Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park Maui, Hawai'i

February 2015

Prepared for

K.C. Environmental, Inc.
P.O. Box 1208
Makawao, HI 96768
(808) 573-1903

Pacific Analytics, L.L.C.
35891 Richardson Gap Road
Scio, Oregon 97374
(541) 258-5919
www.statpros.com

Prepared by:

Pacific Analytics, L.L.C.
35891 Richardson Gap Road
Scio, Oregon 97374
Tel. (541) 258-5919
mail@statpros.com
www.statpros.com

Gregory Brenner
Senior Associate / Project Manager

Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park Maui, Hawai'i

I. TABLE OF CONTENTS

II. EXECUTIVE SUMMARY

The National Science Foundation (NSF) has authorized the development of the Daniel K. Inouye Solar Telescope (DKIST), previously known as the Advanced Technology Solar Telescope (ATST)) within the 18-acre University of Hawai`i Institute for Astronomy High Altitude Observatories (HO) site. The DKIST represents a collaboration of 22 institutions, reflecting a broad segment of the solar physics community. The DKIST project will be the largest and most capable solar telescope in the world. It will be an indispensable tool for exploring and understanding physical processes on the Sun that ultimately affect Earth. The DKIST Project will be contained within a 0.74 acre site footprint in the HO site. An Environmental Impact Statement was completed for the DKIST project (NSF 2009), and the NSF issued a Record of Decision in December of 2009.

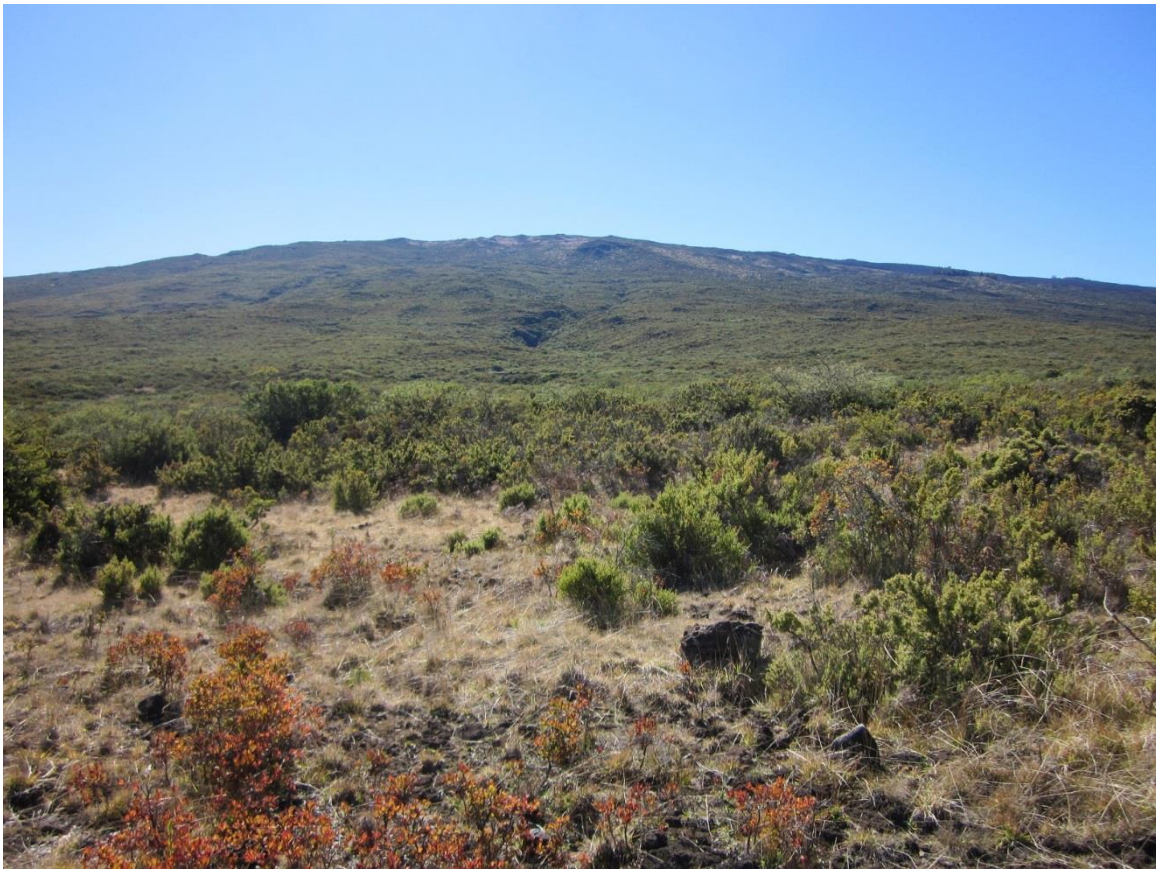
The Haleakalā National Park (HALE) Road Corridor is being used for transportation during construction and use of the DKIST. The HO and HALE road corridor contain biological ecosystems that are both unique and fragile. The landscape at HO is considered to be an alpine dry shrubland vegetation type and resources along the Park road corridor are grouped into alpine and subalpine shrubland habitat zones, depending upon the elevation. These habitats contain several native and non-native species of plants, animals, and arthropods. While the overall impacts on Hawaiian native arthropod resources within the Park road corridor during the construction phase would be considered minor, NSF has committed to several mitigation measures to reduce the impacts to these biological resources, including programmatic monitoring for active preservation of invertebrates before, during and after construction of the DKIST Project.

After preliminary sampling near the HALE Entrance Station and at the DKIST site in 2009, Programmatic Arthropod Monitoring and Assessment at the Haleakalā High Altitude Observatories and Haleakalā National Park was initiated with two sampling sessions in 2010. Monitoring is being conducted twice a year during the construction phase of the DKIST which began in December 2012. Semi-annual monitoring has occurred in 2011, 2012, 2013, and 2014.

This report presents the results of the Winter 2015 sampling. The goal is to monitor the arthropod fauna at the DKIST

site and along the HALE Road Corridor, identify Hawaiian native arthropod species or habitats, if any, that may be impacted by construction of the DKIST, and detect and identify alien invasive arthropod species that could have adverse impacts on the flora and fauna on Haleakalā. Programmatic Arthropod Monitoring studies are being coordinated and conducted with the approval of HALE.

This monitoring project provides a means of gathering reliable information that can be used to protect the native Arthropod species during development of observatory facilities and supports astronomy programs at the Haleakala High Altitude Observatory Site by promoting the good stewardship of the natural resources located there.



Subalpine shrubland above the HALE Entrance Station

III. INTRODUCTION

The Haleakalā volcano on the island of Maui is one of the highest mountains in Hawai`i, reaching an elevation of 10,023 feet (3,055 m) at its summit on Pu`u `Ula`ula. Near the summit is a volcanic cone known as Kolekole with some of the best astronomy viewing in the world.

The National Science Foundation (NSF) has authorized the development of the Daniel K. Inouye Solar Telescope (DKIST), previously known as the Advanced Technology Solar Telescope (ATST)) within the 18-acre University of Hawai`i Institute for Astronomy High Altitude Observatories (HO) site. The DKIST represents a collaboration of 22 institutions, reflecting a broad segment of the solar physics community. The DKIST project will be the largest and most capable solar telescope in the world. It will be an indispensable tool for exploring and understanding physical processes on the Sun that ultimately affect Earth.

The DKIST Project will be contained within a 0.74 acre site in the HO site. An Environmental Impact Statement was completed for the DKIST project (NSF 2009), and the NSF issued a Record of Decision in December of 2009. The Haleakalā National Park (HALE) Road Corridor is being used for transportation during construction and use of the DKIST. Construction began in December 2012 and was ongoing during the winter 2015 sampling.

The HO and HALE road corridor contain biological ecosystems that are both unique and fragile. The landscape at HO is considered to be an alpine dry shrubland vegetation type. A diverse fauna of resident insects and spiders reside there (Medeiros and Loope 1994). Some of these arthropods inhabit unique natural habitats on the bare lava flows and cinder cones with limited vegetation. Vegetation covers less than 5% of the open ground, and food is apparently scarce.

The ecosystem at the HO is extremely xeric, caused by relatively low precipitation, porous lava substrates that retain negligible amounts of moisture, little plant cover, and high solar radiation. The dark, heat-absorbing cinder provides only slight protection from the extreme temperatures. Thermal regulation and moisture conservation are critical adaptations of arthropods that occur in this unusual habitat.

An inventory and assessment of the arthropod fauna at the HO site was conducted in 2003 as part of the Long Range Development Plan (LRDP) for the Haleakalā High Altitude Observatories. This inventory and assessment was updated in December 2005 to provide a more detailed description of the arthropod fauna at the two proposed DKIST sites, and identify Hawaiian native arthropod species or habitats, if any, that could be impacted by construction of the DKIST. In an effort to be complete, supplemental sampling was conducted in 2007 to provide a seasonal component and additional nighttime sampling not included in the previous two inventories. Sampling in June 2009 was conducted to establish baseline conditions for future Programmatic Monitoring.

The landscape along the HALE road corridor is classified as alpine and subalpine shrubland habitat zones, depending upon the elevation. These habitats contain several native and non-native species of plants, animals, and arthropods. The subalpine shrubland within the Haleakalā National Park is also host to a wide variety of indigenous arthropod species (Krushelnycky et al. 2007). The vegetation there covers most of the open ground, mostly with native trees and shrubs, with native and alien grasses growing between. Precipitation in the form of rainfall and fog is frequent, with about 70 inches falling throughout the year (Giambelluca et al. 1986).

While the overall impacts on arthropod resources within the Park road corridor during the construction phase would be considered minor, NSF has committed to several mitigation measures to reduce the impacts to these biological resources, including programmatic monitoring for active preservation of invertebrates during and after construction of the DKIST Project.

Environmental monitoring is the scientific investigation of the changes in environmental phenomena, attributes and characteristics that happen over time. Ecosystems are dynamic. Habitat conditions change daily, seasonally, and over longer periods of time. Animal and plant populations rise or fall in response to a host of environmental fluctuations. The general purpose of monitoring is to detect, understand, and predict the biological changes.

The scientific scope of the current phase of Arthropod Monitoring is to repeatedly sample arthropod habitats that may be impacted by construction of the DKIST, document changes to native arthropod populations, and detect new or potentially threatening invasive species

of arthropods that may impact the native resident arthropod fauna. Programmatic Arthropod Monitoring includes identification and taxonomy for both ground and shrub dwellers and is being conducted in both developed and undeveloped areas of HO (excluding the Air Force site)."

Arthropod Programmatic Monitoring consists of one week sampling sessions conducted in the Summer and Winter months using standard arthropod sampling methods similar to those used during the 2007 inventory of arthropods within HALE (Kruschelnycky et al. 2007), collecting invertebrates both day and night, with identification and taxonomy for both ground and shrub dwellers in developed and undeveloped portions of the sampling areas.

The primary areas being sampled are the Haleakalā High Altitude Observatories (HO) site on Kolekole Hill, but not including the Air Force site, the DKIST Construction Site, and selected portions of the HALE Road Corridor. The 18 acre HO facility hosts several existing observatories and their support buildings, and also includes several undeveloped sites where native vegetation and the associated arthropod fauna is relatively undisturbed. Although the overall footprint of DKIST is about 0.74 ac, the site where DKIST construction is currently taking place is approximately 0.24-ha (0.6 ac) of previously undisturbed land located east of the existing Mees Solar Observatory facility. The portions of the HALE Road Corridor being sampled are determined in collaboration with the HALE staff biologists at the beginning of each sampling session.

Programmatic Monitoring will provide much of the data needed to protect and enhance natural resources, to modify management actions, to aid in compliance with environmental statutes, and to enhance public education and appreciation of the natural resources at the summit of Haleakalā.

The nomenclature used in this report follows the Hawaiian Terrestrial Arthropod Checklist, Third Edition (Nishida 1997) and the Manual of the Flowering Plants of Hawai'i (Wagner and others 1990). Hawaiian and scientific names are italicized unless major taxonomic revisions were available.

Species are discussed as being endemic, indigenous, non-indigenous, adventive, and purposely introduced. These terms are defined as:

Endemic – A species native to, or restricted to Hawai'i.
Indigenous – A species native to Hawai'i but that naturally occurs outside of Hawai'i as well.
Non-indigenous – A species not native to Hawai'i.
Adventive – Not native, a species transported into a new habitat by natural means or accidentally by human activity.
Purposely introduced – A species released in Hawai'i for a particular purpose, usually to control a weedy plant or another insect.

This report describes the results of sampling conducted in January 2015, the first of two sampling sessions for Programmatic Arthropod Monitoring and Assessment this year, and continues monitoring that began in September 2009. The goal is to monitor the arthropod fauna at the HO site, the DKIST construction site, and along the selected portions of the HALE Road Corridor, identify Hawaiian native arthropod species or habitats, if any, that may be impacted by construction of the DKIST, and detect and identify alien invasive arthropod species that could have adverse impacts on the flora and fauna on Haleakalā. Programmatic Arthropod Monitoring studies are being coordinated and conducted with the approval of HALE staff biologists.

Sampling of arthropod habitats was approved in a permit obtained from the Department of Land and Natural Resources (Permit # FHM15-364), effective date January 1, 2015 – December 31, 2015, and the National Park Service (Permit # HALE-2010-SCI-0001) issued on March 22, 2010. Sampling began on January 13, 2015 and was completed on January 20, 2015.

IV. QUESTIONS OF INTEREST

Important Questions of Interest are those with answers that can be efficiently estimated and that yield the information necessary for management decision-making. The following Questions of Interest were developed for Programmatic Monitoring and are the focus of this report.

Question 1

What are the characteristic arthropod populations at the DKIST site, the larger HO site (excluding the Air Force site), and along selected areas of the HALE Road Corridor?

Justification:

Programmatic Monitoring will yield a comprehensive list of the characteristic arthropod fauna at the DKIST site, developed and undeveloped areas of the HO site, and along selected areas of the HALE Road Corridor.

Monitoring goals:

1) To describe the characteristic arthropod populations at the DKIST site, the larger HO site, and along the HALE Road Corridor,

2) To provide historical records of change in native arthropod species population attributes, and characteristics.

The results of this sampling are combined with information gathered during previous studies to develop a comprehensive list of arthropods at the Astronomy High Altitude Observatories (HO) site, the DKIST site, and along selected areas of the HALE Road Corridor, and a qualitative description of seasonal variations in their abundance.

Question 2

What adverse impacts can be detected, if any, on characteristic populations of arthropods at the DKIST site, the larger HO site (excluding the Air Force site), and along selected areas of the HALE Road Corridor that may be due to DKIST construction?

Justification:

Programmatic Monitoring of native arthropod species will yield reliable scientific information about the current status (presence and abundance) of these species at the sampling sites. The information will be useful to detect changes and trends that may be due to the construction of the DKIST.

Monitoring goals:

1) To detect changes, trends, periodicities, cycles, and/or other patterns of change in arthropods at the DKIST site, the larger HO site, and along the HALE Road Corridor during the construction of the DKIST.

Programmatic Monitoring reports provide a discussion of the results of sampling, a description of changes in presence or abundance, and an assessment of those changes that may be due to the DKIST construction, and provide opportunities for adaptive management of construction processes, through the use of control measures, where these changes and/or trends negatively affect the arthropod population.

Question 3

What non-indigenous invasive arthropod species, if any, are detected at the DKIST site, the larger HO site (excluding the Air Force site), and along selected areas of the HALE Road Corridor during DKIST construction?

Justification:

Programmatic Monitoring for non-indigenous invasive arthropod species will detect potential threats to the nearby native ecosystems before they have an opportunity to establish resident populations. Early detection will allow implementation of control measures to eradicate invasive arthropod species (e.g. ants and spiders) before they can damage the nearby native ecosystems.

Monitoring goals:

1) To detect non-indigenous invasive arthropod species at the DKIST site, the larger HO site, and along selected areas of the HALE Road Corridor during construction of the DKIST.

If any invasive arthropod species (e.g. ants and spiders) are detected, eradication measures will be implemented to prevent these species from establishing resident populations.

V. METHODS

Site Description

The Haleakalā High Altitude Observatories (HO) site is located on Kolekole Hill. The highest point on the HO site is at 3,052-m (10,012-ft) above sea level. The 7.3-ha (18.1-ac) site was established in 1961, and the first telescope, the Mees Solar observatory was dedicated in 1964. The site now consists of five substantial telescope facilities, in addition to several smaller facilities.

The DKIST site is on undeveloped land located east of the existing Mees Solar Observatory facility at 3,042-m (9,980-ft) above sea level. Annual precipitation averages 1,349.2-mm (53.14-in), falling primarily as rain and mist during the winter months from November through April. Snow rarely falls at the site.

Haleakalā sampling locations were determined with guidance and cooperation from HALE personnel. During this session, sampling was conducted in the area near the HALE Entrance Station, at about 2,072 m (6,800 ft) on the western slope of Haleakalā.

Procedures

The selection of a trapping technique used in a study was carefully considered. When the target species of the trapping system are rare or important for other reasons (i.e., endangered, keystone species, etc.) live-trapping should be considered. Entomologists have long believed that they can sample without an impact on the population being sampled. It has been assumed that collecting has only a small impact on the populations of interest. While this assumption remains to be tested, responsible entomologists consider appropriate trapping techniques to ensure survival of local populations of interest. The sampling methods that were used during this study are similar to those used during the 2007 arthropod inventory conducted on the western slope of Haleakalā and were reviewed by HALE natural resource staff and modified according to their comments.

Pitfall Trapping

After consultation with HALE natural resources staff, ten pitfall traps were installed near HALE Entrance Station site (five below the road and five above the road). Ten pitfall traps were installed at the Astronomy High Altitude Observatories (HO) site in both developed and undeveloped areas, and ten pitfall traps were deployed at the DKIST site. The traps (300 ml [10 oz], 80 mm diameter cups) were filled with soapy water solution as preservative. Concerns about endangered native birds precluded the use of ethylene glycol. The traps were spaced at least 2 m apart, and left open for seven days at the DKIST site and for seven days at the HALE site. It was decided that pitfall traps would not be baited around the rim with blended fish because they might attract birds. This is a trapping method similar to that used during an arthropod survey conducted in 2007 (Krushelnycky et al. 2007).

Care was taken to avoid archeological sites. These sites have cultural and historical significance and precautions were made to prevent their disturbance. Traps were not placed in or near these sites. A map of significant historic and cultural sites within 50 feet of the road corridor was used to avoid such sites. Habitat was accessed with a minimum of disturbance to the habitat. Care was also taken to prevent creation of new trails or evidence of foot traffic.

Care was also taken to avoid disturbing nesting petrels and other wildlife species. The endangered petrels dig into cinder to make burrows for nesting. Even though the petrels were not nesting at the time of the sampling, efforts were made to avoid known burrows. Pitfall traps are placed below ground and covered with a heavy cap rock. This makes it very unlikely that petrels could access the traps.

All pitfall traps were installed on January 13, 2015 and their contents collected on January 19, 2015.

Light-Trapping

Sampling for nocturnal insects is vital to understanding the complete faunal presence. Some insects are only active and moving around at night. Many insects have a nocturnal activity cycle to evade birds, and to locate certain food sources. Night collecting is important in environments like dry locations where insects may choose this strategy to avoid desiccation.

Battery-powered ultraviolet light traps were operated near the HALE Entrance Station, at the HO site, and at the DKIST site. The traps consisted of a 3.5 gallon polypropylene bucket, a smooth surface

funnel, a 22 watt Circline blacklight tube mounted on top of vanes under an aluminum lid that directs light downwards. The effective range of the 22 watt lamp is less than 100 feet, and traps were always located more than 100 feet from the nearest petrel burrow. Light traps were run for six nights at the DKIST site, HO site, and the HALE site. A seventh night of sampling was suspended due to circumstances beyond our control.

Other Light Sampling at Night

Night collecting can be aided by a UV light source. Small handheld ultraviolet blacklights were used for additional sampling for foliage and ground-dwelling arthropods.

Visual Observations and Habitat Collecting Under Rocks and in Leaf Litter

Time was spent sampling under rocks, in leaf litter, and on foliage to locate and collect arthropods at each sampling station. Hand picking, while sorting through leaf litter and bunch grasses, and searching beneath stones was the most effective sampling for litter and soil associated forms.

Collecting on Foliage

Foliage of various common plant species was sampled by beating sheet. A one-meter square beating sheet or insect net was placed under the foliage being sampled and the branch hit sharply three times using a small plastic pipe. After the initial collection the foliage was beat again to dislodge persistent individuals. Care was taken to avoid sensitive plants and to leave vegetation intact.

Nets

Aerial nets and sweep nets were used as necessary to capture flying insects and arthropods that occur on grasses.

Baited Traps

Baited traps were deployed to detect the presence of ants. These traps consisted of fresh canned tuna placed on sticky trap board and weighted down with a small rock. Traps were set near areas where ants could be introduced or where they may be foraging for food. Five baited traps were deployed on the HO and DKIST sites on three different days. The traps were checked hourly for four hours at which time the traps were be removed. Baited traps were not left opened overnight in order to avoid attracting unwanted pests.

Inspection of construction lay-down and storage areas

Construction material and equipment in developed lay-down areas were visually inspected for invasive arthropod species and evidence of their presence.

Specifically, these areas were inspected for the presence of ants, spiders, spider webs, and indications of the presence of other potentially invasive arthropod species.

Population Estimates

Although NSF committed to "population estimates for developed and undeveloped areas within HO, the DKIST Construction Site, and selected areas of the HALE road corridor" (NSF 2009), they are not possible with the approved sampling techniques. A consultation with the NPS determined that any data collected would be only a snapshot in time, reflective only of the sites sampled, and that the results are seasonal and could not be extrapolated beyond those limits. They also expressed an opinion that any "population estimates" would not be comparable over time and that accurate population estimates for arthropods are not possible with the sampling methods approved for use. In consultation with NPS staff biologists, it was decided that sampling results would be presented as presence/absence, and that qualitative abundance estimates would be a suitable substitute for "population estimates" described in the FEIS (NSF 2009).

Sampling results in this report are presented as presence/absence, and, for selected species, qualitative abundance estimates are substituted for "population estimates" described in the FEIS (NSF 2009). Relative abundance categories are

- *infrequent* (individuals captured or observed < 10),
- *uncommon* (10 < individuals captured or observed < 25),
- *common* (25 < individuals captured or observed < 100), and
- *abundant* (100 < individuals captured or observed).

It should be noted that abundance designations are based exclusively on the capture or observation of specimens encountered at the sampling sites visited during each sampling session, and may be biased against certain species. For example, some ground dwelling species may be under-sampled because traps will not be baited and therefore not attractive to these species. Other species may be more or less abundant at other times of year than those sampled, or not efficiently captured with the sampling methods used. These species may generally be more or less common than indicated from the results. The results presented in reports are only snapshots in time, reflective only of the sites sampled, and the results are seasonal and should not be extrapolated beyond those limits.

Collections

Arthropods that appear in traps were stored and later mounted for identification. Arthropods that are observed during hand collecting and netting were collected only as necessary to provide accurate identification and voucher specimens.

Curation

The contents of the traps were cleaned in 70% ethyl alcohol and placed in vials. The specimens were sorted into the morphospecies for identification. Hard-bodied species, such as beetles, moths, true bugs, flies, and wasps were mounted on pins, either by pinning the specimen or by gluing the specimens to paper points. Pinned specimens were placed into Schmidt boxes. Soft-bodied specimens, such as spiders and caterpillars were stored in vials filled with 70% ethyl alcohol.

Identification

Specimens were mounted and identified to the lowest taxonomic level possible within the time frame of the study. Many small flies and micro-Hymenoptera were sorted to morphospecies and will be sent to reliable experts for identification. Identification of arthropods is difficult, even for experts. More time needs to be allotted for this necessary task in all arthropod inventory projects. All specimen identifications are provisional until they can be confirmed by comparison to museum specimens or by group/taxon experts.

References for general identification of the specimens included *Fauna Hawaiiensis* (Sharp (ed) 1899-1913) and the 17 volumes of *Insects of Hawai'i* (Zimmerman 1948a, 1948b, 1948c, 1948d, 1948e, 1957, 1958a, 1958b, 1978, Hardy 1960, 1964, 1965, 1981, Tentorio 1969, Hardy and Delfinado 1980, Christiansen and Bellinger 1992, Liebherr and Zimmerman 2000, and Daly and Magnacca 2003). Other publications that were useful for general identification included *The Insects and Other Invertebrates of Hawaiian Sugar Cane Fields* (Williams 1931), *Common Insects of Hawai'i* (Fullaway and Krauss 1945), *Hawaiian Insects and Their Kin* (Howarth and Mull 1992), and *An Introduction to the Study of Insects Sixth Edition* (Borror, Triplehorn, and Johnson 1989).

For specific groups specialized keys were necessary. Most of these had to be obtained through library searches. Keys used to identify Heteroptera included those by Usinger (1936, 1942), Ashlock (1966), Beardsley (1966, 1977), Gagné (1997), Polhemus (2002, 2005, 2011, 2014), and Asquith (1994, 1997). Keys used to identify Hymenoptera included

Cushman (1944), Watanabe (1958), Townes (1958), Beardsley (1961, 1969, 1976), Yoshimoto and Ishii (1965), and Yoshimoto (1965a, 1965b).

Species identification of those specimens identified to genus or species levels are unconfirmed and subject to change after comparison to specimens in museums.

In many cases changes in family and generic status and species synonymies caused species names to change from those in the keys. Species names used in this report are those listed in *Hawaiian Terrestrial Arthropod Checklist Third Edition* (Nishida 1997) unless a recent major taxonomic revision was available.

Schedule/Start and End Dates

Sampling was conducted over eight days and seven nights beginning on January 13, 2015 and ending on January 20, 2015. Sampling typically began at 8:00 am and ran until about 3:00 pm. A break was taken to prepare for night sampling which resumed at 6:00 pm and continued until after midnight or until weather conditions prevented further sampling. Pitfall traps were open for 60 trap nights at each of the three sampling sites. Light traps were deployed for 6 trap nights at each sampling site, and. were allowed to run overnight or until batteries failed.

VI. RESULTS and DISCUSSION

HO SITE

The HO site covers about 18 acres and contains observatory facilities. Several areas of the site are being used to store materials and equipment. Twenty-two species of arthropods were detected at the HO site (excluding the Air Force Facility and the DKIST site). The species included eleven endemic species, six non-indigenous species, and five of unknown status.

Spiders and Mites - Arachnida

Abundant juvenile and adult Lycosid spiders, *Lycosa hawaiiensis* Simon, occurred in pitfall traps, and were actively foraging among rocks. In one of the pitfall traps, in which all water had evaporated, an adult Lycosid was captured with numerous juvenile crawling on its back. Wolf spiders often carry their eggs in an egg sac attached to the spinnerets at the end of the abdomen. The abdomen is held in a raised position to keep the egg case from dragging on the ground. The adult Lycosid is not handicapped by this burden, and is still capable of hunting. When the juveniles emerge from their protective silken case, they climb up their mother's legs onto her abdomen.

Small red mites were observed, commonly occurring in leaf litter under vegetation.

Beetles – Order Coleoptera

Three beetle species were observed at the HO site. The non-indigenous seven-spotted lady bird beetle (*Hippodamia convergens* Guerin-Meneville) was infrequent at the site, found on vegetation. A single specimen of the non-indigenous vegetable weevil, *Listroderes costirostris* Schonherr, was found on *Dubautia*. A small rove beetle (family Staphylinidae) was collected in a pitfall trap.

Collembola - Springtails

At least one species of Collembola was observed at the HO site. These small insects were common in leaf litter under plants.

Flies - Order Diptera

Four species of flies were detected at the HO site. Two species were indigenous, a fungus gnat and a humpedback fly. The two non-indigenous species included a blowfly and a flesh fly, both common flying around vegetation and rocks.

True Bugs – Orders Heteroptera and Homoptera

Six species of true bugs (order Heteroptera) were observed including adults and nymphs of four Hawaiian endemic species in the genus *Nysius*. Two of these species (*Nysius coenosulus* and *N. communis*) are common residents at the site and occur in abundance on both *Dubautia* and *pukiawe*. The other two species (*Nysius lichenicola* and *N. terrestris*) occur infrequently in leaf litter. Other true bugs were from the family Miridae, *Engytates hawaiiensis* (Kirkaldy) is uncommon, found on *Dubautia*, and *Trigonotylus hawaiiensis* (Kirkaldy), found on grasses. Both are endemic species.

One endemic species of plant hoppers of the genus *Nesosydne* was common on *Dubautia*.

Butterflies and Moths – Order Lepidoptera

At least four species Lepidoptera were found at the HO site. These include three endemic species in the genus *Agrotis*, and the non-indigenous *Pseudalecia unipuncta* (Meyrick). All were collected in light traps.

Large caterpillars, probably also of the genus *Agrotis*, were common in pitfall traps. These caterpillars were observed foraging at night. During the day they burrow into loose cinder to avoid predation and desiccation. Smaller caterpillars uncommon in pitfall traps were likely larva of the Haleakalā flightless moth.

Other Observations

A single, small red-colored centipede was found near a washing station at HO. This is likely the species *Lamyctes emarginatus* Newport, a non-indigenous resident at the summit.

No yellow-faced bees were observed at the HO site, although they were common at the DKIST site. These bees occur on blooming *pukiawe*, a plant that occurs only infrequently at the HO site.

A complete list of arthropods observed during this sampling session at the HO site can be found in Appendix A at the end of this report. No new invasive species were observed that could impact native arthropod species. The species of indigenous arthropods detected have been observed at the site during other surveys.

DKIST SITE

Construction was started on the DKIST in December 2012 and was ongoing during the winter 2015 sampling session. The excavation for the DKIST foundation resulted in the removal of much of the vegetation at the site. Vegetation is now limited to the area surrounding the excavation and is mostly undisturbed.

Twenty-seven species of arthropods were collected at the DKIST site during the winter 2015 sampling session. The species included fifteen endemic Hawaiian arthropods, eight non-indigenous arthropods, and four species of unknown status.

Spiders and Mites - Arachnida

Juvenile and adult Lycosid spiders, *Lycosa hawaiiensis* Simon, occurred in pitfall traps at the DKIST site, but only juveniles were seen actively foraging among rocks.

Small red mites were observed, commonly occurring in leaf litter under vegetation.

Collembola - Springtails

At least one species of Collembola was observed at the DKIST site. These small insects were common in leaf litter under plants.

Flies - Order Diptera

Six species of flies were detected at the DKIST site. They include blowflies, a midge, two syrphids, a humpbacked fly, and a small gnat. The humpbacked fly, and the small gnat indigenous. No endemic fruit flies (family Tephritidae) were observed.

True Bugs – Orders Heteroptera and Homoptera

Six species of true bugs (Order Heteroptera) were observed at the DKIST site, including five endemic species. Adults and nymphs of two species of the Hawaiian endemic seed bug genus *Nysius* (*N. coenosulus* Stål and *N. communis* Usinger) were abundant on *Dubautia* and *pukiawe*. A third species of this genus (*N. lichenicola* Kirkaldy) was found in leaf litter under plants. The abundance of this species was infrequent. A single specimen of the non-indigenous *Geocoris pallens* Stål was also collected in a pitfall trap.

Adults and nymphs of two plant bugs (family Miridae) were also observed. *Engytates hawaiiensis* (Kirkaldy) is uncommon, found on *Dubautia*, and *Trigonotylus hawaiiensis* (Kirkaldy), is found only on grasses. Both are endemic species.

Three species of Homoptera were collected, including a species of the endemic genus *Nesosydne* that was abundant on *Dubautia*. Non-indigenous species include a species of aphid and planthopper. Both of these species were infrequent.

Bees and Wasps – Order Hymenoptera

The endemic species of yellow-faced bees, *Hylaeus nivicola* Meade Waldo, was common on pukiawi. Other Hymenoptera observed include honey bees and a small parasitic wasp.

Moths – Order Lepidoptera

Five species of Lepidoptera were collected. Four large moths, including three endemic species in the genus *Agrotis*, and the non-indigenous *Pseudalecia unipuncta* (Meyrick) were captured in light traps. Caterpillars of the genus *Agrotis* were abundant in pitfall traps. Caterpillars of the Haleakalā flightless moth were infrequently captured in pitfall traps.

A complete list of arthropods observed during this sampling session at the DKIST site can be found in Appendix B at the end of this report. No new invasive species were observed that could impact native arthropod species. The species of indigenous arthropods detected have been observed at the site during other surveys.

HALE SAMPLING SITE

Sampling in HALE occurred near the Entrance Station (HALE ES) at 6,250 feet elevation. Twenty-nine species of arthropods were collected and observed there. The species included eleven endemic Hawaiian arthropods, thirteen non-indigenous arthropods, and five species of unknown status.

Spiders and Mites - Arachnida

One species of crab spider (family Thomiscidae) was uncommon on vegetation. A single specimen of another spider, of unknown status, was also observed.

Small red mites were observed, commonly occurring in leaf litter under vegetation.

Collembola - Springtails

At least one species of Collembola was observed at the HALE site. These small insects were common in leaf litter under plants and in pitfall traps.

Beetles – Order Coleoptera

Two species of beetles were observed, including the non-indigenous ground beetle *Trechus obtusus* Erichson, and an unknkown rove beetle (family Staphylinidae). Both were infrequent.

Flies – Order Diptera

Four species of flies were seen at the HALE ES, all non-indigenous species from the families Calliphoridae, Muscidae, Tachinidae.

True Bugs – Orders Heteroptera and Homoptera

Two species of true bugs (Heteroptera) were found, both from the family Miridae. *Orthotylus coprosmophila* Polhemus was common on *Coprosma*, and *Orthotylus sophoriodes* Polhemus was abundant on *manane*.

One species of Homoptera was observed. This species, from the indigenous genus *Nesophrosyne* (family Cicadellidae), was uncommon on vegetation.

Bees and Wasps – Order Hymenoptera

The seven species of Hymenoptera found near the HALE Entrance Station included honey bees uncommon on *manane* and *pukiawe*, a parasitoid (family Eurytomidae), one species of Ichneumonidae, one invasive ant, *Linepithema humile* (Mayr), and three species of indigenous yellow-faced bee (*Hylaeus nivicola* Meade Waldo, *H. difficillis* (Perkins), and *H. volitilis* (F. Smith)). The yellow-faced bees were abundant on sunny days, foraging on pukiawe, or flying along the ground. All Hymenoptera observed have been previously reported from Haleakalā.

Butterflies and Moths – Order Lepidoptera

Five species of Lepidoptera were observed or captured during this study at the HALE ES. The list includes three endemic species and two non-indigenous species. Endemic species of microlepidoptera, a Cosmopterigidae, a Crambidae, and a Tortricidae were observed. The introduced Lantana moth was also present, along with a large orange sulphur (*Phoebis agarithe* (Boisduval)).

Other Observations

Four other arthropods were observed at the HALE ES, including a centipede, a millipede, a Pscoptera, and a sowbug.

A complete list of arthropods observed during this sampling session at the HALE ES site can be found in Appendix C at the end of this report. No new invasive species were observed that could impact native arthropod species. The species of indigenous arthropods

detected have been observed at the site during other surveys.

DISCUSSION

The arthropods that were found during this sampling are characteristic of the fauna at both sites. No new invasive arthropods were detected at any of the sites.

No trends in populations were detected beyond normal seasonal variation and weather related abundance. The species reported are reflective only of the sites sampled, and only qualitative data of abundance were taken.

Abundance of arthropods at the DKIST site was lower than that seen in sampling sessions before construction was started. This is due to the removal of native plants during excavation and site preparation for the new telescope. Populations of arthropods on the remaining foliage were similar to that observed during previous preconstruction monitoring sessions.

Native vegetation is recovering at the DKIST site and at least some recovery in arthropod abundance may be expected once these plants mature and flower. This phenomenon has been observed at other locations at HO where plant life recovered after construction, due in part to natural recruitment and conservation efforts.

VII. LITERATURE CITED

Ashlock, P.D. 1966. New Hawaiian Orsillinae (Hemiptera-Heteroptera: Lygaeidae). Pacific Insects 8(4): 805-825.

Asquith, A. 1994. Revision of the endemic Hawaiian genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthotylinae). Bishop Mus. Occas. Pap. 40:1-81.

Asquith, A. 1997. Hawaiian Miridae (Hemiptera: Heteroptera): The Evolution of Bugs and Thought. Pacific Science 51 (4): 356-365

Beardsley, J.W. 1961. A review of the Hawaiian Braconidae (Hymenoptera). Proceedings of the Hawaiian Entomological Society 17(3): 333-366.

Beardsley, J.W. 1966. Investigations of *Nysius* spp. And other insects at Haleakalā , Maui during 1964 and 1965. Proceedings of the Hawaiian Entomological Society 19(2):187-200.

Beardsley, J.W. 1969. The Anagyrina of the Hawaiian Islands (Hymenoptera: Encyrtidae) with descriptions of two new species. Proceedings of the Hawaiian Entomological Society 20(2): 287-310.

Beardsley, J.W. 1976. A synopsis of the Encyrtidae of the Hawaiian Islands with keys to genera and species (Hymenoptera: Chalcidoidae). Proceedings of the Hawaiian Entomological Society 22(2): 181-228.

Beardsley, J.W. 1977. The *Nysius* Seed Bugs of Haleakalā National Park, Maui (Hemiptera: Lygaeidae: Orsillinae). Proceedings of the Hawaiian Entomological Society 22:443-450.

Borror, D.J., C.A. Triplehorn, and N.F. Johnson. An Introduction to the Study of Insects. Sixth Edition. Saunders College Press, San Francisco.

Christiansen, K. and P. Bellinger. 1992. Insects of Hawai'i Collembola. Volume 15. University of Hawai'i Press, Honolulu. 445 pp.

Cole, F. R., A. C. Medeiros, L. L. Loope, and W. W. Zuehlke. 1992. Effects of the Argentine ant on arthropod fauna of Hawaiian high-elevation shrubland. Ecology 73(4): 1313-1322

Cushman, R.A. 1944. The Hawaiian species of Enicospilus and Abanchogastra (Hymenoptera: Ichneumonidae). Proc Haw Ent Soc 12(1): 39-56.

Daly, H.V. and K.N. Magnacca 2003 Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera:Apoidea) Volume 17. University of Hawai'i Press, Honolulu. 234 pp.

Fullaway, D.T. & N.L.H. Krauss. 1945. Common Insects of Hawai'i. Tongg Publishing Co., Honolulu. 228 pp.

Gagne, W.C. 1997. Insular Evolution, Speciation, and Revision of the Hawaiian Genus *Nesiomiris* (Hemiptera:Miridae). Bishop Museum Bulletin in Entomology 7. Bishop Museum Press, Honolulu.

Gambino, P. 1992. Yellowjacket (*Vespula pensylvanica*) Predation at Hawaii Volcanoes and Haleakala National Parks: Identity of Prey Items. Proceedings, Hawaiian Entomological Society Vol 31:157-164.

Giambelluca, T.W., M.A. Nullet and T.A. Schroeder. 1986. Rainfall atlas of Hawaii. Report R76. Hawaii Department of Land and Natural Resources, Division of Water and Land Development, Honolulu.

Hardy, D.E. 1960. Diptera: Nematocera-Brachycera. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 10. Diptera: Nematocera--Brachycera. University of Hawai'i Press, Honolulu. ix + 368 pp.

Hardy, D.E. 1965. Diptera: Cyclorrhapha II, series Schizophora, section Acalypterae I, family Drosophilidae. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 12. University of Hawai'i Press, Honolulu. vii + 814 pp.

Hardy, D.E. 1966. Descriptions and notes on Hawaiian Drosophilidae (Diptera). Pp. 195-244 In: M.R. Wheeler (ed.). Studies in genetics. III. Morgan centennial issue. The University of Texas, Austin. vi + 563 pp.

Hardy, D.E. 1981. Diptera: Cyclorrhapha IV, series Schizophora, section Calyptratae. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 14. University of Hawai'i Press, Honolulu. vi + 491 pp.

Hardy, D.E. & M.D. Delfinado. 1980. Diptera: Cyclorrhapha III, series Schizophora, section Acalypterae, exclusive of family Drosophilidae. Pp. 1-451 In: Insects of Hawai'i.

A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 13. University of Hawai'i Press, Honolulu. vi + 451 pp.

Howarth, F.G. and W.P. Mull. 1992. Hawaiian Insects and their Kin. University of Hawai'i Press, Honolulu.

Krushelnycky, Paul D. and Reimer, Neil J. 1996. Efforts at Control of the Argentine Ant in Haleakala National Park, Maui, Hawaii. Cooperative National Park Resources Studies Unit University of Hawai'i at Manoa Technical Report 109. 33 pages

Krushelnycky, Paul D., Lloyd L. Loope, and Rosemary G. Gillespie. 2007. Inventory Of Arthropods Of The West Slope Shrubland And Alpine Ecosystems Of Haleakala National Park. Technical Report 148 Pacific Cooperative Studies Unit, University Of Hawai'i At Mānoa.

Medeiros, A.C. and L.L. Loope. 1994. A Review of the Arthropod Fauna at the Proposed Air Force Facility Construction Site at the Summit Area of Haleakalā Volcano, Maui, Hawai`i. Report prepared for KC Environmental, Inc., Makawao, Hawai`i. 4 pages.

Liebherr, J.K. and E.C. Zimmerman 2000. Hawaiian Carabidae (coleopteran), Part 1: Introduction and Tribe Platynini. Volume 16. University of Hawai'i Press, Honolulu. 494 pp.

National Science Foundation. 2009. Supplemental Final Environmental Impact Statement Advanced Technology Solar Telescope Haleakalā, Maui, Hawai'i May 2009

Nishida, G. M. 1997. Hawaiian Terrestrial Arthropod Checklist Third Edition. Hawai'i Biological Survey. Bishop Museum Technical Report No. 12. Bishop Museum, Honolulu.

Pacific Analytics. 2009. Arthropod Inventory And Assessment At The Haleakalā National Park Entrance Station And At The Haleakalā High Altitude Observatories, Maui, Hawai`i, In Support Of The Advanced Technology Solar Telescope Environmental Impact Analysis Process. Prepared for KC Environmental, Inc, Makawao, HI.

Polhemus, D. A. 2003. An initial review of *Orthotylus* in the Hawaiian Islands, with descriptions of twenty-two new species (Heteroptera: Miridae). Journal of the New York Entomological Society 110(3–4): 270–340.

Polhemus, D. A. 2005. Further studies on the genus *Orthotylus* (Heteroptera: Miridae) in the Hawaiian Islands, with descriptions of thirty-four new species. Journal of the New York Entomological Society 112(4): 227–333.

Polhemus, D. A. 2011. Continuing studies on the genus *Orthotylus* in the Hawaiian Islands (Heteroptera: Miridae), with descriptions of thirty-two new species. Entomologica Americana 117(1/2): 37–109.

Polhemus, D. A. 2013. A Fourth Contribution to the Study Of Hawaiian *Orthotylus* (Heteroptera: Miridae): New Species, Addenda, Revised Checklist, And Key To The *Perrottetia*-Feeding Species. Entomologica Americana 119(1-2):30–41.

Sharp (ed). 1899-1913. Fauna Hawaiiensis. Cambridge-at-the-University-Press.

Tentorio, J.M. 1969. Insects of Hawai'i Volume 11, Supplement. Diptera: Dolichopodidae Appendix (Phoridae). University of Hawai'i Press, Honolulu. 73 pp.

Townes, H. 1958. Insects of Micronesia Hymenoptera: Ichneumonidae, Stephanidae, and Evaniidae. Insects of Micronesia 19(2):35-87. B.P. Bishop Museum, Honolulu.

USFWS. 2011. Biological Opinion Of The U.S. Fish And Wildlife Service For Construction And Operation Of The Advanced Technology Solar Telescope (ATST) At The Haleakala High Altitude Observatory Site Maui, Hawaii June 15, 2011 (1-2-2011-F-0085)

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1990. Manual of the Flowering Plants of Hawai'i. University of Hawai'i Press, Honolulu.

Watanabe, C. 1958. Insects of Micronesia Hymenoptera: Eucharidae. Insects of Micronesia 19(2):1-34. B.P. Bishop Museum, Honolulu.

Williams, F.X. 1931. Handbook of the insects and other invertebrates of Hawaiian sugar cane fields. Hawaiian Sugar Planters' Association, Honolulu. 400 pp.

Yoshimoto, C.M. 1965a. Synopsis of Hawaiian Eulophidae including Aphelininae (Hym.: Chalcidoidea). Pac Ins 7(4): 665-699.

Yoshimoto, C.M. 1965b. The Hawaiian Thysaninae (Hym.: Chalcidoidea: Encyrtidae). Pac Ins 7(4): 703-704.

Yoshimoto, C.M. and T. Ishii. 1965. Insects of Micronesia Hymenoptera: Chalcidoidea: Eulophidae, Encyrtidae (part), Pteromalidae. Insects of Micronesia 19(4):109-178. B.P. Bishop Museum, Honolulu.

Zimmerman, E.C. 1948a. Introduction. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 1. University of Hawai'i Press, Honolulu. xx + 206 pp.

Zimmerman, E.C. 1948b. Apterygota to Thysanoptera inclusive. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 2. University of Hawai'i Press, Honolulu. viii + 475 pp.

Zimmerman, E.C. 1948c. Heteroptera. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 3. University of Hawai'i Press, Honolulu. 255 pp.

Zimmerman, E.C. 1948d. Homoptera: Auchenorhyncha. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 4. University of Hawai'i Press, Honolulu. vii + 268 pp.

Zimmerman, E.C. 1948e. Homoptera: Sternorhyncha. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 5. University of Hawai'i Press, Honolulu. vii + 464 pp.

Zimmerman, E.C. 1957. Ephemeroptera-Neuroptera-Trichoptera and supplement to volumes 1 to 5. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 6. University of Hawai'i Press, Honolulu. ix + 209 pp.

Zimmerman, E.C. 1958. Macrolepidoptera. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 7. University of Hawai'i Press, Honolulu. ix + 542 pp.

Zimmerman, E.C. 1958. Lepidoptera: Pyraloidea. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 8. University of Hawai'i Press, Honolulu. ix + 456 pp.

Zimmerman, E.C.. 1964. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 11. Diptera: Brachycera, Family Dolichopodidae. Cyclorrhapha, series Aschiza. Families Lonchopteridae, Phoridae, Pipunculidae, and Syrphidae. University of Hawai'i Press, Honolulu. vii + 458 pp.

Zimmerman, E.C. 1978. Microlepidoptera. Part I. Monotrysia, Tineoidea, Tortricoidea, Gracillarioidea, Yponomeutoidea, and Alucitoidea. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 9. University of Hawai'i Press, Honolulu. xx + 882 pp.

Zimmerman, E.C. 1978. Microlepidoptera. Part II. Gelechioidea. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 9. University Press of Hawai'i, Honolulu. 883-1903 pp.

APPENDIX A
HO ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Winter 2015 sampling at the HO site.

Class	Order	Family	Genus	Species	Authority	Status
Arachnida	Acari	mite				unknown
Arachnida	Araneae	Lycosidae	Lycosa	hawaiiensis	simon	endemic
Chilopoda	Lithobiomorpha	Henicopidae	Lamyctes	emarginatus	Newport	non-indigenous
Collembola	Entomobriidae					endemic
Insecta	Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous
Insecta	Coleoptera	Curculionidae	Listroderes	costirostris	Schonherr	non-indigenous
Insecta	Coleoptera	Staphylinidae				unknown
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Insecta	Diptera	Phoridae				endemic
Insecta	Diptera	Sarcophagidae				non-indigenous
Insecta	Diptera	Sciaridae				endemic
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	communis	Usinger	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	lichenicola	Kirkaldy	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	terrestris	Usinger	endemic
Insecta	Heteroptera	Miridae	Engytates	hawaiiensis	(Kirkaldy)	endemic
Insecta	Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic
Insecta	Homoptera	Delphacidae	Nesosydne	sp. 1		endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	mesotoxa	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	larvae			unknown
Insecta	Lepidoptera	Noctuidae	Pseudaletia	unipunctata	(Haworth)	non-indigenous
Insecta	Lepidoptera	Oecophoridae	Thryocopa	apatela	(Walsingham)	endemic

APPENDIX B
DKIST ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Winter 2015 sampling at the DKIST site.

Class	Order	Family	Genus	Species	Authority	Status
Arachnida	Acari	mite				unknown
Arachnida	Araneae	Lycosidae	Lycosa	hawaiiensis	simon	endemic
Collembola	Entomobriidae					endemic
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Insecta	Diptera	Chironomidae				unknown
Insecta	Diptera	Phoridae				endemic
Insecta	Diptera	Sciaridae				endemic
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous
Insecta	Diptera	Syrphidae	Eristalis	tenax	(Linneaus)	non-indigenous
Insecta	Heteroptera	Lygaeidae	Geocoris	pallens	Stål	non-indigenous
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	communis	Usinger	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	lichenicola	Kirkaldy	endemic
Insecta	Heteroptera	Miridae	Engytates	hawaiiensis	(Kirkaldy)	endemic
Insecta	Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic
Insecta	Homoptera	Aphididae				non-indigenous
Insecta	Homoptera	Cicadellidae	SP1			unknown
Insecta	Homoptera	Delphacidae	Nesosydne	sp. 1		endemic
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous
Insecta	Hymenoptera	Colletidae	Hylaeus	nivicola	Meade-Waldo	endemic
Insecta	Hymenoptera	Eurytomidae				non-indigenous
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	mesotoxa	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	larvae			unknown
Insecta	Lepidoptera	Noctuidae	Pseudaletia	unipunctata	(Haworth)	non-indigenous
Insecta	Lepidoptera	Oecophoridae	Thryocopa	apatela	(Walsingham)	endemic

APPENDIX B
HALE ES ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Winter 2015 sampling at the HALE Entrance Station.

Class	Order	Family	Genus	Species	Authority	Status
Arachnida	Acari					unknown
Arachnida	Araneae	Thomisidae				endemic
Arachnida	Araneae	Unknown 2				unknown
Chilopoda	Lithobiomorpha	Henicopidae	Lamyctes	emarginatus	Newport	non-indigenous
Collembola	Entomobriidae					endemic
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous
Diplopoda	Julida	Julidae	Allajulus	latistriatus	(Curtis)	non-indigenous
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Insecta	Coleoptera	Staphylinidae				unknown
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Insecta	Diptera	Muscidae	Haematobia	irritans	(Linnaeus)	non-indigenous
Insecta	Diptera	Tachinidae	SP1			non-indigenous
Insecta	Diptera	Tachinidae	SP2			non-indigenous
Insecta	Heteroptera	Miridae	Orthotylus	coprosmophila	Polhemus	endemic
Insecta	Heteroptera	Miridae	Orthotylus	sophoriodes	Polhemus	endemic
Insecta	Homoptera	Cicadellidae	Nesophrosyne	sp.		endemic
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous
Insecta	Hymenoptera	Colletidae	Hylaeus	nivicola	Meade-Waldo	endemic
Insecta	Hymenoptera	Collitidae	Hylaeus	difficillis	(Perkins)	endemic
Insecta	Hymenoptera	Collitidae	Hylaeus	volatilis	F. Smith	endemic
Insecta	Hymenoptera	Eurytomidae				non-indigenous
Insecta	Hymenoptera	Formicidae	Hypoponera	opaciceps	(Mayr)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Echthromorpha	agrestoria	(Fabricius)	endemic
Insecta	Lepidoptera	Cosmopterigidae	Hyposmocoma	sp.1		endemic
Insecta	Lepidoptera	Crambidae	Omiodes	sp.		endemic
Insecta	Lepidoptera	Pieridae	Phoebis	agarithe	(Boisduval)	non-indigenous
Insecta	Lepidoptera	Pterophoridae	Stenoptilodes	littoralis	(Meyrick)	non-indigenous
Insecta	Lepidoptera	Torticidae	Cydia	plicata	(Walsingham)	endemic
Insecta	Pscoptera					unknown