Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park and Annual Inspection of the DKIST Facilities and Grounds, Maui, Hawaiʻi

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Prepared for

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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 Summer 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.

In addition to semi-annual monitoring required by the FEIS, pursuant to the approved HCP and published BO, an inspection for non-indigenous arthropod species is required to be conducted on an ongoing annual basis during the approximate 5-year construction phase and 50 year lifespan of the DKIST for programmatic monitoring. Facilities and grounds within 100 feet of the DKIST observatory buildings are to be thoroughly inspected for introduced species that may have eluded the cargo inspection processes or transported to the site by construction personnel.

This report also describes the results of the Annual Inspection conducted in July 2015. The goal is to verify that the DKIST is in compliance with the conditions and mitigation measures described in the guiding environmental documents.

The 2015 Annual Inspection was conducted on July 22, 2015. No non-indigenous, invasive arthropods were found at the site or on any of the construction material and equipment. The project was found to be largely compliant with all the mitigation measures in the guiding environmental documents for construction of the DKIST. The construction site and surrounding lay-down/storage areas were clean and free of non-indigenous invasive arthropods.

III. INTRODUCTION

Programmatic Monitoring

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 Summer 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 Hawaiʹi.

Indigenous – A species native to Hawaiʹi but that naturally occurs outside of Hawaiʹi as well.

Non-indigenous – A species not native to Hawaiʹi.

Adventive – Not native, a species transported into a new habitat by natural means or accidentally by human activity.

Purposely introduced – A species released in Hawaiʹi for a particular purpose, usually to control a weedy plant or another insect.

This report describes the results of sampling conducted in July 2015, the second 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 July 20, 2015 and was completed on July 27, 2015.

Annual Inspection

An inspection is required to be conducted on an ongoing annual basis during the approximate 5-year construction phase and 50 year lifespan of the DKIST. The inspection was conducted on July 22, 2015. DKIST interior facilities and grounds within 100 feet of the buildings are to be thoroughly inspected for introduced species that may have eluded the cargo inspection processes or transported to the site by construction personnel. Any newly-discovered non-native, invasive arthropod are to be photo documented, mapped, and described. Arrangements will be made for eradication of any invasive introduced species found inside or within 100 feet of the DKIST buildings. Appropriate control methods include the use of available herbicides and pesticides, in accordance with established practice at HO (University of Hawaii 2010) and pursuant to label requirements.

Annual Inspections provide information about compliance with the guiding environmental documents prepared for the DKIST project. These documents include the DKIST Habitat Conservation Plan, USFWS biological Opinion, and the DKIST FEIS. In addition, the inspection meets the requirements of the University of Hawaii Institute for Astronomy Management Plan, which describes mitigation measures to prevent introduction of introduced species.

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 the Annual Inspection, and are the focus of this report.

Programmatic Monitoring

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.

Annual Inspection

Question 4

What non-indigenous arthropod species, if any, are detected within the interior of DKIST facilities and the grounds within 100 ft. (30 m) of the buildings?

Justification:

Detailed site inspections for non-indigenous arthropod species can detect potential threats to the nearby native ecosystems that may have escaped detection during the regular inspection process or programmatic monitoring. Early detection will allow implementation of control measures to eradicate invasive arthropod species (e.g. ants and spiders) before they have an opportunity to establish resident populations that could damage nearby native ecosystems.

Inspection goals:

1) To detect invasive non-indigenous arthropod species inside of the DKIST facilities and the grounds within 100 feet of the buildings.

If any invasive arthropod species (e.g. ants and spiders) are detected, they will be photo documented, mapped, and described, and then exterminated. Eradication measures may include brushing away spider webs to disrupt mating and foraging, sticky traps to capture ants, and the application of pesticides in accordance with established practice at HO (University of Hawaii 2010) and pursuant to label requirements.

Question 5

What non-indigenous invasive arthropod species, if any, are detected at the DKIST construction, lay-down and staging areas?

Justification:

While these areas are sampled during Programmatic Monitoring, they will receive increased scrutiny during the Annual Inspection. Annual inspection for non-indigenous arthropod species will detect potential threats to the nearby native ecosystems that may have escaped earlier detection and 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.

Inspection goals:

1) To detect invasive non-indigenous arthropod species at the DKIST lay-down and staging areas.

If any invasive arthropod species (e.g. ants and spiders) are detected, they will be photo documented, mapped, and described, and then eradicated to prevent these species from establishing resident populations. Eradication measures may include brushing away spider webs to disrupt mating and foraging, sticky traps to capture ants, and the application of pesticides in accordance with established practice at HO (University of Hawaii 2010) and pursuant to label requirements.

Question 6

Are mitigation measures implemented that prevent the establishment of invasive species due to DKIST construction activities?

Justification:

NSF has committed to several mitigation measures described in the DKIST FEIS, Habitat Conservation Plan (HCP), and USFWS Biological Opinion (BO) to prevent the introduction of invasive species to those areas surrounding the DKIST construction activities. The Annual Inspection will include examination of the DKIST Construction Site to ensure mitigation measures are being implemented correctly.

Monitoring goals:

1) To confirm that mitigation measures to prevent the establishment of invasive non-indigenous arthropod species committed to in the DKIST FEIS, HCP, and BO are being implemented correctly.

If any violations of the mitigation measures are detected, they will be photo documented, mapped, and described, and then reported to the Construction Site Manager, who will arrange for proper implementation of the measures to prevent invasive species from establishing resident populations.

Specific Alien Arthropod Control Measures to be taken
(Habitat Conservation Plan Page 54 – 57 and Biological Opinion Page 20-24)

Alien arthropods can arrive at the site by two general pathways. First, alien species already on Maui can spread to new locations. Second, alien species can arrive on the island with construction materials in or on shipping crates and containers. In order to block the first pathway, heavy equipment, trucks, and trailers will be pressure-washed before being moved to the DKIST construction site. The following specific alien arthropod control measures, adapted from those already required pursuant to the HO Management Plan will be implemented to further minimize the spread and establishment of alien insects. These six specific alien arthropod control measures are as follows:

1) Earthmoving equipment will be free of large deposits of soil, dirt and vegetation debris that could harbor alien arthropods.

a. Pressure-wash to remove alien arthropods: Earthmoving equipment and large vehicles and trailers often sit at storage sites for several days or weeks between jobs. Most of these storage sites are located in industrial areas and usually support colonies of ants and other alien arthropods. These species often use stored equipment as refuges from rain, heat, and cold. Ants may colonize mud and dirt stuck on earthmoving equipment and could then be transported to uninfested areas. Pressure-washing of equipment before it is transported to the site will be thorough enough to remove dirt and mud and to wash away ants, spiders and other alien arthropods, thereby reducing the chances of transporting these species to the site area.

b. As required by the HO Management Plan, large trucks, tractors, and other heavy equipment will be inspected before entering the Park. Inspection will be recorded in a log book kept at the site.

2) All construction materials, crates, shipping containers, packaging material, and observatory equipment will be free of alien arthropods when it is delivered to the site.

a. Inspect shipping crates, containers, and packing materials before shipment to Hawaiʻi: Alien arthropods can be transported to Hawaiʻi via crates and packaging. Therefore, only high quality, virgin packaging materials will be used when shipping supplies and equipment to the DKIST Project site. Pallet wood will be free of bark and other habitat that can facilitate the transport of alien species. Federal and Hawaiʻi State agricultural inspectors do not currently check all imported non-food items for alien arthropods. DKIST construction management will communicate to shippers and suppliers the environmental concerns regarding alien arthropods, and inform them about appropriate inspection measures to ensure that supplies and equipment shipped to Hawaiʻi are free of alien arthropods at the points of departure and arrival.

b. Shipping containers will be inspected and any visible arthropods will be removed. Construction of crates immediately prior to use will prevent alien arthropods from establishing nests or webs. Cleaning containers just prior to being loaded for shipping will also be done to minimize the transport of alien arthropods.

c. After arrival in Hawaiʻi, crates or boxes to be transported to the site will be inspected for spider webs, egg masses, and other signs of alien arthropods. Arthropods are small and easily overlooked during hectic assembly and packaging activity off-island. Many arthropods could escape detection during shipping inspections. Re-inspection prior to transport to the site will be completed to reduce the potential for undetected arthropods to reach the construction site. Arrangements will be made stipulating mandatory use of the Maui Alien Species Action Plan (ASAP) building for complete inspection of all possible items. This will prevent /or best allow for alien species interdiction on arriving materials.

i. Inspect construction materials before entering the Park: Alien arthropods already resident in Hawai'i are capable of hitchhiking on construction material such as bricks and blocks, plywood, dimension lumber, pipes, and other supplies. Precautions will be taken to ensure that alien arthropods are not introduced to the HO site.

ii. Construction materials will be inspected before transport to the construction site.

If any alien arthropods are discovered, the infestation will be removed prior to transport. Infestations of ants can be removed using pressure-washing. Infestations of spiders can be removed using brooms, vacuum cleaners, or other similar methods. Pesticide use on materials to be transported to the site should be avoided.

3) Sanitary control of food and garbage will prevent access to food resources that could be used by invading ants and yellow jackets. Outdoor trash receptacles will be secured to the ground, have attached lids and plastic liners, and their contents will be collected frequently to reduce food availability for alien predators. Heavy, hinged lids will be used to prevent wind dispersal of garbage. Refuse will be collected on a regular basis to ensure containers do not become full or overflow. This could entail collection several times a week, particularly in eating areas and during periods of heavy use of the area. Containers will be regularly washed using steam or soap to reduce odors that attract ants. Plastic bag liners will be used in all garbage containers receiving food to contain leaking fluids.

4) Ensure construction waste and debris is secured to ensure it is not dispersed.

a. Construction activity may generate a considerable amount of waste debris. Typically construction debris is disposed of in “roll-off” containers that are periodically picked up and emptied at a landfill. Large “roll-off” containers can accommodate debris generated over several days of construction. Debris disposed of in these containers consists of wood, scrap insulation, packaging material, waste concrete, and various other construction wastes.

b. High winds at the site can disperse construction debris from the containers and disperse the material into adjacent arthropod habitat. Unsecured building materials and equipment at the site are also susceptible to wind dispersal. Construction trash and building material is not believed to significantly impact native arthropod species, but collection of the wind-blown material could potentially disturb their habitat (e.g., Howarth, et al., 1999).

c. Construction trash containers will be tightly covered to prevent construction wastes from being dispersed by wind. This will be accomplished during construction of DKIST pursuant to the best management practices described in the HO Management Plan.

Covering containers will decrease the amount of construction debris that could be blown onto adjacent native arthropod habitat. “Roll off” containers can be equipped with tarps held securely with cables. Containers will be collected on a regular basis before they are completely full or overflowing. This could entail collection several times a week, particularly during periods of heavy use.

5) Invasive species detection and interdiction will be the responsibility of the resource biologist for DKIST and supporting avian biologist. Detection and interdiction will be conducted routinely by these personnel to ensure that new introductions are controlled.

a. A biological monitor will be employed during construction and programmatic arthropod sampling will be done in accordance with the schedule described within Section 2.3-DKIST Project Description of the HCP, and Section 3.0 of the BO. Monitoring for new alien arthropod introductions will be conducted during construction activities and any populations detected will be eradicated. Monitoring for alien populations is relatively easy and inexpensive to conduct. Baited traps have been shown to detect alien populations before they reach damaging proportions.

b. Ant eradication: Sticky traps designed to capture ants will be deployed immediately after any ants are detected. Persistence of ant detections are indicative of larger infestations, and will prompt a search for and eradication of colonies. Bait and chemical control will be employed only when absolutely necessary and only by a certified pest control professional.

c. Alien spider eradication: Any alien spider webs detected will be removed. Native lycosid wolf spiders do not make webs. Native sheet-web spiders make tiny webs under the cinder surface. Only alien spiders would make large spider webs at HO. Sweeping such webs away with a broom disrupts alien spider food capture success and destroys egg masses. Follow-up measures will be developed and implemented to control alien spiders when they are detected.

6) Construction materials stored at the site will be covered with tarps, or anchored in place, and will not be susceptible to movement by wind. Securing materials will reduce the chances of debris being dispersed from the site into native arthropod habitat. Construction materials and supplies will be prevented from being blown into native arthropod habitat by covering them with heavy canvas tarps, using steel cables, attached to anchors that are driven into the ground. Construction materials at the site will be tied down or otherwise secured during high winds and at close of work each day. If construction materials and trash are blown into native arthropod habitat, they will be collected with a minimum of disturbance to the habitat.

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.

Monitoring 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. 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 July 21, 2015 and their contents collected on July 27, 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 five nights at the DKIST site, HO site, and the HALE site.

An additional night of sampling was suspended due to weather conditions.

Light traps were deployed for five trap nights at each sampling site, and were allowed to run overnight or until batteries failed.

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 an index card 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. Baited traps were deployed on the HO and DKIST sites on three different days. The traps were checked after forty-five minutes at which time the traps were be removed. Baited traps were not left opened overnight in order to avoid attracting unwanted pests.

Baited ant traps were deployed on two different days at the HO/DKIST sites, twenty-five the first day and thirty-five on a second day. Twenty baited traps were deployed at the HALE ES site on one day.

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 July 20, 2015 and ending on July 27, 2015.

Annual Inspection Procedures

Inspection of DKIST building interiors and within 100 feet of the DKIST buildings.

During the inspection, the interiors of all DKIST buildings were be examined for evidence of non-indigenous invasive species. If any invasive arthropod species (e.g. ants and spiders) were detected, they would have been photo documented, mapped, and described, and then arrangements would be made for eradication to prevent these species from establishing resident populations. Eradication measures may include brushing away spider webs to disrupt mating and foraging, sticky traps to capture ants, and the application of pesticides in accordance with established practice at HO (University of Hawaii 2010) and pursuant to label requirements.

Inspection of DKIST construction, lay-down and staging areas.

During the Annual Inspection, construction lay-down and staging areas were examined for evidence of non-indigenous invasive species. If any invasive arthropod species (e.g. ants and spiders) were detected, they would have been photo documented, mapped, and described, and then arrangements would have been made for eradication to prevent these species from establishing resident populations. Eradication measures may include brushing away spider webs to disrupt mating and foraging, sticky traps to capture ants, and the application of pesticides in accordance with established practice at

HO (University of Hawaii 2010) and pursuant to label requirements.

Earthmoving Equipment
Earthmoving equipment and vehicles were inspected to verify they are being properly washed.

Construction materials, crates, shipping containers, packaging material, and observatory equipment
Construction materials, crates, shipping containers, packaging material, and observatory equipment were examined for evidence of non-indigenous arthropod species.

Sanitary control of food and garbage
Outdoor trash receptacles were examined to ensure they were secured to the ground, had attached lids and plastic liners. Containers were examined to verify that they were washed and that odors were not present that may attract ants or yellow jackets.

Construction Waste and Debris
"Roll-off" containers, construction trash, and building materials were inspected to verify that the containers were tightly covered to prevent construction wastes from being dispersed by wind.

Stored Construction materials
Building materials and equipment at the DKIST site, or in lay-down or storage areas that are susceptible to wind dispersal were examined to verify that they were secured to prevent their movement by wind into native arthropod habitats.

Inspection Date

Sampling and inspection was conducted on July 22, 2015.

VI. RESULTS and DISCUSSION

Programmatic Monitoring

HIGH ALTITUDE OBSERVATORIES

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

Spiders and Mites - Arachnida

Juvenile and adult Lycosid spiders, *Lycosa hawaiiensis* Simon, occurred in pitfall traps, and were actively foraging among rocks. Small spiders of the family Linyphiidae were observed under rocks, and may represent several species.

Springtails - Collembola

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

Beetles – Order Coleoptera

Ten beetle species were observed at the HO site. A species of endemic long-horned beetles (genus *Plagithmysus*) was found on *Dubautia*.

The Hawaiian native long-horned beetle found on *Dubautia.*

Trechus obtusus Erichson, an introduced ground beetle native to Europe and North Africa was found under rocks. First reported from Maui in 1998, this species appears regularly in Programmatic Monitoring samples. Six species of non-indigenous ladybird beetles (family Coccinellidae) were observed, including the seven-spotted ladybird beetle (*Coccinella septempunctata* L.) and the convergent ladybird beetle (*Hippodamia convergens* Guerin-Meneville). The larvae of these species feed on small insects, such as aphids, and are considered beneficial insects. A small rove beetle (family Staphylinidae) and feather winged beetle (family Ptiliidae) were collected in pitfall traps, both as single specimens.

Flies - Order Diptera

Thirteen species of flies were detected at the HO site. Two are endemic species of fruit flies (family Tephritidae). Eight species are non-indigenous and have been common in previous monitoring samples. The status of three species of flies collected was unknown.

A species of Hawaiian native fruit fly.

True Bugs – Orders Heteroptera and Homoptera

Eleven species of true bugs (order Heteroptera) were observed including adults and nymphs of three Hawaiian endemic species in the genus *Nysius* (family Lygaeidae). Two of these species (*Nysius coenosulus* and *N. communis*) are common residents at the site and occur in abundance on both *Dubautia* and *pukiawe*. Other Lygaeidae were the non-indigenous white-crossed seed bug (*Neacoryphus bicrucis* (Say)). Specimens from the family Miridae included the endemic species *Engytates hawaiiensis* (Kirkaldy), found on *Dubautia*, *Trigonotylus hawaiiensis* (Kirkaldy), found on grasses, and *Hyalopeplus pelucidus* Stål. Adults and nymphs of *Geocoris pallens* Stål were abundant on vegetation at the HO site.

Six species of Homoptera were found, including an endemic species of plant hopper of the genus *Nesosydne*, common on *Dubautia*. The Acacia psyllid, *Acizzia uncatoides* (Ferris & Klyver) were abundant.

The Haleakalā flightless moth found near a light trap.

Butterflies and Moths – Order Lepidoptera

Eleven species of Lepidoptera were found at the HO site. These include three endemic species in the genus *Agrotis*, and two other unknown species in the same genus. The non-indigenous *Pseudalecia unipuncta* (Meyrick) was also found. Adults of the Haleakalā flightless moth (*Thyrocopa apatela* (Walsingham)) were collected in the morning near light traps that had run all night.

Other Lepidoptera included the endemic Hawaiian Blue (*Udara blackburni* (Tuely)), and a species of *Hyposmocoma*.

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.

Largely undisturbed habitat near the Las Cumbres Telescope at the HO site has native vegetation that supports native Hawaiian arthropods.

DKIST CONSTRUCTION SITE

Construction was started on the DKIST in December 2012 and was ongoing during the Summer 2015 sampling session. Excavation was completed in 2014 and most earth-moving equipment has been removed from the site.

Sixty-two species of arthropods were collected at the DKIST site during the Summer 2015 sampling session. The species included twenty-one endemic Hawaiian arthropods, twenty-eight non-indigenous arthropods, and thirteen species of unknown status.

Spiders and Mites - Arachnida

Juvenile and adult Lycosid spiders, *Lycosa hawaiiensis* Simon, occurred in pitfall traps at the DKIST site, and were seen actively foraging among rocks. A small Linyphiidae spider was also seen under rocks.

Springtails - Collembola

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

Beetles – Order Coleoptera

Nine species of beetles were observed at the DKIST site, all non-indigenous. The species included six ladybird beetles, an unknown leaf beetle (family Chrysomelidae), and the pepper weevil (*Anthonomus eugenii* Cano).

Non-indigenous ladybird beetles are abundant on vegetation.

Flies - Order Diptera

Fourteen species of flies were detected at the DKIST site. Only one endemic species, a fruit fly (family Tephritidae) was observed. The rest were non-indigenous and have been observed at the site during previous sampling.

True Bugs – Orders Heteroptera and Homoptera

Eleven species of true bugs (Order Heteroptera) were observed at the DKIST site, including seven 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.

Non-indigenous species included *Geocoris pallens* Stål and a seed bug from the genus *Pachybrachius*.

The non-indigenous big-eyed bug, *Geocoris pallens* Stål found at the DKIST site.

Adults and nymphs of three plant bugs (family Miridae) were also observed. *Engytates hawaiiensis* (Kirkaldy) is uncommon, found on *Dubautia*, *Trigonotylus hawaiiensis* (Kirkaldy), is found only on grasses, and *Hyalopeplus pelucidus* Stål found on vegetation. All are endemic species.

Other Heteroptera that were collected include the green stink bug (*Nezara viridula* L.) and the white-crossed seed bug (*Neacoryphus bicrucis* (Say)).

Five 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 and the abundant Acacia psyllid.

The Acacia Psyllid was very abundant at the DKIST.

An unknown scale insect (family Pseudococcidae) was present on *Tetramolopium humile* and may be an indigenous species.

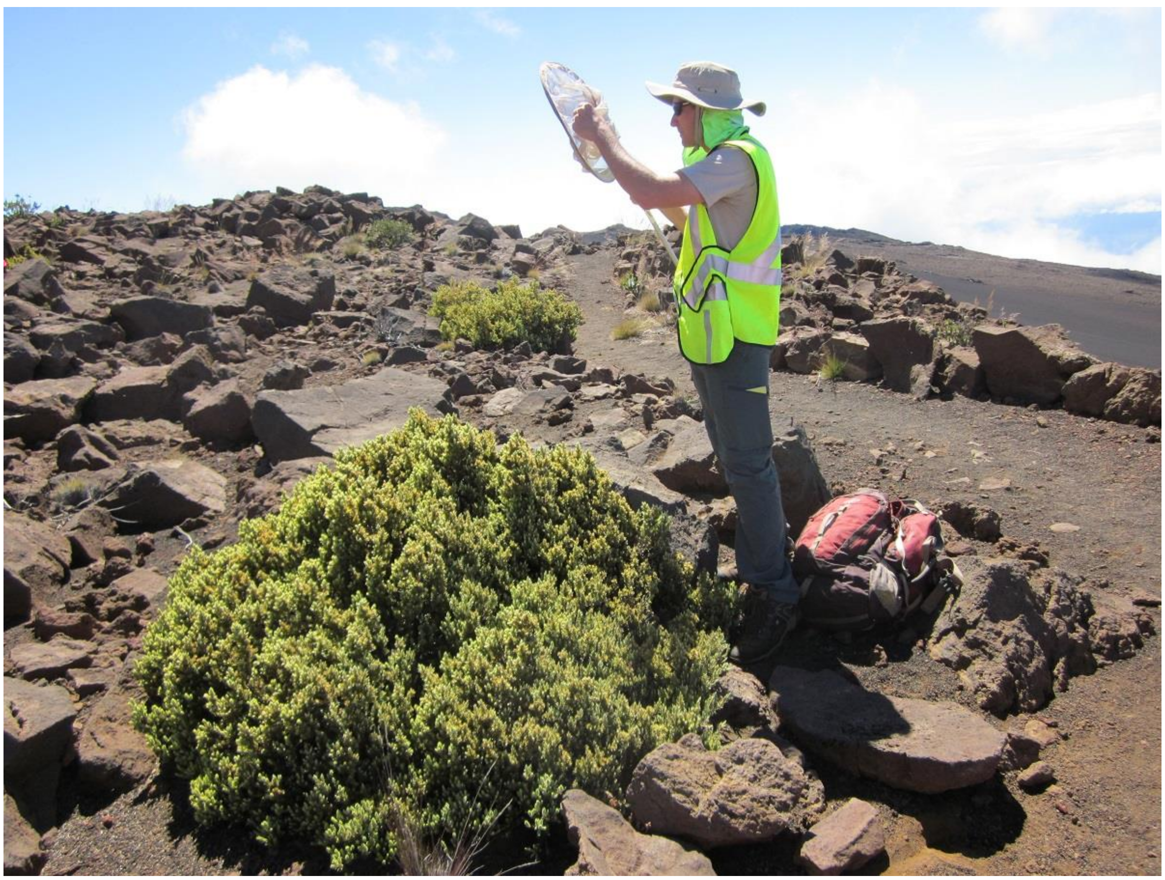
Bees and Wasps – Order Hymenoptera

The endemic species of yellow-faced bees, *Hylaeus nivicola* Meade Waldo, was common on *pukiawe*. Other Hymenoptera observed include small parasitic wasps and yellow jackets, *Vespula pensylvanica* (Saussure).

Moths – Order Lepidoptera

Eight species of Lepidoptera were collected, all endemic species. Four large moths in the genus *Agrotis* were captured in light traps. Caterpillars of the genus *Agrotis* were found in pitfall traps. Haleakalā flightless moths (*Thyrocopa apatela* (Walsingham)) were observed hopping in the cinder habitat.

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.



Dr. Will Haines sampling pukiawe adjacent to the DKIST site.

HALEAKALĀ ENTRANCE STATION

Sampling in HALE occurred near the Entrance Station (HALE ES) at 6,250 feet elevation. Eighty-eight species of arthropods were collected and observed there. The species included thirty-two endemic Hawaiian arthropods, forty-four non-indigenous arthropods, and eleven species of unknown status.

Spiders and Mites - Arachnida

Six species of spiders were recorded at the HALE ES site. The only species identified as endemic was a crab spider (*Mecaphesa sp. nr. kanakanus* (Karsch)), uncommon on vegetation.

A non-indigenous hunting spider (*Cheiracanthium mordax* L. Koch) was uncommon in sweep net sampling over grasses. Another non-indigenous species recorded was a comb-footed spider (*Steatoda grossa* (C. L. Koch)). Similar in appearance to the black widow, this uncommon species was found under logs and rocks. Both of these species have reported from HALE in the past.

Collembola - Springtails

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

Beetles – Order Coleoptera

Nine species of beetles were observed, including an endemic ground beetle (genus *Mecyclothorax*) and a similar-looking, but somewhat smaller, non-indigenous ground beetle, *Trechus obtusus* Erichson.

Non-indigenous beetles include two common species of ladybird beetles and three well known weevils, as well as an unknown rove beetle (family Staphylinidae).

The Eucalyptus leaf beetle (*Paropsisterna (Chrysophtharta) m-fuscum*) was discovered on Eucalyptus trees near the HALE ES. Native to Australia and New Guinea, this species is also widespread in Southern California and was recently found in South Carolina. Adults are 6-7 mm (about ¼ inch) long, brown with darker mottled spots, and look like a brown ladybird beetle. Blue gum Eucalyptus is the principal host plant for this species. Adult beetles and larvae chew notches along the edges of eucalyptus leaves, leaving them unsightly and torn. The beetles alone are not known to kill eucalyptus trees; however, heavy infestations of beetles can consume almost all of the leaf tissue, stressing the plant enough that it will eventually die. This is a new state record for this species and the Hawaii State

Department of Agriculture has been notified of the discovery.

HALE ES is probably not the site of first introduction, and it's not likely to be something that came in on construction equipment or materials. It is more likely that this beetle arrived in Hawaii on cut foliage used in flower arrangements. It probably worked its way up from Kula or the ranch below the National Park. Eucalyptus trees at the lower end of the crater road (Hwy 378) have signs of defoliation by this beetle.

Flies – Order Diptera

Fourteen species of flies were seen at the HALE ES. Ten species were from families of common non-indigenous flies (e.g.: blow flies, and bee flies) previously reported from HALE ES. One specimen of an endemic fruit fly (*Trupanea crassipes* (Thomson)) was found at a light trap.

Fruit fly, fungus gnats, and craneflies of unknown status, complete the species found at the HALE ES.

True Bugs – Orders Heteroptera and Homoptera

Six species of true bugs (Heteroptera) were found, three endemic species from the family Miridae. *Orthotylus coprosmophila* Polhemus, common on *Coprosma*, *Orthotylus sophoriodes* Polhemus, abundant on *manane*, and *Hyalopeplus pelucidus* Stål, which was very common at all three sampling sites. Three non-indigenous species from other families, a seed bug (family Lygaeidae), a damsel bug (family Nabidae), and another seed bug (family Rhyparochromidae).

Four species of Homoptera were observed, one a Hawaiian endemic. This species, from the indigenous genus *Nesophrosyne* (family Cicadellidae), was uncommon on vegetation.

A close up of *Ectemnius nesiotes* (Pate), an indigenous predatory wasp.

Bees and Wasps – Order Hymenoptera

The nine species of Hymenoptera found near the HALE Entrance Station included three indigenous species, a solitary predatory wasp (family (Crabronidae), a hunting wasp (family

Bethylidae), and a vespid wasp (*Odynerus* sp.).

The six non-indigenous species include three ants, *Cardiocondyla kagutsuchi/ venestula*, *Hypoponera opaciceps*, and *Linepithema humile,* and three parasitoids. No yellow-faced bees (genus *Hylaeus*) were detected. Normally present at the HALE ES, the activity of these bees may have been limited by wet weather conditions.

Butterflies and Moths – Order Lepidoptera

Lepidoptera were the most diverse group with twenty-seven species, 20 endemic to Hawaii. The endemics are mostly moths, such as the mamane moth (*Uresiphita polygonalis virescens* (Butler)) but are also represented by seven species of larger noctuid moths and the Hawaiian blue (Udara blackburni (Tuely)). The non-indigenous are mostly larger noctuid moth species, but also include two lantana biocontrols and two smaller tortricid moths.

Other Observations

Other arthropods were observed at the HALE ES, including centipedes, millipedes, and sowbugs common in pitfall traps, under rocks, and in decaying vegetation.

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.

Programmatic Monitoring Discussion

The arthropods that were found during this sampling are characteristic of the fauna found during previous monitoring. Only one new invasive arthropod was detected at any of the sites (HALE ES), the Eucalyptus leaf beetle (*Paropsisterna m-fuscum*).

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.

Sampling at the HALE ES was limited by wet conditions. Dense fog and rain caused the vegetation to be wet which reduces insect activity and detection.

There are three main Questions of Interest that are to be answered by this monitoring:

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?

The Characteristic arthropods found at the monitored sites can be found in the species lists in the appendices at the end of this report.

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?

There have been minor adverse impacts on indigenous arthropod species at the monitored sites. Native vegetation was removed from the construction site during site excavation. This reduced the size of the arthropod population at the site, however, vegetation is already recovering and it can be expected that native arthropods will return to the site to exploit the renewed plant resources.

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?

There were no non-indigenous arthropod species detected at the HO and DKIST sites. One new invasive arthropod species was discovered at the HALE ES site, the Eucalyptus Leaf Beetle (Paropsisterna m-fuscum). It is unlikely that this beetle was carried into the Park on construction materials of vehicles. The species is found on blue gum Eucalyptus leaves where it spends most of its life cycle. The beetle was probably introduced into Hawaii via florist foliage. Leaf damage was detected on the lower section of the Crater Highway (HWY 378), and the beetle has likely migrated up the road to the Park following the Eucalyptus food resources.

Annual Inspection

One day was allocated to the Annual Inspection during the Summer Programmatic Monitoring session. The inspection took place on July 22, 2015. During the inspection, the interiors of DKIST structures were examined for evidence of non-indigenous invasive species. No new invasive arthropod species were detected. The following pages describe the results of the inspection.

The following were inspected:
DKIST Observatory Building
DKIST Utility Building
DKIST Site Manager's Trailer
DKIST First Aid Trailer
Cultural Monitor Trailer
Reef Development Trailer 1
DU-WATTS Trailer
Reber Circle Storage Container 1
Reber Circle Storage Container 2
Reber Circle Storage Container 3
Reber Circle Storage Container 4
Steel Tech Storage Container
Storage Container 1
Storage Container 2
Storage Container 3
Storage Container 4
Container Support Office 1
Container Support Office 2
Material Storage and Lay-Down Areas
Earth-moving Equipment
Motorized Construction Vehicles
Pickups and other Trucks

Office Trailers

Seven office trailer s were inspected. The offices contain desks, chairs, and file cabinets. The seven trailer offices were all found to be free of non-indigenous invasive arthropod species. Trash cans in these offices had liners and containers used for food waste had proper fitting lids.

The Construction Site Manager Office trailer was found to be free of non-indigenous invasive arthropods.

The trash can outside the Reef Development office trailer had an improper lid and contained food waste. The Site Manager was informed and he immediately took steps to correct the violation. The trash can had a plastic liner and the Site Manager said that the waste was taken away from the site daily for proper disposal.

Reef Development office trailer. Red arrow points to trash can with improper lid and food waste.

A trash can outside the Reef Development trailer office with an improper lid and food waste. By the end of the day this can had a proper lid and was emptied.

Storage Containers

There were ten storage containers on the DKIST construction site. Five storage containers were locked and not available for interior inspection. The interiors of the open containers were inspected and found to be free of non-indigenous invasive arthropods. Trash containers inside these storage containers were lined and are dumped daily.

Typical storage container at the DKIST construction site.

Interior of a storage container with lined trash can for disposal of soda bottles. This trash can is emptied daily and trash is taken away from the site for proper disposal.

Observatory Buildings and Support Structures

The DKIST observatory building and the support structures were inspected and found to be free of non-indigenous invasive arthropod species. The interior of these structures are frequently swept clean of debris, and most trash cans are lined and have proper fitting lids. Two trashcans inside the observatory structure had no lids and were overfilled with trash. No food waste was observed in these trash containers.

DKIST observatory building.

Interior of the DKIST observatory building. The building is kept clean and trash is disposed of daily.

Trash cans inside the DKIST observatory building was covered.

Laydown and Construction Material Storage Areas

Laydown and construction material storage areas were inspected and found to be free of non-indigenous invasive arthropod species. The areas are kept free of trash and wind-blown debris and material that can become wind-blown are tied down and secured to prevent movement.

Construction material storage area was free of non-indigenous invasive arthropods. The areas are also free of trash and wind-blown debris.

Earth-moving Equipment

Only one piece of earth-moving equipment is left at the site, a small Caterpillar skid steer. This vehicle was inspected and found to be free of invasive arthropods.

Most earth-moving equipment has been removed from the construction site. This remaining skid steer was free of invasive arthropod species.

Outdoor Construction Waste Containers

There are two large drop-off trash containers at the construction site. Both had secure lids and are dumped when full. The containers were inspected and found to be free of non-indigenous invasive arthropod species.

Drop-off trash container outside of the DKIST observatory building. The container has a secure lid and is dumped frequently as needed.

Sanitary Control

Food waste is disposed of in special lined trash cans with tight fitting lids. Except for the uncovered trash can outside the Reef Development office trailer, the food waste containers were found to be properly covered and lined and free of non-indigenous invasive arthropod species.

Trash containers not used for food waste are labeled to prevent improper disposal of food waste.

ANNUAL INSPECTION DISCUSSION

The DKIST construction site and surrounding lay-down/storage areas were found to be well organized and kept neat and clean. There were no signs of invasive non-indigenous arthropods. Except for one uncovered trash can, the site was compliant with all the incumbent environmental documents.

There are three main Questions of Interest that are to be answered by this annual inspection.

Question 1

What non-indigenous arthropod species, if any, are detected within the interior of DKIST facilities and the grounds within 100 ft. (30 m) of the buildings?

There were no non-indigenous arthropods found in or around the DKIST buildings that were potentially threatening to native flora and fauna.

Question 2

What non-indigenous invasive arthropod species, if any, are detected at the DKIST construction, lay-down and staging areas?

There were no non-indigenous arthropods found in or around the DKIST buildings that were potentially threatening to native flora and fauna.

Question 3

Are mitigation measures implemented that prevent the establishment of invasive species due to DKIST construction activities?

Except for the one uncovered trash container, all mitigation measures were found to be implemented to prevent establishment of invasive species due to construction activities.

Earthmoving equipment were free of large deposits of soil, dirt and vegetation debris that could harbor alien arthropods. All construction materials, crates, shipping containers, packaging material, and observatory equipment were free of alien arthropods. Sanitary control of food and garbage is preventing use by invading ants and yellow jackets. Outdoor trash receptacles are secured to the ground, have attached lids and most have plastic liners. Their contents are collected frequently to reduce food availability for alien predators. The roll-off containers have heavy, hinged lids to prevent wind dispersal of garbage. Refuse is collected on a regular basis to ensure containers do not become full or overflow.

Some trash containers inside the observatory building were uncovered and contained debris susceptible to becoming wind-blown. Trash containers used for food waste were clean and lined with plastic bags. They are apparently washed regularly to reduce odors that attract ants. Plastic bag liners are used in all garbage containers receiving food to contain leaking fluids.

Construction materials stored at the site that are susceptible to becoming wind-blown were covered with tarps, or anchored in place. Excavated material was covered to prevent excess dust and the site is watered several times a day to prevent dust from vehicle traffic. There was no pieces of wind-blown trash in the habitat surrounding the site.

The Construction Site Manager and his crew do an excellent job ensuring that the construction site is a safe place to work, and has a minimal impact on the surrounding habitat.

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APPENDIX A
HO ARTHROPOD SPECIES LIST

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

Order	Family	Genus	Species	Authority	Status
Araneae	Linyphiidae				unknown
Araneae	Lycosidae	Lycosa	hawaiiensis	simon	endemic
Lithobiomorpha					unknown
Entomobryidae					endemic
Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous
Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Coleoptera	Cerambycidae	Plagithmysus	dubautianus	Gressit and Davis	endemic
Coleoptera	Cerambycidae	Plagithmysus	swezeyanus	Gressitt and Davis	endemic
Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous
Coleoptera	Coccinellidae	Harmonia	conformis	(Boisduval)	non-indigenous
Coleoptera	Coccinellidae	Hippodemia	convergens	Gurein-Meneville	non-indigenous
Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous
Coleoptera	Coccinellidae	Rodolia	cardinalis	(Mulsant)	non-indigenous
Coleoptera	Coccinellidae	Scymnus	sp.		non-indigenous
Coleoptera	Ptiliidae				unknown
Coleoptera	Staphylinidae				unknown
Diptera	Anthomyiidae	Delia	platura	(Meigen)	non-indigenous
Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous
Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Diptera	Drosophilidae				unknown
Diptera	Phoridae	Megaselia			non-indigenous
Diptera	Sciaridae				unknown
Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous
Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous
Diptera	Syrphidae	Eristalis	tenax	(Linneaus)	non-indigenous
Diptera	Syrphidae				non-indigenous
Diptera	Tephritidae	Trupanea	crassipes	(Thomson)	endemic
Diptera	Tephritidae	Trupanea	cratericola	(Grimshaw)	endemic
Diptera	Tipulidae	SP1			unknown
Heteroptera	Geocoridae	Geocoris	pallens	Stål	non-indigenous
Heteroptera	Lygaeidae	Neacoryphus	bicrucis	(Say)	non-indigenous
Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic
Heteroptera	Lygaeidae	Nysius	communis	Usinger	endemic
Heteroptera	Lygaeidae	Nysius	palor	Ashlock	endemic
Heteroptera	Miridae	Engytates	hawaiiensis	(Kirkaldy)	endemic
Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic
Heteroptera	Miridae	Koanoa?			endemic?

Order	Family	Genus	Species	Authority	Status
Heteroptera	Miridae	Taylorilygus	apicalis	(Fieber)	non-indigenous
Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic
Heteroptera	Rhyparochromidae	Brentiscerus	putoni (= australis)	(White)	non-indigenous
Homoptera	Aphididae	SP1			non-indigenous
Homoptera	Cercopidae	Clastoptera	xanthocephala	Germar	non-indigenous
Homoptera	Cicadellidae	SP1			unknown
Homoptera	Delphacidae	Nesosydne	sp.		endemic
Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous
Homoptera	Psyllidae	SP1			
Lepidoptera	Cosmopterigidae	Hyposmocoma	sp.1		endemic
Lepidoptera	Crambidae	Nomophila	noctuella	(Denis & Schiffermüller)	non-indigenous
Lepidoptera	Lycaenidae	Udara	blackburni	(Tuely)	endemic
Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Lepidoptera	Noctuidae	Agrotis	sp. A		endemic?
Lepidoptera	Noctuidae	Agrotis	sp. B		endemic?
Lepidoptera	Noctuidae	Agrotis	xiphias	Meyrick	endemic
Lepidoptera	Noctuidae	Peseudaletia	unipunctata	(Haworth)	non-indigenous
Lepidoptera	Oecophoridae	Thyrocopa	apatela	(Walsingham)	endemic
Lepidoptera	Tortricidae				unknown
Odonata	Aeshnidae	Anax	junius	(Drury)	non-indigenous
Psocoptera					unknown

APPENDIX B
DKIST ARTHROPOD SPECIES LIST

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

Order	Family	Genus	Species	Authority	Status
Araneae	Linyphiidae				unknown
Araneae	Lycosidae	Lycosa	hawaiiensis	simon	endemic
Lithobiomorpha					unknown
Entomobryidae					endemic
Hypogastruridae					endemic
"Slugs"					non-indigenous
Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Coleoptera	Chrysomelidae				non-indigenous
Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous
Coleoptera	Coccinellidae	Diomus	notescens	(Blackburn)	non-indigenous
Coleoptera	Coccinellidae	Hippodemia	convergens	Gurein-Meneville	non-indigenous
Coleoptera	Coccinellidae	Hyperaspis	pantherina or sylvestrii		non-indigenous
Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous
Coleoptera	Coccinellidae	Rodolia	cardinalis	(Mulsant)	non-indigenous
Coleoptera	Curculionidae	Anthonomus	eugenii	Cano	non-indigenous
Diptera	Anthomyiidae	Delia	platura	(Meigen)	non-indigenous
Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous
Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Diptera	Chironomidae				unknown
Diptera	Drosophilidae				unknown
Diptera	Phoridae	Megaselia			non-indigenous
Diptera	Sciaridae				unknown
Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous
Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous
Diptera	Syrphidae	Simosyrphus	grandicornis	(Macquart)	non-indigenous
Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous
Diptera	Syrphidae				non-indigenous
Diptera	Tephritidae	Trupanea	cratericola	(Grimshaw)	endemic
Diptera	Tipulidae	SP1			unknown
Heteroptera	Anthocoridae				
Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic
Heteroptera	Lygaeidae	Nysius	communis	Usinger	endemic
Heteroptera	Lygaeidae	Nysius	lichenicola	Kirkaldy	endemic
Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous
Heteroptera	Miridae	Engytates	hawaiiensis	(Kirkaldy)	endemic
Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic
Heteroptera	Miridae	Opuna	n. sp. 1 (of Krushelnycky)		endemic

Order	Family	Genus	Species	Authority	Status
Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic
Heteroptera	Pentatomidae	Nezara	viridula	Linnaeus	ohelo
Heteroptera	Rhyparochromidae	Brentiscerus	putoni (= australis)	(White)	non-indigenous
Homoptera	Aphididae	SP1			non-indigenous
Homoptera	Cicadellidae	SP1			unknown
Homoptera	Delphacidae	Nesosydne	sp.		endemic
Homoptera	Pseudococcidae	SP 1			unknown
Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous
Hymenoptera	Braconidae	Apateles			unknown
Hymenoptera	Colletidae	Hylaeus	nivicola	Meade-Waldo	endemic
Hymenoptera	Ichneumonidae	Gelis			non-indigenous
Hymenoptera	Ichneumonidae	Priostomerus	hawaiiensis	Perkins	non-indigenous
Hymenoptera	Torymidae				
Hymenoptera	Vespidae	Vespula	pensylvanica	(Saussure)	non-indigenous
Lepidoptera	Cosmopterigidae	Hyposmocoma	sp.1		endemic
Lepidoptera	Crambidae	Eudonia	sp.		endemic
Lepidoptera	Geometridae	Eupithecia	monticolans	Butler	endemic
Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Lepidoptera	Noctuidae	Agrotis	giffardi (or mesotoxa)		endemic
Lepidoptera	Noctuidae	Agrotis	sp. A		endemic?
Lepidoptera	Oecophoridae	Thyrocopa	apatela	(Walsingham)	endemic
Psocoptera					unknown
Thysanoptera					unknown

APPENDIX C
HALE ES ARTHROPOD SPECIES LIST

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

Order	Family	Genus	Species	Authority	Status
Araneae	Clubionidae	Cheiracanthium	mordax	L. Koch	non-indigenous
Araneae	Linyphiidae				unknown
Araneae	Tetragnathidae				unknown
Araneae	Theridiidae	Steatoda	grossa	(C. L. Koch)	non-indigenous
Araneae	Theridiidae				unknown
Araneae	Thomisidae	Mecaphesa	sp. nr. kanakanus	(Karsch)	endemic
Lithobiomorpha					unknown
Entomobryidae					endemic
Hypogastruridae					endemic
Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous
Julida	Allajulus	latistriatus		(Curtis)	non-indigenous
"Slugs"					non-indigenous
Stylommatophora	Zonitidae	Oxychilus	alliarius	(J.S. Miller)	non-indigenous
Coleoptera	Carabidae	Mecyclothorax	spp.		endemic
Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Coleoptera	Chrysomelidae	Paropsisterna	m-fuscum		non-indigenous
Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous
Coleoptera	Coccinellidae	Rhyzobius	lophanthae	(Blaisdell)	non-indigenous
Coleoptera	Curculionidae	Gonipterus	scutellatus		non-indigenous
Coleoptera	Curculionidae	Otiorhynchus	cribricollis	Gyllenhal	non-indigenous
Coleoptera	Curculionidae	Tychius	picirostris	(Fabricius)	non-indigenous
Coleoptera	Staphylinidae				unknown
Dermaptera	Forficulidae	Forficula	auricularia	Linnaeus	non-indigenous
Diptera	Anisopodidae	Sylvicola	cinctus	(Fabricius)	non-indigenous
Diptera	Anthomyiidae	Delia	platura	(Meigen)	non-indigenous
Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous
Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Diptera	Calliphoridae	Lucilia	sericata	(Meigen)	non-indigenous
Diptera	Calliphoridae	Phormia	regina	(Meigen)	non-indigenous
Diptera	Drosophilidae				unknown
Diptera	Sarcophagidae	Blaesoxipha	plinthopyga	(Wiedemann)	non-indigenous
Diptera	Sciaridae				unknown
Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous
Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous
Diptera	Syrphidae				non-indigenous

Order	Family	Genus	Species	Authority	Status
Diptera	Tephritidae	Trupanea	crassipes	(Thomson)	endemic
Diptera	Tipulidae	SP1			unknown
Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous
Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic
Heteroptera	Miridae	Orthotylus	coprosmaphila	Polhemus	endemic
Heteroptera	Miridae	Orthotylus	sophoriodes	Polhemus	endemic
Heteroptera	Nabidae	Nabis	capsiformis	Germar	non-indigenous
Heteroptera	Rhyparochromidae	Brentiscerus	putoni (= australis)	(White)	non-indigenous
Homoptera	Aphididae	SP1			non-indigenous
Homoptera	Cicadellidae	Nesophrosyne	sp. 1		endemic
Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous
Homoptera	Psyllidae	Ctenarytaina	eucalypti	(Maskell)	non-indigenous
Hymenoptera	Bethylidae	Sierola	spp.		endemic
Hymenoptera	Braconidae	Meteorus	laphygmae	Viereck	non-indigenous
Hymenoptera	Crabronidae	Ectemnius	nesiotes	(Pate)	endemic
Hymenoptera	Encyrtidae	Psyllaephagus	pilosus	(Maskell)	non-indigenous
Hymenoptera	Formicidae	Cardiocondyla	kagutsuchi/venestula		non-indigenous
Hymenoptera	Formicidae	Hypoponera	opaciceps	(Mayr)	non-indigenous
Hymenoptera	Formicidae	Linepithema	humile	(Mayr)	non-indigenous
Hymenoptera	Ichneumonidae	Gelis			non-indigenous
Hymenoptera	Vespidae	Odynerus			endemic
Lepidoptera	Carposinidae	Carposina	sp. A		endemic
Lepidoptera	Carposinidae	Carposina	sp. B		endemic
Lepidoptera	Carposinidae?	Carposina?	sp. C?		endemic?
Lepidoptera	Cosmopterigidae	Hyposmocoma	sp.1		endemic
Lepidoptera	Crambidae	Eudonia	sp.		endemic
Lepidoptera	Crambidae	Mestolobes			endemic
Lepidoptera	Crambidae	Udea	heterodoxa	(Meyrick)	endemic
Lepidoptera	Crambidae	Udea	pyranthes	(Meyrick)	endemic
Lepidoptera	Crambidae	Uresiphita	polygonalis	(Butler)	endemic
Lepidoptera	Geometridae	Eupithecia	monticolans	Butler	endemic
Lepidoptera	Geometridae	Scotorythra	corticea	(Butler)	endemic
Lepidoptera	Geometridae	Scotorythra	paludicola	(Butler)	endemic
Lepidoptera	Lycaenidae	Udara	blackburni	(Tuely)	endemic
Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Lepidoptera	Noctuidae	Agrotis	giffardi (or mesotoxa)		endemic
Lepidoptera	Noctuidae	Agrotis	ipsilon	(Hufnagel)	non-indigenous
Lepidoptera	Noctuidae	Agrotis	xiphias	Meyrick	endemic
Lepidoptera	Noctuidae	Athetis	thoracica	(Moore)	non-indigenous
Lepidoptera	Noctuidae	Chrysodeixis	eriosoma	(Doubleday)	non-indigenous
Lepidoptera	Noctuidae	Haliophyle	sp. A		endemic
Lepidoptera	Noctuidae	Megalographa	biloba	(Stephens)	non-indigenous
Lepidoptera	Noctuidae	Peridroma	cinctipennis	(Warren)	endemic

Order	Family	Genus	Species	Authority	Status
Lepidoptera	Noctuidae	Peridroma	cinctipennis	(Butler)	endemic
Lepidoptera	Noctuidae	Peseudaletia	unipunctata	(Haworth)	non-indigenous
Lepidoptera	Noctuidae	Pseudaletia	sp. A (large reddish)		endemic
Lepidoptera	Pterophoridae	Stenoptilodes	littoralis	(Meyrick)	non-indigenous
Lepidoptera	Pterophoridae	Stenoptilodes	littoralis	(Meyrick)	non-indigenous
Lepidoptera	Tortricidae	Bactra	straminea	(Butler)	non-indigenous?
Lepidoptera	Tortricidae				unknown
Neuroptera	Hemerobiidae	SP1			
Neuroptera	Hemerobiidae				unknown
Psocoptera					unknown