed from Saddle and Power line roads.

## SITE DESCRIPTIONS

### Site 1

Site 1 is located within the Waiākea 1942 Lava Flow Natural Area Reserve. Access is either from Stainback highway south of the reserve or from Saddle road to the north. The vegetation in the reserve is comprised of *Metrosideros polymorpha*, *Acacia koa*, *Dodonea*, *Styphelia*, and many undetermined grasses and sedges. There are many rocky outcrops, which harbor numerous native plants. These outcrops provide a multitude of hiding places for arthropods. The larger trees are widely spaced providing little shade. The ground cover is of low stature plants often on open lava and exposed rocks.

### Site 2

This site is located north of site 1 along Tree Planting road. Vegetation is similar to site 1 except there are several standing water catchments formed by lava. Lush grasses and sedges surround the pools. These pools provided refuge for many aquatic species. 'Ōhi'a and a'ali'i were in abundance growing at the bases of tall rock outcrops. The understory was thicker compared to Site 1 due mainly to wetter conditions that seem to derive from larger trees and higher altitude.

### Site 3

Site 3 is accessed from Power Line Road south of Saddle Road. Vegetation here is very dry with many areas of open lava and rock outcrops. Several small collapsed lava bubbles provide areas where soil and moisture accumulate and plants thrive. 'Ōhi'a remains the largest species with a few *koa* in wetter areas. Many large a'ali'i are in abundance mainly in or near the collapsed lava bubbles. Dry grasses with some green sedges making up the understory.

### Site 4

Site 4 is accessed south of Saddle road along the upper Waiākea forest reserve road. The site is located roughly 400 m. northwest of the dirt road following a ridge topped by many large 'ōhi'a and *koa*. Large

clumps of sedges and several *Dubautia* spp. are in abundance. The area is very wet and a few bogs are evident. Most of the day was marked by heavy fog that comes in from the north.

#### **Site 5**

Similar to site 4 but at southeast side of a small *kīpuka*. Large ‘*ōhi*’*a* and *koa* dominate the vegetation with an occasional *naio* tree and ‘*akāla*’ bush present. Higher altitudes with abundant moisture create habitat suitable for *Styphelia* to dominate the vegetation surrounding the outer edges of *kīpuka*. As with most *kīpuka*, this one drops several feet down from the lava flow that has encircled it. The *kīpuka* floor is very wet with areas of mud several feet deep. Pig activity is very evident at this site and wild turkey are abundant.

#### **Sites 6, 8, 9, 10, 11, 13, & wpt 163**

All similar in vegetation to site 5 with a few exceptions. Size, shape, and location distinguish one from the other.

#### **Site 7**

Located on the southeastern side of Pu’u Huluhulu, this site is heavily impacted by human activity. Several hiking trails cross the *pu’u* which is very dry. The argentine ant (*Linepithema humile*), is very common through out the *pu’u* and covered our banana baits within minutes of setting them out. Vegetation is sparse with large *koa* being the dominant tree species. Grasses, mostly alien, dominate the understory.

#### **Site 12**

Site 12 is located along Tree Planting road which runs north off of Stainback highway. The sample site is about 100 ft. from the road in what is known as the Waiākea Timber Managements Area at roughly the 3000 ft. elevation. Patches of intact vegetation remain amongst the alien trees. Rock outcrops support many native plants that have spread to fill in an understory of ‘*ōhi*’*a*, *hāpu’u*, and tropical ash. Pig damage is very noticeable with many wallows in the area. Several large *hāpu’u* have been knocked over and their cores eaten by pigs. Many large trees with dense stands of tree fern provide habitat for many species of pomace flies. Table 2 lists all the species of pomace flies collected in the study area.

Sampling sites and GPS readings are found in Table 1 and Figure 1. A preliminary list of historical records of sensitive species of insects and related arthropods from the Mauna Loa Kīpuka Mosaic and Saddle Road areas is found in Table 3. A listing of candidate species of arthropods known to occur (or have historically occurred) on Hawai‘i Island is found in Table 4. Arthropod species of concern known to occur (or have historically occurred) on Hawai‘i Island is found in Table 5.

## PREVIOUS SURVEYS IN THE AREA

### Survey Period

### Project

August – October 1996

Saddle Road Project: Assessment of the Impacts on Invertebrates (Land Snails, Insects, and Other Arthropods)  
Report: N.L. Evenhuis, R.H. Cowie, G.M. Nishida, G.A. Samuelson, and F.G. Howarth (1996)

August, September, & October 1996

Proposed New Hawai'i Island Correctional Facility, Waiakea, South Hilo, Island of Hawai'i: Assessment of Potential Impacts on Invertebrates (Snails, Insects and Other Arthropods) of Proposed Improvements to Stainback Highway  
Report: F.G. Howarth, R.H. Cowie, D.J. Preston, R.A. Englund, R.J. Rundell, F.D. Stone, and S.L. Montgomery (1999)

October – December, 1998  
& January 1999

Proposed New Hawai'i Island Correctional Facility, Waiakea, South Hilo, Island of Hawai'i: Assessment of Potential Impacts on Invertebrates (Snails, Insects and Other Arthropods)  
Report: R.H. Cowie, F.G. Howarth, D.J. Preston, R.J. Rundell, F.D. Stone, and S.L. Montgomery (1999)

27 May 2001

Heteroptera and Homoptera Collected from the Waiākea Forest Reserve, Hawai'i.  
Report: D.A. Polhemus (2001)

**Table 1. Collection Sites – Samples were taken from sites located along and within areas bordered by Stainback Highway, Power Line Road, Tree Planting Road, and Saddle Road, Hawai‘i.**

Site #	Method	NAD 83 Datum	
		Latitude	Longitude
wpt 163	Yellow pan traps	N19° 39' 49.72"	W155° 22' 10.60"
wpt 163	Banana bait	N19° 39' 49.99"	W155° 22' 10.15"
wpt 163	Banana bait	N19° 39' 49.33"	W155° 22' 10.27"
wpt 163	Banana bait	N19° 39' 49.29"	W155° 22' 10.93"
wpt 163	Banana bait	N19° 39' 49.72"	W155° 22' 11.13"
wpt 163	Banana bait	N19° 39' 50.18"	W155° 22' 10.85"
1	Yellow ban traps	N19° 37' 48.17"	W155° 14' 29.69"
1	Banana bait	N19° 37' 48.59"	W155° 14' 29.97"
1	Banana bait	N19° 37' 48.38"	W155° 14' 29.21"
1	Banana bait	N19° 37' 47.89"	W155° 14' 29.26"
1	Banana bait	N19° 37' 47.68"	W155° 14' 29.69"
1	Banana bait	N19° 37' 48.02"	W155° 14' 30.19"
1	Mushroom bait	N19° 37' 48.59"	W155° 14' 29.97"
1	Mushroom bait	N19° 37' 48.38"	W155° 14' 29.21"
1	Mushroom bait	N19° 37' 47.68"	W155° 14' 29.69"
1	Fog mossy <i>ōhi'a</i> log	N19° 37' 48.59"	W155° 14' 30.94"
1	Mossy rock outcropping	N19° 37' 49.06"	W155° 14' 31.20"
1	Fog mossy <i>'ōhi'a</i> log	N19° 37' 49.29"	W155° 14' 31.57"
1	Fog mossy <i>'ōhi'a</i> log	N19° 37' 49.54"	W155° 14' 31.25"
2	Yellow pan traps	N19° 38' 44.95"	W155° 15' 46.24"
2	Banana bait	N19° 38' 45.37"	W155° 15' 45.96"
2	Banana bait	N19° 38' 44.97"	W155° 15' 45.68"
2	Banana bait	N19° 38' 44.48"	W155° 15' 46.07"
2	Banana bait	N19° 38' 44.71"	W155° 15' 46.73"
2	Banana bait	N19° 38' 45.29"	W155° 15' 46.60"
2	Mushroom bait	N19° 38' 45.37"	W155° 15' 45.96"
2	Mushroom bait	N19° 38' 44.48"	W155° 15' 46.07"
2	Mushroom bait	N19° 38' 44.71"	W155° 15' 46.73"
2	Fog mossy <i>'ōhi'a</i> log	N19° 38' 44.99"	W155° 15' 45.16"
2	Fog mossy <i>'ōhi'a</i> log	N19° 38' 45.49"	W155° 15' 44.92"
2	Fog mossy <i>'ōhi'a</i> log	N19° 38' 44.60"	W155° 15' 45.13"



**Table 1. (continued) Collection Sites – Samples were taken from sites located along and within areas bordered by Stainback Highway, Power Line Road, Tree Planting Road, and Saddle Road, Hawai‘i.**

Site #	Method	NAD 83 Datum	
		Latitude	Longitude
3	Yellow pan traps	N19° 35' 37.27"	W155° 23' 36.91"
3	Banana bait	N19° 35' 36.85"	W155° 23' 36.63"
3	Banana bait	N19° 35' 36.93"	W155° 23' 37.33"
3	Banana bait	N19° 35' 37.42"	W155° 23' 37.56"
3	Banana bait	N19° 35' 37.78"	W155° 23' 37.12"
3	Banana bait	N19° 35' 37.51"	W155° 23' 36.42"
3	Mushroom bait	N19° 35' 36.85"	W155° 23' 36.63"
3	Mushroom bait	N19° 35' 36.93"	W155° 23' 37.33"
3	Mushroom bait	N19° 35' 37.78"	W155° 23' 37.12"
3	Fog mossy 'ōhi'a log	N19° 35' 37.27"	W155° 23' 38.06"
3	Fog mossy 'ōhi'a log	N19° 35' 37.66"	W155° 23' 38.84"
4	Yellow pan traps	N19° 39' 7.89"	W155° 21' 19.91"
4	Banana bait	N19° 39' 8.61"	W155° 21' 20.28"
4	Banana bait	N19° 39' 7.70"	W155° 21' 20.44"
4	Banana bait	N19° 39' 7.39"	W155° 21' 19.70"
4	Banana bait	N19° 39' 8.00"	W155° 21' 19.33"
4	Banana bait	N19° 39' 8.39"	W155° 21' 19.95"
4	Mushroom bait	N19° 39' 7.70"	W155° 21' 20.44"
4	Mushroom bait	N19° 39' 7.39"	W155° 21' 19.70"
4	Mushroom bait	N19° 39' 8.39"	W155° 21' 19.95"
4	Fog mossy 'ōhi'a log	N19° 39' 8.66"	W155° 21' 20.80"
4	Fog mossy 'ōhi'a log	N19° 39' 8.58"	W155° 21' 21.55"
4	Fog mossy 'ōhi'a log	N19° 39' 9.16"	W155° 21' 21.34"
4	Fog mossy <i>hapu'u</i>	N19° 39' 9.16"	W155° 21' 21.96"
5	Yellow pan traps	N19° 38' 59.43"	W155° 21' 22.57"
5	Banana bait	N19° 38' 59.93"	W155° 21' 22.41"
5	Banana bait	N19° 38' 59.78"	W155° 21' 22.94"
5	Banana bait	N19° 38' 59.08"	W155° 21' 22.98"
5	Banana bait	N19° 38' 58.97"	W155° 21' 22.37"
5	Banana bait	N19° 38' 59.39"	W155° 21' 22.04"
5	Mushroom bait	N19° 38' 59.78"	W155° 21' 22.94"
5	Mushroom bait	N19° 38' 58.97"	W155° 21' 22.37"
5	Mushroom bait	N19° 38' 59.39"	W155° 21' 22.04"

**Table 1. (continued) Collection Sites – Samples were taken from sites located along and within areas bordered by Stainback Highway, Power Line Road, Tree Planting Road, and Saddle Road, Hawai'i.**

Site #	Method	NAD 83 Datum	
		Latitude	Longitude
5	Fog mossy ' <i>ōhi</i> 'a log	N19° 39' 0.32"	W155° 21' 22.00"
5	Fog mossy ' <i>ōhi</i> 'a log	N19° 39' 0.16"	W155° 21' 21.71"
5	Fog mossy ' <i>ōhi</i> 'a log	N19° 39' 0.71"	W155° 21' 22.45"
6	Yellow pan traps	N19° 40' 4.78"	W155° 22' 11.03"
6	Banana bait	N19° 40' 4.28"	W155° 22' 11.07"
6	Banana bait	N19° 40' 4.70"	W155° 22' 11.56"
6	Banana bait	N19° 40' 5.25"	W155° 22' 11.19"
6	Banana bait	N19° 40' 5.04"	W155° 22' 10.49"
6	Banana bait	N19° 40' 4.47"	W155° 22' 10.62"
6	Mushroom bait	N19° 40' 4.70"	W155° 22' 11.56"
6	Mushroom bait	N19° 40' 5.25"	W155° 22' 11.19"
6	Mushroom bait	N19° 40' 4.47"	W155° 22' 10.62"
6	Fog mossy ' <i>ōhi</i> 'a log	N19° 40' 5.21"	W155° 22' 10.00"
6	Fog mossy ' <i>ōhi</i> 'a log	N19° 40' 5.82"	W155° 22' 9.72"
6	Fog mossy ' <i>ōhi</i> 'a log	N19° 40' 5.40"	W155° 22' 9.63"
6	Fog mossy rock outcropping	N19° 40' 4.98"	W155° 22' 9.31"
7	Yellow pan traps	N19° 41' 11.76"	W155° 27' 56.67"
7	Banana bait	N19° 41' 11.41"	W155° 27' 57.17"
7	Banana bait	N19° 41' 12.10"	W155° 27' 57.04"
7	Banana bait	N19° 41' 12.22"	W155° 27' 56.43"
7	Banana bait	N19° 41' 11.64"	W155° 27' 56.14"
7	Banana bait	N19° 41' 11.21"	W155° 27' 56.59"
7	Mushroom bait	N19° 41' 11.41"	W155° 27' 57.17"
7	Mushroom bait	N19° 41' 12.22"	W155° 27' 56.43"
7	Mushroom bait	N19° 41' 11.64"	W155° 27' 56.14"
7	Fog mossy fallen <i>koa</i>	N19° 41' 10.71"	W155° 27' 58.06"
7	Fog mossy fallen <i>koa</i>	N19° 41' 11.14"	W155° 27' 58.85"
8	Yellow pan traps	N19° 40' 11.73"	W155° 21' 29.30"
8	Banana bait	N19° 40' 12.24"	W155° 21' 29.26"
8	Banana bait	N19° 40' 11.93"	W155° 21' 28.81"
8	Banana bait	N19° 40' 11.35"	W155° 21' 28.97"
8	Mushroom bait	N19° 40' 11.35"	W155° 21' 28.97"
8	Mushroom bait	N19° 40' 11.81"	W155° 21' 29.83"

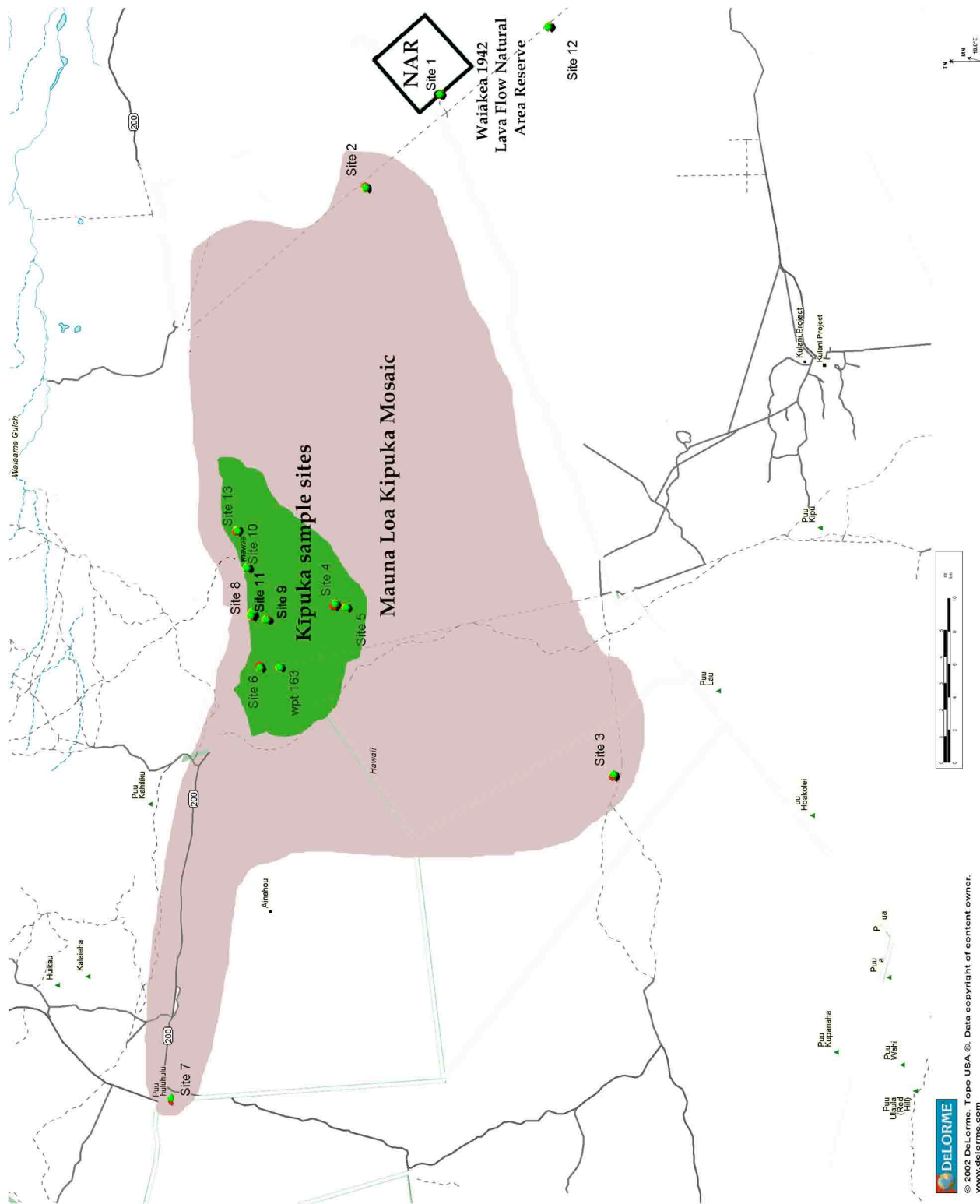
**Table 1. (continued) Collection Sites – Samples were taken from sites located along and within areas bordered by Stainback Highway, Power Line Road, Tree Planting Road, and Saddle Road, Hawai‘i.**

Site #	Method	NAD 83 Datum	
		Latitude	Longitude
8	Fog mossy ‘ōhi‘a log	N19° 40' 10.81"	W155° 21' 29.84"
8	Fog mossy ‘ōhi‘a log	N19° 40' 10.46"	W155° 21' 30.00"
8	Fog mossy fallen <i>koa</i>	N19° 40' 10.73"	W155° 21' 30.70"
8	Fog mossy ‘ōhi‘a log	N19° 40' 11.08"	W155° 21' 30.25"
9	Yellow pan traps	N19° 39' 59.95"	W155° 21' 32.34"
9	Banana bait	N19° 40' 0.42"	W155° 21' 32.54"
9	Banana bait	N19° 40' 0.34"	W155° 21' 31.93"
9	Banana bait	N19° 39' 59.80"	W155° 21' 31.80"
9	Banana bait	N19° 39' 59.49"	W155° 21' 32.62"
9	Banana bait	N19° 39' 59.84"	W155° 21' 32.87"
9	Mushroom bait	N19° 40' 0.42"	W155° 21' 32.54"
9	Mushroom bait	N19° 40' 0.34"	W155° 21' 31.93"
9	Mushroom bait	N19° 39' 59.49"	W155° 21' 32.62"
9	Fog mossy log and rocks	N19° 39' 58.80"	W155° 21' 32.10"
9	Fog mossy rocks	N19° 39' 58.37"	W155° 21' 32.34"
9	Fog mossy ‘ōhi‘a log	N19° 39' 58.37"	W155° 21' 32.83"
10	Yellow pan traps	N19° 40' 14.71"	W155° 20' 50.83"
10	Banana bait	N19° 40' 15.17"	W155° 20' 51.12"
10	Banana bait	N19° 40' 15.06"	W155° 20' 50.42"
10	Banana bait	N19° 40' 14.40"	W155° 20' 50.42"
10	Banana bait	N19° 40' 14.24"	W155° 20' 51.03"
10	Banana bait	N19° 40' 14.63"	W155° 20' 51.36"
10	Mushroom bait	N19° 40' 15.17"	W155° 20' 51.12"
10	Mushroom bait	N19° 40' 14.40"	W155° 20' 50.42"
10	Mushroom bait	N19° 40' 14.24"	W155° 20' 51.03"
10	Fog mossy fallen <i>koa</i>	N19° 40' 13.70"	W155° 20' 51.20"
10	Fog mossy tree stump	N19° 40' 13.24"	W155° 20' 51.61"
10	Fog mossy ‘ōhi‘a log	N19° 40' 13.74"	W155° 20' 50.71"
10	Fog mossy ‘ōhi‘a log	N19° 40' 13.43"	W155° 20' 50.95"
10	Fog mossy ‘ōhi‘a log	N19° 40' 13.24"	W155° 20' 50.58"
11	Yellow pan traps	N19° 40' 10.54"	W155° 21' 26.92"
11	Banana bait	N19° 40' 11.00"	W155° 21' 26.68"
11	Banana bait	N19° 40' 10.50"	W155° 21' 26.35"

**Table 1. (continued) Collection Sites – Samples were taken from sites located along and within areas bordered by Stainback Highway, Power Line Road, Tree Planting Road, and Saddle Road, Hawai‘i.**

Site #	Method	NAD 83 Datum	
		Latitude	Longitude
11	Banana bait	N19° 40' 10.03"	W155° 21' 26.88"
11	Banana bait	N19° 40' 10.38"	W155° 21' 27.46"
11	Banana bait	N19° 40' 10.88"	W155° 21' 27.33"
11	Mushroom bait	N19° 40' 11.00"	W155° 21' 26.68"
11	Mushroom bait	N19° 40' 10.50"	W155° 21' 26.35"
11	Mushroom bait	N19° 40' 10.38"	W155° 21' 27.46"
11	Fog mossy 'ōhi'a log	N19° 40' 10.11"	W155° 21' 27.96"
11	Fog mossy 'ōhi'a log	N19° 40' 9.76"	W155° 21' 28.19"
11	Fog mossy rock	N19° 40' 9.84"	W155° 21' 28.65"
11	Fog mossy koa	N19° 40' 9.42"	W155° 21' 28.73"
12	Yellow pan traps	N19° 36' 26.09"	W155° 13' 36.34"
12	Banana bait	N19° 36' 26.60"	W155° 13' 36.13"
12	Banana bait	N19° 36' 25.90"	W155° 13' 35.85"
12	Banana bait	N19° 36' 25.59"	W155° 13' 36.46"
12	Banana bait	N19° 36' 25.94"	W155° 13' 36.87"
12	Banana bait	N19° 36' 26.48"	W155° 13' 36.71"
12	Mushroom bait	N19° 36' 25.90"	W155° 13' 35.85"
12	Mushroom bait	N19° 36' 25.94"	W155° 13' 36.87"
12	Mushroom bait	N19° 36' 26.48"	W155° 13' 36.71"
12	Fog of mossy 'ōhi'a log	N19° 36' 27.02"	W155° 13' 36.80"
12	Fog of mossy hapu'u	N19° 36' 26.75"	W155° 13' 37.57"
13	Yellow pan traps	N19° 40' 22.09"	W155° 20' 20.79"
13	Banana bait	N19° 40' 22.36"	W155° 20' 21.28"
13	Banana bait	N19° 40' 22.59"	W155° 20' 20.83"
13	Banana bait	N19° 40' 22.43"	W155° 20' 20.38"
13	Banana bait	N19° 40' 21.70"	W155° 20' 20.46"
13	Banana bait	N19° 40' 21.74"	W155° 20' 21.20"
13	Mushroom bait	N19° 40' 22.36"	W155° 20' 21.28"
13	Mushroom bait	N19° 40' 22.43"	W155° 20' 20.38"
13	Mushroom bait	N19° 40' 21.74"	W155° 20' 21.20"
13	Fog mossy 'ōhia log	N19° 40' 21.08"	W155° 20' 20.10"
13	Fog mossy 'ōhia log	N19° 40' 22.20"	W155° 20' 22.23"
13	Fog mossy 'ōhia log	N19° 40' 22.82"	W155° 20' 21.90"

**Figure 1. Survey area map with collection sites**



**Table 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i.**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>ACARI (Mites)</b>						
Not yet identified	Adv.?	√	√	√	√	
<b>Astigmata</b>						
Genus species: facultative cave species or accidental in cave	Adv.?			√		
<b>Mesostigmata</b>						
Genus species: facultative cave species	Adv.?			√		
<b>Oribatiloidea Unk. family</b>						
Genus species: facultative cave species or accidental in caves	Adv.?			√		
<b>ARANEAE (Spiders)</b>						
<b>Agelenidae (House spiders)</b>						
<i>Tegenaria</i> sp.	Adv.	√	√			
<b>Araneidae (Orb weavers)</b>						
<i>Cyclosa</i> species: uncommon	End.		√			
<b>Nesticidae</b>						
<i>Nesticella mogera</i> (Yaginuma): uncommon in cave, tree trunks	Adv.		√	√		
<b>Linyphiidae</b>						
<i>Erigone</i> cf. <i>stygius</i> Gertsch	End.				√	
<b>Lycosidae</b>						
<i>Lycosa</i> sp.	End.				√	
<b>Salticidae (Jumping spiders)</b>						
Genus species.: on <i>Pritchardia</i> palm	End.?			√		
Genus species: common in fogging samples	End.	√	√	√		
<b>Tetragnathidae (Long-jawed spiders)</b>						
<i>Tetragnatha brevignatha</i> Gillespie	End.	√				
<i>Tetragnatha quasimodo</i> Gillespie: nocturnal, common	End.	√	√	√		
<i>Tetragnatha</i> sp. A	End.	√	√	√		
<i>Tetragnatha</i> sp. B	End.	√	√	√		
<i>Tetragnatha</i> sp. C	End.	√	√	√		
<i>Tetragnatha</i> sp. D	End.	√	√	√		
<b>Theridiidae (Widows, Comb-footed spiders)</b>						
<i>Achaearanea tepidariorum</i> (Koch): in twilight zone of cave	Adv.		√		√	

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIAKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIAKEA FOREST
<b>TAXON</b>	<b>STATUS<sup>1</sup></b>					
<b>ARANEAE (Spiders)</b>						
<b>Theridiidae</b> (Widows, Comb-footed spiders) continued						
<i>Argyrodes</i> sp. 1: cave	End.		√			
<i>Argyrodes</i> sp. 2: common in fogging samples	End.	√	√	√		
<i>Theridion grallator</i> Simon: happy face spider , in foggings	End.			√		
<b>Thomisidae</b> (Crab spiders)						
<i>Mecaphesa</i> sp.:	End.?		√			
<i>Mecaphesa</i> sp.: on <i>Pritchardia</i> palm	End.			√		
<b>PSEUDOSCORPIONIDA: Pseudoscorpions</b>						
<b>Chernetidae</b>						
<i>Eumecochernes?</i> sp.: common on <i>Pritchardia</i>	End.		√	√		
Genus species: fog of mossy log	End.	√				
<b>COLLEMBOLA: Springtails</b>						
<b>Entomobryidae:</b>						
<i>Entomobrya</i> sp.1: Common leaf litter and caves	End.	√	√			
<i>Entomobrya</i> sp.: uncommon cave species.	End.		√			
<i>Tomocerus minor</i> Common leaf litter	Adv.	√	√	√		
<i>Salina celebensis</i> (Schaeffer):	Adv.	√	√	√		
<i>Sinella?</i> sp.: uncommon in cave	Adv.?		√		√	
<b>Hypogastruridae:</b>						
<i>Neanura hawaiiensis</i> (Bellinger & Christiansen)	End.				√	
<i>Neanura muscorum</i> (Templeton)	Adv.		√			
<b>Isotomidae</b>						
Genus species	Adv.		√			
<b>ODONATA: Dragonflies &amp; Damselflies</b>						
<b>Aeshnidae</b> (Darners)						
<i>Anax strenuus</i> Hagen: seen hawking along trails at the site	End.	√	√			
<b>Libellulidae</b> (Skimmers)						
<i>Pantala flavescens</i> (Fabricius): Seen hawking at site	Ind.	√	√	√	√	
<b>Coenagrionidae</b> (Damselflies)						
<i>Megalagrion amaurodytum peles</i> (Perkins): in <i>Astelia</i> axils	End.	√	√	√	√	

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
<b>TAXON</b>	<b>STATUS<sup>1</sup></b>					
<b>ODONATA: Dragonflies &amp; Damselflies continued</b>						
<b>Coenagrionidae (Damselflies) continued</b>						
<i>Megalagrion calliphya microdemas</i> (Perkins): pools	End.	√	√		√	
<i>Megalagrion hawaiiense</i> (McLachlan): pools	End.	√	√		√	
<b>BLATTODEA: Cockroaches</b>						
<b>Blatellidae</b>						
<i>Balta similis</i> (Saussure)	Adv.	√	√	√	√	
<i>Periplaneta Americana</i> (Linnaeus): facultative cave species	Adv.			√		
<b>ORTHOPTERA: Grasshoppers, Katydid &amp; Crickets</b>						
<b>Gryllidae (Crickets)</b>						
<i>Caconemobius</i> sp. nr. <i>varius</i> Gurney & Rentz: Caves and a'a voids	End.		√	√		
<i>Caconemobius</i> sp. nr. <i>albus</i> Otte: caves	End.		√			
<i>Laupala</i> sp. 1.: on shrubs	End.		√			
<i>Laupala</i> sp. 2.: on shrubs	End.		√			
<i>Leptogryllus</i> sp.: on shrubs and foggings	End.	√	√	√	√	
<i>Prognathogryllus puna</i> Otte: nocturnal, heard only	End.		√			
<i>Trigonidium</i> sp.: nocturnal on vegetation	End.	√	√	√		
<b>Tettigoniidae (Katydid)</b>						
<i>Banza</i> sp.: nocturnal on vegetation	End.		√	√		
<i>Phaneroptera furcifera</i> Stål	Adv.		√			
<b>MANTODEA: Mantids</b>						
<b>Mantidae (Mantids)</b>						
<i>Tenoderella angustipennis</i> Saussure	Adv.		√			
<b>PSOCOPTERA: Bark Lice</b>						
Undetermined	End.?	√	√	√		
Undetermined: on <i>Pritchardia</i> palms	End.?				√	
<b>HETEROPTERA: True Bugs</b>						
<b>Anthocoridae</b>						
Genus species: in fogging samples	Adv.		√	√		



**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIAKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIAKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>HETEROPTERA: True Bugs continued</b>						
<b>Lygaeidae (Seed Bugs)</b>						
<i>Nesius fasciata fasciata</i> (Usinger): ex. <i>Psychotria hawaiiensis</i>	End.					✓
<i>Nesius nitida pipturi</i> (Usinger): ex. <i>Pipturus albidus</i>	End.					✓
<i>Nesius whitei whitei</i> (Blackburn): mossy logs on forest floor	End.					✓
<i>Nesius</i> sp. 1: mossy logs on forest floor	End?	✓	✓	✓		
Rhyparochrominae: new genus and species?: nocturnal, mossy log	End.		✓			
<b>Miridae (Plant Bugs)</b>						
<i>Hyalopeplus pellucidus</i> (Stal): uncommon	End.	✓	✓	✓		
<i>Nesidiorchestes</i> sp.: mossy logs on forest floor	End.					✓
<i>Orthotylus kanakanus</i> (Kirkaldy): ex. <i>Coprosma</i> sp.	End.					✓
<i>Orthotylus kassandra</i> (Kirkaldy): ex. <i>Pipturus albidus</i>	End.					✓
<i>Orthotylus psychotriae</i> Polhemus: ex. <i>Psychotria hawaiiensis</i>	End.					✓
<i>Orthotylus</i> n. sp. 1: ex. <i>Hedyotis terminalis</i>	End.					✓
<i>Nesiomiris</i> sp.	End.		✓	✓		
<i>Sarona mamaki</i> Asquith: ex. <i>Pipturus albidus</i>	End.					✓
<i>Sarona</i> n. sp.: ex. <i>Perotettia sandwicensis</i>	End.					✓
<i>Sarona</i> spp.: 2 rare species collected	End.		✓	✓		
Genus species: restricted range?, plant feeder/ <i>Pritchardia associate</i>	End.			✓		
<b>Nabidae (Damsel Bugs)</b>						
<i>Nabis capsiformis</i> Germar: Malaise trap & fern understory	Ind./Adv.?		✓			
<i>Nabis blackburni</i> White: on ferns, mosses and vegetation	End.		✓			
<i>Nabis oscillans</i> Blackburn: mossy logs on forest floor	End.	✓				✓
<i>Nabis</i> sp.: fern understory	End.		✓			
<i>Nabis</i> n. sp. (green): fern understory	End.					✓
<b>Reduviidae (Kissing bugs)</b>						
<i>Empiccoris rubromaculatus</i> (Blackburn): in fogging samples	Adv.			✓		
<i>Haematoloecha rubescens</i> Distant: common tramp species	Adv.	✓	✓	✓		
<i>Nesidolestes selium</i> Kirkaldy: mossy logs on forest floor	End.		✓	✓		✓

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>HETEROPTERA: True Bugs continued</b>						
<b>Reduviidae (Kissing bugs) continued</b>						
<i>Saicella mulli</i> Polhemus: mossy logs on forest floor	End.		✓	✓		✓
<b>Saldidae (shore bugs)</b>						
<i>Saldula</i> sp.: in fogging samples	End.			✓		
<b>HOMOPTERA: Leafhoppers, Planthoppers</b>						
<b>Aphididae (Aphids)</b>						
<i>Aphis</i> sp.	Adv.		✓	✓		
<i>Rhopalosiphoninus latysiphon</i> (Davidson)	Adv.	✓			✓	
<b>Cicadellidae (Leafhoppers)</b>						
<i>Nesophrosyne pluvialis</i> Kirkaldy: ex. <i>Coprosma</i> sp. undet.	End.				✓	
<i>Nesophrosyne</i> cf. <i>affinis</i> Osburn: in fogging	End.		✓	✓		
<i>Nesophrosyne</i> sp. #1 (black + yellow): ex. <i>Melicope clusifolia</i>	End.					✓
<i>Nesophrosyne</i> sp. #2 (pale spot on back): ex. <i>Psychotria hawaiiensis</i>	End.					✓
<i>Nesophrosyne</i> sp. #3: ex. <i>Broussaisia arguta</i>	End.					✓
<i>Nesophrosyne</i> sp. #4 (saddle back; rare): ex. <i>Myrsine lessertiana</i>	End.					✓
<i>Nesophrosyne</i> sp. 5 (green clavus): understory ferns	End.					✓
<b>Cixiidae: Planthoppers</b>						
<i>Iolania perkinsi</i> Kirkaldy: nocturnal, common	End.	✓	✓			
<i>Oliarus polyphemus</i> Fennah: blind obligate cave species	End.			✓		
<i>Oliarus</i> sp.: nocturnal, on vegetation	End.	✓	✓			
<b>Delphacidae: Planthoppers</b>						
<i>Aloha</i> sp. 1: in fogging samples	End.		✓	✓		
<i>Nesosydne?</i> sp.: on <i>Clermontia</i> and fogging samples	End.		✓	✓		
<i>Nesodryas swezeyi</i> Zimmerman: extremely rare, host specific to <i>Pritchardia</i>	End.			✓		
genus species: uncommon	End.	✓	✓	✓	✓	

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>HOMOPTERA: Leafhoppers, Planthoppers continued</b>						
<b>Flatidae (Flatid planthoppers)</b>						
<i>Melormenis basalis</i> (Walker): very common	Adv.	✓			✓	
<i>Syphanta acuta</i> (Walker)	Adv.		✓	✓		
<b>COLEOPTERA: Beetles</b>						
<b>Aglycyderidae (short-nosed weevils)</b>						
<i>Proterhinus</i> spp.: 4 species, on twigs and mossy logs, local	End.		✓	✓		
<i>Proterhinus</i> sp. A2	End.	✓				
<i>Proterhinus</i> sp.	End.				✓	
<b>Anobiidae (Anobiid beetles)</b>						
<i>Xyletobius</i> sp. 1: in fogging	End.		✓	✓		
<i>Xyletobius</i> sp. 2: in fogging	End.		✓	✓		
Unidentified species: uncommon on tree trunks	End.?	✓				
<b>Carabidae (Ground beetles)</b>						
<i>Bembidion</i> sp.: on mossy log, uncommon	End.		✓	✓		
<i>Blackburnia hawaiiensis</i> (Sharp)	End.	✓				
<i>Blackburnia kilauea</i> Liebherr & Zimmerman	End.	✓				
<i>Mecyclothorax</i> sp. A	End.	✓				
<i>Mecyclothorax</i> sp. B	End.	✓				
<i>Mecyclothorax</i> sp. C	End.	✓				
<i>Mecyclothorax</i> spp.: 2+ species on mossy logs, common	End.		✓		✓	
<i>Tachys</i> sp.: in cave	End.		✓			
<b>Cerambycidae (Long-horned beetles)</b>						
Genus species: general collecting	End.		✓			
<b>Ciidae (Minute tree-fungus beetles)</b>						
<i>Apterocis strigosus</i> Perkins	End.	✓				
<i>Cis porcatus</i> Sharp	End.	✓				
<i>Cis simulator</i> Perkins	End.	✓				
<i>Cis</i> sp. 1: in fogging sample	End.		✓			
<i>Cis</i> spp. : more than one species in fogging samples	End.			✓		

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIAKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIAKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>COLEOPTERA: Beetles continued</b>						
<b>Coccinellidae</b> (Lady-bird beetles)						
<i>Halmus chalybeus</i> (Boisduval)	Pur.	√				
<i>Hippodamia convergens</i> Guérin	Pur.		√			
<i>Hyperaspis fimbriolata</i> Melsheimer	Pur.		√			
<i>Scymnus loewii</i> Mulsant	Pur.		√			
<b>Curculionidae</b> (Weevils)						
<i>Achalles</i> cf. <i>tuberculatus</i> Perkins: rare species, local at site on mossy logs	End.		√	√		
<i>Achalles</i> sp.: no cells, pillar cup truncate, rare species, on mossy logs	End.	√				
<i>Asynonychus godmanni</i> Crotch	Adv.	√	√			
<i>Dryophthorus insignis</i> Sharp	End.	√				
<i>Dryophthorus modestus</i> Sharp	End.	√	√	√		
<i>Nesotocus munroi</i> Perkins: rare, on <i>Cheirodendron</i>	End.		√			
<i>Oodemus</i> sp.: extremely rare, on tree trunk	End.		√			
<i>Syagrius fulvitaris</i> Pascoe: fern weevil, common	Adv.	√	√	√		
Genus species	Adv?	√				
<b>Cucujidae</b>						
<i>Psammoechus insularis</i> (Sharp): in fogging samples	Adv.		√	√		
<b>Elateridae</b> (Click beetles)						
<i>Conoderus exul</i> (Sharp)	Adv.	√	√		√	
<b>Hydrophilidae</b>						
Genus species: larvae fogged from mossy log	End.	√				
<b>Nitidulidae: (Souring beetles)</b>						
<i>Eupetinus striatus</i> (Sharp): mossy logs	End.	√				
Genus species: several small species, on vegetation	End.		√			
<i>Gonioryctus</i> sp. 1	End.		√	√		
<i>Lasiodactylus</i> sp. prob. <i>limbata</i> (Boheman): very common	End.	√	√			
<i>Nesopectinus quadraticollis</i> (Blackburn): host-specific on <i>Pritchardia</i> fruits	End.			√		

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kūpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIAKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIAKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>COLEOPTERA: Beetles continued</b>						
<b>Nitidulidae: (Souring beetles) continued</b>						
<i>Haptoncus mundus</i> Sharp	Adv.		√			
<b>Staphylinidae (Rove beetles)</b>						
Genus species: small, epigeal species in caves and <i>a'a</i> voids	Adv.?		√			
<i>Aleochara</i> sp. 1 of Newton	Adv.?	√				
<i>Liophaena gracilipes</i> Sharp	End.				√	
<i>Nesomedon</i> n. sp.: new to science, blind, obligate cave sp.	End.			√		
<b>Tenebrionidae: Darkling beetles</b>						
Genus species: several species	Unk.	√	√		√	
<b>LEPIDOPTERA: Butterflies &amp; moths</b>						
<b>Carposinidae: Carposinid fruit moths</b>						
<i>Carposina gracillima</i> (Walsingham): nocturnal, at MV light	End.		√			
<i>Carposina</i> spp.: At least 4 species, nocturnal, at MV light	End.		√			
<b>Cosmopterygidae: Cosmopterygid moths</b>						
<i>Hyposmocoma</i> spp.: 2 nocturnal species, rare at MV light	End.		√			
<b>Crambidae: Crambid moths</b>						
<i>Eudonia</i> spp.: at least 6 species: locally common at MV light	End.		√	√		
<i>Mestolobes</i> sp. near <i>abnormis</i> (Butler): possibly new, rare	End.		√			
<i>Mestolobes miniscula</i> (Butler): common species, rare at site	End.		√	√		
<i>Omiodes accepta</i> (Butler): sugarcane leafroller	End.		√	√		
<i>Omiodes pritchardii</i> Swezey: Stainback <i>Pritchardia</i> leafroller: a local endemic species	End.		√	√		
<i>Omiodes scotaea</i> (Hampson): uncommon species	End.		√			
<i>Orthomecyna metalycia</i> Meyrick: uncommon species	End.		√			
<i>Spoladea recurvalis</i> (Fabricius): beet webworm, rare at site	Adv.		√			
<i>Udea calliastra synastra</i> (Metrick): rare	End.		√			
<i>Udea eucrena</i> (Meyrick): rare	End.		√			
<i>Udea micacea</i> (Butler): rare	End.		√			
<i>Udea pyranthes</i> (Meyrick): common	End.		√	√		
<i>Udea</i> sp. A: rare	End.		√			

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>LEPIDOPTERA: Butterflies &amp; moths (continued)</b>						
<b>Crambidae: Crambid moths (continued)</b>						
<i>Udea</i> sp. B: rare	End.		√			
<i>Uresiphita polygonalis virescens</i> (Butler): rare	End.		√			
<b>Geometridae: Inchworms</b>						
<i>Eupithecia craterias</i> (Meyrick): very rare, larvae predaceous	End.		√			
<i>Eupithecia dryinombra</i> (Meyrick): very rare at MV light	End.			√		
<i>Eupithecia monticolans</i> Butler: locally common, larvae feed on <i>Metrosideros</i>	End.	√	√	√		
<i>Eupithecia orichloris</i> (Meyrick): locally common: larvae predaceous.	End.		√	√		
<i>Eupithecia staurophragma</i> (Meyrick): very rare: larvae predaceous.	End.	√	√	√		
<i>Progonostola?</i> sp.: very rare.	End.		√			
<i>Scotorythra arboricolans</i> Butler: common	End.		√			
<i>Scotorythra artemidora</i> Meyrick: rare	End.		√			
<i>Scotorythra euryphaea</i> Meyrick: rare	End.		√			
<i>Scotorythra goniastis</i> Meyrick: rare	End.		√			
<i>Scotorythra oxyphractis</i> Meyrick: rare	End.		√			
<i>Scotorythra rara</i> (Butler): common	End.		√			
<i>Scotorythra</i> sp. A: rare	End.		√			
<b>Lycaenidae : Blues</b>						
<i>Udara blackburni</i> (Tuely): Blackburn’s butterfly, sparse	End.	√	√	√		
<b>Noctuidae: Underwings, cutworms, and relatives</b>						
<i>Agrotis baliopa</i> Meyrick: rare	End.		√			
<i>Agrotis ceramophaea</i> Meyrick: common	End.		√			
<i>Agrotis charmocrita</i> (Meyrick): rare	End.		√			
<i>Agrotis hephaestaea</i> Meyrick	End.		√			
<i>Agrotis ipsilon</i> (Hufnagel): greasy cutworm	Adv.	√	√			
<i>Agrotis xiphias</i> Meyrick: rare	End.		√			
<i>Agrotis?</i> / <i>Peridroma</i> sp.: 7 specimens	End.		√			

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>LEPIDOPTERA: Butterflies &amp; moths continued</b>						
<b>Noctuidae: Underwings, cutworms, and relatives (continued)</b>						
<i>Ascalapha odorata</i> (Linnaeus): black witch, transient	Adv.	√	√			
<i>Callopietria maillardi</i> Guenée	Adv.		√			
<i>Chrysodeixis eriosoma</i> (Doubleday)	Adv.		√			
<i>Haliophyle</i> sp. nr. <i>euclidias</i> (Meyrick): common: this genus feeds on ferns	End.		√			
<i>Haliophyle ignita</i> Warren: rare, local endemic	End.		√			
<i>Haliophyle compsias</i> (Meyrick): rare, local endemic	End.		√			
<i>Haliophyle</i> spp.: at least 2 common species appear to be represented	End.		√			
<i>Hypena laceratalis</i> Walker: lantana moth	Pur.		√			
<i>Lophoplusia pterolota</i> (Meyrick): very rare	End.		√			
<i>Pseudaletia unipuncta</i> (Haworth): common pest	Adv.		√			
<i>Pseudaletia</i> sp.	End.		√			
<i>Rhynchopalpus brunellus</i> Hampson: melastome moth	Pur.		√			
<i>Schrankia altivolans</i> (Butler): common	End.		√			
<i>Schrankia</i> sp. A: twilight zone cave species	End.		√	√		
<i>Schrankia</i> spp.: at least 5 species, all undescribed	End.		√			
<i>Schrankia</i> sp. 1	End.				√	
<i>Schrankia</i> sp. 2	End.				√	
<i>Schrankia</i> spp.: at least 2 species	End.	√				
<b>Nymphalidae: Admirals and relatives</b>						
<i>Vanessa tameamea</i> Eschscholtz: Kamehameha butterfly	End.	√	√	√		
<b>Oecophoridae: Oecophorid moths</b>						
<i>Thyrocopa</i> spp.: at least 4 species were found, none common	End.		√			
<i>Thyrocopa</i> sp.: uncommon	End.	√				
<i>Thyrocopa</i> sp. 1: on <i>Pritchardia</i>	End.		√	√		
<i>Thyrocopa</i> sp. 2: on <i>i‘ei‘e</i> tips in stems, uncommon	End.	√	√	√		
<b>Pterophoridae: Plume moths</b>						
<i>Leioptilus beneficus</i> (Yano & Heppner)	Pur.	√	√			

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS					
<b>LEPIDOPTERA: Butterflies &amp; moths continued</b>						
<b>Pyralidae: Pyralid moths</b>						
<i>Homeosoma</i> sp. near <i>alboparsum</i> (Butler): rare	End.		√			
<b>Sphingidae: Hawk moths</b>						
<i>Agrius cingulata</i> (Fabricius): sweet potato hornworm	Adv.		√			
<i>Hyles wilsoni</i> (Rothschild): common	End.		√			
<i>Macroglossum pyrrhostictum</i> (Butler)	Adv.	√	√			
<i>Theretra nessus</i> (Drury)	Adv.		√			
<b>Tineidae: Clothes moths</b>						
<i>Opogona omoscopa</i> (Meyrick)	Adv.		√	√		
<b>Tortricidae (Leaf rollers, leaf tiers)</b>						
<i>Amorbia imigratella</i> Busck	Adv.			√		
<i>Bactra straminea</i> (Butler)	Adv.		√			
<i>Cydia</i> sp. 1	End.		√			
<i>Pararrhaptica</i> sp. 1	End.		√			
Genus species	Unk.		√	√		
<b>DIPTERA: Flies</b>						
<b>Agromyzidae</b>						
<i>Phytoliriomyza montana</i> Frick: common on forest floor	End.?	√				
<b>Anisopodidae</b>						
<i>Sylvicola cinctus</i> (Fabricius)	Adv.		√			
<b>Asteiidae</b>						
<i>Asteia</i> sp.: rare <i>Pritchardia</i> associate	End.		√			
<b>Calliphoridae: Blow flies</b>						
<i>Calliphora vomitoria</i> (Linnaeus)	Adv.		√	√		
<i>Dyscritomyia grimshawi</i> James: rare	End.	√				
<i>Dyscritomyia</i> spp: at least 2 species	End.		√			
<i>Dyscritomyia</i> sp.	End.		√	√	√	
<i>Eucalliphora latirons</i> (Hough)	Adv.	√				
<i>Lucilia</i> sp.	Adv.?		√	√		



**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS					
<b>DIPTERA: Flies (continued)</b>						
<b>Ceratopogonidae: Biting midges</b>						
<i>Dasyhelea hawaiiensis</i> Macfie: uncommon	End.	✓				
<i>Forcipomyia hardyi</i> Wirth & Howarth: common	End.	✓	✓			
<i>Forcipomyia pholetor</i> Wirth & Howarth	End.			✓	✓	
<i>Forcipomyia</i> sp. 1	End.	✓				
<i>Forcipomyia</i> sp. 2	End.	✓				
<i>Forcipomyia</i> sp. 3	End.	✓				
<b>Chironomidae: Midges</b>						
<i>Cricotopus bicinctus</i> (Meigen)	Adv.		✓			
<i>Orthocladus</i> sp. 1	End.		✓	✓		
<b>Dolichopodidae: Long-legged flies</b>						
<i>Campsicnemus</i> species: uncommon	End.		✓			
<i>Campsicnemus brevitibia</i> Hardy & Kohn	End.	✓				
<i>Campsicnemus crispatus</i> Tenorio	End.	✓				
<i>Campsicnemus dicondylus</i> Hardy & Kohn: uncommon	End.		✓	✓		
<i>Campsicnemus flaviventer</i> Hardy & Kohn: uncommon	End.		✓	✓		
<i>Campsicnemus longiquus</i> Tenorio	End.	✓				
<i>Campsicnemus penicillatus</i> Parent	End.	✓				
<i>Campsicnemus</i> n. sp. nr. <i>loxothrix</i> Hardy & Kohn	End.				✓	
<i>Campsicnemus scolimerus</i> Hardy & Khon	End.	✓			✓	
<i>Campsicnemus</i> n. sp. near <i>kuku</i> Evenhuis	End.	✓				
<i>Campsicnemus</i> n. sp. near <i>macula</i> Parent	End.	✓				
<i>Campsicnemus</i> n. sp. near <i>pherocteis</i> Hardy & Kohn	End.	✓				
<i>Campsicnemus</i> n. sp. near <i>truncatus</i> Hardy & Kohn	End.	✓				
<i>Campsicnemus</i> n. sp. with “sinuous tibia”	End.	✓				
<i>Dolichopus exsul</i> Aldrich	Ind.		✓	✓		
<i>Eurynogaster</i> sp.	End.		✓	✓	✓	
Genus species	End.		✓			

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIAKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIAKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>DIPTERA: Flies (continued)</b>						
<b>Drosophilidae: Pomace Flies</b>						
<i>Drosophila</i> n. sp. nr <i>apicisetae</i> Hardy	End.	√				
<i>Drosophila adiastrata</i> Hardy	End.	√				
<i>Drosophila basisetae</i> Hardy & Kaneshiro: uncommon	End.		√			
<i>Drosophila canipolita</i> Hardy: uncommon	End.		√			
<i>Drosophila cilifemorata</i> Hardy: uncommon	End.		√			
<i>Drosophila claytonae</i> Hardy & Kaneshiro: uncommon	End.		√			
<i>Drosophila conformis</i> Hardy: locally common	End.		√			
<i>Drosophila crassifemur</i> Grimshaw	End.				√	
<i>Drosophila dasyncnemia</i> Hardy: common	End.		√			
<i>Drosophila fungiperda</i> (Hardy): locally common	End.		√			
<i>Drosophila hawaiiensis</i> Grimshaw	End.	√				
<i>Drosophila iki</i> Bryan	End.	√				
<i>Drosophila immigrans</i> Sturtevant	Adv.				√	
<i>Drosophila latigena</i> Hardy: uncommon	End.		√			
<i>Drosophila lissodora</i> Hardy & Kaneshiro	End.	√				
<i>Drosophila longiperda</i> Kambyzellis	End.	√				
<i>Drosophila mitchelli</i> Hardy: common	End.		√			
<i>Drosophila mulli</i> Perreira & Kaneshiro: rare, restricted to <i>Pritchardia</i> palm, candidate species for endangered status	End.		√	√		
<i>Drosophila neutralis</i> Hardy: common, bait trap	End.			√		
<i>Drosophila ochracea</i> Grimshaw: common: `ie`ie picture-wing pomace fly	End.		√			
<i>Drosophila nigrocirrus</i> Hardy: uncommon, bait trap	End.			√		
<i>Drosophila ochrobasis</i> Hardy & Kaneshiro	End.	√				
<i>Drosophila paracracens</i> Hardy & Kaneshiro	End.				√	
<i>Drosophila percnosoma</i> Hardy: locally common	End.		√			
<i>Drosophila pilimana</i> Grimshaw	End.	√				
<i>Drosophila prolaticilia</i> Hardy: locally common	End.		√			
<i>Drosophila reducta</i> Hardy: locally common	End.		√			

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i**

		THIS STUDY	WAIAKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIAKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>DIPTERA: Flies (continued)</b>						
<b>Drosophilidae: Pomace flies (continued)</b>						
<i>Drosophila septuosa</i> Hardy: rare	End.	✓	✓			
<i>Drosophila setosimentum</i> Hardy & Kaneshiro: common	End.		✓			
<i>Drosophila simulans</i> Sturtevant: in cave	End.			✓		
<i>Drosophila sordidapex</i> Grimshaw: rare	End.		✓			
<i>Drosophila sproati</i> Hardy & Kaneshiro: common, ‘ōlapa-bark picture-wing	End.		✓			
<i>Drosophila sulfurigaster</i> Duda:	Adv.					
<i>Drosophila suzukii</i> (Matsumura): very common	Adv.	✓	✓		✓	
<i>Drosophila tanythrix</i> (Hardy): very common: <i>ex</i> : ‘ōlapa-leaf	End.	✓	✓			
<i>Drosophila waddingtoni</i> Basden	End.	✓				
<i>Drosophila</i> sp. A	End.		✓			
<i>Drosophila</i> sp. B	End.		✓			
<i>Drosophila</i> spp.: at least 3 species	Adv	✓				
<i>Drosophila</i> sp.	Unk.		✓		✓	
<i>Scaptomyza ichneumon</i> (Knab): uncommon, spider egg parasite.	End.		✓			
<i>Scaptomyza perkinsi</i> (Grimshaw): locally rare	End.		✓			
<i>Scaptomyza</i> sp.: uncommon	End.		✓			
<i>Scaptomyza</i> sp.: in cave	End.			✓		
<b>Ephydriidae: Shore flies</b>						
<i>Hydrellia tritici</i> Coquillet	Adv.	✓	✓			
<b>Muscidae: House flies</b>						
<i>Brontaea quadristigma</i> (Thompson)	Adv.				✓	
<i>Lispocephala</i> sp.: rare	End.	✓	✓			
<b>Phoridae: Scuttle flies, Coffin Flies</b>						
<i>Megaselia scalaris</i> (Loew): uncommon in caves and leaf litter	Adv.		✓	✓		
<i>Megaselia</i> n. sp. A: small-eyed, pale cave species.	End.		✓	✓		
<i>Megaselia</i> sp. B: dark species in caves.	End.?		✓			
<i>Puliciphora?</i> sp.: facultative cave species	Adv.			✓		

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (Continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
TAXON	STATUS <sup>1</sup>					
<b>DIPTERA: Flies (continued)</b>						
<b>Phoridae:</b> Scuttle flies, Coffin flies (continued)						
Genus species: facultative cave species	Adv.			✓		
<b>Pipunculidae:</b> Big-headed flies						
<i>Cephalops</i> sp.: uncommon, in Malaise trap, parasite of homoptera.	End.		✓			
<b>Psychodidae:</b> Moth flies						
<i>Psychoda</i> sp.: common	End.?	✓	✓	✓		
<b>Sciaridae:</b> Black fungus gnats						
<i>Phytosciara vulcanata</i> ? Steffan: caves	End.?		✓	✓		
<i>Sciara (Lycoriella)</i> sp.	End.	✓				
<b>Sciomyzidae:</b> Snail flies						
<i>Sepedon</i> sp. near <i>oriens</i> Steyskal	Pur.	✓	✓			
<b>Sphaeroceridae</b>						
<i>Leptocera</i> sp.: common collected in Malaise traps	Adv.		✓			
<i>Leptocera</i> sp.: in fogging samples, cave, and on <i>Pritchardia</i>	Adv.			✓		
<i>Poecilosomella punctipennis</i> (Wiedmann)	Adv.	✓			✓	
<b>Syrphidae:</b> Flower flies						
<i>Syritta hackeri</i> Kloecker	Adv.		✓	✓		
<i>Toxomerus marginatus</i> Say	Adv.				✓	
<b>Tachinidae:</b> Parasite flies, tachinid flies						
<i>Gonia longipulville</i> Tothill	Adv.				✓	
<b>Tipulidae:</b> Crane flies						
<i>Limonia advena</i> (Alexander)	End.		✓	✓		
<i>Limonia hawaiiensis</i> (Grimshaw)	End.		✓	✓		
<i>Limonia jacobae</i> (Alexander)	End.		✓	✓		
<i>Limonia</i> sp. nr. <i>jacobae</i> (Alexander)	End.	✓			✓	
<i>Limonia nigropolita</i> (Alexander)	End.				✓	
<i>Limonia stigipennis</i> Alexander	End.		✓			
<i>Limonia swezeyi</i> (Alexander)	End.	✓				

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (Continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
<b>TAXON</b>	<b>STATUS<sup>1</sup></b>					
<b>DIPTERA: Flies (continued)</b>						
<b>Tipulidae: Crane flies (continued)</b>						
<i>Limonia variabilis</i> (Grimshaw)	End.	✓				
<i>Limonia variabilis</i> or near: light, very slight infuscation	End.	✓				
? <i>Limonia</i> n. sp. A	End.	✓				
? <i>Limonia</i> n. sp. B near <i>hawaiiensis</i> (Grimshaw)	End.	✓				
<i>Limonia</i> spp.: 2 indet.	End.		✓			
<b>HYMENOPTERA: Wasps, bees &amp; ants</b>						
<b>Apidae: Bees</b>						
<i>Apis mellifera</i> Linn.	Pur.	✓	✓		✓	
<b>Bethylidae: Bethylid wasps</b>						
<i>Sierola</i> sp.: uncommon	End.	✓				
<b>Braconidae: Braconid wasps</b>						
<i>Apanteles</i> sp. 1: in fogging samples	Adv.?		✓	✓		
<i>Apanteles</i> sp. 2	Adv.?		✓	✓		
<i>Bracon terryi</i> (Bridwell)	Pur.		✓	✓		
<i>Meteorus laphygmae</i> Viereck	Pur.				✓	
<b>Colletidae: Yellow-faced bees</b>						
<i>Hylaeus (Nesoprosope)</i> sp.	End.				✓	
<i>Hylaeus (Nesoprosope)</i> sp.: 2 species ?	End.	✓				
<b>Diapriidae (Diapriid wasps)</b>						
<i>Trichopria soror</i> (Perkins)	End.		✓	✓	✓	
<b>Encyrtidae: Encyrtid wasps</b>						
Genus species	Adv.?	✓	✓		✓	
<b>Eucoilidae: Eucoilid wasps</b>						
<i>Pseudeucoila</i> cf. <i>oreias</i> (Perkins): rare	End.	✓			✓	
<b>Eucoilidae: Eucoilid Wasps</b>						
Genus species 1	End.	✓	✓	✓	✓	
Genus species 2	End.		✓			
<b>Formicidae: Ants</b>						
<i>Anoplolepis longipes</i> (Jerdon)	Adv.			✓		

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kīpuka Mosaic, Hawai‘i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
<b>TAXON</b>	<b>STATUS<sup>1</sup></b>					
<b>HYMENOPTERA: Wasps, bees &amp; ants (continued)</b>						
<b>Formicidae: Ants (continued)</b>						
<i>Cardiocondyla</i> sp.	Adv.				√	
<i>Linepithema humile</i> (Mayer)	Adv.	√	√		√	
<i>Paratrechina</i> sp.: at bait stations and fogging samples	Adv.			√		
<i>Pheidole megacephala</i> (Fabricius)	Adv.			√		
<i>Solenopsis papuana</i> Emery	Adv.			√		
<b>Ichneumonidae: Ichneumon wasps</b>						
<i>Enicospilus</i> sp. 1	End.		√			
<i>Enicospilus</i> sp. 2	End.		√			
<i>Enicospilus</i> sp. 3	End.		√			
<i>Trathala flavoorbitalis</i> (Cameron): in fogging samples	Adv.		√	√		
Genus species: in caves	Adv.?			√		
<b>Platygasteridae</b>						
<i>Platygaster</i> sp. 1: in fogging samples	Adv.	√	√	√		
<b>Scelionidae: Spider egg parasites</b>						
<i>Baeus</i> sp.	Pur.				√	
<b>Sphecidae: Sphecid wasps</b>						
<i>Ectemnius</i> sp. 1	End.		√			
Genus species	Adv.?	√				
<b>Vespidae: Paper wasps, potter wasps, yellow-jacket wasps</b>						
<i>Paravespula pensylvanica</i> (Saussure)	Adv.	√	√		√	
<b>CRUSTACEANS</b>	<b>CLASS CRUSTACEA</b>					
<b>CRABS AND RELATIVES</b>	<b>SUBCLASS MALACOSTRACA</b>					
<b>AMPHIPODA: Scuds, sandhoppers</b>						
<b>Talitridae: Sandhoppers</b>						
<i>Talitroides topitotum</i> Burt	Adv.	√	√	√	√	

**TABLE 2. List of Species Collected or Observed During Surveys Conducted Near and Within the Mauna Loa Kipuka Mosaic, Hawai'i (continued)**

		THIS STUDY	WAIĀKEA PRISON	STAINBACK ROAD	SADDLE ROAD.	WAIĀKEA FOREST
<b>TAXON</b>	<b>STATUS<sup>1</sup></b>					
<b>ISOPODA: Pill bugs, slaters</b>						
<b>Styloniscidae</b>						
<i>Styloniscus mauritiensis</i> (Bernard)	Adv.	√	√	√		
<i>Styloniscus spinosus</i> (Patience)	Adv.	√	√	√		
<b>Porcellionidae: Sow bugs</b>						
<i>Porcellio scaber</i> Latreille	Adv.	√	√	√		
<i>Porcellio</i> sp. 1	Adv.				√	
<b>CENTIPEDES</b>	<b>CLASS CHILOPODA</b>					
<b>GEOPHILOMORPHA (Soil centipedes)</b>						
Unidentified: uncommon in cave	Adv.?		√	√		
<b>Lithobiidae</b>						
<i>Lithobius</i> sp.	End.?		√	√	√	
<i>Lithobius</i> sp. 1: in fogging samples	End.?	√				
<i>Lithobius</i> sp. 2: in fogging samples	End.?	√				
<b>CLASS DIPLOPODA</b>						
<b>MILLIPEDES</b>						
<b>POLYDESMIDA</b>						
<b>Paradoxosomatidae</b>						
<i>Oxidus gracilis</i> Koch: common in leaf litter and mossy logs, and caves	Adv.	√	√		√	
<b>SPIROSTREPTIDA</b>						
<b>Cambalidae</b>						
<i>Nannolene</i> spp.: rare in leaf litter	End.	√	√	√	√	

<sup>1</sup> = Status: End=endemic to Hawai'i; Adv=adventive; Ind=indigenous; Pur=purposefully introduced, Unk=unknown.

**Table 3. Preliminary List of Historical Records of Sensitive Species of Insects and Related Arthropods from the Mauna Loa Kīpuka Mosaic and Saddle Road Area from (Evenhuis *et. al.*, 1996)**

<b>TAXON</b>	<b>RARITY</b>
<b>Archaeognatha:</b> Machilidae <i>Neomachilis heteropus</i> Silvestris	Rarely seen
<b>Coleoptera:</b> Aglycyderidae <i>Proterhinus</i> spp.	Many spp. on rare plant hosts
<b>Coleoptera:</b> Cerambycidae <i>Plagithmysus montgomeryi</i> Gressitt & Davis	Rare, on rare plant host
<b>Coleoptera:</b> Cerambycidae <i>Plagithmysus mezoneuri</i> Swezey	Rare, on rare plant host
<b>Coleoptera:</b> Curculionidae <i>Rhyncogonus giffardi</i> Sharp	?Rare, limited distribution
<b>Diptera:</b> Dolichopodidae <i>Campsicnemus hawaiiensis</i> Hardy & Kaneshiro	?Extinct
<b>Diptera:</b> Drosophilidae <i>Drosophila heteroneura</i> Perkins	Rare
<b>Heteroptera:</b> Reduviidae <i>Nesidiolestes ana</i> Gagné & Howarth	Rare, specialized habitat (cave)
<b>Lepidoptera:</b> Lycaenidae <i>Udara blackburni</i> (Tuely)	Sparce
<b>Odonata:</b> Coenagrionidae <i>Megalagrion amaurodytum peles</i> (Perkins)	Sparce, specialized habitat (leaf axils)
<b>Orthoptera:</b> Gryllidae <i>Caconemobius varius</i> Gurney & Rentz	Rare, specialized habitat (cave)
<b>Orthoptera:</b> Gryllidae <i>Thaumatogryllus cavicola</i> Gurney & Rentz	Rare, specialized habitat (cave)



## NOTABLE ARTHROPOD SPECIES COLLECTED

### **Coleoptera**

**Aglycyderidae** (Proterinid weevils): These tiny (less than 3 mm long) primitive weevils are remarkably diverse in Hawai'i. About 175 species are known only from the Hawaiian Islands; these constitute more than 90% of the world's fauna in the family. The larvae are woodborers, mostly in twigs and stems of native plants, and most species are host specific. Unidentified species were collected using pyrethrum fogging and general collecting.

**Carabidae** (Ground beetles): There were five endemic species contained in two genera collected during this study. Carabids are predaceous on other arthropods both as larvae and adults. Most are flightless and as such restricted as to their habitat and distribution.

### **Diptera**

#### **Dolichopodidae (Long-legged Flies)**

*Campsicnemus* are common dolichopodid flies (long-legged flies) that are found in many environments but especially so in the mesic forests throughout the Hawaiian Islands where they prey on other small invertebrates including immatures. Many are endemic to an island or to restricted ecosystems within an island. There are 155 species described from the Hawaiian Islands with an estimated 150 undescribed new species either awaiting description or discovery. Species fall into three "eco-groups" based on general body coloration: 1) canopy dwellers (yellowish in coloration); 2) low-growing vegetation and leaf-litter and ground dwellers (brown to yellowish brown in coloration); 3) stream and pond water skaters (black in coloration). Five described and five species new to science were found in this study. The new species will be described in a separate publication.

#### ***Campsicnemus brevitibia* Hardy & Kohn**

This species is a relatively uncommon species found only on the Big Island and previously known only from a few specimens from the Kohala Mountains in the north region of the island. The specimens collected in this survey mark a range extension southward into the Saddle area of the Big Island. The coloration indicates that this is most likely a leaf-litter or ground inhabiting species.

#### ***Campsicnemus crispatus* Tenorio**

Like *C. brevitibia* above, collection of this species here marks a range extension of this endemic Big Island species into the Saddle area. It was originally described from the Hāmākua coast area near Keanakolu. Based on body coloration, it most likely inhabits moss-covered vegetation and/or leaf litter.

#### ***Campsicnemus longiquus* Tenorio**

A relatively uncommon endemic Big Island *Campsicnemus* known previously only from the Kulani area of the Waiākea Forest Reserve on the Big Island. Its brownish coloration indicates that it is probably a leaf-litter or ground dwelling species.

#### ***Campsicnemus penicillatus* Parent**

A common large *Campsicnemus* that occurs throughout the Saddle, Mauna Kea, Mauna Loa, and Kīlauea regions of the Big Island. It is a canopy dweller and is frequently collected in yellow pans, to

which it is easily attracted. Its size is roughly two times the size of the majority of *Campsicnemus* species and is easily distinguished by the conspicuous combs of hairs on the male mid tibiae.

***Campsicnemus scolimerus* Hardy & Kohn**

One of the most common species of *Campsicnemus* on the Big Island, this endemic species occurs in mesic forests throughout the island. It is frequently collected in pan traps and has been observed on resting on the ground and leaf litter where it patrols small territories and preys on small invertebrates including other individuals of its own species. It is easily distinguished from other species by the contorted mid femora and tibiae of the male.

***Campsicnemus* n. sp. near *kuku* Evenhuis**

This species, based on only one collected male specimen represents a new species most closely related to *C. kuku* Evenhuis, which is a species endemic to the island of Kaua'i. Its dark body coloration and infuscated wing indicate that is probably a ground dwelling or leaf-litter dwelling species.

***Campsicnemus* n. sp. near *macula* Parent**

This species is only represented by a single collected male specimen but is easily distinguished from all other species by the spot of color on the wing (only known in *C. macula* Parent from Maui, *C. halonae* Evenhuis from O'ahu). This is the first representative of this species group from the Big Island.

***Campsicnemus* n. sp. near *pherocteis* Hardy & Kohn**

This species is represented by four specimens collected at two sites on the Big Island during this survey. It represents a new species most closely related to *C. pherocteis* Hardy & Kohn, an endemic species known only from the island of Kaua'i. It is easily distinguished by the conspicuous swelling and tuft of hairs on the male mid tibia. Its dark coloration indicates that it is most likely a leaf-litter or ground dwelling species.

***Campsicnemus* n. sp. near *truncatus* Hardy & Kohn**

This relatively small-sized brownish species is represented in collections in this survey by six specimens collected at three sites in the Saddle area of the Big Island. It is a new species most close in appearance to *C. truncatus* Hardy & Kohn, which is only known from Maui.

***Campsicnemus* n. sp. with "sinuous tibia"**

This species is only represented by a single male specimen collected at Site 13 during this survey. It is unlike any other *Campsicnemus* species and is characterized by the sinuous mid tibiae. Its brownish coloration indicates that it is probably a leaf-litter or ground dwelling species.

**Diptera**

**Drosophilidae** (Pomace flies): Hawaiian Drosophilidae represents one of the best-studied examples of adaptive radiation. Over 600 species have been described, and another 200 species are known but not yet named. The common pomace fly (*Drosophila melanogaster*) has been used for genetic studies for over 75 years; thus, the existence of such a diverse fauna in Hawai'i provides an ideal natural laboratory for comparative studies in evolutionary biology (Carson, 1987, Kaneshiro & Boake, 1987). At least 13 *Drosophila* species were collected. There was one species new to science collected during this survey.

**Muscidae** (House flies and relatives): The endemic genus *Lispocephala* contains over 100 known species, which are all predatory on other insects. Thirty species are known from the Big Island, and of these only 1 undetermined species was collected in a yellow pan trap at Pu'u Huluhulu.

### **Heteroptera**

**Miridae** (Plant bugs): Hawaiian plant bugs remain poorly studied. About 50 species have been named, but at least another 100 species are in collections. Most species are plant feeders, but many are predaceous or omnivorous. Many species are found only in a small geographical area and feed on a single species of plant. Species in the endemic genus *Sarona* have been collected in Pu'u Maka'ala and in selected areas along the Stainback Hwy, between Tree Planting Rd. and Pu'u Huluhulu; 9 species have been described from the Big Island (Asquith, 1994).

**Nabidae** (Damsel bugs): The damsel bugs are all predatory on other insects. There are 30 Hawaiian species, but new species continue to be discovered. *Nabis oscillans* Blackburn, 1888 was collected using sweep nets on vegetation.

**Pentatomidae** (Stink bugs and Shield bugs): *Coleotichus blackburniae*, the koa bug, is the largest and most conspicuous native true bug. It is nearly an inch long and iridescent blue, green, maroon, and yellow. Once common on *koa* and *a'ali'i* on all of the main islands, it has become rare following the introduction, beginning in the 1960s, of several parasites for biological control of the pestiferous southern green stink bug, *Nezara viridula*. Historically, *C. blackburniae* was known from Pu'u Maka'ala, but none were seen during this survey.

### **Homoptera**

*Iolania perkinsi* Kirkaldy, a native cixiid, was common. This species is restricted to the Big Island and is associated with native ferns. Specimens in the other native genus *Oliarus* were collected using fogging and sweep nets. A lack of expertise in this group made identification difficult.

### **Lepidoptera**

**Lycaenidae** and **Nymphalidae** (Blue and Brush-footed butterflies): Only two species of butterflies are native to Hawai'i, a blue (Blackburn's butterfly, or *Udara blackburni* (Tuely), which feeds on *koa*, *a'ali'i* and other legumes) and an admiral or brush-footed butterfly (Kamehameha butterfly, or *Vanessa tameamea* Eschscholtz, which feeds on *māmaki* and other Urticaceae). Both species are locally common where their hosts are found.

### **Odonata**

**Aeshnidae (Darners)**: There are two species represented in the Aeshnidae in Hawai'i. The largest one is *Anax strenuus* Hagen. It is not only the largest species in Hawai'i but has the distinction of being the largest dragonfly species in the United States. Although not an uncommon species, it is difficult to capture and as such they was only observed during this survey.

**Coenagrionidae** (Damselflies): There are 29 species in the endemic genus *Megalagrion*. Only one species was actually captured, *M. peles* (Perkins). This species breeds in leaf axils of *ie'ie* and *Astelia*. The historic record yielded 5 other species of damselflies known to inhabit areas within the proposed NARS extension. *Megalagrion calliphya microdemas* (Perkins) *M. hawaiiense* (McLachlan) and two alien species: *Enallagma civile* (Hagen, 1862) and *Ischnura ramburii* (Selys-Longchamps).

## **Orthoptera**

**Gryllidae** (Crickets): There are 243 native species of crickets known from Hawai‘i (Otte, 1994), which is more than twice as many as the total number known from the rest of the United States. Most native species have restricted ranges; some are known from only small areas within single islands. Their great diversity makes them ideal for evolutionary studies (Otte, 1994). Hawaiian crickets live mostly in trees and shrubs, but a few forage in the leaf litter. Most are omnivores, feeding on both plant and animal material. Representatives of two native genera were collected in this survey. Both are genera of swordtail crickets (*Trigonidium* and *Laupala*).

## **DISCUSSION**

Our survey focused primarily on rare and sensitive species. The study area is comprised of many different habitat types including open lava flows, dry forest, cloud forest, *kīpuka*, caves, as well as open grasslands created by clearing for cattle operations. Many of these habitats are impacted by both natural and human disturbances.

### **Kīpuka**

Kīpuka are formed when lava flows around a section of forest and isolates that section from the rest of the forest. The *kīpuka* represent a unique island-within-an island ecosystem (Evenhuis *et. al*, 1996). Mauna Loa has many *kīpuka* which harbor a multitude of unique arthropod, plant, and bird species. These *kīpuka* are especially vulnerable to invasive plant and animal species. In particular, pig damage is evident in most *kīpuka*. Many arthropod species are flightless and can't move outside the confines of *kīpuka*. Some species, although they can fly long distances, are specially adapted to the wet humid environments of the *kīpuka* and will not venture out into the hot and dry, open lava flow to move to another *kīpuka* or intact forest. It is vitally important to protect these *kīpuka* in order to preserve these unique species that cannot be found anywhere else.

### **Caves**

Caves formed by lava tubes are characteristic of young *pahoehoe* lava flows and are important landforms on young volcanoes such as Mauna Loa (Evenhuis *et. al.*, 1996). Many caves are found in the study area. Several unique cavernicolous species inhabit these caves. Caves are especially vulnerable to disturbance by humans and animals. Disturbance of the vegetation above a lava tube can dramatically alter the caves fragile environment. It is therefore important to consider protecting the above ground vegetation in order to preserve the cave faunas in these lava tubes. Several cave species were collected during the Upper *Waiākea* Prison EIS and these species are listed in Table 2. Emesine Cave in the 1881 lava flow from Mauna Loa is one of the longest and most significant caves in Hawai‘i. It gets its name from being the type locality for the blind cave-adapted thread-legged bug (*Nesidiolestes ana*) discovered in 1973. The main entrance is near Powerline Road at about 5600 ft elevation. The cave extends both upslope and downslope. The upslope passage is several thousand feet long. The downslope passage is complex, with mazes and remarkable formations, and long currently extending to just upslope of Tree Planting Road at about 3000 ft elevation. This makes the cave one of the deepest in the U.S. Kaumana Cave near Hilo is a downslope section within the same lava flow. Continuing exploration may connect the two caves, which would make the cave one of the longest and deepest caves in the world. In spite of its youth (123 years), the cave supports a highly significant biological community. In addition to the thread-legged bug, at least 10 cave adapted arthropods live in the cave. These include the cave planthopper (*Oliarus polyphemus*), moth (*Schrankia* sp.) rock crickets (*Caconemobius varius* and

undescribed related forms), tree cricket (*Thaumtogryllus cavicola*), millipede (*Nannolene* sp.), rock centipede (*Lithobius* sp.) and several springtails (Collembola). The cave is a natural laboratory to study cave biology, especially as the changing temperature along its great range in elevation provides an opportunity for comparative physiological studies. Other significant lava tubes undoubtedly occur within the proposed area, but the difficulty of access and exploration has prevented their discovery to date. Potentially the area is a valuable one speleologically.

## CONCLUSIONS

Although collections were made in a wide variety of habitats, total coverage of all areas within the study site was not possible. Collecting methods for this study were limited to baiting, fogging and the use of traps designed to collect the widest variety of species. Previous surveys in this area employed different collecting methods that produced varying results. These results have been included in this report. Combined, these surveys have produced the most comprehensive listing of arthropod species collected to date from the Waiākea 1942 Lava Flow Natural Area Reserve and selected *kīpuka* within the Mauna Loa Kīpuka Mosaic. This study has produced many species new to science and therefore, it is clear there is much more to be learned from our remaining native forests. Poorly understood interactions between faunas, especially the arthropods as food for rare and endangered native birds, requires that we protect what remains and restore that which has been degraded. Expanding the Waiākea 1942 Lava Flow Natural Area Reserve to include the Mauna Loa Kīpuka Mosaic is a much-needed step towards preserving our natural heritage. It is only through protection of these lands that we give ourselves time to understand our place in the environment. We cannot let nature take its course. We have an obligation to take the initiative and save these precious resources for future generations to enjoy and learn from. Natural Area Reserve status will be a positive step in the right direction that ensures a future for our remaining wildlife.

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**Table 4. Candidate Species of Arthropods Known to Occur (or Have Historically Occurred) on Hawai'i Island.**

Scientific Name	Common Name
<b>ODONATA: Coenagrionidae</b>	
<i>Megalagrion nesiotes</i> (Perkins)	Nesiotes megalagrion damselfly
<i>Megalagrion nigrohamatum nigrolineatum</i> (Blackburn)	Blackline megalagrion damselfly
<i>Megalagrion pacificum</i> McLachlan)	Pacific megalagrion damselfly
<i>Megalagrion xanthomelas</i> (Selys-Longchamps)	Orangeblack megalagrion damselfly
<b>DIPTERA: Drosophilidae</b>	
<i>Drosophila aglaia</i> Hardy, 1965	pomace fly (no common name)
<i>Drosophila alsophila</i> Hardy & Kaneshiro, 1971	pomace fly (no common name)
<i>Drosophila digressa</i> Hardy & Kaneshiro, 1968	pomace fly (no common name)
<i>Drosophila heteroneura</i> (Perkins, 1910)	pomace fly (no common name)
<i>Drosophila mulli</i> Perreira & Kaneshiro, 1990	pomace fly (no common name)
<i>Drosophila musaphilia</i> Hardy, 1965	pomace fly (no common name)
<i>Drosophila psilotarsalis</i> Hardy & Kaneshiro, 1975	pomace fly (no common name)

**Table 5. Arthropod Species of Concern Known to Occur (or Have Historically Occurred) on Hawai‘i Island.**

Scientific Name	Common Name
ARCHAEOGNATHA: Machilidae <i>Neomachilis heteropus</i> (Silvestri)	Hawaiian long-palp bristletail
COLEOPTERA: Aglycyderidae 72 spp. (not specified)	Hawaiian short-nosed weevils
COLEOPTERA: Cerambycidae <i>Plagithmysus claviger</i> (Sharp) <i>Plagithmysus decorus</i> Perkins <i>Plagithmysus elegans</i> Sharp <i>Plagithmysus greenwelli</i> Gressitt & Davis <i>Plagithmysus kohalae</i> Perkins <i>Plagithmysus kraussi</i> Gressitt & Davis <i>Plagithmysus laticollis</i> (Sharp) <i>Plagithmysus mezoneuri</i> (Swezey) <i>Plagithmysus nihoae</i> Perkins <i>Plagithmysus platydesmae</i> Perkins <i>Plagithmysus podagricus</i> (Perkins) <i>Plagithmysus simplicicollis</i> Sharp <i>Plagithmysus sulphurescens</i> Sharp <i>Plagithmysus swezeyi</i> Perkins <i>Plagithmysus vicinus</i> Sharp	Hawai‘i clubbed long-horned beetle Hawaii‘ decorus long-horned beetle Hawai‘i elegant long-horned beetle Grenwell’s long-horned beetle Kohala long-horned beetle Krauss’ long-horned beetle Maui wide-necked long-horned beetle Hawai‘i uhiuhi long-horned beetle Nihoa long-horned beetle Swezey’s long-horned beetle Hawai‘i podagricus long-horned beetle Simple-necked long-horned beetle Hawai‘i opuhe long-horned beetle Swezey’s long-horned beetle Hawai‘i alani long-horned beetle
COLEOPTERA: Curculionidae <i>Deinocossonus nesiotetes</i> Perkins <i>Nesotocus giffardi</i> Perkins <i>Nesotocus munroi</i> Perkins <i>Rhyncogonus giffardi</i> Sharp	Oahu nesiotetes weevil Giffard’s nesotocus weevil Munro’s nesotocus weevil Giffard’s rhyncogonus weevil
COLEOPTERA: Elateridae <i>Eopenthes cognatus</i> Sharp	Cognatus eopenthes click beetle
<b>Table 5 . (continued). Arthropod Species of Concern Known to Occur (or Have Historically Occurred) on Hawai‘i Island.</b>	
Scientific Name	Common Name
<i>Eopenthes tinctus</i> Sharp	Tinged eopenthes click beetle
HETEROPTERA: Lygaeidae	



*Metrarga obscura* Blackburn  
*Nesocryptias villosa* (White)  
*Oceanides bryani* Usinger

Mauna Loa seed bug  
 Villosan flightless seed bug  
 Bryan's oceanides seed bug

HETEROPTERA: Mesoveliidae  
*Cavaticovelia aaa* (Kirkaldy)

Aaa water treader bug

HETEROPTERA: Miridae  
*Kalania hawaiiensis* (Kirdaldy)

Lanai kalanian leaf bug

HETEROPTERA: Pentatomidae  
*Coleotichus blackburniae* White  
*Oechalia grisea* (Burmeister)  
*Oechalia patruelis* (Stål)

Koa bug  
 Gray oechalia stink bug  
 Patruelis oechalia stink bug

HETEROPTERA: Rhopalidae  
*Empicoris pulcher* (Blackburn)  
*Nesidiolestes ana* Gagné & Howarth  
*Nesidiolestes insularis* Kirkaldy

Pulchrus thread bug  
 Ana wingless thread bug  
 Robert's wingless thread bug

HOMOPTERA: Delphacidae  
*Nesosydne cyrtandricola* Muir

Glenwood Nesosydne planthopper

HYMENOPTERA: Colletidae  
*Hylaeus anthracina* (F. Smith)  
*Hylaeus assimulans* (Perkins)  
*Hylaeus blackburni* (F. Smith)  
*Hylaeus comes* (Perkins)  
*Hylaeus coniceps* (Blackburn)

Anthracinan yellow-faced bee  
 Assimulans yellow-faced bee  
 Blackburn's yellow-faced bee  
 Comes yellow-faced bee  
 Conehead yellow-faced bee

**Table 5. (continued). Arthropod Species of Concern Known to Occur (or Have Historically Occurred) on Hawai'i Island.**

Scientific Name	Common Name
<i>Hylaeus crabronoides</i> (Perkins)	Crabronoid yellow-faced bee
<i>Hylaeus difficilis</i> (Perkins)	Difficult yellow-faced bee
<i>Hylaeus dimidiata</i> (Perkins)	Dimidiatan yellow-faced bee
<i>Hylaeus erythrodemas</i> (Perkins)	Erythrodeme yellow-faced bee
<i>Hylaeus facilis</i> (F. Smith)	Easy yellow-faced bee
<i>Hylaeus filicum</i> (Perkins)	Fern yellow-faced bee
<i>Hylaeus flavipes</i> (F. Smith)	Yellow-footed yellow-faced bee
<i>Hylaeus homoeochroma</i> (Perkins)	Monocolor yellow-faced bee
<i>Hylaeus hula</i> (Perkins)	Hulan yellow-faced bee
<i>Hylaeus insignis</i> (Perkins)	Insignis yellow-faced bee
<i>Hylaeus kona</i> (Blackburn)	Kona yellow-faced bee

<i>Hylaeus laeta</i> (Perkins)	Laetan yellow-faced bee
<i>Hylaeus obscurata</i> (Perkins)	Obscuratan yellow-faced bee
<i>Hylaeus ombrias</i> (Perkins)	Ombrias yellow-faced bee
<i>Hylaeus pele</i> (Perkins)	Pele yellow-faced bee
<i>Hylaeus psammobia</i> (Perkins)	Psammobian yellow-faced bee
<i>Hylaeus pubescens</i> (Perkins)	Furry yellow-faced bee
<i>Hylaeus rugulosa</i> (Perkins)	Rugulose yellow-faced bee
<i>Hylaeus setosifrons</i> (Perkins)	Bristlefront yellow-faced bee
<i>Hylaeus simplex</i> (Perkins)	Simple yellow-faced bee
<i>Hylaeus specularis</i> (Perkins)	Specular yellow-faced bee
<i>Hylaeus sphecodoides</i> (Perkins)	Sphecodoid yellow-faced bee
<i>Hylaeus vicina</i> (Perkins)	Vicinan yellow-faced bee
<i>Hylaeus volatilis</i> (F. Smith)	Volatile yellow-faced bee

HYMANOPTERA: Sphecidae

<i>Deinomimesa hawaiiense</i> Perkins	Hawaiian deinomimesan sphecid wasp
<i>Deinomimesa punae</i> Perkins	Puna deinomimesan sphecid wasp
<i>Ectemnius bidecoratus</i> (Perkins)	Bidecoratus sphecid wasp
<i>Ectemnius curtipes</i> (Perkins)	Short-foot ectemnius sphecid wasp

**Table 5. (continued). Arthropod Species of Concern Known to Occur (or Have Historically Occurred) on Hawai'i Island.**

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**Scientific Name**

**Common Name**

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<i>Ectemnius fulvicrus</i> (Perkins)	Brown cross ectemnius sphecid wasp
<i>Ectemnius rubrocaudatus</i> (Blackburn)	Red-tail ectemnius sphecid wasp
<i>Ectemnius yoshimotoi</i> Bohart	Yoshimoto's ectemnius sphecid wasp

HYMENOPTERA: Vespidae

<i>Odynerus nigripennis</i> (Holmgren)	Black-winged odynerus vespid wasp
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LEPIDOPTERA: Crambidae

<i>Glyphodes cyanomichla</i> (Meyrick)	Blue margaronian moth
<i>Omiodes anastrepta</i> Meyrick	Molokai sedge hedyleptan moth
<i>Omiodes anastreptoides</i> Swezey	Kohala Mountain sedge hedyleptan moth
<i>Omoides euryprora</i> Meyrick	Ola'a banana hedyleptan moth
<i>Omoides fullawayi</i> Swezey	Fullaway's banana hedyleptan moth
<i>Omoides giffardi</i> Swezey	Giffard's 'ohe hedyleptan moth
<i>Omoides iridias</i> Meyrick	Kilauea pa'iniu hedyleptan moth
<i>Omoides meyricki</i> Swezey	Meyrick's banana hedyleptan moth
<i>Omoides monogona</i> Meyrick	Hawaiian bean leafroller (moth)
<i>Omoides pritchardii</i> Swezey	Hawaiian lo'ulu hedyleptan moth
<i>Omiodes telegrapha</i> Meyrick	Telegraphic hedyleptan moth
<i>Stemorrhages exaula</i> (Meyrick)	Green margaronian moth

LEPIDOPTERA: Geometridae

*Scotorythra megalophylla* Meyrick

*Tritocleis microphylla* (Meyrick)

Kona giant looper moth

'Ola' a peppered looper (moth)

LEPIDOPTERA: Lycaenidae

*Udara blackburni* (Tuly)

Blackburn butterfly

**Table 5 . (continued). Arthropod Species of Concern Known to Occur (or Have Historically Occurred) on Hawai'i Island.**

Scientific Name	Common Name
LEPIDOPTERA: Noctuidae	
<i>Agrotis cinigera</i> (Butler)	Larger Hawaiian cutworm
<i>Agrotis melanoneura</i> Meyrick	Black-veined Agrotis noctuid moth
<i>Agrotis microreas</i> Meyrick	Microreas agrotis noctuid moth
<i>Helicoverpa confusa</i> Hardwick	Confused heliothis noctuid moth
<i>Hypena newelli</i> (Swezey)	Hilo hypenan noctuid moth
<i>Hypena plagiota</i> (Meyrick)	Lovegrass noctuid moth
NEUROPTERA: Hemerobiidae	
<i>Micromus usingeri</i> (Zimmerman)	Usinger's brown lacewing
NEUROPTERA: Myrmeleontidae	
<i>Distoleon perjurus</i> (Walker)	Molokai antlion
ODONATA: Coenagrionidae	
<i>Megalagrion amaurodytum peles</i> (Perkins)	Pele ie'ie damselfly
<i>Megalagrion nigrohamatum</i> (Blackburn)	Nigrohamatum melagrion damselfly
ORTHOPTERA: Gryllidae	
<i>Caconemobius varius</i> Gurney & Rentz	Kaumana cave cricket
<i>Thaumatogryllus cavicola</i> Gurney & Rentz	Volcanoes cave cricket
ORTHOPTERA: Tettigoniidae	
<i>Ruspolia remotus</i> (Walker)	Remote conehead katydid

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## GLOSSARY

**Adventive:** relating to organisms introduced to an area by means other than purposeful.

**Alien:** A non-native species introduced to a region either purposefully or inadvertently through the actions of humans.

**Aerial Sweep Net:** A hand net used for general collecting. Modified versions may be used in aquatic situations or for beating and sifting.

**Arthropod:** insects and related invertebrate animals.

**Canopy:** the highest vegetation cover of a community.

**Endemic:** Native to and restricted to a geographical region.

**Fauna:** the animals of a specified region.

**Immature:** the stage of an animal that is not an adult.

**Indigenous:** Native to but not restricted to a geographical region.

**Invertebrate:** animals without backbones, including such groups as insects, spiders, shrimps, and snails.

**Kīpuka:** an “island” of land (older substrate) with vegetation surrounded by a more recent lava flow (often without vegetation). Also applies to other discrete islands of vegetation within lava flows, such as vertical lava tube entrances that protect native plants from damage by feral ungulates.

**Litter:** plant and other mixed organic debris found on the surface of a substrate.

**Mesic:** a moisture regime or requirement between wet and arid; receiving from 50-75 inches of annual rainfall,

**Native:** Naturally occurring in a region, i.e., having colonized the region without the aid of humans (See Endemic).

**Obligate cave-adapted species:** troglobite; a population that can survive only in caves and mesocaverns (e.g., the endemic Hawaiian cave planthopper, *Oliarus polyphemus*).

**Pan Trap:** A shallow pan filled with a fluid preservative and surfactant. (See fig. 4).

**Predatory:** the state of being a predator; preying on other biota for food requirements.

**Purposefully introduced:** organisms that are brought into an area for a specific purpose; often

as biological control agents in the control of unwanted plants or animals.

**Pu'u:** hill or volcanic cone.

**USFWS:** United States Fish & Wildlife Service.

**Rare:** threatened by extinction due to low numbers. Any plant, animal or natural community that can be immediately threatened by such factors as alien invasion, direct destruction, or loss of habitat.

**Species of Concern:** rare or threatened species formerly given the designation of C2 by USFWS. Now not formally listed by USFWS but given this designation.

**spp.:** abbreviation for more than one species.

**Taxa:** (plural of **Taxon**): a group of plants or animals making up one of the categories or formal units in taxonomic classification. In this report a taxon can be a phylum, order, family, genus, species, subspecies, variety, or form. This distinction is important because certain species have endemic Hawai'ian subspecies and varieties that are considered rare.

**Twilight zone:** in caves, area between the entrance zone and total darkness, which receives some light but vascular green plants are absent, and the environment is influenced by surface conditions.