



**RESULTS OF THE 2012 ALIEN SPECIES AND WĒKIU  
BUG (*NYSIUS WEKIUCOLA*) SURVEYS ON THE SUMMIT  
OF MAUNA KEA, HAWAI'I ISLAND**

**Hawaii  
Biological  
Survey**

Final Report

July 2013

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**FINAL REPORT**

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## **EXECUTIVE SUMMARY**

As part of a continuing long-term study, the Hawaii Biological Survey of the Bishop Museum was contracted by the Office of Mauna Kea Management (OMKM) to monitor for alien arthropod species and to continue monitoring populations of the wēkiu bug (*Nysius wekiuicola* Ashlock and Gagné), which is endemic to the Mauna Kea summit area of Hawai'i Island. A ten-day field trip was conducted in July 2012 to continue the monitoring of introduced arthropod species and monitor wēkiu bug populations within known critical core habitats found at the Mauna Kea summit. The objective of the alien arthropod monitoring surveys was to detect any potential threats to endemic Mauna Kea arthropod species such as the wēkiu bug. As in previous monitoring surveys, traps for ants were set out to determine if they are found within wēkiu bug habitat. Because ants are established at the summit regions of Haleakalā National Park on Maui, monitoring for ants on Mauna Kea became necessary because ants have caused the extinction and decline of native arthropods throughout Hawai'i. We placed bait traps in areas determined to be high-risk sites for ants to be found around the Mauna Kea summit region.

During the 2012 monitoring survey we collected 2,430 wēkiu bugs at selected cinder cones throughout the Mauna Kea summit region. For wēkiu bugs, sampling consisted of shrimp pitfall traps placed at the Pu'u 's South and North of the VLBA, around the VLBA parking lot, Pu'u Hau Kea, Pu'u Hau Oki, Pu'u Poliahu and Pu'u Wēkiu. Surveys for alien arthropod species were conducted in a wide variety of locations, starting around Hale Pohaku and then going up into areas around and in the observatories. At each alien trapping site the following traps were set: yellow sticky traps, peanut butter sticks (for ants), yellow pan traps, and pitfall traps. Peanut butter sticks were placed along the Mauna Kea access road at selected elevations between the 10-13,000 ft. levels. Ants were not collected in 2012 at any of the areas determined to have the highest potential for ants, such as areas around roadways, vehicle parking, trash receptacles and around Hale Pohaku where human activity is high.

## INTRODUCTION

The Hawaii Biological Survey of the Bishop Museum was contracted for the 2012 field season by the Office of Mauna Kea Management (OMKM) to continue to monitor and document alien arthropod species found at the Mauna Kea summit area. A baseline for alien arthropod species currently occurring at the Mauna Kea summit area has been established and species with the potential to negatively affect wēkiu bugs (*Nysius wekiuicola* Ashlock and Gagné) or other native arthropod species are being monitored. Additionally, to provide long-term capture data in areas of known critical wēkiu bug habitat, wēkiu bug population monitoring continued during the 2012 field season at the Mauna Kea summit area.

The 2012 surveys are a continuation of Bishop Museum's wēkiu bug research that originated in the early 1980s (Howarth and Stone 1982), and resumed again in the late 1990s to the present [Howarth *et al.* 1999, Englund *et al.* (2002, 2005, 2006, 2007, 2009, 2010, 2012), Porter and Englund 2006, and Preston *et al.* 2012].

The main objectives for the 2012 monitoring surveys were to 1) monitor for alien arthropod species in areas of known wēkiu bug core habitat at the Mauna Kea summit area and at site less favorable to the wēkiu bug, 2) compare the 2012 alien arthropod species composition to the 2011 field season, 3) repeat a baseline survey following the 2009 field season methods for alien arthropod species, and 4) continue to monitor wēkiu bug populations in selected known wēkiu bug habitats to provide comparisons to previous Bishop Museum surveys.

## STUDY AREA

The overall study area for the 2012 field season has been thoroughly described in previous Bishop Museum reports and this can be found Preston *et al.* 2011. The survey collections sites started at the Hale Pohaku visitor center and staff quarters at 2,850 m (9,300 ft) elevation, and encompassed portions of the alpine zone of the Mauna Kea volcano (Figure 1), including both the Mauna Kea Science Reserve (MKSR) and the Mauna Kea Ice Age Natural Area Reserve (NAR). For the purposes of this study, we defined cinder cones as non-vegetated, dormant volcanic cones in the alpine zone above 2,925 m, (9,600 ft). Elevations sampled for alien arthropods during the 2012 fieldwork ranged from a maximum of 4,205 m (13,796 ft) at the summit of Pu'u Wēkiu to a low of 2,850 m (9,300 ft) around Hale Pohaku. Visual observations were also made throughout the study area while hiking between sampling points. Tables 1–4 contain GPS coordinates, elevations, and date traps were set for all sample points within the study area. Because the present study was for both wēkiu bugs and alien arthropod species, all species (except live wēkiu bugs) collected in traps during these studies were kept for further analysis. This is also why some of the sample locations are duplicated for the alien species and wēkiu bug data tables (i.e., Tables 1 and 2). Sample locations were duplicated in Tables 1-4 when non-wēkiu bug taxa were collected in wēkiu bug pitfall traps.

Unless otherwise stated, Pu'u names are derived from USGS topographic quad maps. WGS 84 datum was used for recording GPS locations. Many Pu'u have not yet been

given official names, and when possible these cinder cones are identified by their altitude as stated on USGS topo maps. However, when no altitudes are given names of nearby landmarks or distinctive features were used. These names should not be viewed as official, but instead allow us to more easily identify specific areas of the vast summit region of Mauna Kea. Altitudes were determined using a combination of USGS 7.5 minute topographic quad maps, a handheld altimeter, and a barometric altimeter on the GPS unit, calibrated daily at Hale Pohaku and at the elevation markers on the road up to the observatories.

## **METHODS**

Alien Arthropod Species The objectives for the 2012 fieldwork was to documenting alien species found within the Mauna Kea summit area. Identifications were made of all arthropod species collected during the 2012 field trip with comparisons to previous catches and referenced to authoritatively identified specimens in the entomology collections. Species were identified to the lowest possible taxonomic unit, which was dependent upon expertise available for each taxonomic group. Species were identified to the lowest possible taxonomic unit for all trapping methods except sticky traps. Sticky traps were scanned for species that may pose a threat to the wēkiu bugs. The specimen would then be removed from the sticky trap with a solvent and identified to the lowest possible taxonomic unit.

The main purpose of the 2012 surveys was to continue to monitor for alien species on Mauna Kea and to identify those species having the potential to negatively affect wēkiu bugs and other native arthropods. To accomplish this goal we sampled at previous trapping sites over a broad range of habitats at the summit, focusing on various pathways whereby alien arthropods might first become introduced. We also sampled a wide variety of undisturbed habitat types where wēkiu bugs are historically known to have high concentrations, and nearby disturbed habitats that are associated with past or present human activities. Trapping followed the 2009 field season protocols. Yellow pan traps and yellow sticky traps were used to collect flying insects that are attracted to the color of the traps and the shimmering of the dilute ethylene glycol used in the pan traps. The pan and sticky traps were secured so that they did not become dislodged or blown from the trap sites and become scattered over the summit area. Ethylene glycol was used because it prevents freezing during the nighttime temperatures and is a preservative keeping the arthropod specimen from rotting until they can be processed and identified. Glycol pitfall traps were constructed as in previous year's wēkiu bug traps (Englund *et al.* 2002), they are baited with shrimp paste around their cup rims and around a cap-rock used to cover the traps to prevent rain or snow from filling the traps. The traps are filled with a mixture of water and glycol. The glycol pitfall traps were not placed in habitats likely to contain wēkiu bugs.

Ants are a major concern in Hawaii and are ranked as one of the greatest threats to native arthropods including the wēkiu bug. Monitoring for the presence of ants is of the utmost importance. Ants were sampled for in high traffic areas where vehicles and people activities occur. Sampling areas included the Onizuka Visitor Center picnic and trashcan locations. The Hale Pohaku staff areas and the summit lunchroom building as well as

several observatory structures were trapped for ants. Ant traps rely on baits as attractants. Peanut butter has proven to be excellent bait and it is a simple and easy way to sample for ants. Ant traps were constructed using wooden tongue depressors dipped into peanut butter and placed in areas previously sampled from 2009 - 2011. The ant traps were checked at 2-3 day intervals through out the 10-days of fieldwork. Shrimp bated traps were also checked for ants and provided additional monitoring points.

Traps were placed at the exact same locations as in 2011 by navigating to each site using GPS points taken in 2011.

#### Wēkiu Bug Sampling

As in 2009 -2011, glycol pitfall traps were not used in areas known or suspected to contain wēkiu bugs. During the 2012 fieldwork, wēkiu bug sampling consisted of using baited shrimp pitfall traps (which generally do not harm the wēkiu bugs) in areas of previously known wēkiu bug populations. Visual observations for wēkiu bugs were also conducted. A detailed explanation of techniques used for shrimp pitfall traps in this study can be found in Preston *et al.* (2011). Individual wēkiu bug pitfall trap locations were recorded with GPS (WGS 84 datum), and locations where wēkiu bugs were visually observed. Trap locations, dates, habitat type, and habitat descriptions can be found in Appendix B, Table 2.



## RESULTS AND DISCUSSION

The study period at the Mauna Kea summit for alien arthropod and wēkiu bug sampling ran from July 5 - 14, 2012. Tables 2 and 3 (Appendix B) summarize trap locations by cinder cone, elevation, date set, trap type, and GPS coordinates. Overall the 2012 wēkiu bug sample effort consisted of 50 pitfall traps and 100 alien arthropod traps.

### **Wēkiu Bug Trap Placements in Study Area**

A total of 50 shrimp pitfall traps, were set in various cinder cone areas at selected elevations during the 2012 fieldwork season (Figure 2, Table 2). Sampled areas from 2012 included the main summit region, with permanent monitoring stations at Pu'u Hau Kea, Pu'u Wēkiu, Pu'u Hau Oki, and the Pu'u 's north, south of the VLBA, and Poi Bowl. Other areas sampled included the Thirty Meter Telescope (TMT) site and the batch plant staging area.

### **Wēkiu Bug Collections**

A total of 2,430 wēkiu bugs were collected in early July of 2012 during a total of 300 trap days, for an average catch of 8.1 wēkiu bugs/trap-day (Table 3). The 2012 sampling coincided with sampling done during the summers of 2009 - 2011. Pu'u Hau Kea has been intensively sampled nearly every year since 2001 because of its unaltered habitat and usually high wēkiu bug captures. Wēkiu bug collection data from the Pu'u Hau Kea monitoring station in 2012 is summarized in Table 4.

### **Summary of Alien Arthropod Species Collected in 2012**

The following is a summary of arthropods collected in discrete sampling areas during the 2012 field season, including a brief description of sample location along with any arthropod by-catch found during wēkiu bug collections. Detailed GPS locations and additional information for these sampling sites can be found in Tables 1-4 in the appendices section. Aeolian species found during these surveys are likely not a major threat to native species at this time, and it is likely that resident alien arthropod species have greater potential impacts.

To allow more information to be displayed, we have abbreviated standard entomological terms in the tables. Often it was difficult to determine the status of a particular species, which is why many have question marks next to their habitat and their (end/adv/native/introduced) status. The following abbreviations in the 2012 species tables are based upon Nishida (2002):

end = endemic: native to the Hawaiian Islands, and found only in Hawai'i

ind = indigenous: native to the Hawaiian Islands but can be found elsewhere

adv = adventive: introduced into Hawai'i, most likely accidentally introduced

pur = purposeful introduction: introduced into Hawai'i usually for biological control of insect and plant pests

unk = unknown

Aeolian = species is not a resident of the area where it was collected, but blown up from lower elevations

Resident = lives and reproduces in the area where the species was collected

Below are brief descriptions of the 2012 sample areas followed by a list of species for each area. Areas or sample sites with no insect collections are not included in the list below.

**HP Parking Lot (lower) (Sites 001, 002, 003, 004)**

*Hale Pohaku parking lot area:* Located near the Hale Pohaku living quarters and cafeteria, this area was located at an elevation of approximately 2,850 m. In 2012, there were no alien species of concern found around this area. An agromyzid fly in genus *Phytomyza* and new to the State of Hawaii was collected in large numbers in a pan trap at this site. Their larvae are leaf miners and not any threat to the Wēkiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
ARANEAE	Gnaphosidae	<i>Urozelotes rusticus</i> (L. Koch, 1872)	adv	Resident
ARANEAE	Salticidae	?Genus?species	adv	Resident?
COLEOPTERA	Dermestidae	<i>Dermestes frischii</i> Kugelann, 1792	adv	Resident
COLEOPTERA	Cryptophagidae	<i>Henoticus serratus</i> (Gyllenhal, 1808)	adv	Aeolian
COLEOPTERA	Staphilinidae	?Genus ?species	unk	Resident
DERMAPTERA	Forficulidae	<i>Forficula auricularia</i> Linnaeus, 1758	adv	Resident
DIPTERA	Agromyzidae	<i>Phytomyza</i> sp. not <i>plantaginis</i> or <i>diminuta</i>	adv	Aeolian <b>NEW STATE RECORD</b>
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Drosophilidae	<i>Drosophila</i> sp. <i>suzukii</i> grp.	adv	Aeolian
DIPTERA	Sciaridae	several species	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Resident
HETEROPTERA	Lygaeidae	<i>Geocoris pallens</i> Stål, 1854	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Graptostethu smanillensis</i> (Stal, 1862)	adv	Resident
HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end?	Resident
HYMENOPTERA	Chalcidoidea	several species	adv	Resident
HYMENOPTERA	Colletidae	<i>Hylaeus</i> sp.	end	Resident
HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian
HYMENOPTERA	Sphecidae	<i>Ectemnius</i> sp.	end	Resident
LEPIDOPTERA	Pieridae	<i>Pieris rapae</i> (Linnaeus, 1758)	adv	Aeolian
LEPIDOPTERA	Noctuidae	<i>Agrotis</i> sp.	end	Resident

**Onizuka Visitor Center (Sites 005, 006, 007, 008)**

Sampling took place around the parking lot and around the trashcans at the visitor center; no ants were collected or observed. Salticid spiders were collected here in 2012.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
ARANEAE	Corinnidae	<i>Meriola arcifera</i> (Simon, 1886)	adv	Resident
ARANEAE	Salticidae	?Genus?species	adv	Resident?
COLEOPTERA	Curculionidae	?Genus?species	unk	Resident
DERMAPTERA	Forficulidae	<i>Forficula auricularia</i> Linnaeus, 1758	adv	Resident
DIPTERA	Agromyzidae	<i>Phytomyza</i> sp. not <i>plantaginis</i> or <i>diminuta</i>	adv	Aeolian <b>NEW STATE RECORD</b>
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Muscidae	?Genus?species	unk	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Sciaridae	?Genus ?species	unk	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Resident
HETEROPTERA	Lygaeidae	<i>Geocoris pallens</i> Stål, 1854	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end?	Resident
HOMOPTERA	Psyllidae	?Genus ?species	adv	Aeolian
HYMENOPTERA	Apidae	<i>Apis mellifera</i> Linnaeus, 1758	pur	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian
HYMENOPTERA	Colletidae	<i>Hylaeus</i> sp.	end	Resident
HYMENOPTERA	Ichneumonidae	<i>Ichneumon cupitus</i> Cresson, 1877	adv	Aeolian
HYMENOPTERA	Sphecidae	<i>Ectemnius</i> sp.	end	Resident
LEPIDOPTERA	Noctuidae	<i>Lycophotia porphyrea</i> (Denis & Schiffermuller, 1775)	adv	Resident?

**Pu'u Lilinoe (Site: 200)**

Trap results were negative for this site except for a few unidentified dipterans captured on a sticky trap. No species collected here are a threat to the Wēkiu bug.

**VLBA Parking Lot and Wēkiu trap bycatch (Sites VLBA24, VLBA100 - 104, VLBA105 - 109)**

Two alien species were trapped at the VLBA parking lot (3,725 m elevation), and found in the bycatch of the wēkiu traps placed at one Pu'u north and another south of the VLBA. All species captured were aeolian and no threat the Wēkiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
HOMOPTERA	Psyllidae	?Genus ?species	adv	Aeolian

**Burns Cone Parking Lot (Site BURNS43)**

This area was located at a parking lot at 3,667 m elevation and is near an unnamed cinder cone at the John Burns Highway sign. Sampling at this location consisted of peanut butter traps, glycol pitfall, sticky, and yellow pan traps. Ant traps were negative and no harmful alien species were collected.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Muscidae	several species	unk	Aeolian
DIPTERA	Scarcophagidae	several species	unk	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end?	Resident
HOMOPTERA	Psyllidae	?Genus ?species	end	Aeolian

**Batch Plant Parking Lot (trailhead area to Lake Waiau) (Sites 048, 049, 050, 051)**

The batch plant parking lot is a large, flat, graded area at approximately 4,063–4,105 m elevation, adjacent to the base of Pu'u Hau Kea. This area is also used as a parking lot for visitor day hikes to Lake Waiau. No harmful introduced species were found during the 2012 summer trapping season. Several Wēkiu bugs were captured in traps at this site.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
COLEOPTERA	Cleridae	<i>Necrobia rufipes</i> (De Geer, 1775)	adv	Aeolian
COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin-Méneville, 1843	pur	Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Calliphoridae	?Genus, ?species A	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Muscidae	?Genus ?species	unk	Aeolian
DIPTERA	Sarcophagidae	several species	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Sphaeroceridae	several species	adv	Aeolian
DIPTERA	Syrphidae	<i>Simosyrphus grandicornis</i> (Macquart, 1842)	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
DIPTERA	Tachinidae	several species	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Graptostethus manillensis</i> Stål, 1859)	adv	Resident
HETEROPTERA	Lygaeidae	<i>Nysius wekiuicola</i> Ashlock and Gagné	end	Resident 3 adults, 1 immature
HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end?	Resident
HETEROPTERA	Lygaeidae	<i>Geocoris pallens</i> Stål, 1854	adv	Aeolian
HOMOPTERA	Psyllidae	?Genus ?species	unk	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> (several spp.)	adv	Aeolian
HYMENOPTERA	Braconidae	?Genus ?species	unk	Aeolian
HYMENOPTERA	Pompilidae	<i>Anoplius toluca</i> (Cameron, 1893)	adv	Aeolian

**Pu'u Hau Kea (Sites 009, 010, 011, 012, 013, 014, 015, 016, 018)**

This cinder cone was part of our annual wēkiu bug monitoring. Bycatch of native and alien arthropod species were found in wēkiu bug shrimp traps during the 2012 trapping season. Bycatch diversity as well as species numbers were very low compared to previous trapping seasons. No harmful alien arthropod species were collected here. The dermestid beetle and calliphorid flies were probably attracted to the rotting shrimp paste used as bait in the wēkiu bug traps.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
ARANEAE	Lycosidae	<i>Lycosa hawaiiensis</i> Simon, 1899	end	Resident
COLEOPTERA	Dermestidae	<i>Dermestes frischii</i> Kugelann, 1792	adv	Resident
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian

**Lake Waiau (Site Waiau7)**

Although part of the Natural Area Reserve and not in the Science Reserve, Lake Waiau continued to be monitored in 2012 because the waters of Lake Waiau serve as an attractant to aeolian arthropods that can remain active during the warmer daytime hours however, it is unlikely that any of the alien (adv/pur) species shown below can withstand the near-daily freezing temperatures at the 4,000 m elevation. While turning over large rocks and small boulders in a grassy area 10 m from the shoreline of Lake Waiau, 3 small carabid beetles were collected. The carabid specimens were tentatively determined to be *Trechus obtusus* Erichson, 1837 and subsequently confirmed by G.A. Samuelson, BPBM. This predatory beetle represents a new record for the Big Island of Hawaii (Evenhuis & Imada 2013). The predatory carabid beetle species (*Agonum muelleri*) was not collected or observed at the Lake Waiau site or nearby areas in 2012. Specimens of this alien ground beetle were collected during the 2009 and 2011 trapping seasons suggesting that they may be an established resident at the lake. This species is of potential concern as its dietary habits overlap with that of the wēkiu bug. Negative results for this alien predator at Lake Waiau were a welcomed event. However, while searching at lower elevations during a break from the summit surveys, a single specimen of *A. muelleri* was collected at the 6600' elevation extending its range (Evenhuis & Imada 2013).

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
COLEOPTERA	Carabidae	<i>Trechus obtusus</i> Erichson, 1837	adv	Resident
COLEOPTERA	Coccinellidae	<i>Coccinella septempunctata</i> Linnaeus 1758	pur	Aeolian
COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin-Ménéville, 1843	pur	Aeolian
COLEOPTERA	Staphylinidae	<i>Creophilus maxillosus</i> (Linnaeus, 1758)	adv	Resident
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Phoridae	?Genus ?species	unk	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1883	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)	adv	Aeolian

HETEROPTERA	Rhopalidae	<i>Liorhyssus hyalinus</i> (Fabricius, 1794)	adv	Resident
HOMOPTERA	Psyllidae	?Genus ?species	unk	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian
HYMENOPTERA	Ichneumonidae	<i>Diadegma blackburni</i> (Cameron, 1883)	adv	Aeolian
HYMENOPTERA	Ichneumonidae	<i>Ichneumon purpuripennis</i> Cresson, 1877	pur	Aeolian 4- found under rock

**Pu'u Wēkiu (Sites 029-038, 042)**

In 2012 traps were placed around the weather station area that was operating in the bottom of Pu'u Wēkiu crater. All arthropods collected in this area were aeolian species and not considered a threat to the wēkiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Calliphoridae	?Genus, ?species B	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1883	adv	Aeolian
HOMOPTERA	Psyllidae	?Genus ?species	end	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian
HYMENOPTERA	Ichneumonidae	<i>Diadegma blackburni</i> (Cameron, 1883)	adv	Aeolian

**Pu'u Poliahu (Sites 019–023)**

Five wēkiu bug pitfall traps were placed here. The volume of bycatch at Pu'u Poliahu was unusually low compared to the catch in 2011 with only a single muscid fly species collected. Muscid flies are not a threat to the Wēkiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian

**Poi Bowl (Sites 121-125)**

Poi Bowl is the locally named bowl-shaped ski slope area behind the Subaru and Keck telescopes, and is a known area of high wēkiu bug concentration. This area was sampled with five wēkiu bug pitfall traps. The bycatch results here were similar to Pu'u Poliahu. Only 2 alien species were collected compared to more than 16 species in 2011. No alien species of concern were found at Poi Bowl in 2012.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1883	adv	Aeolian

**Pu'u Hau Oki and around Keck Observatory (Sites 025–028, 112)**

The uppermost slopes of this cinder cone contain the Keck and Subaru Observatories. Trapping here included using alien arthropod insect traps placed near the Keck Observatory as well as wēkiu bug traps placed at selected areas of the cinder cone. There were 14 wēkiu bugs as well as 9 alien arthropod species collected in an alien pitfall trap placed near a staircase at the Keck observatory. No alien species of concern were collected in 2012.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin-Méneville, 1843	pur	Aeolian
COLEOPTERA	Coccinellidae	<i>Coccinella septempunctata</i> Linnaeus 1758	pur	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Geocoris pallens</i> Stål, 1854	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Nysius wekiuicola</i> Ashlock and Gagné	end	Resident 2 adults, 12 immature
HOMOPTERA	Psyllidae	?Genus ?species	end	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian

**Summit Lunchroom (Site 110)**

The area sampled here included areas inside and around the summit lunchroom building at 4223 m elevation. Insect traps were placed around the building, inside the building on trashcans, and in a long underground hallway area. Results were negative for ants and no species collected are a threat to the Wekiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	?Genus ?species	unk	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
DIPTERA	Tachinidae	?Genus ?species	adv	Aeolian
HOMOPTERA	Psyllidae	?Genus ?species	end	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian

**Gemini Telescope (Site 111)**

The Gemini telescope observatory building area was sampled with a variety of insect traps within a 0–5 m distance of the observatory buildings. It was no surprise that two wēkiu bugs were collected in our traps, because they were set a short distance from known wēkiu bug habitat. The remainder of the arthropod species collected here in 2012 was aeolian and not considered a threat to the Wekiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin-Méneville, 1843	pur	Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	?Genus ?species	unk	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Phoridae	?Genus ?species	unk	Aeolian
DIPTERA	Sarcophagidae	several species	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Nysius wekiuicola</i>	end	Resident
HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end	Aeolian
HOMOPTERA	Psyllidae	? <i>Trioza</i> sp.	end	Aeolian

**Thirty Meter Telescope area (Sites 39, 40, 41)**

This area is in the flats region within the Thirty Meter Telescope (TMT) site. Wēkiu bugs have never been collected in or around the TMT site because it lies in a heavily glaciated region (Englund *et al.* 2007). In 2012 a comprehensive arthropod survey was again conducted here, including glycol pitfall and other various insect traps. Only one resident species was collected here, the large native *Lycosa* spider. Baited ant traps were negative at the TMT site. Except for the resident native lycosid spider all other species collected are aeolian and not considered a threat to the wēkiu bug.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
ARANEAE	Lycosidae	<i>Lycosa hawaiiensis</i> Simon, 1899	end	Resident
COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin-Méneville, 1843	pur	Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Muscoidea	?Genus ?species	unk	Aeolian
DIPTERA	Phoridae	?Genus ?species	unk	Aeolian
DIPTERA	Sarcophagidae	several species	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Geocoris pallens</i> Stål, 1854	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end	Aeolian
HOMOPTERA	Psyllidae	?Genus ?species	unk	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles</i> several spp.	adv	Aeolian



**Pu'u Pohaku (Sites 115–120)**

This sample area is located in the Mauna Kea Natural Area Reserve. As in previous surveys two sets of alien arthropod traps were used in 2012 at this cinder cone. One set was placed at the base of the cinder cone, and the other set of traps near the summit around the intermittent Henderson Lake. No wēkiu bugs were captured at Pu'u Pohaku. Bycatch from the wēkiu bug traps at Pu'u Pohaku are listed below.

order	family	genus-species-author	end/ind/adv/pur/unk	Resident/Aeolian
COLEOPTERA	Coccinellidae	<i>Coccinella septempunctata</i> Linnaeus 1758	pur	Aeolian
COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin- Ménéville, 1843	pur	Aeolian
COLEOPTERA	Cleridae	<i>Necrobia rufipes</i> (De Geer, 1775)	adv	Aeolian
DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
DIPTERA	Muscidae	<i>Neomyia cornicina</i> (Fabricius, 1782)	adv	Aeolian
DIPTERA	Muscidae	?Genus ? species	unk	Aeolian
DIPTERA	Phoridae	?Genus ?species	unk	Aeolian
DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
DIPTERA	Sepsidae	<i>Sepsis thoracica</i> (Robineau- Desvoidy, 1830)	adv	Aeolian
DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
HETEROPTERA	Lygaeidae	<i>Nysius sp.</i>	end	Aeolian
HOMOPTERA	Psyllidae	?Genus ?species	unk	Aeolian
HYMENOPTERA	Braconidae	<i>Apanteles sp.</i>	adv	Aeolian
HYMENOPTERA	Ichneumonidae	<i>Ichneumon cupitus</i> Cresson, 1877	adv	Aeolian
HYMENOPTERA	Pompilidae	<i>Anoplius toluca</i> (Cameron, 1893)	adv	Aeolian

## Introduced Species of Concern and Potential Threats to Wēkiu Bugs

Alien ant species remain the greatest potential threat to wēkiu bugs at the Mauna Kea summit area. Argentine ants (*Linepithema humile*) are currently found at Haleakalā National Park, Maui in elevational ranges close to overlapping with that of the lower distribution of wēkiu bugs (Krushelnycky *et al.* 2005). At Haleakalā National Park ant invasions have been documented to decrease native arthropod species diversity, with native predators such as the large endemic wolf spider (*Lycosa* sp.) rapidly declining in the face of ant invasions (Krushelnycky and Gillespie 2008). Ants are also implicated in the decline of the rare flightless *Thyrocopa apatela* moth found around the summit area of Haleakalā crater, and a closely related flightless species (*Thyrocopa kikaeleka*) was recently described from the Mauna Kea summit region in 2008 (Medeiros 2008). The potential for ant invasion to the Mauna Kea summit region is high, as ants are abundant along the Saddle Road area around the Pu'u Huluhulu turnoff (Evenhuis *et al.* 1996). The European earwig was again very common in 2012. It is predatory and a scavenger, and thus also has the potential to interact negatively with wēkiu bugs. These earwigs have not been found above the Hale Pohaku area and apparently are unable to handle the harsher summit conditions. However, changes in climate could see this predator increase its elevational range. The predatory ground beetle (*Trehus obtusus*) was found in the Lake Waiau area and may present a threat to the wēkiu bugs as well as other native arthropods in the area. Monitoring for *T. obtusus* at Lake Waiau and nearby areas should be continued. The alien carabid beetle (*Agonum muelleri*) collected in previous surveys at lake Waiau was not collected in 2012. The first specimen of *A. muelleri* was collected by Steven L. Montgomery in 2006 in a Berlese funnel from material collected near a snowbank at the University of Hawaii's 2.2 meter telescope at the Mauna Kea summit (Liebherr *et al.* 2009), but all other specimens since that time have only been collected around the Lake Waiau shoreline with the exception of a single specimen collected at the 6600' elevation along Mana road during the 2012 surveys.

An endemic wolf spider (*Lycosa* sp.) is also found at Mauna Kea and is one of the top predators of the summit region, and along with the wēkiu bug would be negatively impacted if ants were to become established. Because wēkiu bugs are much more restricted in their habitat choice than the wider ranging native wolf spiders, it is expected that wēkiu bugs would be even more vulnerable to ant invasions than the spiders. No new species of alien spiders were found during the 2012 fieldwork.

Continued monitoring and a rapid response to any ant introductions at the summit areas, including roadways leading to and around the science reserve should continue. The European earwig mentioned above is predatory and may have the potential to interact negatively with wēkiu bugs at their lowest elevational range. Earwigs have not yet been found above the Hale Pohaku area but as climate patterns change conditions could allow this predator to expand their range to higher elevations. The flightless moth (*Thyrocopa kikaeleka*) collected or observed in previous years was not seen or collected in 2012. There is some concern that the consistently high densities of European earwigs at the Hale Pohaku area may be impacting this rare endemic moth. Additional monitoring of the earwig is necessary to determine what if any impact this species has on the native moth as well as other native species.

## Acknowledgments

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**APPENDIX A: FIGURES**

Figure 1. Overall study area for alien arthropod species sampling conducted during the 2011 field season.

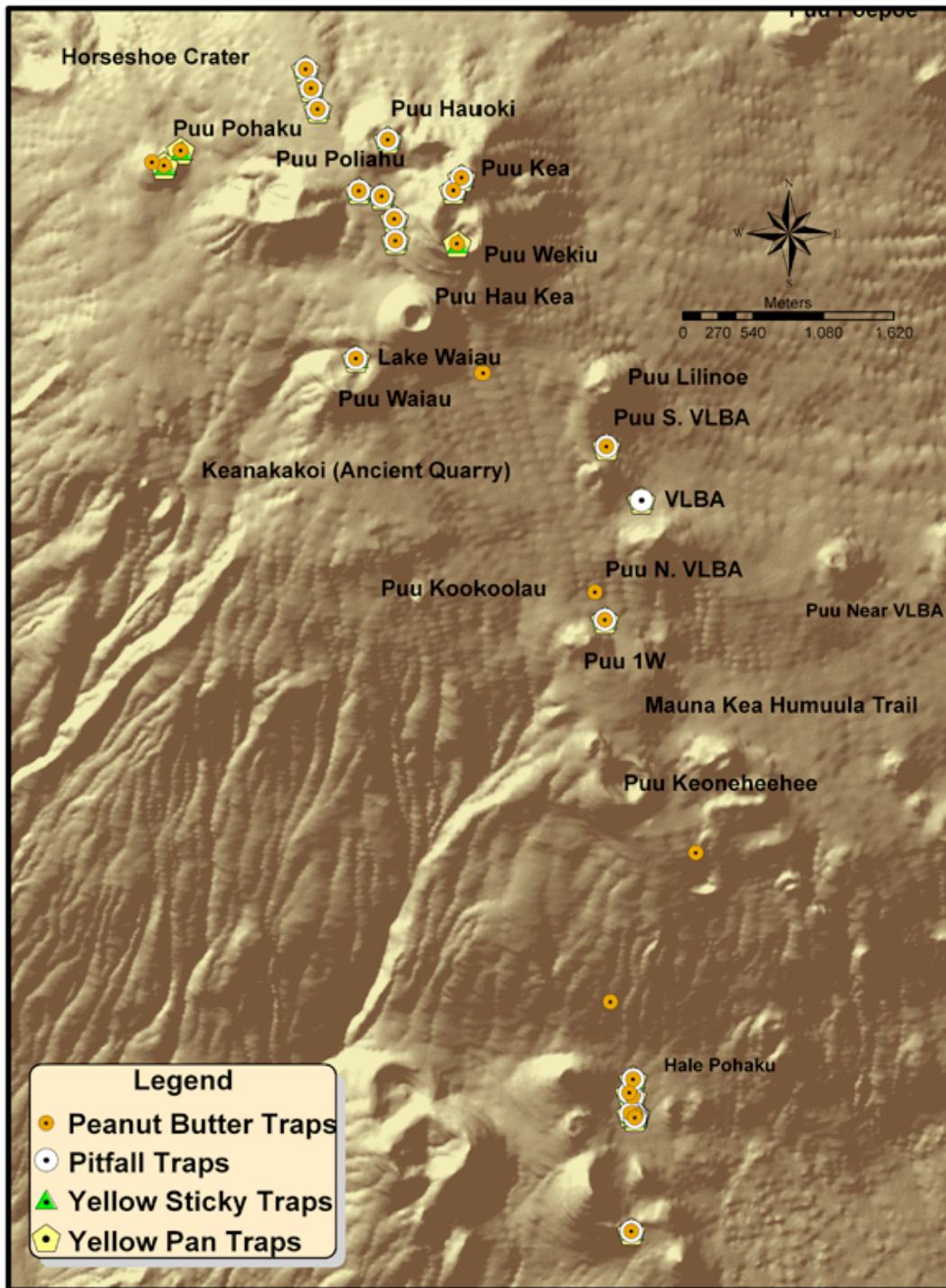


Figure 2. Overall study area for wēkiu bug sampling conducted during the 2011 field season.

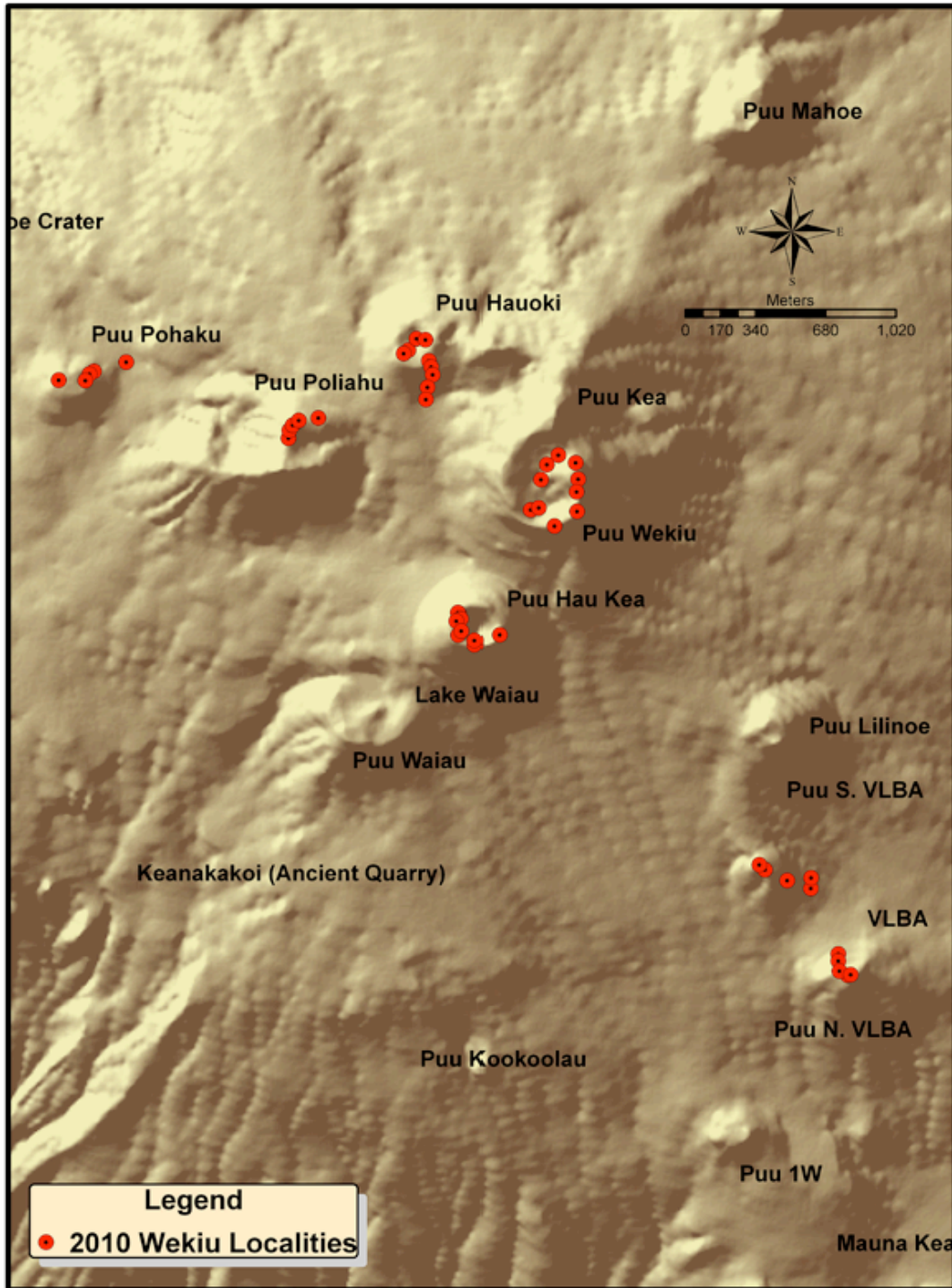
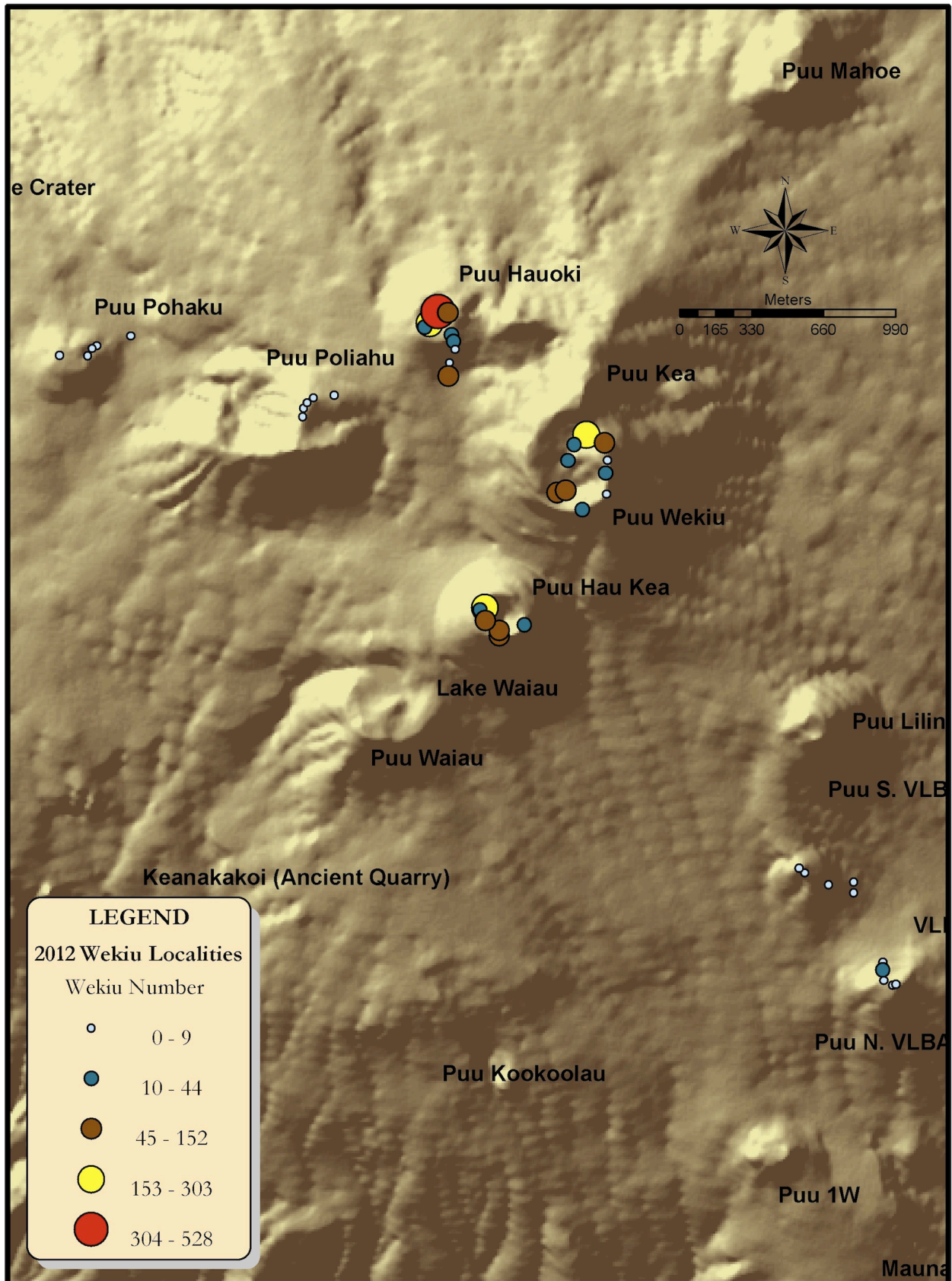




Figure 3. Wēkiu bug concentrations during the 2011 field season.



**APPENDIX B: TABLES**

**2012**

**Table 1.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat/Area	Trap type
001	Hale Pohaku	5-14. VII 2012	2851	19.76059 N 155.45604 W	Parking (Lower)	Pitfall
001	Hale Pohaku	5-14. VII 2012	2851	19.76059 N 155.45604 W	Parking (Lower)	Peanut butter
001	Hale Pohaku	5-14. VII 2012	2851	19.76059 N 155.45604 W	Parking (Lower)	Yellow pan
001	Hale Pohaku	5-14. VII 2012	2851	19.76059 N 155.45604 W	Parking (Lower)	Sticky trap
002	Hale Pohaku	5-14. VII 2012	2853	19.76086 N 155.45627 W	Parking- Side opposite Kitchen	Peanut Butter
002	Hale Pohaku	5-14. VII 2012	2853	19.76086 N 155.45627 W	Parking- Side opposite Kitchen	Sticky Trap
002	Hale Pohaku	5-14. VII 2012	2853	19.76086 N 155.45627 W	Parking- Side opposite Kitchen	Pitfall
002	Hale Pohaku	5-14. VII 2012	2853	19.76086 N 155.45627 W	Parking- Side opposite Kitchen	Yellow Pan
003	Hale Pohaku	5-14. VII 2012	2865	19.76131 N 155.45598 W	Parking lot- Next to Kitchen	Peanut Butter
003	Hale Pohaku	5-14. VII 2012	2865	19.76131 N 155.45598 W	Parking lot- Next to Kitchen	Sticky Trap
003	Hale Pohaku	5-14. VII 2012	2865	19.76131 N 155.45598 W	Parking lot- Next to Kitchen	Pitfall
003	Hale Pohaku	5-14. VII 2012	2865	19.76131 N 155.45598 W	Parking lot- Next to Kitchen	Yellow Pan
004	Hale Pohaku	5-14. VII 2012	2868	19.76180 N 155.45601 W	Near the staircase to the Machine shop	Peanut Butter
004	Hale Pohaku	5-14. VII 2012	2868	19.76180 N 155.45601 W	Near the staircase to the Machine shop	Sticky Trap
004	Hale Pohaku	5-14. VII 2012	2868	19.76180 N 155.45601 W	Near the staircase to the Machine shop	Pitfall
004	Hale Pohaku	5-14. VII 2012	2868	19.76180 N 155.45601 W	Near the staircase to the Machine shop	Yellow Pan

**Table 1.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat/Area	Trap type
005	Onizuka Visitor Center	5-14. VII 2012	2832	19.75933 N. 155.45576W	Picnic tables/trash cans	Peanut Butter
005	Onizuka Visitor Center	5-14. VII 2012	2832	19.75933 N. 155.45576W	Picnic tables/trash cans	Sticky Trap
005	Onizuka Visitor Center	5-14. VII 2012	2832	19.75933 N. 155.45576W	Picnic tables/trash cans	Pitfall
005	Onizuka Visitor Center	5-14. VII 2012	2832	19.75933 N. 155.45576W	Picnic tables/trash cans	Yellow Pan
006	Onizuka Visitor Center	5-14. VII 2012	2833	19.75941 N 155.45587W	Uphill side of parking lot near lightpole	Peanut Butter
006	Onizuka Visitor Center	5-14. VII 2012	2833	19.75941 N 155.45587W	Uphill side of parking lot near lightpole	Sticky Trap
006	Onizuka Visitor Center	5-14. VII 2012	2833	19.75941 N 155.45587W	Uphill side of parking lot near lightpole	Pitfall
006	Onizuka Visitor Center	5-14. VII 2012	2833	19.75941 N 155.45587W	Uphill side of parking lot near lightpole	Yellow Pan
007	Onizuka Visitor Center-	5-14. VII 2012	2833	19.75944 N 155.45616 W	Above parking lot by mamane trees	Peanut Butter
007	Onizuka Visitor Center	5-14. VII 2012	2833	19.75944 N 155.45616 W	Above parking lot by mamane trees	Sticky Trap
007	Onizuka Visitor Center	5-14. VII 2012	2833	19.75944 N 155.45616 W	Above parking lot by mamane trees	Pitfall
007	Onizuka Visitor Center-	5-14. VII 2012	2833	19.75944 N 155.45616 W	Above parking lot by mamane trees	Yellow Pan
008	Onizuka Visitor Center-	5-14. VII 2012	2831	19.75915 N 155.45584 W	Mamane Grove immediately by bathroom area	Peanut Butter
008	Onizuka Visitor Center	5-14. VII 2012	2831	19.75915 N 155.45584 W	Mamane Grove immediately by bathroom area	Sticky Trap

**Table 1.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat/Area	Trap type
008	Onizuka Visitor Center	5-14. VII 2012	2831	19.75915 N 155.45584 W	Mamane Grove immediately by bathroom area	Pitfall
008	Onizuka Visitor Center-	5-14. VII 2012	2831	19.75915 N 155.45584 W	Mamane Grove immediately by bathroom area	Yellow Pan
Waiau 7	Lake Waiau	6-12. VII. 2012	3990	19.81122 N 155.47691 W	Near the Shoreline	Peanut Butter
Waiau 7	Lake Waiau	6-12. VII. 2012	3990	19.81122 N 155.47691 W	Near the Shoreline	Sticky Trap
Waiau 7	Lake Waiau	6-12. VII. 2012	3990	19.81122 N 155.47691 W	Near the Shoreline	Pitfall
Waiau 7	Lake Waiau	6-12. VII. 2012	3990	19.81122 N 155.47691 W	Near the Shoreline	Yellow Pan
PB 001	10, 000 ft. Marker	6-12. VII. 2012	3032	19.76710 N 155.45775 W	Roadside in cobble/cinder/sand	Peanut Butter
PB 002	11, 000 ft. Marker	6-12. VII. 2012	3390	19.77748 N 155.45166 W	Roadside in cobble/cinder/sand	Peanut Butter
PB 003	12, 000 ft. Marker	6-12. VII. 2012	3658	19.79535 N 155.45930 W	Cobble/cinder behind boulder	Peanut Butter
PB 004	13, 000 ft. Marker	6-12. VII. 2012	3932	19.81034 N 155.46770 W	Roadside in cobble/cinder on slope	Peanut Butter
048	Batch Plant Area- by Maxwell	6-12. VII. 2012	4106	19.82279 N 155.47687 W	cobble/gravel/sand	Sticky
048	Batch Plant Area- by Maxwell	6-12. VII. 2012	4106	19.82279 N 155.47687 W	cobble/gravel/sand	Peanut Butter
048	Batch Plant Area- by Maxwell	6-12. VII. 2012	4106	19.82279 N 155.47687 W	cobble/gravel/sand	Pitfall
048	Batch Plant Area- by Maxwell	6-12. VII. 2012	4106	19.82279 N 155.47687 W	cobble/gravel/sand	Yellow Pan

**Table 1.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat/Area	Trap type
049	Batch Plant Area- Cal Tech side	6-12. VII. 2012	4100	19.82243 N 155.47520 W	Large cobble on flat area with cinder and gravel	Pitfall
049	Batch Plant Area- Cal Tech side	6-12. VII. 2012	4056	19.81976 N 155.47408 W	Large cobble on flat area with cinder and gravel	Sticky
049	Batch Plant Area- Cal Tech side	6-12. VII. 2012	4056	19.81976 N 155.47408 W	Large cobble on flat area with cinder and gravel	Peanut Butter
049	Batch Plant Area- Cal Tech side	6-12. VII. 2012	4056	19.81976 N 155.47408 W	Large cobble on flat area with cinder and gravel	Yellow Pan
050	Batch Plant Area- midway below Cal Tech	6-12. VII. 2012	4082	19.82089 N 155.47426 W	Among boulders adjacent to main rd. on cindery substrate	Yellow Pan
050	Batch Plant Area- midway below Cal Tech	6-12. VII. 2012	4082	19.82089 N 155.47426 W	Among boulders adjacent to main rd. on cindery substrate	Sticky
050	Batch Plant Area- midway below Cal Tech	6-12. VII. 2012	4082	19.82089 N 155.47426 W	Among boulders adjacent to main rd. on cindery substrate	Peanut Butter
050	Batch Plant Area- midway below Cal Tech	6-12. VII. 2012	4082	19.82089 N 155.47426 W	Among boulders adjacent to main rd. on cindery substrate	Pitfall
051	Batch Plant Area- adjacent to portable toilets	6-12. VII. 2012	4064	19.81938 N 155.47415 W	On ground - sand area adjacent to guardrail on downhill side of toilets	Yellow Pan
051	Batch Plant Area- adjacent to portable toilets	6-12. VII. 2012	4064	19.81938 N 155.47415 W	On ground - sand area adjacent to guardrail on downhill side of toilets	Sticky

**Table 1.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS (N) WGS 84	GPS (W) WGS 84	Habitat	Trap type
051	Batch Plant Area- adjacent to portable toilets	6-12. VII. 2012	4064	19.81938 N 155.47415 W		On ground - sand area adjacent to guardrail on downhill side of toilets	Peanut Butter
042	Pu'u Wēkiu: by weather station	7-13. VII. 2012	4148	19.81924° N 155.46964°W		crater floor by weather station, cobbly, some cinder	Yellow Pan
042	Pu'u Wēkiu: by weather station	7-13. VII. 2012	4148	19.81924° N 155.46964°W		crater floor by weather station, cobbly, some cinder	Sticky
042	Pu'u Wēkiu: by weather station	7-13. VII. 2012	4148	19.81924° N 155.46964°W		crater floor by weather station, cobbly, some cinder	Peanut Butter
024	VLBA Facility Parking Lot	7-13. VII. 2012	3753	19.80174°N 155.45601		parking lot	Pitfall
024	VLBA Facility Parking Lot	7-13. VII. 2012	3753	19.80174°N 155.45601		parking lot	Peanut Butter
024	VLBA Facility Parking Lot	7-13. VII. 2012	3753	19.80174°N 155.45601		parking lot	Sticky
024	VLBA Facility Parking Lot	7-13. VII. 2012	3753	19.80174°N 155.45601		parking lot	Yellow Pan
200	Pu'u noe	7-13. VII. 2012	3824	19.80541°N 155.45863°W		sandy glaciated valley floor	Yellow Pan
200	Pu'u Lilinoe	7-13. VII. 2012	3824	19.80541°N 155.45863°W		sandy glaciated valley floor	Sticky

**Table 1. cont.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat	Trap type
200	Pu'u Lilinoe	7-13.VII.2012	3824	19.80541°N 155.45863°W	sandy glaciated valley floor	Peanut Butter
200	Pu'u Lilinoe	7-13.VII.2012	3824	19.80541°N 155.45863°W	sandy glaciated valley floor	Yellow Pan
110	Summit Lunchroom	7-13.VII.2012	4223	19.82292°N 155.46996°W	food service building area	Peanut Butter
110	Summit Lunchroom	7-13.VII.2012	4223	19.82292°N 155.46996°W	food service building area	Pitfall
110	Summit Lunchroom	7-13.VII.2012	4223	19.82292°N 155.46996°W	food service building area	Sticky
110	Summit Lunchroom	7-13.VII.2012	4223	19.82292°N 155.46996°W	food service building area	Yellow Pan
111	Gemini Scope	7-13.VII.2012	4213	19.82379°N 155.46938°W	cobble	Peanut Butter
111	Gemini Scope	7-13.VII.2012	4213	19.82379°N 155.46938°W	cobble	Pitfall
111	Gemini Scope	7-13.VII.2012	4213	19.82379°N 155.46938°W	cobble	Sticky
111	Gemini Scope	7-13.VII.2012	4213	19.82379°N 155.46938°W	cobble	Yellow Pan
112	Keck	7-13.VII.2012	4174	19.82637°N 155.47481°W	by back staircase of Keck	Peanut Butter
112	Keck	7-13.VII.2012	4174	19.82637°N 155.47481°W	by back staircase of Keck	Pitfall
112	Keck	7-13.VII.2012	4174	19.82637°N 155.47481°W	by back staircase of Keck	Sticky
112	Keck	7-13.VII.2012	4174	19.82637°N 155.47481°W	by back staircase of Keck	Yellow Pan



**Table 1. cont.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat	Trap type
039	Thirty Meter Scope	8-14.VII.2012	4044	19.83112°N 155.48088°W	glaciated rock area	Peanut Butter
039	Thirty Meter Scope	8-14.VII.2012	4044	19.83112°N 155.48088°W	glaciated rock area	Pitfall
039	Thirty Meter Scope	8-14.VII.2012	4044	19.83112°N 155.48088°W	glaciated rock area	Sticky
039	Thirty Meter Scope	8-14.VII.2012	4044	19.83112°N 155.48088°W	glaciated rock area	Yellow Pan
040	Thirty Meter Scope	8-14.VII.2012	4058	19.82981°N 155.48047°W	glaciated valley floor area	Pitfall
040	Thirty Meter Scope	8-14.VII.2012	4058	19.82981°N 155.48047°W	glaciated valley floor area	Yellow Pan
040	Thirty Meter Scope	8-14.VII.2012	4058	19.82981°N 155.48047°W	glaciated valley floor area	Sticky
040	Thirty Meter Scope	8-14.VII.2012	4058	19.82981°N 155.48047°W	glaciated valley floor area	Peanut Butter
041	Thirty Meter Scope	8-14.VII.2012	4068	19.82838°N 155.47997°W	glaciated valley floor area	Pitfall
041	Thirty Meter Scope	8-14.VII.2012	4068	19.82838°N 155.47997°W	glaciated valley floor area	Yellow Pan
041	Thirty Meter Scope	8-14.VII.2012	4068	19.82838°N 155.47997°W	glaciated valley floor area	Sticky
041	Thirty Meter Scope	8-14.VII.2012	4068	19.82838°N 155.47997°W	glaciated valley floor area	Peanut Butter
043	Burns Cone	8-14.VII.2012	3667	19.79345°N 155.45845°W	glaciated valley floor area	Pitfall
043	Burns Cone	8-14.VII.2012	3667	19.79345°N 155.45845°W	glaciated valley floor area	Yellow Pan

**Table 1. cont.** Alien arthropod sampling locations for the 2012 field season.

Site Number	Locality	Date	Elevation in meters	GPS WGS 84	Habitat	Trap type
043	Burns Cone	8-14.VII.2012	3667	19.79345°N 155.45845°W	glaciated valley floor area	Sticky
043	Burns Cone	8-14.VII.2012	3667	19.79345°N 155.45845°W	glaciated valley floor area	Peanut Butter
114	Pu'u Pohaku	8-14.VII.2012	4001	19.82538°N 155.48994°W	outer slope, cobbly	Peanut Butter
114	Pu'u Pohaku	8-14.VII.2012	4001	19.82538°N 155.48994°W	outer slope, cobbly	Yellow Pan
114	Pu'u Pohaku	8-14.VII.2012	4001	19.82538°N 155.48994°W	outer slope, cobbly	Sticky
119	Pu'u Pohaku	8-14.VII.2012	4033	19.82432°N 155.49113°W	flat cobble section where "lake" occurs	Peanut Butter
119	Pu'u Pohaku	8-14.VII.2012	4033	19.82432°N 155.49113°W	flat cobble section where "lake" occurs	Yellow Pan
119	Pu'u Pohaku	8-14.VII.2012	4033	19.82432°N 155.49113°W	flat cobble section where "lake" occurs	Sticky

**Table 2.** Wēkiu bug trap sites and capture data from the 2012 field season.

Sample Number	Cinder Cone	Date	Elevation in Meters	GPS WGS 84	Wēkiu #'s	Trap Type
009	Pu'u Hau Kea-Poliahu side	6-12.VII. 2012	4124	19.81455 N 155.47333 W	9	Wēkiu bug
010	Pu'u Hau Kea- Just below the rim	6-12.VII. 2012	4120	19.81463 N 155.47339 W	3	Wēkiu bug
011	Pu'u Hau Kea- Inside Crater	6-12.VII. 2012	4116	19.81436 N 155.47325 W	176	Wēkiu bug
012	Pu'u Hau Kea- Cinder-crater rim-Keck side	6-12.VII. 2012	4125	19.81426 N 155.47346 W	16	Wēkiu bug
013	Pu'u Hau Kea	6-12.VII. 2012	4118	19.81383 N 155.47322 W	127	Wēkiu bug
014	Pu'u Hau Kea	6-12.VII. 2012	4128	19.81365 N 155.47336 W	8	Wēkiu bug
015	Pu'u Hau Kea	6-12.VII. 2012	4124	19.81323 N 155.47261 W	70	Wēkiu bug
016	Pu'u Hau Kea	6-12.VII. 2012	4115	19.81342 N 155.47261 W	131	Wēkiu bug
017	Pu'u Hau Kea	6-12.VII. 2012	4116	19.81358 N 155.47192 W	152	Wēkiu bug
018	Pu'u Hau Kea	6-12.VII. 2012	4126	19.81368 N 155.47151 W	28	Wēkiu bug
019	Pu'u Poliahu	6-12.VII. 2012	4150	19.82215 N 155.48135 W	1	Wēkiu bug
020	Pu'u Poliahu	6-12.VII. 2012	4152	19.82250 N 155.48131 W	1	Wēkiu bug
021	Pu'u Poliahu	6-12.VII. 2012	4162	19.82272 N 155.48116 W	0	Wēkiu bug
022	Pu'u Poliahu	6-12.VII. 2012	4160	19.82294 N 155.48088 W	0	Wēkiu bug
023	Pu'u Poliahu	6-12.VII. 2012	4139	19.82306 N 155.47998 W	1	Wēkiu bug
025	Pu'u Hau Oki	7-13.VII. 2012	4151	19.82608°N 155.47586°W	230	Wēkiu bug
026	Pu'u Hau Oki	7-13.VII. 2012	4164	19.82593°N 155.47607°W	14	Wēkiu bug
26A = 008	Pu'u Hau Oki	7-13.VII. 2012	4144	19.82659°N 155.47549°W	303	Wēkiu bug
027	Pu'u Hau Oki	7-13.VII. 2012	4171	19.82628°N 155.47493°W	528	Wēkiu bug
028	Pu'u Hau Oki	7-13.VII. 2012	4162	19.82654°N 155.47507°W	88	Wēkiu bug
029	Pu'u Wēkiu: inner slope	7-13.VII. 2012	4196	19.82158°N 155.46893°W	174	Wēkiu bug
030	Pu'u Wēkiu: outer slope	7-13.VII. 2012	4214	19.82126°N 155.46812°W	75	Wēkiu bug
031	Pu'u Wēkiu	7-13.VII. 2012	4225	19.82054°N 155.46799°W	5	Wēkiu bug
032	Pu'u Wēkiu: inside slope on ahu side	7-13.VII. 2012	4215	19.81999°N 155.46806°W	16	Wēkiu bug
033	Pu'u Wēkiu: outer slope	7-13.VII. 2012	4207	19.81913°N 155.46802°W	2	Wēkiu bug

**Table 2.** Cont. Wēkiu bug trap sites and capture data from the 2012 field season.

Sample Number	Cinder Cone	Date	Elevation in Meters	GPS WGS 84	Wēkiu #'s	Trap Type
034	Pu'u Wēkiu: outer slope	7-13.VII. 2012	4186	19.81848°N 155.46906°W	14	Wēkiu bug
035	Pu'u Wēkiu: inner crater 2/3 down	7-13.VII. 2012	4159	19.81917°N 155.47017°W	59	Wēkiu bug
036	Pu'u Wēkiu, crater floor	7-13.VII. 2012	4148	19.81927°N 155.46980°W	108	Wēkiu bug
037	Pu'u Wēkiu	7-13.VII. 2012	4178	19.82050°N 155.46971°W	17	Wēkiu bug
038	Pu'u Wēkiu	7-13.VII. 2012	4183	19.82116°N 155.46945°W	14	Wēkiu bug
115	Pu'u Pohaku, base nr. weather station	8-14.VII. 2012	4004	19.82538°N 155.48991°W	0	Wēkiu bug
116	Pu'u Pohaku, outer slope near drainage	8-14.VII. 2012	4026	19.82495°N 155.49039°W	3	Wēkiu bug
117	Pu'u Pohaku, slope adjacent to drainage	8-14.VII. 2012	4035	19.82483°N 155.49059°W	0	Wēkiu bug
118	Pu'u Pohaku, flat top of Pu'u	8-14.VII. 2012	4036	19.82454°N 155.49078°W	2	Wēkiu bug
120	Pu'u Pohaku, summit slope	8-14.VII. 2012	4044	19.82454°N 155.49202°W	2	Wēkiu bug
121	Poi Bowl - right behind Keck	8-14.VII. 2012	4168	19.82563°N 155.47490°W	44	Wēkiu bug
122	Poi Bowl	8-14.VII. 2012	4153	19.82536°N 155.47479°W	13	Wēkiu bug
123	Poi Bowl - mid-way down	8-14.VII. 2012	4144	19.82502°N 155.47472°W	8	Wēkiu bug
124	Poi Bowl	8-14.VII. 2012	4123	19.82447°N 155.47495°W	8	Wēkiu bug
125	Poi Bowl	8-14.VII. 2012	4105	19.82393°N 155.47501°W	62	Wēkiu bug
VLBAN 100	Pu'u N. VLBA	7-13.VII. 2012	3776	19.80279°N 155.45695°W	1	Wēkiu bug
VLBAN 101	Pu'u N. VLBA	7-13.VII. 2012	3819	19.80312°N 155.45805°W	3	Wēkiu bug
VLBAN 102	Pu'u N. VLBA	7-13.VII. 2012	3860	19.80325°N 155.45892°W	0	Wēkiu bug
VLBAN 103	Pu'u N. VLBA	7-13.VII. 2012	3858	19.80358°N 155.45909°W	0	Wēkiu bug
VLBAN 104	Pu'u N. VLBA	7-13.VII. 2012	3864	19.80379°N 155.45935°W	0	Wēkiu bug
VLBAS 105	Pu'u S.VLBA	7-13.VII. 2012	3770.00	19.79994°N 155.45564°W	7	Wēkiu bug
VLBAS 106	Pu'u S.VLBA	7-13.VII. 2012	3786.00	19.79963°N 155.45563°W	13	Wēkiu bug
VLBAS 107	Pu'u S.VLBA	7-13.VII. 2012	3811.00	19.79901°N 155.45518°W	0	Wēkiu bug

**Table 3.** Summary of 2012 sample effort and wēkiu bug captures from surveyed Mauna Kea cinder cones using shrimp pitfall traps in July 2012.

Cinder Cone	Highest Elevation	Total Traps	Wēkiu bugs in traps	Wēkiu bugs Visual observation outside trap	Trap Dates	Total Trap Days <sup>1</sup>
Pu'u Hau Kea	4,128 m	10	720	0	6-12.VII	60
Pu'u Hau Oki	4,171.49m	5	1163	0	2-8.VII	30
Pu'u Wēkiu	4,225.44 m	10	484	0	2-8.VII	60
Pu'u N. VLBA	3,864 m	5	4	0	7-13.VII	30
Pu'u S. VLBA	3,811 m	5	20	0	7-13.VII	30
Pu'u Pohaku	4,046 m	5	7	1	8-14.VII	30
Pu'u Poliahu	4,169.66 m	5	3	0	6-12.VII	30
Poi Bowl	4,168 m	5	29	0	8-14.VII	30
<b>Totals</b>		<b>50</b>	<b>2430</b>	<b>0</b>		<b>300</b>

<sup>1</sup>Trap days = total nights x total traps per cinder cone.

**Table 4.** Summary of wēkiu bugs captured at the Pu'u Hau Kea (within the Natural Area Reserve) cinder cone in Bishop Museum related studies since 2001. Data includes using a combination of glycol and shrimp pitfall data for all years except 2007 - 2012 when only shrimp traps were used.

Year and Month when Trapping Occurred	Total Wēkiu bugs	Trap Days	Catch Corrected for Effort (Bugs/Trap Day)
2001 (June) (Polhemus, 2001) <sup>1</sup>	473	40	11.8
2002 (Sept)	13	48	0.27
2004 (July)	0	90	0
2005 (April/May)	20	144	0.14
2006 (April/May)	56	80	0.7
2007 (June)	217	78	2.8
2008 (July)	43	60	0.7
2009 (July)	1	60	0.02
2011 (June)	261	60	4.35
2011 (May/June)	207	60	3.4
2012 (July)	720	60	12.0
			<b>Avg = 3.61</b>

<sup>1</sup> Data from Polhemus (2001) was from glycol traps only and results may not be directly comparable to our shrimp traps.

**APPENDIX C: 2012 ALIEN AND NATIVE ARTHROPOD TABLES**

**Table 5.** Overall species list of native and alien arthropods found during the 2012 field season, specific sites where each taxa were found are listed in main text.

Taxa	Order	Family	Genus-Species-Author	Biogeographic Status: (end/ind adv/pur/unk)	Resident/Aeolian
1	ARANEAE	Corinnidae	<i>Meriola arcifera</i> (Simon, 1886)	adv	Resident
2	ARANEAE	Gnaphosidae	<i>Urozelotes rusticus</i> (L. Koch, 1872)	adv	Resident
3	ARANEAE	Lycosidae	<i>Lycosa hawaiiensis</i> Simon, 1899	end	Resident
4	COLEOPTERA	Carabidae	<i>Trechus obtusus</i> Erichson, 1837	adv	Resident
5	COLEOPTERA	Cleridae	<i>Necrobia rufipes</i> (De Geer, 1775)	adv	Aeolian
6	COLEOPTERA	Coccinellidae	<i>Coccinella septempunctata</i> Linnaeus 1758	pur	Aeolian
7	COLEOPTERA	Coccinellidae	<i>Hippodamia convergens</i> Guérin-Méneville, 1843	pur	Aeolian
8	COLEOPTERA	Dermestidae	<i>Dermestes frischii</i> Kugelann, 1792	adv	Resident
9	COLEOPTERA	Staphylinidae	<i>Creophilus maxillosus</i> (Linnaeus, 1758)	adv	Resident
10	COLEOPTERA	Staphylinidae	?Genus ?species	unk	Aeolian
11	DERMAPTERA	Forficulidae	<i>Forficula auricularia</i> Linnaeus, 1758	adv	Resident
12	DIPTERA	Agromyzidae	<i>Phytomyza</i> sp. not <i>plantaginis</i> or <i>diminuta</i>	adv	Aeolian NEW STATE RECORD
13	DIPTERA	Calliphoridae	?Genus, ?species A	adv	Aeolian
14	DIPTERA	Calliphoridae	?Genus, ?species B	adv	Aeolian
15	DIPTERA	Calliphoridae	<i>Calliphora vomitoria</i> (Linnaeus, 1758)	adv	Aeolian
16	DIPTERA	Ephydriidae	?Genus ?species	unk	Aeolian
17	DIPTERA	Muscidae	<i>Atherigona orientalis</i> Schiner, 1868	adv	Aeolian
18	DIPTERA	Muscidae	several species	unk	Aeolian
19	DIPTERA	Phoridae	several species	unk	Aeolian
20	DIPTERA	Sphaeroceridae	<i>Leptocera</i> sp.	adv	Aeolian
21	DIPTERA	Sarcophagidae	several species	unk	Aeolian
22	DIPTERA	Sciaridae	several species	unk	Aeolian
23	DIPTERA	Sepsidae	<i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893	adv	Aeolian
24	DIPTERA	Sepsidae	<i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)	adv	Aeolian
25	DIPTERA	Sphaeroceridae	several species	unk	Aeolian
26	DIPTERA	Syrphidae	<i>Toxomerus marginatus</i> (Say, 1823)	adv	Aeolian
27	DIPTERA	Tachinidae	several species	adv	Aeolian
28	DIPTERA	Nematocera	indet Fam.	unk	Aeolian
29	HETEROPTERA	Lygaeidae	<i>Graptostethus manillensis</i> Stål, 1859)	adv	Resident
30	HETEROPTERA	Lygaeidae	<i>Geocoris pallens</i> Stål, 1854	adv	Aeolian
31	HETEROPTERA	Lygaeidae	<i>Nysius</i> sp.	end?	Resident
32	HETEROPTERA	Rhopalidae	<i>Liorhyssus hyalinus</i> (Fabricius, 1794)	unk	Resident
33	HOMOPTERA	Psyllidae	?Genus ?species	end	Aeolian
34	HYMENOPTERA	Braconidae	<i>Apanteles</i> sp.	adv	Aeolian
35	HYMENOPTERA	Chalcidoidea	several species	unk	Aeolian
36	HYMENOPTERA	Colletidae	<i>Hylaeus</i> sp.	end	Resident

**Table 5. Cont.** Overall species list of native and alien arthropods found during the 2012 field season, specific sites where each taxa were found are listed in main text.

<b>Taxa</b>	<b>Order</b>	<b>Family</b>	<b>Genus-Species-Author</b>	<b>Biogeographic Status: (end/ind adv/pur/unk)</b>	<b>Resident/Aeolian</b>
37	HYMENOPTERA	Ichneumonidae	<i>Diadegma blackburni</i> (Cameron, 1883)	adv	Aeolian
38	HYMENOPTERA	Ichneumonidae	<i>Ichneumon cupitus</i> Cresson, 1877	adv	Aeolian
39	HYMENOPTERA	Ichneumonidae	<i>Ichneumon purpuripennis</i> Cresson, 1877	pur	Aeolian
41	HYMENOPTERA	Ichneumonidae	?Genus ?species	unk	Aeolian
42	HYMEOPTERA	Pompillidae	<i>Anoplus toluca</i> (Cameron, 1893)	adv	Aeolian
43	HYMENOPTERA	Sphecidae	<i>Ectemnius</i> sp.	end	Resident
44	LEPIDOPTERA	Noctuidae	<i>Agrotis</i> sp.	end	Resident