Haleakalā High Altitude Observatory Site Management Plan

2017 Annual Report

Introduction to Management of the Haleakalā High Altitude Observatory Site

The Haleakalā High Altitude Observatory Site (HO) Management Plan (MP) was approved by the Board of Land and Natural Resources (BLNR) on December 1, 2010.
Condition #2 states:
"Beginning in November 2012 the University will submit to DLNR an annual report summarizing any construction activities occurring at HO; Habitat Conservation Plans; Monitoring Plans for Invertebrates, Flora, and Fauna; Programmatic Agreements on Cultural Resources; Invasive Species Control Plans and other related plans, The Report should be brief but thorough. This report should also be presented to the Board of Land and Natural Resources for the first year, and every five years thereafter."

Therefore, this report summarizes activities that occurred under the MP from December 1, 2016 to November 30, 2017.

The land use described in this report, on activities under the HO MP, qualifies as an identified use in the General Subzone and is consistent with the objectives of the General Subzone of the land. The objectives of the General Subzone (HAR 13-5-14) are to designate open space where specific conservation uses may not be defined, but where urban uses would be premature. The land use is consistent with astronomical research facilities for advanced studies of astronomy and atmospheric sciences. HO is located within a General Subzone of the State of Hawai'i Conservation District that has been set aside for observatory site purposes only. Identified applicable land uses in the General Subzone, include R-3 Astronomy Facilities and (D-1) Astronomy facilities under an approved management plan (HAR 13-5-25).

The HO MP offers a physical plan and management structure that seeks to preserve a balance within HO, in which astronomy can continue to evolve at a premier ground-based viewing location, bringing with it the associated economic benefits, while protecting cultural and environmental resources and values.

Construction Activities Occurring at HO Since December 2016

Section 3.5.3.1 of the MP implements a number of measures regarding construction practices, including IfA-approved environmental training for contractors, prevention of introduction of new species during construction, protection of the endangered Hawaiian petrel (’ua’u) residing in burrows on the upper slopes of Haleakalā, pollution prevention, dust prevention, and management of solid waste. In addition, the IfA requires that facilities designed for construction at HO follow certain guidelines regarding obscuration of other facilities, timing of construction to avoid impacts to nesting petrels, avoiding impacts to known archeological resources, painting to blend with surroundings where possible, consideration of site plans to population centers on Maui, use of natural materials, etc. The following construction activities have occurred at HO since December 2, 2016:

Construction Activities

1. November 13, 2012-CDUP MA-3542/MA-11-04 Advanced Technology Solar Telescope/underway

Compliance

- Construction activities listed above are undertaken in compliance with applicable statutes, ordinances, rules, regulations, and conditions of the federal, state, and county governments, and applicable parts of the Hawai’i Administrative Rules, Chapter 13-5;
- Where applicable, plans were submitted and approved;
- Where applicable, notice of commencement and completion was provided;
- Where applicable, mitigations in specific or related CDUPs were/are being adhered to;
- All commercial related vehicles, equipment and materials brought to the HO site were inspected by a qualified biologist before entering Haleakalā National Park;
- Requirements set out in the Haleakalā Observatories Management Plan for Monitoring Strategies,
- Cultural and Historic Preservation Management, Environmental Protection of Site Resources,
- Construction Practices, and Facility Design Criteria were complied with and a Cultural Specialist was retained when the activity required a permit from DLNR.

Habitat Conservation Plans (HCPs)

The National Science Foundation’s Advanced Technology Solar Telescope (ATST) Project, renamed the Daniel K. Inouye Solar Telescope (DKIST) on December 15, 2013, obtained approval of an HCP from BLNR in May 27, 2011 and an Incidental Take License from U.S. Fish and Wildlife Service (USFWS) on November 30, 2011 to address anticipated impacts to state and federal threatened, endangered, and listed species from construction, pursuant to Chapter 195D, Hawaiʻi Revised Statutes (HRS 195D). The Hawaiian petrel (ʼuaʼu) is the principal species of interest in the HCP. In order to initiate and pursue the mitigation measures described in the DKIST HCP, the DKIST Project has had a Resource Biologist on staff since 2011, along with seasonal and permanent field technicians under his direction implemented HCP related mitigation measures that included but are not limited to:

a) Botanical and archeological surveys of the 328 acre HCP Conservation Area assigned to DKIST;
b) Survey and census of burrows within that mitigation area;
c) Video monitoring of burrows in the area closest to DKIST site;
d) Identification of an approved control area that will not be subject to mitigation measures;
e) Initial predator control-ungulate removal and cat trapping;
f) Reproductive success monitoring; and,
g) Formal reporting on these efforts to Endangered Species Recovery Committee (ESRC)

HCP requirements for the DKIST Project correspond with the requirements in Section 3.5.3.2 (2) of the MP regarding protection of the Hawaiian petrel (ʼuaʼu) from noise, vibration, burrow collapse, flight collisions, lighting, and reporting on mortality. (*2017 DKIST HCP Fiscal Year Report*[1])

Monitoring Plans for Invertebrates, Flora, and Fauna

For about a year before the December 1, 2010 approval of the MP by the BLNR, programmatic monitoring of invertebrates, flora, and fauna was initiated at HO. The surveys conducted pursuant to the MP at HO are part of the long-term effort to characterize floral and faunal populations at the site that may be impacted or benefit from practices and procedures at HO, and thus be more effectively conserved, protected, and preserved by adaptive management of the site.

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, 2014, 2015, 2016 and 2017. The 2017 Annual Inspection was conducted on September 7, 2017. 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 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. (*DKIST Arthropod Monitoring & Inspection Report Summer-Fall 2017*[2]) (*DKIST Arthropod Monitoring Report Winter-Spring 2017*[3])

Programmatic faunal monitoring is being implemented during and after construction of the DKIST, which began in 2012, to insure impacts on biological resources are minimized.

The main area affected is where the DKIST telescope is being built. Other areas of HO that have been affected include a corridor running from the Advanced Electro-Optical System (AEOS) over Pu`u Kolekole to Mees.

These areas received much ground disturbance and many native and non-native plants were removed in the process. There are also large piles of rocks and soil that have been staged on the margin of the retention basin.

No Threatened or Endangered plants appear to have been impacted by construction. As construction wanes, it is likely that native and non-native vegetation will re-colonize much of the site, as has happened at HO in the past. No new non-native, invasive plants were found during the annual inspection. (*HO-Floral_Survey_and_Annual_Inspection-Fall_2017-Starr*[4]) (*HO-Floral_Survey-Spring_2017-Starr*[5]) (*P-200-Annual_Report-2017-Silverswords-Starr*[6])

No signs of non-native invasive animal species were found inside or within 30 m (100 ft) of the DKIST buildings. (*HO-Faunal_Survey_and_Annual_Inspection-Fall_2017-Star*[7]) (*HO-Faunal_Survey-Spring_2017-Starr*[8])

Invasive Species Control

The MP provides for active prevention of introduction of invasive species that may threaten HO site resources. The implemented practices include but are not limited to weeding of HO property, vector control for rodents, soil and erosion control in accordance with the HO Storm Water

Management Plan, and frequent removal of trash.

The Haleakala High Altitude Observatory Site (HO) consists of relatively intact native shrublands and rocklands as well as a variety of disturbed habitats. Native shrublands and rocklands of HO currently support low levels of invasive plant species, both in abundance and species diversity. All identifiable invasive plants located in close-spaced multiple sweeps were removed or treated. It is estimated that 98-99% of all invasive plants within the project site were located this year and treated. After multiple years of invasive plant control, native shrublands and rocklands of HO are now more weed-free than equivalent areas of adjacent Haleakala National Park. (*Invasive Plant Control Haleakala High Altitude Observatory Site (HO) 2017 report.pdf*[9]) & (*Maui Space Surveillance Complex located within the Haleakala High Altitude Observatory Invasive Plant Control Report (Reporting Period I Nov 2016 to 31 Oct 2017)*[10])

Programmatic Agreements on Cultural Resources

The National Science Foundation (NSF), the National Park Service, the University of Hawai'i, the State Historic Preservation Officer, and the Advisory Council on Historic Preservation signed the Programmatic Agreement (PA). The PA established mitigation measures that include but are not limited to the establishment of a Native Hawaiian Working Group (NHWG), the retention of a Cultural Specialist; reserving up to 2% of the total DKIST usage time for Native Hawaiian scientists, when there are Native Hawaiians among the pool of qualified scientists; and providing support to an educational initiative addressing the intersection between Native Hawaiian culture and science. The IfA commits to continued mitigation of impacts on cultural resources on the Region of Impact (ROI). The IfA will provide a written annual report to the Board on the status of the implementation of the Programmatic Agreement, including: listing the proposed mitigations to impacts on cultural resources developed by the ATST/DKIST Native Hawaiian Working Group (NHWG); the response to those proposed mitigations by the signatory parties to the Programmatic Agreement; and, the implementation of any such mitigation measures by the IfA."

Status of the Implementation of the Programmatic Agreement

The following summarizes the status of pertinent items under Section II- NSF's Area of Responsibility of the PA. These items are discussed as applicable during the NHWG meetings.

Establishment of the DKIST Native Hawaiian Working Group

The PA was fully executed on November 13, 2009. The NHWG first met on December 5, 2009, which was within 60 days of the fully executed date. For calendar year 2017, NHWG meetings were held on March 1st and November 8th.

Implementation of Best Management Practices

Best Management Practices as outlined in the BLNR approved HO MP have been and will continue to be implemented.

Naming of HO Roads

During the November 8, 2017 meeting, discussion moved toward not pursuing to rename the road. Follow-up on whether this will indeed be the conclusion will be discussed at the next NHWG meeting. The group was reminded that the road is managed by UH IfA.

Retention of a Cultural Specialist

CKM Cultural Resources, LLC (Kahu Dane Uluwehiokalani Maxwell) is the DKIST Cultural Specialist.

Possible Repainting

DKIST expressed that the project continues to pursue possibilities of new technologies with respect to colors; however, to date, no improved technology exists.

Removal of Reber Circle Site #50-50-11-5443

The Reber Circle concrete ring was removed on December 3, 2012.

Required "Sense of Place" Training

All contractors and employees continue to participate in this training.

Exterior Design

During the November 8, 2017 meeting, discussion moved toward not pursuing an exterior design. Follow-up on whether this will indeed be the conclusion will be discussed at the next NHWG meeting.

Possible Shelter for Cultural Practitioners

During the November 8, 2017 meeting, the DKIST project presented a possible location for a shelter area that would not be considered further desecration to Haleakalā.

State Road 378

Under Contract to IARII, Mason Architects completed the State Highway 378 Historic Evaluation Report identifying and photographing Contributing Features of historic significance along the roadway consisting of 10.1 miles from the Crater Road junction to the Haleakalā National Park entrance. The final State Road Historic Archival Engineering Report was completed and transmitted to NPS and SHPD on 11/21/13.

Acknowledgment of Significance of Haleakala and NSF's Gratitude

NHWG determined that acknowledgment language would be inappropriate (closed).

Status of Implementation of this PA Reported on Project Website

The "Status of Implementation of Programmatic Agreement" web page is available on the Internet at: http://dkist.nso.edu/node/747

DKIST Telescope time for Native Hawaiian Scientists

Reserving up to 2% of the total DKIST usage time for Native Hawaiian scientists, when there are Native Hawaiians among the pool of qualified scientists. Not applicable at this time.

Providing support to an educational initiative addressing the intersection between Native Hawaiian culture and science

The Division of Astronomical Sciences of the National Science Foundation funded the seventh year of a ten-year, $20M award has been made to the University of Hawaii Maui College (UHMC). This brings the total amount funded to UHMC under this award to $14M. The award is being funded, contingent upon the availability of appropriations, at a rate of $2M annually and is being used to operate the Ka Hikina O Ka Lā program http://maui.hawaii.edu/hikina/, which addresses the intersection of Native Hawaiian culture and science, technology, engineering and mathematics.

Details of the award can be found at:
http://nsf.gov/awardsearch/showAward?AWD_ID=1135694

Proposed mitigations to impacts on cultural resources developed by the NHWG and the response to those proposed mitigations by the signatory parties to the Programmatic Agreement the implementation of any such mitigation measures by the University

The role of the DKIST NHWG is to provide consultation concerning historic property matters related to the construction and operation of the DKIST Project. The NHWG meeting minutes are summarized and posted to the "Status of Implementation of Programmatic Agreement" web page is available on the Internet at:
http://dkist.nso.edu/node/747

Summary of Activities Under the HO Site Management Plan

The IfA, its lessees, and contractors conducted numerous studies, surveys, and inventories at HO during the reporting period from December 2016 to November 2017, and undertook preventive actions to protect and preserve environmental and cultural resources. The above descriptions of programmatic activities do not include or assign credit for the many day-to-day actions by the employees and contractors at HO to preserve and protect environmental and cultural resources and values at HO. A few examples of such daily actions (and non-actions) by site occupants include:

a) Construction within HO requiring a permit from DLNR requires the consultation and monitoring of a Cultural Specialist;
b) Respectful, helpful and courteous support to Native Hawaiian practitioners who enter the HO site for traditional cultural practices;
c) Vigilance to keep seeds, spores, or invasive plants from “hitchhiking” on persons or personal items;
d) Parking only in designated areas;
e) Avoiding known archeological sites and features;
f) Care to avoid harassment or injury to endangered petrels during nesting season;
g) Not damaging or removing endangered Silversword plants; and,
h) Avoiding noise not absolutely necessary for construction or operations.

It is the commitment of the IfA to use past, present, and future knowledge of the dynamic environment at HO to continually inform its site MP, so that site personnel who work there can preserve a balance within HO. It is the objective of IfA to proactively provide effective stewardship of an environment where astronomy can continue to evolve to move mankind toward a deeper understanding of the Universe in which we live while ensuring the cultural and environmental resources and values of HO are protected.

References

1. Chen, Huisheng / DKIST Resource Biologist. 2016 DKIST HCP State Fiscal Year Report.

2. Pacific Analytics, LLC. Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park, Maui Hawai‘i, September 2017.

3. Pacific Analytics, LLC. Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park, Maui Hawai‘i, May 2017.

4. Starr, Forest & Kim. Starr Environmental. 2017 Botanical Survey, November 2017 Haleakalā High Altitude Observatories, Maui, Hawai‘i.

5. Starr, Forest & Kim. Starr Environmental. 2017 Botanical Survey, May 2017 Haleakalā High Altitude Observatories, Maui, Hawai‘i.

6. Starr, Forest & Kim. Starr Environmental. 2017 Yearly Report Threatened and Endangered Plant Species Permit P-200, Haleakalā High Altitude Observatories, Maui, Hawai‘i.

7. Starr, Forest & Kim. Starr Environmental. 2017 Faunal Survey, November 2017 Haleakalā High Altitude Observatories, Maui, Hawai‘i.

8. Starr, Forest & Kim. Starr Environmental. 2017 Faunal Survey, May 2017 Haleakalā High Altitude Observatories, Maui, Hawai‘i.

9. Arthur C. Medeiros Ph.D. Haleakala High Altitude Observatory Invasive Plant Control Project at the Haleakalā High Altitude Observatories, Maui Hawai‘i, May 2017.

10. Maui Space Surveillance Complex located within the Haleakalā High Altitude Observatory (HO) Invasive Species Report (Reporting Period 1 Nov 2016 to 31 Oct 2017).

Daniel K. Inouye Solar Telescope (DKIST)
Habitat Conservation Plan and Biological Opinion 2017 Fiscal Year Report

H. Chen, C. Ganter, J. Panglao, G. Spencer & R. Geelhood

I. INTRODUCTION

This fiscal year report to the State of Hawai`i is being submitted by the Daniel K. Inouye Solar Telescope (DKIST) Resource Management Team, in accordance with the DKIST Habitat Conservation Plan (HCP) and the Final Biological Opinion (BO) of the U.S. Fish and Wildlife Service (USFWS, 1-2-2011-F-0085). The purpose of this report is to provide the collaborative primary agencies with an update on the progress and compliance of the project, as well as to summarize results of mitigation and monitoring activities being implemented for the DKIST project.

II. SUMMARY OF DKIST HCP/BO ACCOMPLISHMENTS

DKIST began the Hawaiian Petrel monitoring tasks in accordance with the State of Hawaii HCP and USFWS BO in early 2011, nearly two years prior to the actual construction start date in December of 2012. The project has been in compliance with State of Hawaii HCP and USFWS BO requirements from 2013 through June of 2017 (IV).

The data shows that to-date DKIST has had no measurable adverse impacts on the Hawaiian Petrel population, and that the implementation of the mitigation measures prescribed in the HCP and BO has benefited the Hawaiian Petrel population in DKIST's Conservation Area, both in terms of increased productivity and reduced predation rates. The fencing and outplanting of Haleakalā Silversword seedlings has facilitated the Haleakalā Silversword recovery process.

- 306 Haleakalā Silversword seedlings were planted on December 8, 2015 (section IVA, pp 4)
- No damage to burrows was detected during inspections following the 2015- early 2017 breeding seasons. (section IV B, pp 5).
- No ungulate populations have reestablished inside the fenced Conservation Area since September 12, 2013, shortly after construction of the fence began. (section IVD, pp 7-8 and section IVG-i, Table 4, pp 12-13).
- A total of 155 rodents have been removed by long-term rodent control grid traps (section IV F-ii, Table 3 a, pp 10-12).
- Based on additional rodent population monitoring results, the long-term rodent control grid has further reduced the rodent population in the Conservation Area to 3.13% of the Control site level (section IVG-ii, Figure 6, pp 13-14).
- The noise and vibration monitoring results show that construction activities have never exceeded authorized thresholds (section IV H, pp 14-15).

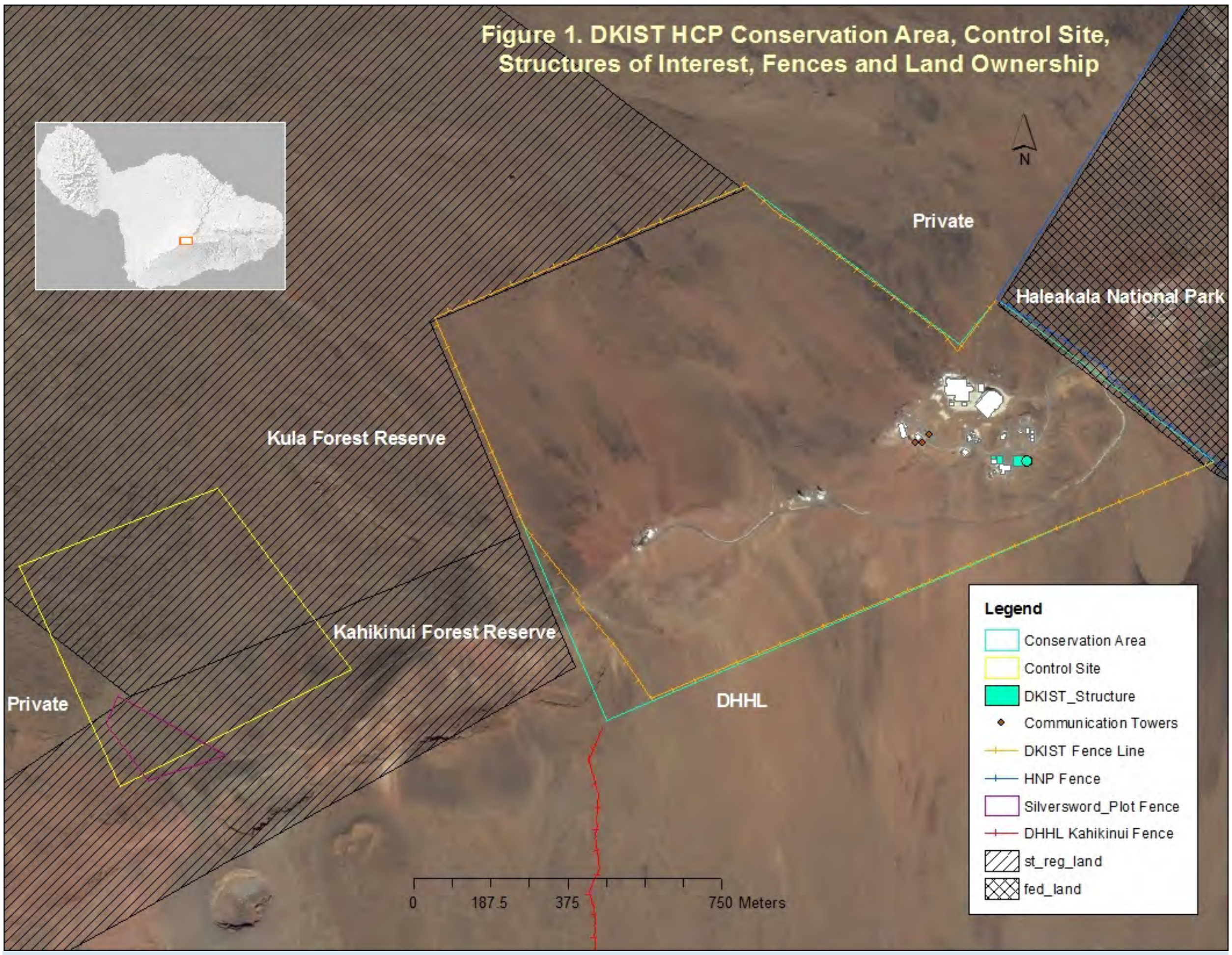
- No petrel collisions were recorded during all the monitoring periods from 2011 to June 30, 2017 at the DKIST construction site (Area A & B), the FAA/Coast Guard towers, or along the conservation fence. (section IV K, pp 16-18).
- A significant ($\chi 2 = 9.324$, $P<0.05$, $df=1$) increase of 75.4% in "Nesting Success %" has been observed since the conservation measures were implemented in the Conservation Area. (section VI B, Table 5, Figure 10, pp 20-23).
- The Hawaiian Petrel productivity in the Conservation Area increased by 62.7% (69.4% if 2013 is not included) after the HCP was fully implemented (section VI B, Table 5, pp 20-21, Figure 11, pp 23-26).
- DKIST HCP/BO mitigation measures have facilitated Hawaiian Petrel fledging by an average of 16.7 more successful fledglings annually, or by a total of 50 more successful fledglings) from 2014 to 2016 (section VI B, Table 5, pp 20-21, Figure 11, pp 23-26).
- DKIST predator/ungulate control measures have reduced expected annual predation events after 2013 by an average of 90.5% of the (section VI C, Table 6, pp 26).
- DKIST HCP/BO measures have reduced the number of eggs, chicks and adults lost due to predation by 1.5 eggs, 3.2 chicks and 1.3 adults annually, or saving a total of 4.5 eggs, 9.5 chicks and 4 adult petrels from predation between 2014 and 2016 (section VI C, Table 6, pp 26-27).
- It appears that DKIST construction activities have not deterred new petrels from coming to breed and nest in areas adjacent to the DKIST construction site, nor has it reduced the reproductive success of the petrels. (section VI D, Figure 16, pp 28).
- The fledging timing pattern has been similar to that of Haleakalā National Park (HNP) data throughout the monitoring period, indicating that construction has not had an impact on the nesting cycle. (section VI E, Figure 17, pp 30-31).

III. THE DKIST HCP CONSERVATION AREA AND CONTROL SITE

The DKIST HCP requires the establishment of a Conservation Area to mitigate the potential negative effects related to construction of the DKIST facility. In addition, the HCP also specifies the need to establish a Control Site to compare and evaluate the DKIST Resource Management Team's conservation efforts within the HCP Conservation Area. Both of these areas have been established and maintained since 2011. The Conservation Area, Control Site and other features are shown in Figure 1.

The Conservation Area is located between approximately 8,800 and 10,000 ft. (2,686 to 3,048 m) in elevation, and includes observatory facilities, broadcast facilities, communication towers, and the portion of Skyline Trail dividing the area from the northeast to the southwest. Adjacent lands include the Kula Forest Reserve, Kahikinui Forest Reserve, National Park Service (NPS), Department of Hawaiian Home Lands (DHHL), and private land. The Conservation Area contains a number of cinder cones, of which Puʻu Kolekole is the highest in elevation. Pu'u Kolekole is about 0.3 mi (0.5 km) from the highest point on the mountain; Puʻu ʻUlaʻula (Red Hill) Overlook, which is inside the Park but outside of state land (Figure 1). Based on the State of Hawaiʻi website published TMK GIS layer, the Conservation Area was estimated to be 328 acres (133 ha). However, after the ground survey using existing metes and bounds was completed, it was determined the area covers an area of 321.79 acres (130.22 ha). The topography within the Conservation Area is rugged and barren, and the elevation drops with an average slope greater than 30 percent (DKIST 2010).

The Control Site (Figure 1) encompasses 80 acres and is one kilometer west of the west boundary of the Conservation Area, just north of the Skyline Trail, at an elevation of 8,700 to 9,300 ft. (2652 to 2835 m). The topography within the Control Site is similar to that of the Conservation Area.



Note: The ground-truth DKIST HCP Conservation Area boundary on the map is different from the State of Hawaiʻi website published TMK GIS layer. The actual metes and bounds on the ground may vary from the GIS layer up to 33 meters.

IV. DKIST HCP AND BO COMPLIANCE

The DKIST Resource Management team continues to meet or exceed compliance with HCP and BO required mitigation measures. Following is a summary in regressing chronological order highlighting compliance activities.

IV A. Silversword Seed Propagation and Outplanting: November 2014-December 2015

Eight hundred seeds from four flowering Haleakalā Silversword (A.K.A. 'ahinahina, *Argyroxiphium sandwicense subsp. macrocephalum*) plants within the DKIST Conservation Area were collected on November 18, 2014 by the subcontractors Starr Environmental, under DLNR permit. The seeds were turned over to Haleakalā National Park (HNP) for propagation. In compliance with the HCP, the DKIST Resource Management team carefully checked the source area during its June 2015 monitoring for natural regeneration from the Silversword seed bank in the area from which the seeds were collected. The resource management team could not locate any seedlings during its June and August 2015 monitoring, and therefore outplanting was initiated to add to the local population. In total, **306 seedlings were planted on December 8, 2015** by Starr Environmental, the DKIST Resource Management team and an HNP employee. Each plant was tagged, foliage crown width was measured and GPS coordinates were also recorded. As of November 2016, 258 of the 306 (84.3%) outplanted seedlings survived the first year. Annual survival and growth monitoring will be conducted during the next few years (Starr and Starr 2016, Figure 2).

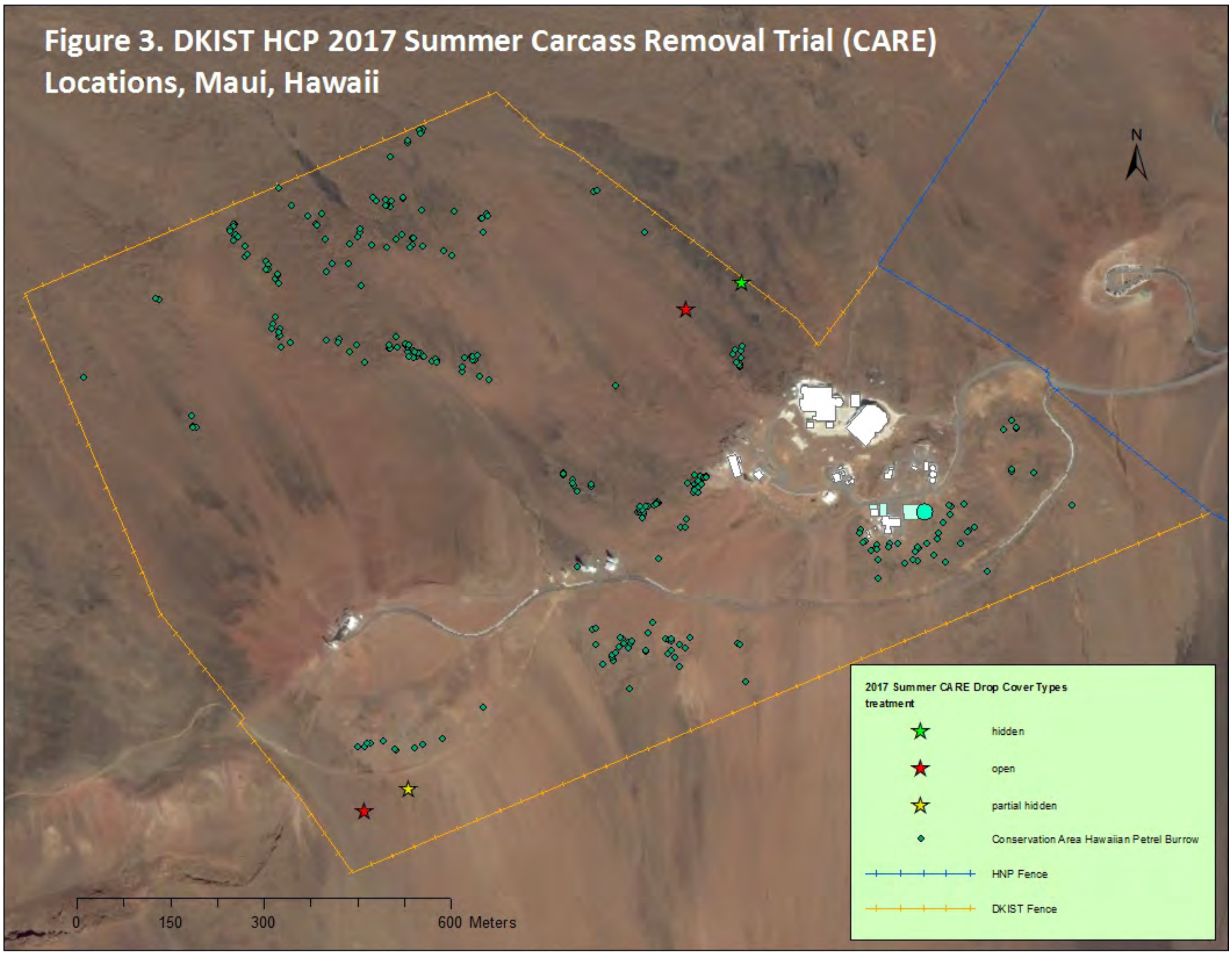
Figure 2. Silversword outplanting in the winter of 2015 in the area where seeds were collected in the winter of 2014.

Silversword seed collection (DKIST in background) | **Silversword propagation** | **Silversword outplanting** | **Silversword outplanting**

IV B. Monitoring Burrow Structures in the Impact Area: February 2015

In 2015, KC Environmental, Inc. (KCE) developed a new burrow scope with a remote directional control capacity to maneuver more easily in burrows during inspection. The burrow scope is only used during the non-breeding season to avoid risk of burrow damage. After an initial test period in 2015, routine monitoring for potential impact due to vibration and ground disturbance to burrow structures adjacent to the DKIST construction site was implemented. **No damage to burrows was detected during inspections following the 2015-early 2017 breeding seasons.**

IV C. Carcass Removal Trials (CARE): Ongoing Since September 2013



Carcass Removal Trials are undertaken to determine the scavenging rate by cats, rats, mongoose or other scavengers of birds that may have been killed due to collisions with project structures. Pursuant to the adaptive management changes approved by DOFAW and USFWS for the HCP and BO on July 29, 2014, two CARE trials are to be conducted each year during the remainder of the 6 year construction period. These trials are to be conducted by a third party contractor and the information will be used to guide search intervals for monitoring petrel mortalities that may result from collision with project structures at the DKIST site.

CARE trials have been conducted by KCE since the fall of 2013. Trials are conducted in locations within the DKIST Conservation Area that are approved by USFWS and DOFAW and that are at least 50 meters from a Hawaiian Petrel burrow and 30 meters from baited traps. Figure 3 is an example of surrogate bird placements (from the 2017 summer trial). Four surrogate birds (Wedge Tailed Shearwater, *Ardenna pacificus,* which is morphologically and taxonomically similar to Hawaiian Petrel) carcasses were placed in a variety of positions, including two that were exposed (thrown), one that was hidden to simulate a crippled bird, and one that was partially hidden in each trial.

The results of the CARE trials conducted through the summer of 2017 are presented in Table 1. In trials since 2013, only two birds have been partially scavenged, and even during an extended 60-day trial in the summer of 2014, all four trial carcasses remained intact after the full 60 days. The 2013 fall scavenge event occurred in a partially concealed location within two weeks of placement, with only feathers left behind, while the 2015 summer scavenge event was in a concealed location within two weeks of placement, with a partially dismembered carcass remaining. The overall scavenge rate was 5% (based on ten 30-day trial periods (if the extended trial is counted as two trials) with four birds in each trial, in which two of the 40 total carcasses were scavenged. Most importantly, the rate of total carcass removal has been zero as of summer 2017.

Table 1. The Outcome of DKIST HCP Carcass Removal Trial Fall of 2013 - Spring of 2016

Year	Season	Period (days)	# Birds Scavenged	% Birds Scavenged	% Birds Removed	Remarks
2013	Fall	30	1	25	0	Remains still detectable at the end of the trial
2014	Spring	30	0	0	0	
	Summer/fall	60	0	0	0	Extended trial
2015	Spring	30	0	0	0	
	Summer	30	1	25	0	Remains still detectable at the end of the trial
2016	Spring	30	0	0	0	
	Summer	30	0	0	0	
2017	Spring	30	0	0	0	
	Summer	30	0	0	0	
Summary		300	2	5	0	Based on 10 30-day trial periods

The results of the CARE trials are consistent with the experience of the DKIST Resource Management team, who has found Hawaiian Petrel carcass remains in the Conservation Area which were often more than a year old, in that Hawaiian Petrel carcasses are rarely totally removed. The CARE trials show further evidence that scavenging rates at these higher altitudes is extremely low. After nine such trials (ten, if the extended trial is considered as two trials), only two surrogate birds showed any sign of scavenging.

The results of CARE trials, corroborating empirical data and knowledge of constraints associated with high alpine xeric ecosystems all continue to suggest that the 10% carcass removal rate used in the calculation of unobserved take for DKIST may be overestimated. Almost all carcasses that were within the search area for DKIST were recorded, because the carcass scavenging rate is very low, and even the rare carcass scavenging that takes place does not seem to remove all evidence of bird mortality for as long as a year or more. The longevity of carcasses in the field also indicates that searches for downed birds at the elevations of the Conservation Area may not have to be as frequent as thought before evidence from these CARE trials and empirical data became available. (Fein and Allan 2013b, 2014b, 2014c, 2015b, 2015c, 2016b, 2016c, 2017b, 2017c.). Based on this information, DOFAW and USFWS have modified the requirements for search frequency, which is discussed in more detail in section IV M, Birdstrike Monitoring.

IV D. Conservation Fence and Ungulate Eradication: <u>July 2013</u>

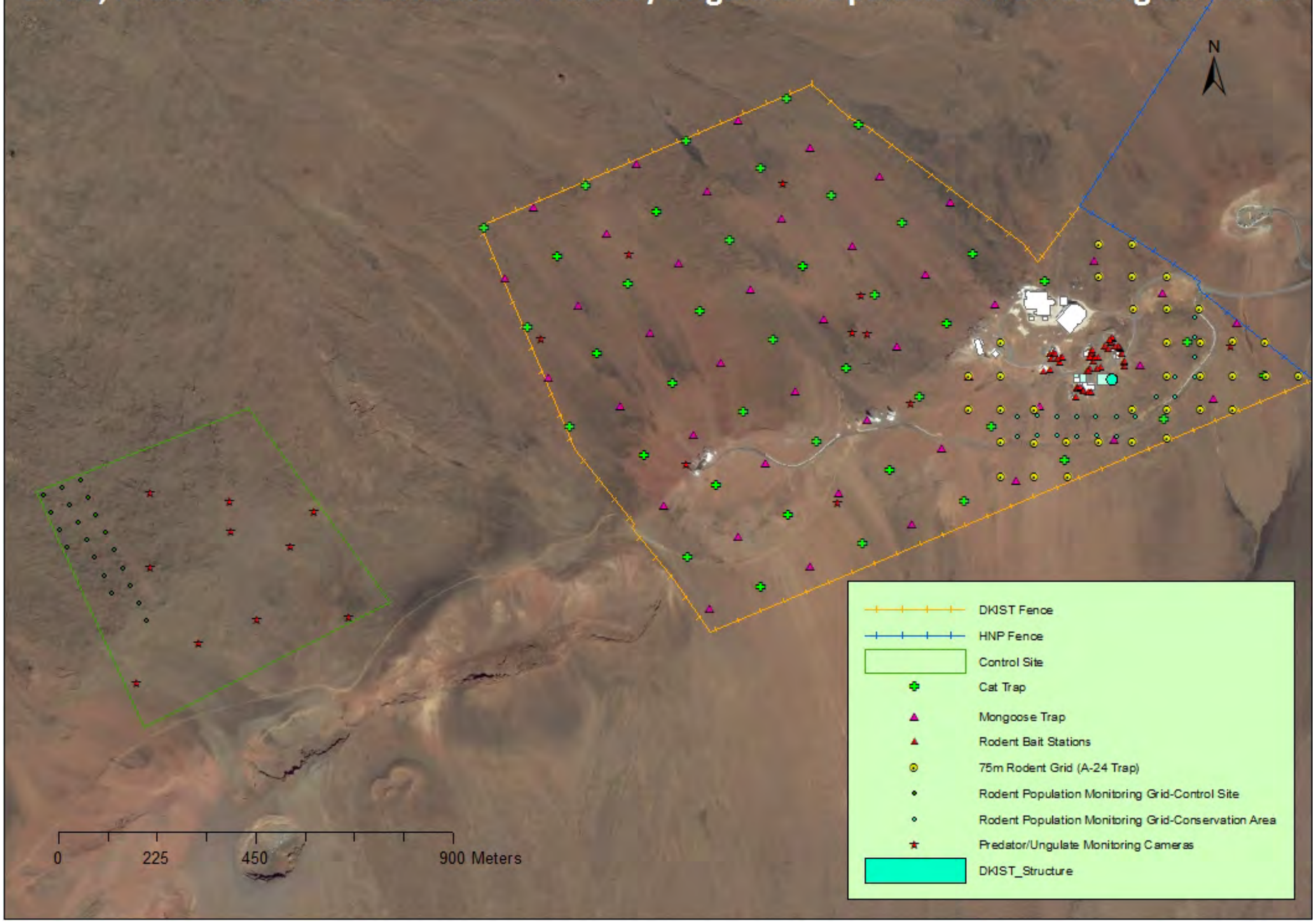


Figure 4. DKIST HCP Long-term Rodent Control Grid, Rodent Population Monitoring Grids, Predator Control Grid and Predator/Ungulate Population Monitoring Cameras

A Conservation District Use Permit (CDUP) for the conservation fence was issued on May 17, 2013. On July 25, 2013, Rock N H Fencing, LLC was awarded the contract to construct the conservation fence. The construction started on September 1, 2013 and was completed on November 18, 2013. A total of 4.23 km (2.63 mi) of fence was built and 126.53 ha (312.66 acres) of Conservation Area was enclosed, which included 0.66 ha (1.64 acres) of Haleakalā National Park land outside of the park fence (Figure 1, 3 & 4).

To prevent bird collision with the conservation fence, three strands of steel wire-enforced Poly-tape were installed horizontally along the entire length of the fence, which was completed on March 13, 2014 in compliance with HCP and BO requirements.

As a result of the fence construction process and the intensive monitoring / conservation activities that were being implemented during the fence construction, all ungulates vacated the Conservation Area before the fence was completed. Based on footage from 10 long-term predator/ungulate monitoring camera traps and six additional ungulate monitor camera traps (Figure 4), no ungulates were detected within the Conservation Area since September 12, 2013, until June 1, 2017 when a juvenile goat was observed inside the fenced Conservation Area. The DKIST Resource Management Team systematically searched the area thereafter, however, no further signs of the goat's presence were found, to include any fresh tracks, droppings, or any images of the goat captured via camera traps. We believe it is likely that the goat ingress was due to some Skyline Trail users obstructing the fence gate from closing, and the goat likely left the fenced area either through the same gate, or it may have been able to jump over the fence in one of the few areas where the higher rocky terrain would make it possible. It is also possible the goat died inside the area due to dehydration, hypothermia and starvation, although no carcass has been found. **No ungulate populations have reestablished inside the fenced Conservation Area since September 12, 2013, shortly after fence construction began.**

IV E. Searcher Efficiency Trials (SEEF): Annually Since May 2013

In order to accurately evaluate the overall efficiency of carcass detection in the DKIST project area, SEEF trials are conducted annually, as prescribed in the HCP. Trials were conducted within the DKIST's approved birdstrike monitoring Search Area A, as discussed in detail in Section IV X, and shown in Figures 5 and 7.

In accordance with the requirements of the HCP and BO, these trials are to be conducted by a third party contractor, and are to take place unbeknownst to the searcher(s). KCE was the Maui-based third party contractor selected to conduct the SEEF Trials on behalf of DKIST. In order to recover bird carcasses found during the trials, the DKIST Resource Management team operates as a sub-permittee of KCE's Migratory Bird Permit (USFWS February 27, 2013, # MB97892A-0) and Protected Wildlife Permit (DLNR March 04, 2013, # WL 15-02).

During the 8- week SEEF trials, Wedge-tailed Shearwater carcasses are used as surrogates for the Hawaiian Petrels. Over the trial period, 20 carcasses are placed within the search area on random days and in random quantities, with up to 3 carcasses being placed per day. After each search is completed, the searchers will report the result only to KCE, with the number of shearwater carcasses found, photos, bird tag numbers, and the coordinates at which the carcasses were found included in the report. The carcasses are then returned to the freezer which is maintained by KCE at the site.

FIGURE 5. Demarcation of Area A and B of the DKIST Construction Site Birdstrike / Search Area. Searcher Efficiency Trials Were Only Conducted in Area A.

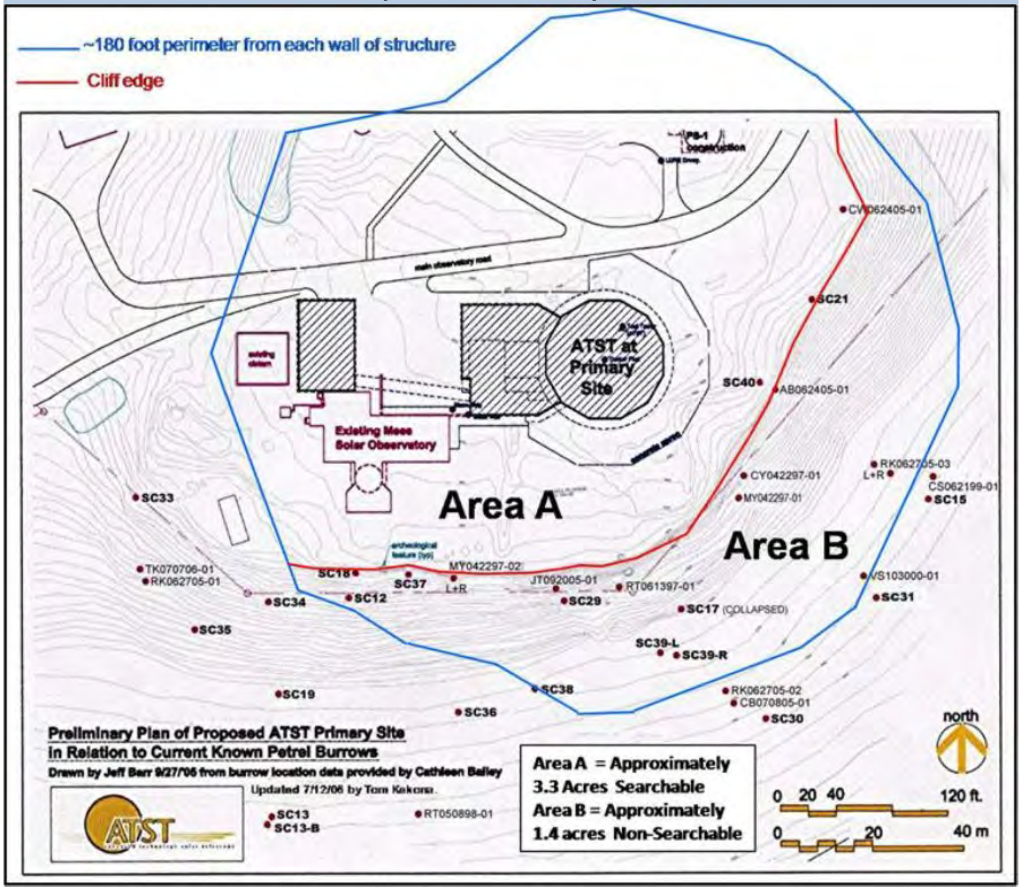


Table 2 shows the results of SEEF trials since 2013, resulting in an overall searcher efficiency rate of 92%. In the most recent trial, in 2017, All 20 dropped carcasses were found, resulting in a searcher efficiency rate of 100%. (Fein and Allan 2013a, 2014a, 2015a, 2016a, 2017a).

Table 2. 2013-2016 DKIST Searcher Efficiency Trail Results

Year	# birds dropped	# birds located	Searcher Efficiency %
2013	20	17	85
2014	20	18	90
2015	20	18	90
2016	20	19	95
2017	20	20	100
Summary	**100**	**92**	**92**

IV F. Long-term Rodent Control Grid: <u>Ongoing Since March 2013</u>

i. <u>Methods, grid configurations and the chronicle of their modifications</u>

The original rodent control grid in the final HCP and BO was a conceptual guideline; it needed to meet the minimum pesticide product Special Local Need Supplemental Label (SLN) requirements. In order to meet the SLN label requirements, a 50 meter grid layout plan was initially submitted to the agencies by the DKIST team. However, after consultations with USFWS, it was agreed that the project would implement a denser 48-meter bait box grid of 51 stations. The newer 48 meter grid layout plan was approved by USFWS in March 2013, and the implementation of the grid was completed April 2, 2013.

Each station is equipped with a Protecta ™ tamper-resistant rat bait box and a mouse box. Due to the ongoing DKIST construction activities taking place on site, 44 of the planned 51 stations are in place as of this report. Each rat bait box was deployed with eight 1-oz Ramik™ diphacinone blocks, for a total of 22 lbs. of diphacinone. The stations were checked after 1 week and then again in 2 weeks to evaluate the diphacinone take (stage one grid). However, the diphacinone SLN label expired on May 30, 2013, and the use of diphacinone had to be discontinued. The blocks were removed May 28, 2013. T-Rex rat and mouse snap traps baited with peanut butter have been deployed subsequently (stage two grid).

The requirements under the new SLN label published in December 2013 prohibited future diphacinone use in the Conservation Area due to boundary issues. The label requires the grid to be extended 225 meters beyond the resource to be protected, which for the Conservation Area would cross the neighboring boundaries of Haleakalā National Park, the U. S. Air Force, and Department of Hawaiian Homelands. In response to these new labeling constraints, the DKIST Resource Management team worked closely with USFWS and DOFAW to develop a new long-term rodent control grid methodology that is not regulated by an SLN label.

A total of 47 Protecta ™ tamper-resistant rat bait boxes were placed every 30 ft. along the perimeter of all permanent structures and trailers (office, storage) within Haleakalā Observatory (HO), with the exception of the US Air Force compound and areas affected by construction activities. For 40 ft trailers/containers, two bait boxes were placed, each at diagonal corners, and for 20 ft or shorter trailers/containers, one bait box was placed. Because diphacinone is not regulated by an SLN label for use next to buildings, each rat bait box was deployed with six 1-oz Ramik™ diphacinone blocks, for a total of 17.6 lbs. We began installing the boxes on April 30, 2015 and completed the installation on May 07, 2015. More boxes will be installed once remaining minor DKIST external construction activities are completed, in order to further reduce the risk of introducing rodents due to these residual construction activities. Outside of the construction area, we began installing a 75 meter A-24 rodent killing trap grid on May 12, 2015 and completed the grid on May 18, 2015. A total of 35 A-24 traps were installed. A 25 meter A-24 trap system will be installed around HO buildings once all remaining DKIST external construction activities are completed (stage three grid, Figure 4).

ii. Effectiveness of the long-term rodent control grid

Table 3 a. Effectiveness of DKIST Long-Term Rodent Control Grid Between 2013 and 2016 at the Summit of Haleakala, Maui – Rodents Removed

Grid Stage	One[1]	Two[2]	Three[3]	Total
Time Period	04/02-05/28/2013	05/29/2013-04/20/2015	05/07/2015 – 06/30/2017	
Rodent Captured				
Field Mice	n/a	42	7[5]	49
Roof Rats	n/a	16	4	20
Norwegian Rats	n/a	9	0	9
Unidentifiable Rats	n/a	21	8	29
Subtotal	n/a	88	15	105
A-24 Trap Hits[4]	n/a	n/a	50	50
Total Rodents Removed by Different Trap Types				155

1: 48-meter bait box grid of 51 stations- eight 1-oz Ramik™ diphacinone blocks per- Protecta ™ tamper-resistant rat bait box.
2: 48-meter bait box grid of 51 stations- T-Rex rat and mouse snap traps baited with peanut butter in each Protecta ™ tamper-resistant rat bait box and mouse bait box.
3: 47 Protecta ™ tamper-resistant rat bait boxes baited with six 1-oz Ramik™ diphacinone blocks every 30 ft. along the perimeter of all permanent structures and trailers within Haleakalā Observatory (HO) plus 35 A-24 traps with peanut butter bait in 75 meter grid outside of HO.
4: A-24 estimate based on trap counter registered trap triggered without carcasses being found.
5. by predator control grid A-24 trap.

Table 3 b. Effectiveness of DKIST Long-Term Rodent Control Grid Between 2013 and 2016 at the Summit of Haleakala, Maui – Rodenticide Intake

Grid Stage	One	Two	Three	Total
Time Period	04/02-05/28/2013	05/29/2013-04/20/2015	05/07/2015 – 06/30/2017	
Rodenticide Intake (OZ)	6.6	n/a	130.15	136.75 OZ

Resulting data from the stage one diphacinone grid implemented from April 2, 2013 to May 28, 2013 showed only 6.6 oz. of diphacinone bait was taken. The stage two snap traps used for the remainder of 2013 removed 18 field mice (*Mus musculus*), 10 roof rats (*Rattus rattus*) and 2 unidentifiable rats (*Rattus spp*.). In 2014, 20 field mice, 8 Norwegian Rats (*Rattus norvegicus*), 2 roof rats and 12 unidentifiable rats were caught (prior to November 4). In 2015, prior to changing to the new stage three grid system (before April 20), four field mice, four roof rats, one Norwegian rat and seven unidentifiable rodents were caught.

After the new stage three rodenticide/A-24 killing trap grid system was installed in May of 2015, the A-24 traps recorded 7 hits and two roof rats and two field mice carcasses were found near the traps during the remainder of the 2015 season. In 2016, a total of 35 hits were recorded and two roof rats, four field mice and five unidentifiable rodent carcasses were found near the traps. During the six-month period of 2015, 27.6 oz. of rodenticide were consumed by rodents, in 2016, 72.65 oz. of rodenticide were consumed by rodents and in the first half of 2017, 29.9 oz. were removed. While it is not possible to determine exact removal rates specific to the amount of rodenticide consumed, it can be assumed that there are additional rodents killed which were not accounted for through a carcass count.

A total of 136.85 oz. (=3879632 mg) of diphacinone was consumed or removed from bait boxes, presumably by local rodents (Table 3). However, the amount of bait consumed or removed is difficult to directly correlate to the number of rodents that may have been lethally controlled. Based on information from Cornell University's Extension Toxicology Network (http://pmep.cce.cornell.edu/profiles/extoxnet/dienochlor-glyphosate/diphacinone-ext.html), the oral LD50 (The amount of a chemical that is lethal to one-half (50%) of experimental animals fed) in rats is 0.3 to 7 mg/kg. Even using the maximum LD50 of 7 mg, the amount of diphacinone consumed in the long-term rodent control grid was enough to kill 2,771,165 roof rats with an average body mass of 200 g (150-250 g, http://icwdm.org/handbook/rodents/RoofRats.asp). Although it was not possible to document the exact number of rodents killed by the rodenticide we administered, we are confident that a large number of rodents were killed without being accounted for based on the quantity of rodenticide intake and our rodent population data (IV G ii).

Based on the empirical data, the traps in DKIST's long-term rodent control grid have removed a total of 105 rodents between all trap types. In addition, it can be estimated that the A-24 traps may have also removed as many as 50 unidentifiable rodents for which the carcasses were not located such that **a total of 155 rodents have been removed by long-term rodent control grid traps** (Table 3).

IV G. Predator and Rodent Population Monitoring *[Please Note: The monitoring discussed in this section is not required by the HCP or BO, and is a separate activity from, and in addition to the effectiveness of the predator control and long-term rodent control grids mentioned above. This is intended to evaluate the impact of the predator control and long-term rodent control grids on the local predator and rodent populations]*

Removing many individuals from a population from a specific space during a specific time doesn't always mean the population has been suppressed. While efforts to monitor predator and rodent population trends are not required by the HCP or BO, the DKIST resource management team has implemented invasive mammal monitoring programs, in addition to the control program (discussed in sections IV F & I), to understand what predators exist within the Conservation Area and Control Site and help achieve Net Recovery Benefit through an adaptive management approach. Predator/ungulate population monitoring camera traps and rodent population monitoring grids in the DKIST Conservation Area and Control Site are part of these efforts.

i. Predator population monitoring: Ongoing Since April 2013

Ungulate/predator population monitoring data was collected with camera traps. Twenty Bushnell Trophy Cam HD camera traps, 10 at each site (Conservation Area and Control Site), were installed at random locations generated by ArcGIS 10.0 on April 23, 2013 in the Conservation Area and on April 24, 2013 in the Control Site (Figure 4). Six additional camera traps were mounted at six selected fence posts along the fence line between December 3, 2013 and February 11, 2014, where previous goat tracks had been detected. These camera traps were initially used to monitor and determine whether ungulate eradication was needed after the completion of the ungulate fence, and continue to be utilized to obtain predator population data. Table 4 summarizes the number of photos for different animal categories recorded in the camera traps. No goats have been recorded since September 12th of 2013, although a juvenile goat was observed inside the Conservation Area on June 1, 2017. All human photos were images of DKIST Resource Management team personnel. The total numbers of animals (goats, birds and rodents) captured in photos seemed to peak in 2014, and has progressively declined in 2015, 2016 and 2017. No predator images have been captured with these camera traps since 2014.

Table 4. Number of Pictures of Different Identifiable Animal Categories Captured by DKIST HCP Monitoring Camera Traps.

Site	*Year*	Goat	Bird[2]	*Rodent*[3]	*Human*[4]
Control	2013[1]	476	3	*0*	*1*
	2014	938	39	*6*	*0*
	2015	485	23	0	0
	2016	192	16	0	0
	2017[5]	26	0	0	6
Conservation	2013[1]	61	11	*0*	*6*
	2014	0	29	*1*	*29*
	2015	0	16	0	16
	2016	0	13	0	14
	2017[5]	0	8	0	3

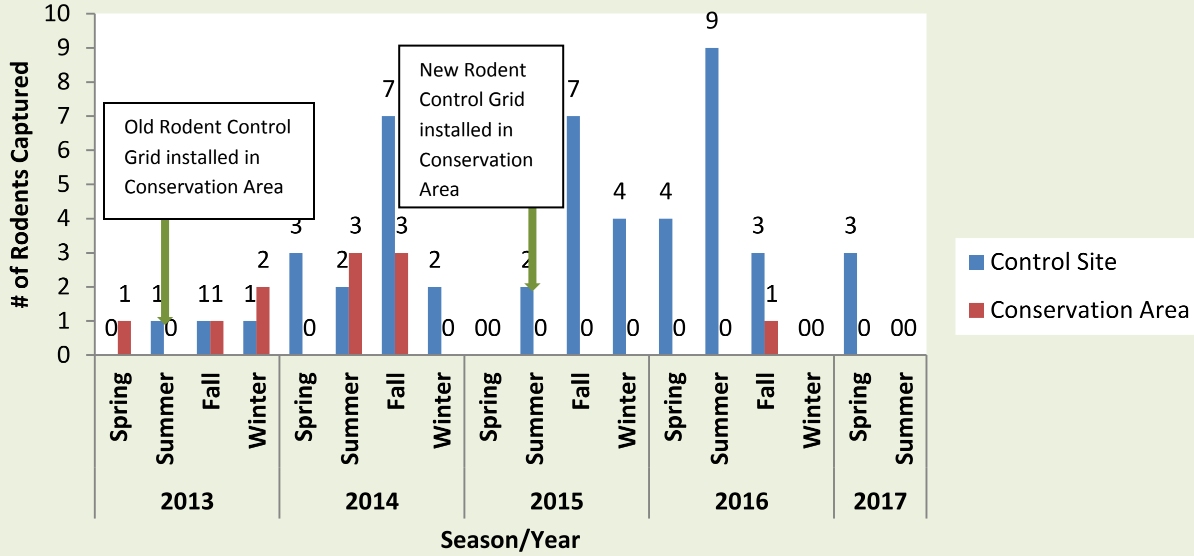
1: initiated in April
2: mostly Chukars (*Alectoris chukar*), with a few Pacific Golden Plovers (*Pluvialis fulva*)
3: unidentified rodent species
4: including DKIST personnel
5. 01/01-06/30/2017

ii. Rodent Population Monitoring: Ongoing Since March 2013

The purpose of rodent population monitoring is to evaluate the impacts of the long-term rodent control grid relative to the local rodent population. Due to the proximity and habitat similarity of the two sites, we assumed the rodent capture probability (per-capita) in the Conservation Area was similar to that at the Control Site on the same sampling date. By employing the same trapping effort on these two sites on the same date, we can use the rodent capture rate as the index of local rodent population.

We utilized the 20 remaining bait box stations in what is now the previous Long-Term Rodent Control 48 m grid system in the DKIST Conservation Area, and 20 bait box stations in the 48 m grid system in the Control Site (Figure 4). These two rodent population monitoring grids are 2,030 meters apart to ensure independence of the Control Site grid from the Long-Term Rodent Control Grid treatment. For this monitoring, each station was equipped with a T-Rex rat and a T-Rex mouse trap housed in Protecta tamper-resistant bait boxes. Peanut butter was used as bait and the traps were pre-baited one week before the traps were set. Each monitoring period consisted of 2 trap nights. The rodent population was monitored seasonally in March, June, September and December of each year. Figure 6 summarizes the rodent population monitoring results.

Figure 6. Rodent Population Reduction Within DKIST Long-term Rodent Control Grid,Between 2013 and First Half of 2017 at the Summit of Haleakala, Maui



***Based on two-trap-night/season rodent population monitoring data**

Assuming the rodent densities in both the Control Site and Conservation Area are similar, with slightly higher density in the Conservation Area due to human activity in this area, e.g. spring 2013 prior to the installation of the rodent control grid in the Conservation Area (Figure 6). The overall rodent density in the Conservation Area was reduced to 20.4% of the Control Site (2.9 rodents per season in the Control Site vs. 0.6 rodents per season in the Conservation Area) after the Long Term Rodent Control Grid systems were implemented (Figure 6). During the eight seasons when stage one and two Rodent Control Grid systems were employed (summer 2013 to spring 2015), these two older Rodent Control Grid systems had reduced the rodent population in the Conservation Area to 52.94% of the Control site level. (2.13 rodents per season in the Control Site vs. 1.13 rodents per season in Conservation Area). Based on the data collected during the two-trap night population monitoring, in the seven seasons since the stage three grid system was installed, **the long-term rodent control grid has further reduced the rodent population in the Conservation Area to 3.1% of the Control site level**. (3.6 rodents per season in the Control Site vs. 0.1 rodents per season in the Conservation Area).

IV H. Noise and Vibration Monitoring: Ongoing Since December 2012

Hawaiian Petrel burrows nearest to construction are monitored for vibration and noise to ensure the agreed upon thresholds documented in the HCP and BO are not exceeded during ground disturbing construction activities. Noise and vibration monitoring of the construction site is conducted by a third party, KCE, and has been underway since December 1, 2012, the first day of construction.

To measure vibration, measuring stations can be equipped with seismometers; depending on the location of the vibration source, one or more of six measuring stations are used to monitor ground disturbance. Two seismometers have been consistently deployed at the two burrows nearest to construction (SC-40 and SC-21 shown on Figure 5). As required by the HCP and BO, noise producing activity is also monitored at the closest burrow to the construction footprint (SC-40, Figure 5); both at the burrow entrance, and at a distance of 5 meters from the burrow. The data from ongoing vibration monitoring shows that as of this report no construction activity during the four years of measurements have resulted in vibration levels that met or exceeded the threshold of 0.12 in/sec.

Most often, noise has not been above ambient wind levels at the burrow entrances, which can range up to 70+ dBA. KCE reported that noise levels at the burrow entrance have averaged about 56 dBA during construction, and actually decreased by about 10 dBA 5 meters closer to the source of construction. KCE explained that this decrease in noise closer to the construction can be attributed to the location of the burrow entrance being at the edge of a cliff, and often the strong trade winds at those locations induce more noise than the construction activities (due to a Venturi-like effect of higher wind speeds).

Based on KCE monitoring data, **<u>the noise and vibration monitoring results show that construction activities have never exceeded authorized thresholds</u>**.

Most external construction was completed as of early March of 2016, and therefore, as of March 7, 2016 USFWS and DOFAW have agreed that during the period of interior construction noise and vibration monitoring is not necessary at the DKIST site except when large, noisy, or earth-moving operations resume.

IV I. Predator Control: <u>Ongoing Since September 2012</u>

Examination of footage from surveillance cameras in September 2012 identified the presence of a feral cat below the Mees Observatory. Camera footage revealed that the feral cat had visited five different burrows and entered at least one. A Havahart trap was set near burrow SC37 on September 13, 2012 just below the Mees Observatory. Friskies brand cat food was used as bait. The trap was labeled (CT001) along with the GPS coordinates of the trap location. The cat was captured and removed from the site. There has been only one cat sighting (in 2015) since this sighting and capture in 2012. However, in the Conservation Area a cat image was recorded on a burrow camera (two weeks after the petrel chick fledged from the burrow) in 2015. After consulting with USFWS, a 125-meter predator control grid system was installed consisting of 18 Havahart traps (for cats) and 19 A-24 automatic traps (New Zealand Goodnature Company, for mongoose) that cover the northern part (the lower portion with higher risk of predation) of the Conservation Area. This grid is not as uniform as it appears in plan - in the actual on-ground layout of the grid; traps were not placed within 50 meters of any known petrel burrow to avoid attracting predators into petrel colonies. Each Havahart trap was equipped with a Telonics TBT-600NH or 503-1 trapsite transmitter to allow the traps to be monitored at least every other day to avoid petrel by-catch and to ensure the welfare of the trapped animals. The installation of the northern trap grid was completed on September 16, 2013, and was operational until November 18, 2013, when all known petrels left the Conservation Area.

In order to improve the predator control efficiency, USFWS predator control experts recommended that the project employ a more unified predator control grid system. Based on this recommendation, the DKIST resource management team installed 22 additional cat traps and 23 new mongoose traps, and relocated the traps in the northern half in 2014. The new grid of 40 cat traps and 42 A-24 mongoose traps was completed on June 19, 2014 (Figure 4).

Peanut butter was used as bait in the A24 mongoose traps at first. Using this bait, the A-24 traps killed three roof rats but no mongoose. In an attempt to better lure mongoose, a change to utilize predator-specific bait was initiated on July 24, 2014, starting with cod liver oil and then changing monthly to include salmon oil, synthetic catnip oil, and then moving to meat-based "Violator 7" and "Feline fix" products. After these changes from the peanut butter bait, no additional predators were caught in these traps. Mongoose images were recorded by a burrow camera for two days at a burrow entrance where only rodent activity was recorded in 2016 in the Conservation Area. In the Control Site, mongoose images were captured by burrow cameras at three different burrows, each on two different days.

The predator control traps are baited for use during the first week of February of each year and decommissioned when the last known petrel departs from the colony in late October to mid-November each year until the next petrel season begins.

In 2014, the Havahart traps caught two roof rats and no cats. As of this report, only one field mouse has been caught in one of the A-24 traps in the first half of 2017.

On May 25, 2017, a petrel was caught in a predator trap and was released unharmed. This is the only petrel that has been caught in a DKIST predator trap.

IV J. Hawaiian Petrel Burrow/Reproductive Success Monitoring: <u>Since June 2011</u>

Hawaiian Petrel burrow/reproductive success monitoring has been conducted annually since the 2011 breeding season by DKIST's Resource Management team, in both the Conservation Area and Control Site (Figure 1).

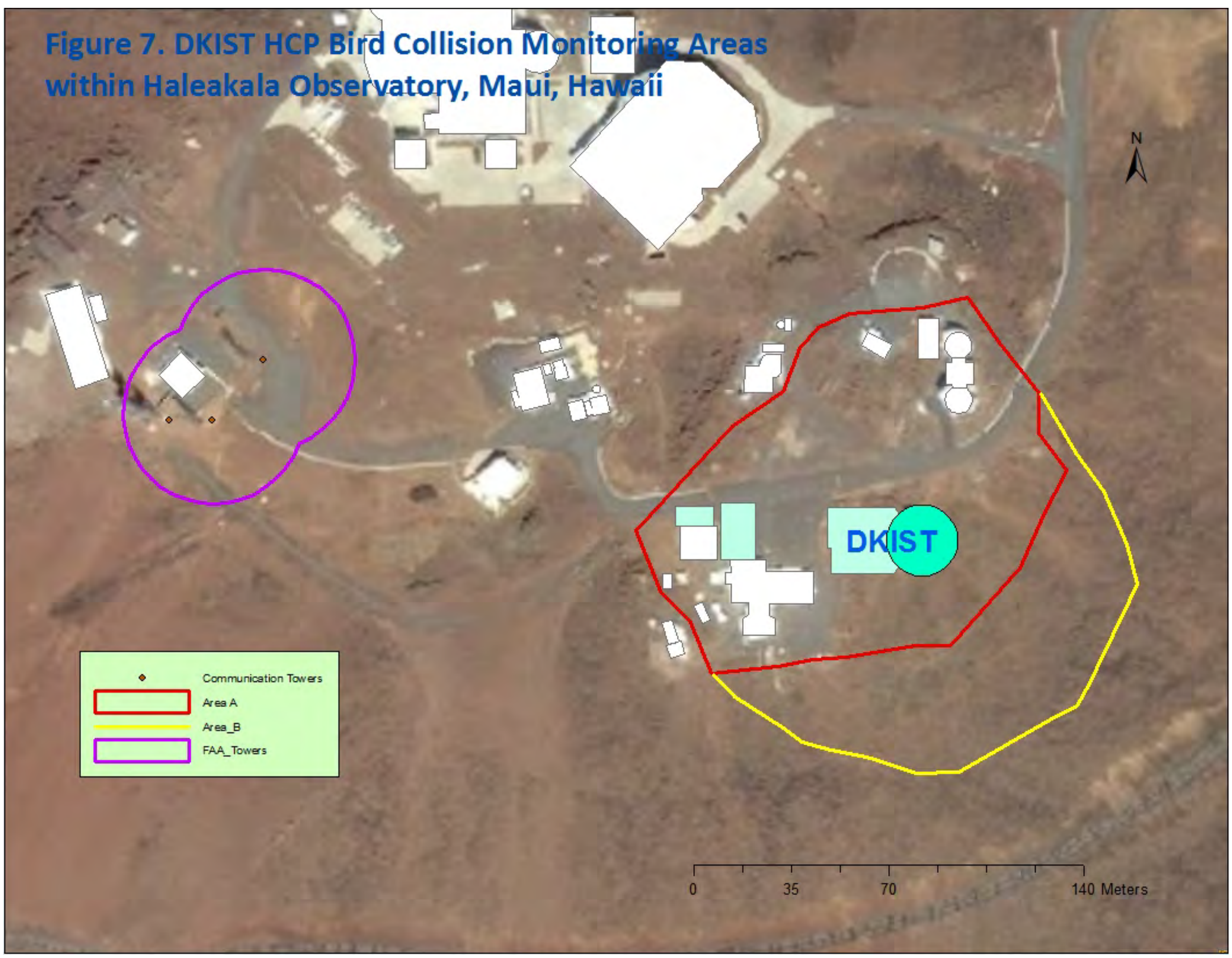
The new burrow scope that is now in use at DKIST is capable of detecting damage to burrow walls or features that may indicate collapse has occurred after nesting season. However, due to the acute angle shapes of petrel burrows and the volcanic rock, utilizing a burrow scope in the Haleakalā summit area to accurately observe eggs within burrows without risk of damage to them has not been feasible to-date. Therefore, data on the number of petrel pairs that laid eggs is not available, and for the purpose of this report, "fledgling success" is being used as a measurement of reproductive success in this area. This issue was discussed with USFWS and DOFAW on February 25, 2014 and September 25, 2014. As a result, DOFAW (October 20, 2014) and USFWS (October 30, 2014) issued letters confirming acceptance of this adaptive management approach.

IV K. Birdstrike Monitoring: <u>Ongoing Since June 2011</u>

In 2011 birdstrike monitoring took place from June 7 to November 30. Monitoring was conducted between February 1 and November 30 in 2012 and 2013. From 2014 and thereafter, the monitoring period ended on October 31, as required by the HCP and BO.

In 2011 and 2012, prior to the start of construction of the DKIST, only the two FAA communication towers were monitored. An area equal to a 75-ft. radius of the FAA towers (Figure 7) was delineated, and this radius is 1.25 x the height of the two FAA towers (60 ft.). The site was monitored every morning, seven days a week from June 7, 2011 to the second week of March 2014. Since 2014 monitoring has been conducted twice a week (primarily on Mondays and Thursdays) to reflect the HCP and BO required frequency.

Since 2013, HO search areas A and B have been monitored (Figure 7). The perimeter boundary of Area A and B is approximately 1.25 x the height of the DKIST observatory (136 ft.) extending from the perimeter of the DKIST observatory site. DKIST resource management team members conducted birdstrike monitoring within these two sites. Due to the cultural sensitivity of the summit area, no additional transect marking is appropriate, therefore the resource management team uses only existing landmarks to mark search routes and systematically search these two sites. During the search, the team systematically searches Area A twice and scans Area B once. When conducting the second search, the crew swaps their positions in the formation to increase the probability of detecting downed birds.



- Area A (3.3 acres (1.3 ha)): Lies on the more level area of Kolekole cinder cone and includes other observatories. This area includes roads, pathways, and roofs of buildings, plus open rocky habitat with little obstruction for detecting bird carcasses. No restriction within this search area exists, and all monitoring of Area A is done by systematic foot search.
- Area B (1.4 acres (0.6 ha)): Lies on the steep slopes south and east below the relatively flat area of Area A in an existing Hawaiian Petrel habitat. As instructed in the HCP, monitoring of Area B is conducted via use of binoculars to scan through the areas, since frequent monitoring by foot search is discouraged. Foot traffic could degrade breeding habitat in that area. Searchers are able to access the edge of the cliff at the demarcation between Area A and Area B for visual scanning (binocular-assisted) of Area B. However, because Area B includes rocks and boulders of various sizes that would obstruct simple observation of bird carcasses, it cannot be covered adequately enough to accurately count downed birds. Visual scanning, however, is useful in detecting and recovering any downed birds in the open, so that they do not become a predator attraction.

In 2014, monitoring of the conservation fence (Figure 1) was conducted twice a week until July 5. On July 6, 2014, USFWS notified the DKIST resource management team that such monitoring could be reduced to once every other week. An adaptive management amendment to the BO to confirm the change was issued on July 29, 2014. On September 23, 2014, the monitoring schedule was again amended to once each month from February to October, because the extended two-month CARE trial identified no carcasses removed by scavengers. The USFWS was satisfied that fence monitoring once each month is adequate to recover any downed birds.

No petrel collisions were recorded during all the monitoring periods from 2011 to June 30, 2017 at the DKIST construction site (Area A & B), the FAA/Coast Guard towers, or along the conservation fence.

However, if any collisions were to occur, the protocol requires recording the following information: date, time, location coordinates, species, photo of the bird in question, and person attending. This information would be included in a report that would be forwarded to the USFWS, Pacific Islands Fish and Wildlife Office, USFWS Office of Law Enforcement, and DOFAW. In accordance with the protocol, the downed birds or carcasses would be handled according to the official State of Hawai'i Downed Wildlife and the USGS Wildlife Health Center, Honolulu office protocols, and if still alive, injured individuals would be delivered to appropriate local Maui veterinarians. DKIST would fund any acute care and the transport of the bird, if necessary, to a permitted wildlife rehabilitation center (currently located on O'ahu and the island of Hawai'i).

V. HAWAIIAN PETREL REPRODUCTIVE SUCCESS MONITORING: METHODS

V A. Personnel Training

All current members of the DKIST Resource Management Team received extensive training in 2011. This training included both field and administrative training. Members were trained on petrel carcass search and handling, petrel burrow identification, classification of burrow status based on signs of petrel activity, and avoidance of cultural resources during field work. In addition, the Predator Control Technician is certified for Commercial Applicators of Restricted Pesticides and each member was trained in handling rodenticide and rodent carcasses. Two of the team members were either State of Hawai'i Hunter Education certified or National Rifle Association (NRA) firearm certified. All members were previously trained in the use of GPS and ArcGIS software and all completed First Aid/First Responder and CPR certifications.

V B. Petrel Burrow Search

The DKIST Resource Management Team began monitoring known burrows and searching for new burrows in the Conservation Area and Control site on August 10, 2011 and again on February 22, 2012. Based on experience and data collected during 2012, we realized that starting burrow monitoring in late February is likely to result in an overestimate of the number of active burrows, because petrels returning at this time of the year are just prospecting and forming pairing bonds, so multiple possible burrow sites might be visited by each pair. We changed our burrow monitoring starting date to better coincide with the start of nesting season in the first part of May in 2013 (May 7, 2013, May 7, 2014, May 19, 2015, April 14, 2016 and May 2, 2017). Monitoring ends each season after the petrel chick from the last known burrow fledges, which was November 16 in 2011, November 10 in 2012, October 24 in 2013, November 11 in 2014, November 16 in 2015 and November 28 in 2016. The 2017 season is still on-going as of the writing of this report.

The team begins annual monitoring by visiting all the burrows that were recorded from previous breeding seasons. Any newly identified burrows are documented as they are discovered and a systematic search of the DKIST Conservation Area and Control Site is also conducted. Newly identified burrows may be a previously undiscovered burrow, or a newly excavated burrow. The DKIST resource management team utilizes recorded information provided by the Park regarding established burrows that were confirmed prior to 2011. In order to avoid mislabeling some of the thousands of rock crevices within the Conservation Area as new burrows, a structural feature isn't officially documented as a 'burrow' until its use is established by some evidence of petrel activity. When DKIST began monitoring in 2011, the same burrow identification system was used, following earlier Park convention. That is, the coordinates of the newly identified burrows are recorded with handheld Garmin Oregon 450 and 550 GPS units. Signs of petrel activity (feathers, droppings, egg shells, footprints, regurgitation, odor and other body parts) and GPS coordinates at each burrow are recorded. Toothpicks are placed vertically along the entrance of each burrow to monitor petrel movement in and out of burrows; fallen or height-altered toothpicks suggest current activity, while undisturbed toothpicks denote no activity (Hodges 1994, Hodges & Nagata 2001).

V C. Principles of Reproductive Success Monitoring

Breeding success is initially categorized based on signs at the entrance, status of placed toothpicks, and the latest date of activity. Burrows that were "Active" were then re-checked weekly until signs of success or non-productivity were observed. Using the same methodology as employed by the Haleakalā National Park (Hodges 1994, Hodges & Nagata 2001), a burrow was defined to be "successful" by the presence of petrel chick down feathers at the burrow entrance, and disturbed toothpicks after mid - September of each year. Burrows classified as “non-productive” showed signs of activity during initial search, but no further signs were found while conducting the subsequent re-checks, suggesting that these burrows were either occupied by non-breeders, the nest was abandoned, or the chicks did not reach fledgling age.

V D. Camera Monitoring of Reproductive Success

To establish a baseline for petrel behaviors and burrow activity near the DKIST site in the years before construction, and to supplement means of monitoring reproductive success after construction began, cable surveillance video cameras were installed and monitored by KCE every year since 2006 at burrows adjacent to the Mees Observatory, from February until all petrels left the monitored burrows.

In addition, the DKIST resource management team installed Bushnell “Trophy Cam HD™” camera traps at active burrows outside of the cable accessible area. 16 camera traps were installed in the Conservation Area between October 15 and November 07, 2013, 39 camera traps were installed between September 10 and November 11, 2014; 38 camera traps were installed in the Conservation Area and one was installed in the Control Site. 35 camera traps were installed in the Conservation Area and two were installed in the Control Site between September 08 and November 18, 2015. 70 camera traps were installed in the Conservation Area between September 27 and November 23, 2016 and five were installed in the Control Site between September 22 and November 28, 2016. No camera traps have yet been deployed at this stage of the 2017 season.

VI. HAWAIIAN PETREL REPRODUCTIVE SUCCESS MONITORING: <u>RESULTS AND DISCUSSION</u>

VI A. Number of Petrel Burrows Monitored:

Based on monitoring data, Hawaiian Petrel burrows were classified as “Active”, “Not Active” and “Not a Burrow” (burrows that were active in at least one of the previous seasons, but for which the burrow passage is no longer present in the current season). Table 5 summarizes the adjusted and updated number of possible Hawaiian Petrel burrows monitored in these three categories within DKIST monitoring areas in the past six nesting seasons. As new burrows were located each year, the number of burrows monitored increased from 272 in 2011 to 365 in 2016. In the updated table, only burrows that are within the 2013 built conservation fence, not the boundary and Control Site burrows were included. The Conservation Area data of 2011 in this report is different from the previous reports, because the previously recorded “Not a Burrow”, newly recorded “Not Active” and newly recorded “Not a Burrow” from 2011 in the Conservation Area were not included in the previous reports.

VI B. Burrow Status

In the analysis, only burrows that were inside the boundary were included. “Nesting Activity %” is the number of “Active” burrows divided by the total number of burrows monitored that year, while “Nesting Success %” is calculated by dividing the “successful” number of burrows by the number of “Active” burrows.

Table 5 summarizes the adjusted status of burrows found between 2011 and early 2017, along with successful/non-productive statistics. In the Conservation Area, both the active burrow number (119) and Nesting Activity % (36%) showed a significant drop in 2016 (36%, compared to 54% in 2015, $\chi2$ =8.216, $P<0.05$, df=1, Figure 8), probably as a result of what caused the poor nesting success rate of 2015. Both the successful burrow number of 49 and the "Nesting Success %" of 41.2% recorded in 2016 was the highest ever recorded in the Conservation Area, which significantly increased from 2015 (17.3%, $\chi2$ =11.261, $P<0.05$, df=1). All the 2016 statistics in the Control Site were similar to the previous years except no additional successful burrows were recorded in 2016. Twenty three new active burrows were located within the Conservation Area prior to June 30, 2017. 2017 is the first year that no new active burrows were recorded in the Control Site (Table 5). It is too early to determine the status of the 'old' burrows at this stage of the breeding season.

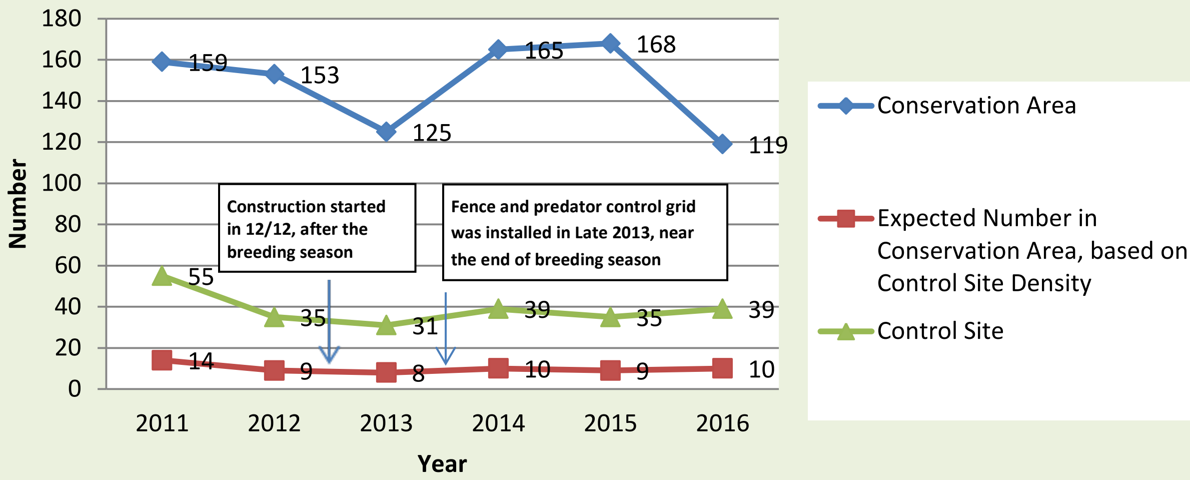
Table 5. Hawaiian Petrel Burrows and Reproductive Success in DKIST HCP Conservation Area and Control Site on Haleakalā, Maui, Hawaii (Cons. =Conservation Area, Cont. =Control Site).

	Year	2011		2012		2013		2014		2015		2016		2017[5]	
Status	Location	**Cons.**	**Cont.**	**Cons.[1]**	**Cont.**	**Cons.[2]**	**Cont.**	**Cons.[3]**	**Cont.**	**Cons.[4]**	**Cont.**	**Cons.**	**Cont.**	**Cons.**	**Cont.**
Old	**Active**	73	0	140	6	122	7	158	7	154	7	106	8		
	Successful	24	0	16	0	26	0	42	1	29	2	48	0		
	Non productive	49	0	124	6	96	7	116	6	125	5	58	8	332	33
	Not Active	38	0	103	15	151	18	128	19	143	22	200	23		
	Not a Burrow	10	0	15	0	8	0	2	0	0	0	5	0		
New	**Active**	86	14	13	3	3	1	7	3	14	2	13	2	23	0
	Successful	8	0	0	0	1	0	2	0	0	0	1	0		
	Non productive	78	14	13	3	2	1	5	3	14	2	12	2		
	Not Active	39	7	9	1	3	0	1	0	0	0	8	0		
	Not a Burrow	5	0	0	0	0	0	0	0	0	0	0	0		
Subtotal	**Old**	121	0	258	21	281	25	288	26	297	29	311	31	332	33
	New	130	21	22	4	6	1	8	3	14	2	21	2	23	0
Total		251	21	280	25	287	26	296	29	311	31	332	33	355	33
Nesting Activity %		67.37	66.67	57.74	36.00	44.80	30.77	56.12	34.48	54.02	29.03	35.84	30.30	n/a	n/a
Nesting Success %		20.13	0.00	10.46	0.00	21.60	0.00	26.67	10.00	17.26	22.22	41.18	0.00		

1. Seven of the old burrows recorded in 2012 were burrows that were marked prior to 2011, but were found in 2012.
2. One of the old burrows recorded in 2013 was burrows that were marked prior to 2011, but was found in 2013.
3. Including one burrow separated from an old burrow in 2014.
4. Including one burrow separated from an old burrow in 2015, and one burrow found in 2014 w/out recording the coordinates that was re-located in 2015.
5. Ongoing season, 01/01-06/30/2017 data.

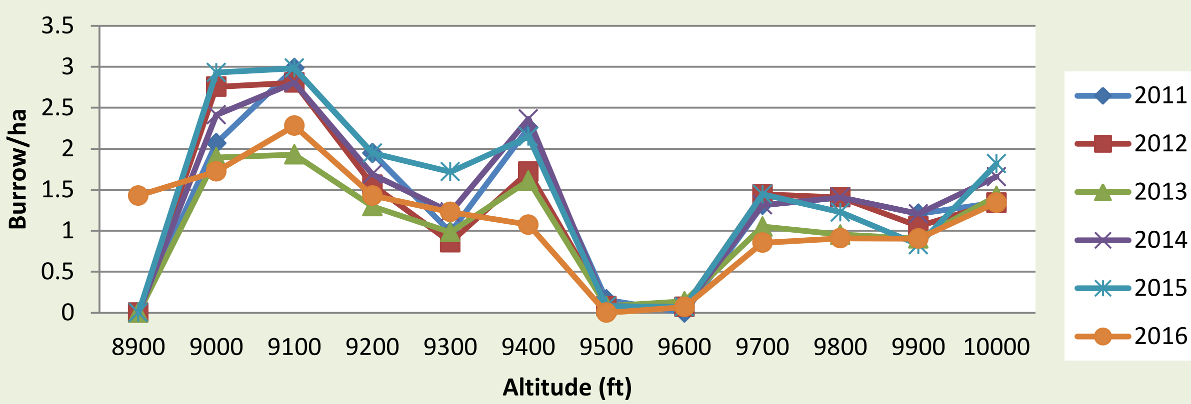
The density of active petrel burrows recorded from 2011 to 2016 in the Control Site (80 acres) was used to predict the number of active petrel burrows in the Conservation Area (312.66 acres). It was found that more active petrel burrows (3-5 times more) were recorded in the Conservation Area than expected from 2011 to 2016, even in the years prior to the installation of the conservation fence and predator/rodent grids (Figure 8). This phenomenon might be explained by the relatively lower quality of petrel nesting habitat or less suitable burrowing sites located in the Control Site. It could also be that this site sustained long term predation pressure due to its proximity to the source of predators.

Figure 8. Active Hawaiian Petrel Burrow Number Recorded in DKIST HCP monitoring Area on the Summit of Haleakala, Maui from 2011 t0 2016



Upon examination of the density distribution of active petrel burrows within the Conservation Area in different years and at different elevations, almost identical density distribution patterns in different years can be observed. Although the least active burrow number was recorded in 2016, this was the first time active burrows were recorded below 8,900 ft. elevation. An uninhabited zone between the 9,400 and 9,600 ft. elevation levels (Figure 9) was also observed in 2016. Figure 9 also shows that petrel burrows in the HCP monitored areas are neither evenly nor randomly distributed. Further investigation of the active burrow distribution indicates that burrows are only located in lava rock areas and that cinder areas are vacant of petrel burrows.

Figure 9. Active Hawaiian Petrel Burrow Density at Different Altitudes Recorded from 2011 to 2016 in DKIST HCP Conservation Area on the Summit of Haleakala, Maui



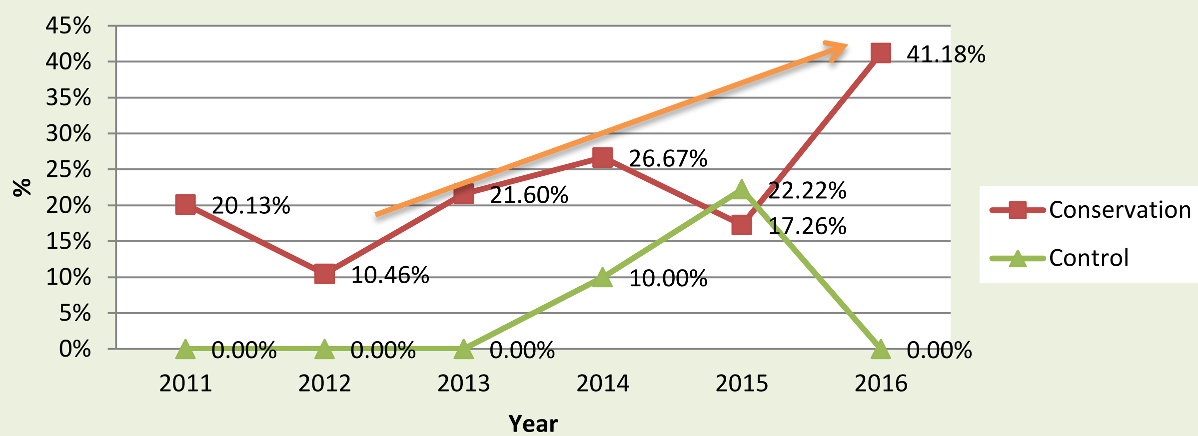
Based on recent genetic and isotope studies (Judge 2011, Welch et. al. 2012, Wiley et al. 2013), the DKIST resource management team assumes that all Hawaiian Petrel colonies on the summit of Haleakalā, Maui form a meta-population. We speculate that petrels from these colonies forage in the same foraging area, and experience the same survival conditions and challenges during the same year. Intrayear comparisons between the Conservation Area and Control Site are examined and presented in order to reduce the uncontrollable effects of inter-year environmental variances; e.g. prey population fluctuation due to yearly climate, pollution, fishery pressure, prey accessibility due to debris, and declined predatory fish population to Hawaiian Petrel reproductive performance, the survival rate of adults/chicks, and young recruitment.

We have attempted to compare trends of active burrow numbers and successful burrow numbers between the Conservation Area and Control Site, to evaluate whether the DKIST conservation fence and predator/rodent control grids have promoted recovery for the Hawaiian Petrel in the Conservation Area. The sample size of active/successful burrows recorded in the Control Site from 2011 to 2016 was too small to conduct appropriate statistical comparisons. Even population trends are difficult to identify due to the small sample size in the Control Site. For example, in 2015 the 22.2%"Nesting Success %" in the Control Site is higher than in the Conservation Area (17.2%), but the statistic is only based on nine active burrows (Table 5, Figure 10). After the first burrow successfully fledged a chick in the Control Site in 2014, two petrel burrows produced fledglings in 2015, but the number went down to zero again in 2016.

If we compare the average "Nesting Success %" prior to the implementation of all the conservation measures (15.4%, 2011 & 2012)[1] with that of post implementation years (27%, 2014 to 2016)[2] in the Conservation Area, we can observe **a significant (χ^2 =9.324, P<0.05, df=1) increase of 75.4%[3] in "Nesting Success %" after the conservation measures were implemented in the Conservation Area**.

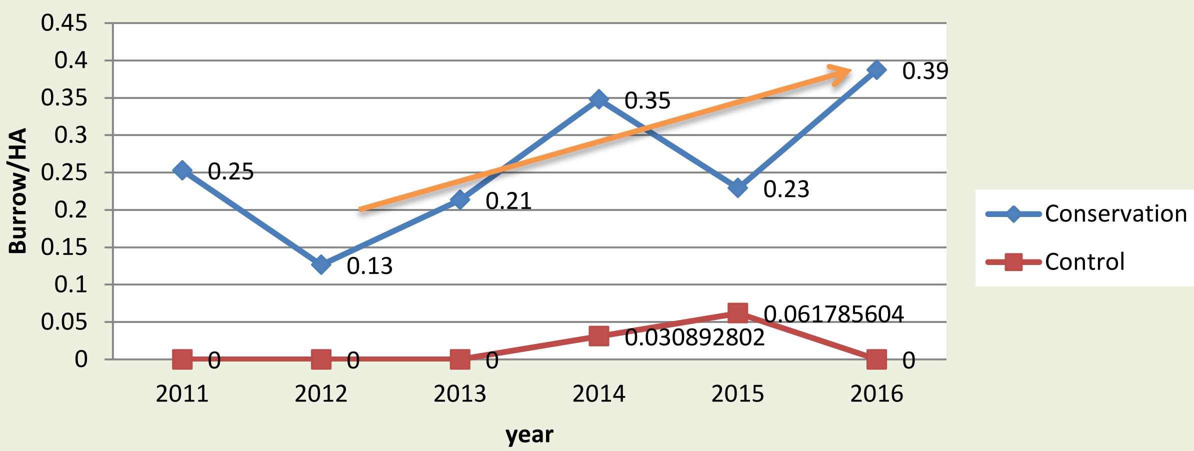
1. **(32[2011 successful burrow]+16[2012 successful burrow])/(159[2011 active burrow]+153[2012 active burrow])=15.38%**
2. **(44[2014 successful burrow] +29[2015 successful burrow] +49[2016 successful burrow])/(165[2014 active burrow] +168[2015 active burrow] +119[2016 active burrow])=26.99%**
3. **(26.99%-15.38%)/15.38%=75.48%**

Figure 10. Hawaiian Petrel Nesting Success % Recorded in DKIST HCP Monitored Areas on the Summit of Haleakala, Maui, From 2011 to 2016



Comparing the succesful burrow densities or numbers prior to 2013 and after 2013, when the installation of the mitigation measures was completed (Figure 11), seems to be a more appropiate way of determining whether the DKIST HCP mitigation measures facilitated petrel reproductive performance in the Conservation Area. The attempt to determine the effect by comparing succesful burrow densities or numbers in the Conservation Area and Control Site may be skewed due to the low number of active burrows recorded in the Control Site. Also, the habitat quality in the Control Site and the Conservation Area is very different (as illustrated in Figure 8 of this section).

Figure 11. Hawaii Petrel Successful Nest Density Recorded in DKIST HCP Monitored Areas on the Summit of Haleakala, Maui, From 2011 to 2016



Climatologically, 2015 was considered an anomaly in the North Pacific Ocean. Unusually high ocean surface temperatures (A.K.A. “Blob”) induced shifting fish distribution and algae blooms, resulting in mass seabird and marine mammal stranding and die-off in this area (Cavole et al. 2016). The 2015 Pacific hurricane season was the most active Pacific hurricane season on record in recent years with 16 named storms (National Weather Service Central Pacific Hurricane Center, http://www.prh.noaa.gov/cphc/summaries/), which was two to three time the number recorded from 2013 to 2016. This extraordinarily active hurricane season might have impacted petrels’ traveling between their breeding colonies and foraging grounds in the North Pacific. All of these anomolies in 2015 may have resulted in the high egg abandonment and roll out number observed in 2015 (Table 6). Once again, successive years of data will shed more light on trends of reproductive success within the DKIST HCP monitored areas.

There was a great reproductive performance improvement in 2016 in elevations below 8,900 ft. and in elevations between 9,200 and 9,400 ft. within the Conservation Area. This was likely due to the effectivness of predator control, as no nest predation or trampling has been recorded in this area since 2014, although one adult each was predated in 2014 and 2016 near the conservation fence (Figure 12 and 13).

Figure 12. Hawaiian Petrel Nesting Success % at Different Altitudes Recorded Between 2011 and 2016 in DKIST Conservation Area, Near the Summit of Haleakala, Maui

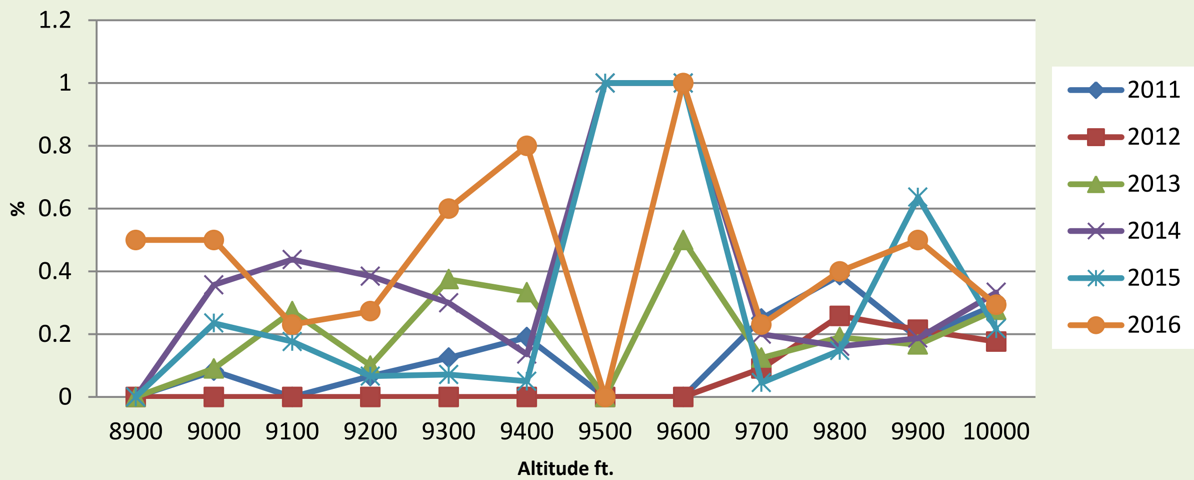
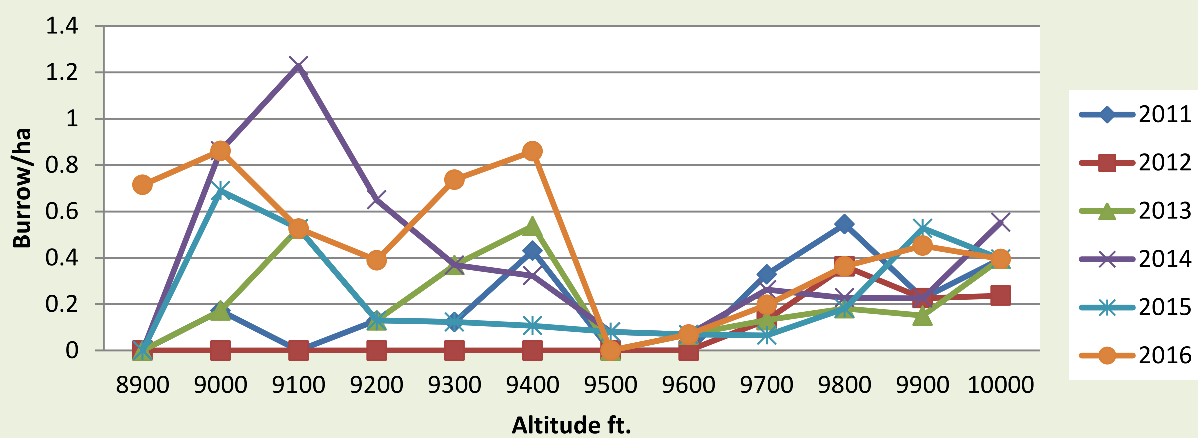


Figure 13. Successful Hawaiian Petrel Burrow Density at Different Altitudes Recorded From 2011 to 2016 in DKIST Conservation Area, Near the Summit of Haleakala, Maui



When we look at the number of successful fledglings before and after DKIST implemented the HCP/BO conservation measures, the average annual successful fledgling number from 2011 to 2013 in the Conservation Area was 25 (24 if 2013 is not included), while the average annual successful burrow number from 2011 to 2013 in the Control Site was zero. The average annual successful burrow number from 2014 to 2016 in the Conservation Area was 40.7, while the average successful burrow number from 2014 to 2016 in Control Site was 1.0. **The Hawaiian Petrel productivity in the Conservation Area increased 62.7% (69.4% if 2013 is not included) after the HCP was fully implemented**. Based on the empirical data, **DKIST HCP/BO mitigation measures have facilitated Hawaiian Petrel fledging by 16.7[1] more successful fledglings annually or 50[2] more successful fledglings) from 2014 to 2016**. This result significantly demonstrates the net benefit from DKIST HCP mitigation measures.

1. $40.67^{\text{average successful fledgling \# 2014-2016}} - 24^{\text{average successful fledgling \# 2011-2012}} = 16.67^{\text{annual increased successful fledgling \#}}$
2. $16.67^{\text{annual increased successful fledgling \#}} \times 3\ \text{year}^{\text{2014-2016}} = 50^{\text{2014-2016 total increased successful fledgling \#}}$

VI C. Hawaiian Petrel Mortality

Table 6 summarizes all known mortality events recorded between the 2011 breeding season and the first half of the 2017 breeding season. In the first half of 2017, an adult petrel was found dead with an injured wing outside of its burrow near the DKIST construction site in the Conservation Area. Pre-necropsy examination identified no broken bones, however, the cause of mortality is still undetermined as of the writing of this report. Based on our surveillance camera record, this bird injured its wing inside its burrow, not while flying, so we have temporarily categorized it as 'other' mortality. Two eggs were found outside of two different burrows with no signs of predation on May 22nd of 2017. The first egg was located above the burrow and had cracks at the bottom, but no chew marks. This was during the early incubation period, therefore this egg may have been prematurely laid. A second egg was found in tact outside another burrow, again during the early incubation period, and was likely due to an accidental roll-out.

Table 6. Known Hawaiian Petrel Mortality Events Recorded between 2011 and 2016 in the DKIST Conservation Area and Control Site (Cons.: Conservation Area, Cont.: Control Site)

Year	2011		2012		2013[1]		2014		2015		2016		2017[4]	
Age/Site	Cons.	Cont.	Cons.	Cont.	Cons.	Cont.	Cons.[2]	Cont.	Cons.	Cont.	Cons.	Cont.	Cons.	Cont.
Other														
Egg	4	0	1	0	1	0	2	0	14	1	4	0	2	0
Chick	2	0	0	0	2	0	1	0	0	0	2[3]	0	0	0
Adult	1	0	0	0	3	0	0	0	2	0	0	0	1[5]	0
Predation/burrow trampling														
Egg	1	0	2	0	0	0	0	1	0	0	0	0	0	0
Chick	6	3	1	0	3	0	0	0	0	1	0	1	0	0
Adult	1	9	3	1	0	0	1	0	0	0	1	0	0	0
TOTAL	15	12	7	1	9	0	4	1	16	2	7	1		

1. Not including a burrow trampled by ungulates in the early stage of breeding season, and an adult and a chick mortality event that occurred prior to 2013.
2. Not including one burrow collapse in each site due to an unknown cause and consequence in early stage of breeding season. The collapsed burrow in Conservation Area was 210 m from the nearest DKIST staging area and more than 400 m from construction site.
3. Two chicks first emerged from their burrows in November still covered with down, one left the same night, which died of emaciation two days later, the other chick, stayed around its burrow for six nights and disappeared. Based on the condition of this chick, we assumed this chick didn't fledge successfully.
4. Ongoing season.
5. The Cause of mortality is still not determined as of June 30, 2017.

Prior to the installation of DKIST's predator control grid and ungulate fence in 2013, invasive mammalian predators were the cause of an average annual predation of 7 birds/year of all detected petrel mortality in the DKIST Conservation Area, but this number has been reduced an average annual predation of 0.7 birds/year between 2014 and 2016. Using 2011 and 2012 data as a baseline, **DKIST predator/ungulate control measures have reduced an average of 90.5% of the expected annual predation events since 2013**, even without any predators being caught in the predator control grid. This fact also demonstrates the effectiveness of the DKIST predator control measures.

Considering all HCP conservation measures implemented by DKIST, we should expect a diminishing trend for predation but not necessarily a direct Hawaiian Petrel population increase, although DKIST has demonstrated both. This is due to the indeterminable and uncontrollable impacts to the ocean from global weather change, pollution and resource overexploitation. For example, the egg roll-out/abandonment observed in 2015 in the Conservation Area (n=14) is equal to the sum of all predation events observed in 2011 and 2012 (n=8+6=14), the years prior to the implementation of predator control measures. Although the implementation of predator control measures had effectively reduced the amount of predation events, egg roll-out/abandonment still occurred, meaning that the factors at play were probably not ones we can control. As the data accumulates, we will likely be able to determine definitively that impacts from outside of the Hawaiian Petrel colonies actually play a more significant role in the petrel mortality observed in DKIST HCP monitored areas than previously thought.

Based on Table 6 Conservation Area data: prior to the completion of implementing the conservation measures (2011-2012), the annual egg loss due to predation was 1.5 eggs/year, the annual chick loss due to predation was 3.5 chicks/year and the annual adult loss due to predation was 2 adults/year. After the completion of implementing the conservation measures (2014-2016); no eggs were lost due to predation, the annual chick loss due to predation was 0.33 chicks/year and the annual adult loss due to predation was 0.67 adults/year. In other words, **DKIST HCP/BO measures have reduced the number of eggs, chicks and adults lost due to predation by 1.5 eggs, 3.2 chicks and 1.3 adults annually, or saving a total of 4.5 eggs, 9.5 chicks and 4 adult petrels from predation between 2014 and 2016**.

It should be noted that Control Site predation diminished more quickly than in the Conservation Area during the period from 2011 to 2016. However, once we factor in burrow density and the difference in size (the Conservation Area is approximately four times larger than the Control Site), we can see that predation in the Conservation Area actually diminished more than in the Control Site.

Figure 14. Density of Hawaiian Petrel Predation/Burrow Trampling Recorded at Different Elevations in DKIST HCP Conservation Area from 2011 to 2016 on the Summit of Haleakala, Maui

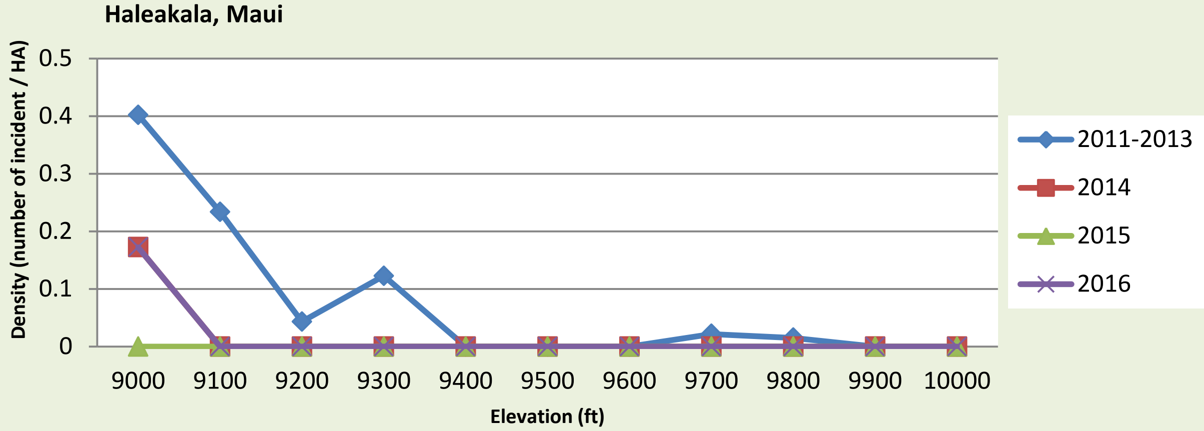
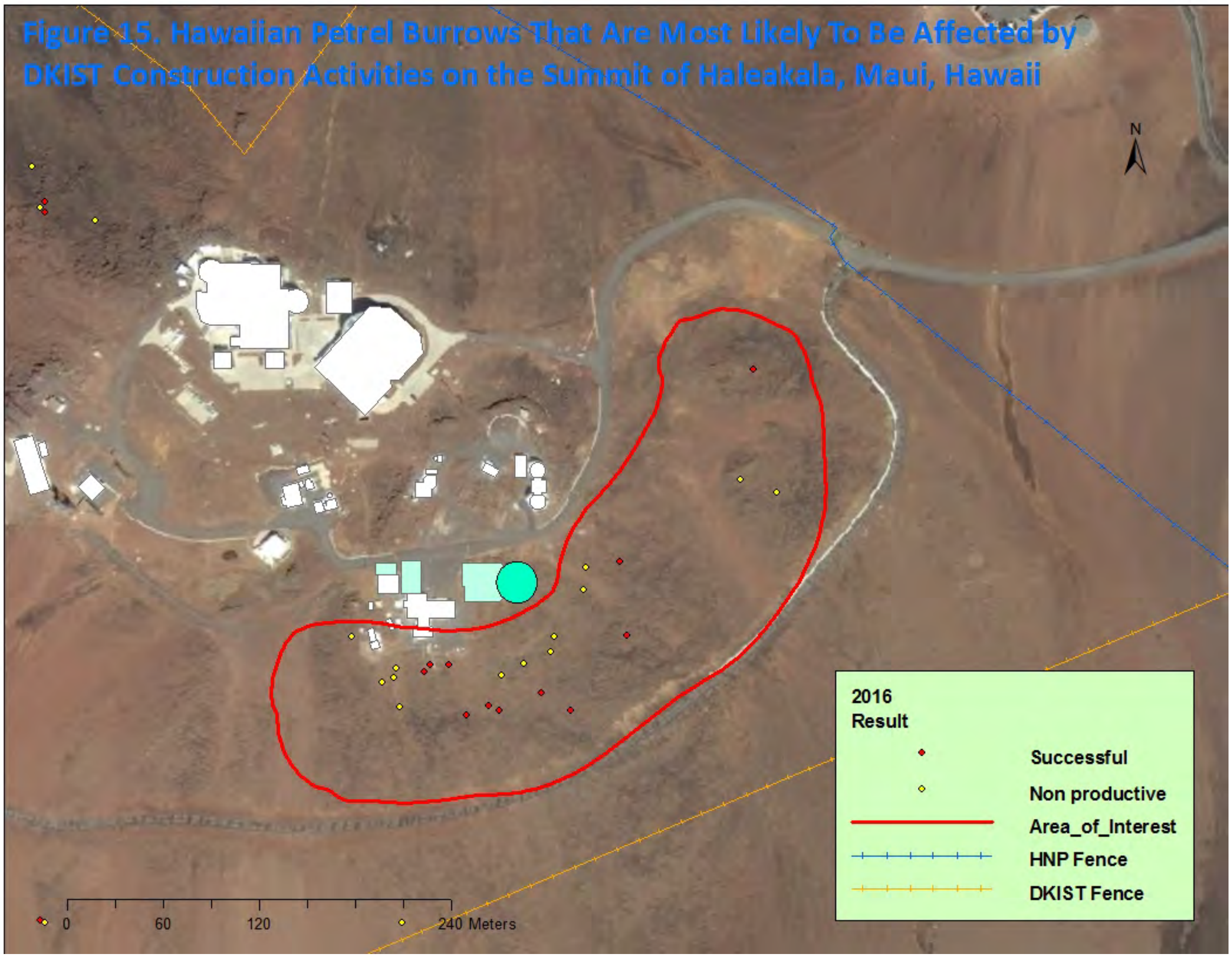


Figure 14 demonstrates the effectiveness of the conservation fence and predator control grid implemented in 2013 and completed in early 2014 in the Conservation Area; all predation events above 9,000 ft. were reduced to zero.

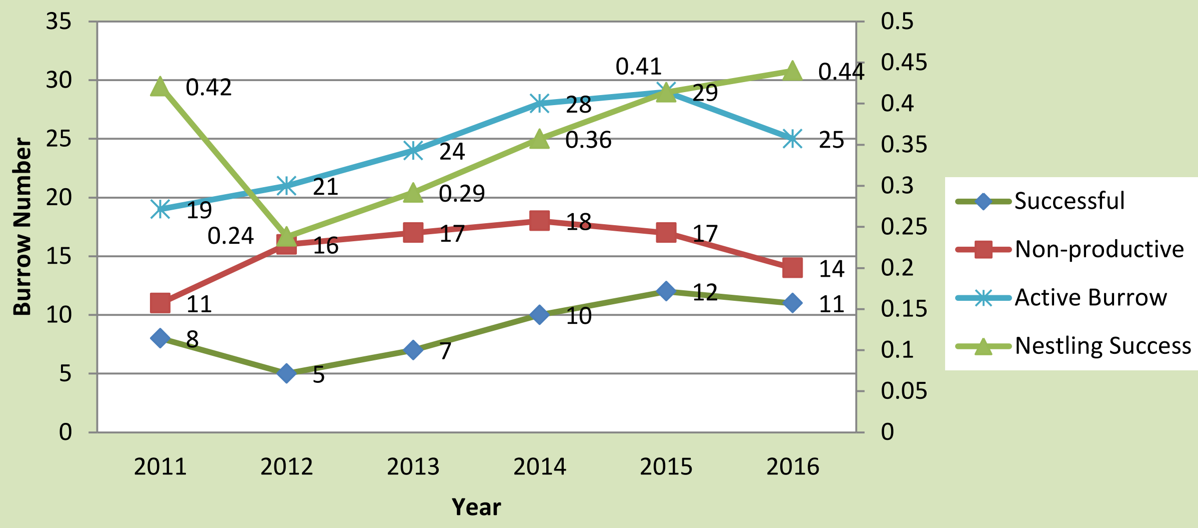
VI D. Hawaiian Petrel Burrows Adjacent to the Construction Site



Furthermore, in order to understand whether DKIST construction activities resulted in the decline of active Hawaiian Petrel burrow numbers, the trend of petrel burrow status and reproductive performance adjacent to the DKIST construction site was also examined (Figure 15). Active and successful burrows adjacent to the construction site continued to increase until plateauing in 2016 and Nesting Success % reached the highest point in 2016 (Figure 16). **It appears that DKIST construction activities have not deterred new petrels from coming to breed and nest in areas adjacent to the DKIST construction site, nor has it reduced the reproductive success of the petrels.**

Based on the trend of reduced predation events (which we was assume helped increase the number of active burrows (Figure 14), an increase in the active burrows adjacent to the DKIST site from 2011 to 2016 (Figure 16), and the fact that DKIST construction did not begin until December of 2012 after the 2012 petrel season was complete, it seems highly unlikely that the decrease noted in overall active burrow numbers from 2011 to 2013 (Figure 8) were related in any way to construction activities. The initial decline of active petrel burrows recorded in the larger DKIST HCP/BO monitoring area probably resulted from a combination of invasive predators, ungulates, and factors external to the breeding colonies.

Figure 16. Number of Active Hawaiian Petrel Burrow Adjacent to DKIST Construction Site Recorded from 2011 to 2016, Near the Summit of Haleakala, Maui



The data discussed in the sections above suggest some conclusions:

1. A reduced predation event density nearest to the DKIST construction site before and after construction began may have been the result of relatively high human activity intensity at the summit area, which may have reduced predator activities or predation frequency.

2. A trend of reduced predation/trampling was detected in both the Conservation Area and Control Site although it was not statistically significant due to a small sample size.

3. The implementation of the DKIST HCP conservation fence and predator control grid has greatly reduced the number of predation and trampling events in the predator impacted lower portion of the Conservation Area, even though no feral cats or mongooses were trapped.

4. It may be that DKIST construction has attracted additional breeding petrels to nests, and the dense rodent control grid installed in this area seemed to benefit petrel reproductive success.

5. The type of petrel collision with DKIST construction structures of most concern to biologists prior to construction has not been observed since construction began in December of 2012. As the external construction activity nears its completion, the probability of such events will further diminish.

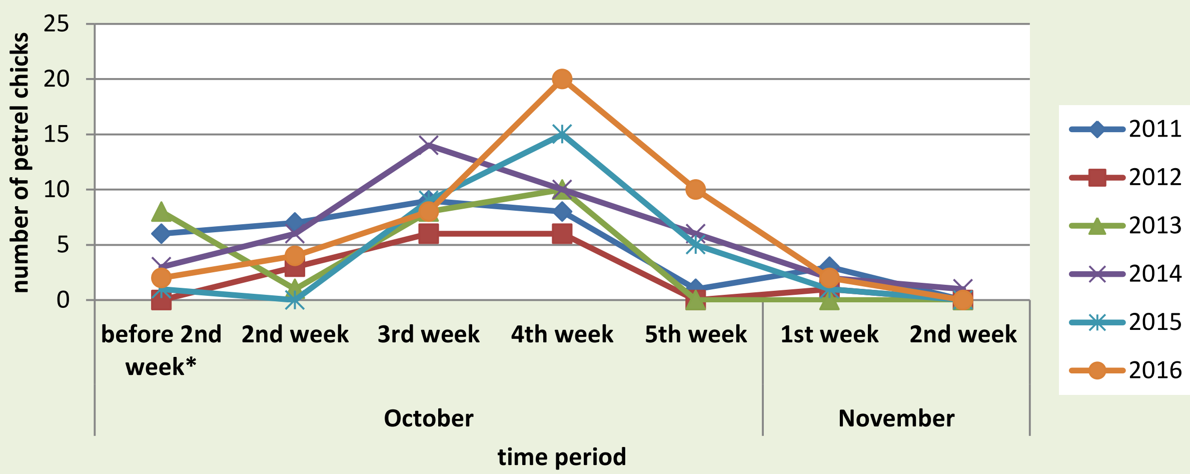
6. Due to the life history and home range of the Hawaiian Petrel, there are still variables that impact petrel mortality and reproductive performance that cannot be controlled or even influenced by DKIST HCP/BO conservation efforts. These include global weather changes, over- fishing of apex predator fish, plastic particles suspended in the marine ecosystem, etc. However, conservation efforts implemented under the DKIST HCP and BO are more likely to reduce predation effects that influence mortality and reproductive performance while petrels are present in the Conservation Area.

VI E. Fledgling Dates

Historical Data: During the three years of his study, Simon (1985) reported that the Hawaiian Petrel fledging period extends from October 8 to October 30. The median fledging dates were October 23, 1979 (±6.5 days), October 19, 1980 (±6.7 days), and October 19, 1981 (±6.1 days). To investigate the potential impacts of DKIST construction on fledgling dates, the resource management team has monitored chicks' first appearance outside active burrows and fledgling departures since 2011. Since the number of active burrows varies from year to year, the number of burrows being monitored by cameras also varies from year to year.

Project Data: Figure 17 presents the overall fledging departure dates from 2011-2016 in weekly intervals.

Figure 17. Hawaiian Petrel Fledging Dates Recorded from 2011 to 2016 in DKISt Monitoring Areas Near the Summit of Haleakala, Maui



2011 -2015

- In 2011, 8 of the 17 burrows being monitored by cable connected surveillance cameras were successful. Based on the video recordings of the eight successful burrows around the Mees Observatory, the earliest fledging date was on October 19 and the latest date was on October 25 (median date: October 22).

- In 2012, 6 of the 18 burrows being monitored by cameras were successful. Based on the video recordings of the six successful burrows around the Mees Observatory, the earliest fledging date was on October 12 and the latest date was on October 19 (median date: October 17).

- In 2013, 7 of the 19 burrows being monitored by cameras were successful in fledging petrels. We also placed 16 camera traps at active burrow sites outside of the Mees Observatory area. Among these 16 additional camera traps, we recorded fledging dates at 10 burrows. Based on

17 image recordings, the fledging dates were between October 10 and October 24 (median date: October 19).

- In 2014, 10 of the 19 burrows being monitored by cameras were successful in fledging petrels. We also placed 39 camera traps at active burrow sites outside of the Mees Observatory area. Among these camera traps, the exact fledging dates at 25 burrows were recorded. The exact fledging dates at 3 burrows manually monitored were also observed. Based on 38 fledging date recordings, the fledging dates were between September 24 and November 09 (median date: October 17).

- In 2015, 11 of the 19 burrows being monitored by cameras were successful in fledging petrels, which is the highest number yet counted. We also installed 35 camera traps at active burrow sites outside of the Mees Observatory area. Among these camera traps, the exact fledging dates at 20 burrows were recorded (including 2 in the Control Site). Based on 31 fledging date recordings, the fledging dates were between September 29 and November 01 (median date: October 22).

The fledging dates collected from 2011 to 2015 were within the range of what Simons (1985) reported, suggesting that no impact on petrel fledging dates from DKIST construction activities could be detected.

2016

In 2016, 10 of the 20 burrows being monitored by cameras were successful in fledging petrels. We also installed 75 camera traps at active burrow sites outside of the Mees Observatory area (including 5 in the Control Site). Among these camera traps, the exact fledging dates at 39 burrows were recorded (one burrow was monitored by both systems). Based on 48 fledging date recordings, the fledging dates were between October 1 and November 02 (median date: October 19).

Similar to previous years and historical data; the recorded events of 2016 confirmed that Hawaiian Petrels begin fledging from their burrows during the latter part of September, as has been the case in previous breeding seasons. The 3rd and 4th weeks of October accounted for the largest number of fledged chicks. By the end of the 1st week of November, most chicks had already fledged and left the breeding colony.

Besides the successful petrel fledglings, DKIST also documented two petrel chicks still in their downy plumage that left their burrows as late as November 9, one could not be tracked in darkness, and the other one was found near the DKIST structure and died after arriving at the Maui Nui Seabird Recovery facility the next day due to malnutrition.

Based on the observed petrel fledging dates within our sites, **the fledging timing pattern has been similar to that of Haleakalā National Park (HNP) data throughout the monitoring period, indicating that construction has not had an impact on the nesting cycle.**

VII. SUMMARY OF RESULTS

Petrel Collision: The DKIST team did not detect any Hawaiian Petrel collisions with any structures between June 7, 2011 and June 30, 2017, including DKIST-related structures that first appeared on site in December 2012.

Impact on Nesting Activity and Fledgling Success:

- No direct take of listed Hawaiian Petrel caused by DKIST construction activities and conservation measures implemented in the Conservation Area was recorded since monitoring started in the summer of 2011.
- No adverse impacts were statistically detected on Hawaiian Petrel Nesting Activity and percentage of Nesting Success that resulted from DKIST construction activities and conservation measures implemented in the Conservation Area.
- The number of active and successful burrows increased adjacent to the DKIST construction site (around Mees Observatory) until 2015 with a small decline in 2016.
- The Control Site has very limited utility for comparison with the Conservation Area. Each has a different quality of Hawaiian Petrel breeding habitat such that even before construction began and mitigation measures were in place, burrow density and nesting success rates in the Conservation Area were four to five times higher. Additionally, we cannot assess whether the DKIST conservation fence and predator/rodent control grids have promoted recovery for the Hawaiian Petrel in the Conservation Area or assess population trends in comparison to the Control Site, because the sample size of active/successful burrows in the Control Site is too small for statistical comparisons.
- Thus far, the largest number of active and highest density of active burrows, were recorded in 2015.
- To date, the highest nesting success rate and density were recorded in 2016.
- The active and successful burrow density increased at the lower boundary area after the predator grid was fully installed in 2014.
- Compared to "Nesting Success %" before mitigation measures were installed in 2011-12, Hawaiian Petrel "Nesting Success %" increased by 75.4% after the DKIST HCP was fully implemented (2014-2016) in the Conservation Area.
- The annual number of petrel chicks successfully fledged from the Conservation Area increased by 69.4% after DKIST conservation measures implementation was completed.
- DKIST HCP increased the number of successful Hawaiian petrel fledglings between 2014 and 2016 by 50 after the mitigation measures were installed.

All of the above have demonstrated that thus far, DKIST construction activities seem to have no adverse impact on petrel reproductive performance in this area, and in 2014 to 2016 DKIST conservation measures were likely aiding petrels in high predator impact areas in the lower part of the Conservation Area.

Predation Mortality:

It appears that DKIST mitigation measures have helped reduce predation mortality by 90.5% within the Conservation Area and reduced the total predation mortality number by 4.5 eggs, 10 chicks and 4 adult petrels from 2014 to 2016.

Fledging Dates:

No obvious fledging date deviation could be detected in the last five years. An extended fledging period in 2014 was recorded; this might be due to higher nesting success observed in the Conservation Area.

Measuring Net Benefit:

Although the implementation of DKIST HCP/BO mitigation measures has demonstrated increased "Percent of Nesting Success", more successful fledglings and lowered predation rate (or less individuals being predated), both "Nesting Activity Percent" and "Percent Nesting Success " or the density of both indexes could be greatly affected by variables that occur outside of petrel breeding colonies, such that over the long term, conservation measures implemented in the DKIST Conservation Area can only reliably reduce predation, not eradicate it completely. Given that the ungulate fence is not predator—proof, ingress by predators will continue. Since sufficient burrow sites and breeding pairs already exist inside the Conservation Area, predation reduction may be DKIST's greatest benefit to the Hawaiian Petrel population sustainability thus far. Ultimately, using the density of predation incidents might be a more objective approach to measuring DKIST's Net Recovery Benefit.

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

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Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park Maui, Hawaiʻi

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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, 2014, 2015, 2016 and 2017.

This report presents the results of the Summer 2017 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 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 September 2017. The goal is to verify that the DKIST is in compliance with the conditions and mitigation measures described in the guiding environmental documents.

The 2017 Annual Inspection was conducted on September 7, 2017. 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 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 2017 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. DKIST construction is currently taking place in 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 September 2017, 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.

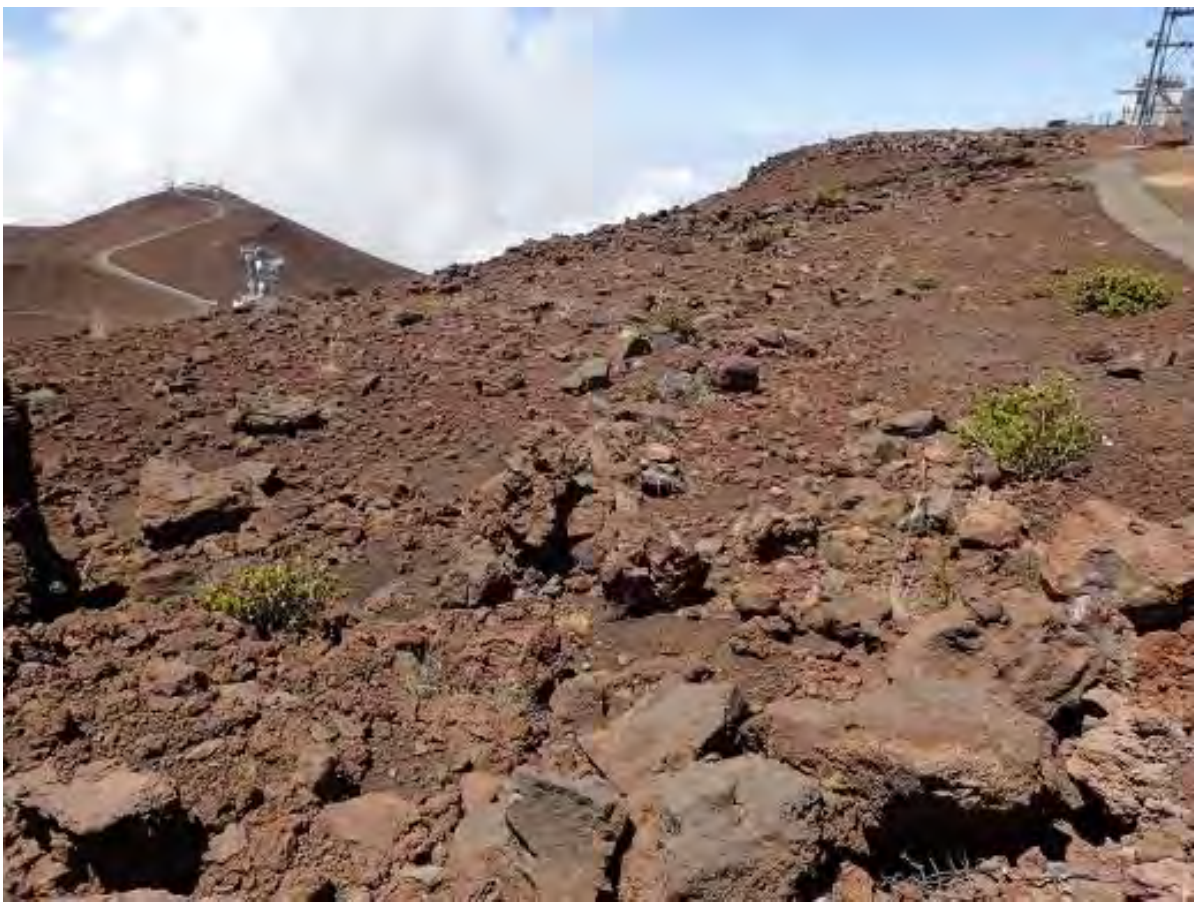
Sampling of arthropod habitats was approved in a permit obtained from the Department of Land and Natural Resources (Endorsement No. I1014), effective date February 1, 2017 – February 1, 2018, and the National Park Service (Permit # HALE-2015-SCI-0003) issued on April 16, 2015. Sampling began on September 2, 2017 and was completed on September 10, 2017.

Annual Inspection

An inspection is required to be conducted on an ongoing annual basis during the construction phase and 50 year lifespan of the DKIST. The inspection was conducted on September 7, 2017. 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 Hawaiʻi 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 Hawaiʻi Institute for Astronomy Management Plan, which describes mitigation measures to prevent introduction of introduced species.



Native Arthropod Habitat adjacent to the DKIST construction lay-down area. Photo taken September 7, 2017.

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 Haleakalā 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 Hawai'i 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 Hawai‘i 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 Hawai'i: Alien arthropods can be transported to Hawai'i 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 Hawai'i 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 Hawai'i 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 Hawai'i, 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 Haleakalā 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 September 2, 2017 and their contents collected on September 10, 2017.

Locations of pitfall traps (blue circles) and light traps (yellow circles) at the HALE Entrance Station.

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 seven nights at the DKIST site, HO site, and the HALE site. Light traps were set at each sampling site near sunset, and were allowed to run overnight or until batteries failed.

Locations of pitfall traps (blue circles) and light traps (yellow circles) at the HO and DKIST.

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.

Leaf litter and plant debris were placed in a plastic tub and searched for arthropods.

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 beaten 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 an index card, baited with tuna, honey, and peanut butter, 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 removed. Baited traps were not left open overnight in order to avoid attracting unwanted pests.

Fifty baited ant traps were deployed on September 3, 2017 at the HO/DKIST sites.

Fourteen baited traps were deployed at the HALE ES site on September 4, 2017.

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 a research library. 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 nine days and seven nights beginning on September 2, 2017 and ending on September 10, 2017.

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 Hawai'i 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 Hawai'i 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 September 7, 2017.

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. Seventy-six species of arthropods were detected at the HO site (excluding the Air Force Facility and the DKIST site). The species included seventeen endemic species, forty-five non-indigenous species, and fourteen species of unknown status.

Spiders and Mites - Arachnida

Seven species of spiders and mites were found at the HO. Two mites were uncommon in leaf litter. Juvenile and adult Lycosid spiders, *Hogna (Lycosa) hawaiiensis*, were common in pitfall traps and foraging among rocks. An unknown species of jumping spider (family Salticidae) was infrequent on rocks and cinder. Two other unknown species of spiders (families Linyphiidae and Theridiidae) were uncommon in HO sampling.

Beetles – Order Coleoptera

Sixteen beetle species were observed at the HO site, all non-indigenous. The most common beetles at the HO site were lady-bird beetles (family Coccinellidae), including the seven-spot ladybird beetle (*Coccinella septempunctata*), the large spotted ladybird beetle (*Harmonia conformis*), the convergent ladybird beetle (*Hippodemia convergens*), and seven other less common species.

The vedalia beetle *Rodolia cardinalis* is a biocontrol agent endemic to Australia. This small ladybird beetle feeds on small arthropods such as aphids and mites.

Three species of non-indigenous leaf beetles (family Chrysomelidae) and two species of rove beetles (family Staphylinidae) were infrequent, and one species of carabid beetle (*Trechus obtusus*) was uncommon.

Flies - Order Diptera

Twelve species of flies were detected at the HO site, only two that are native to Hawaiʻi. An endemic species of fruit fly (*Trupanea cratericola*) was uncommon on *Dubautia* and one specimen of *Trupanea limpidapex* was found at Reber Circle.

The nine non-indigenous species had been collected in previous monitoring samples. The status of five species of flies collected was unknown.

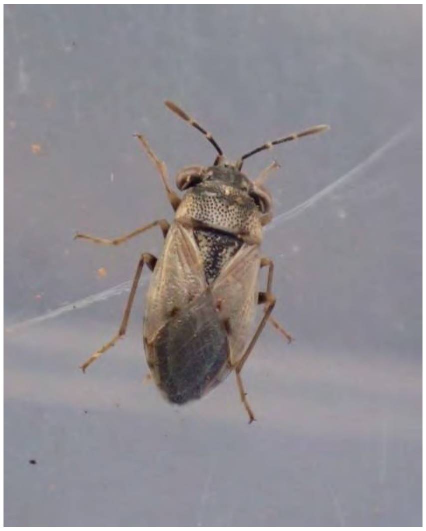
True Bugs – Orders Heteroptera and Homoptera

Thirteen species of true bugs (order Heteroptera) were observed including six Hawaiian endemic species.

Endemic seed bug species *Nysius coenosulus* (family Lygaeidae) was common on both *Dubautia* and *pukiawe*. Two other endemic seed bugs (Nysius palor and *Nysius rubescens*) were less common. Also at the HO was an uncommon non-indigenous seed bug, *Pachybrachius fracticollis*, an introduction from Europe, where it inhabits bogs, fens and wet heathland.

Species from the family Miridae included the Hawaiian endemic insects *Engytates hawaiiensis*, abundant on *Dubautia*, *Trigonotylus hawaiiensis*, found on grasses, and *Hyalopeplus pelucidus* Stål. A non-indigenous species of Miridae, the broken-backed bug (*Pachybrachius fracticollis*) was uncommon at the HO site.

Adults and nymphs of the non – indigenous seed bug *Geocoris pallens* were common on vegetation at the HO site. This species is a predator on small insects.



The Western bigeyed bug (*Geocoris pallens***) was common on vegetation in HO sampling.**

Six species of Homoptera were found at HO, including an endemic species of plant hopper of the genus *Nesosydne*, abundant on *Dubautia*. The non-indigenous Acacia psyllid, *Acizzia uncatoides* was common. Also common was an unidentified plant hopper (family Cicadellidae.

Bees and Wasps – Order Hymenoptera

Twelve species of bees and wasps were found at the HO site, two endemic to Hawaiʻi. One endemic species of yellow-faced bees (genus *Hylaeus*) was common on *Dubautia* and *pukiawe*. Only female yellow-faced bees were collected, and because species level determination is based on male characters, identification to species was not possible.

Two specimens of a small endemic parasitoid, *Sierola sp*., were found. *Sierola* is a genus that represents a very large radiation of native parasitic wasps. The genus has been little studied, especially on Maui, where relatively few species have been described. The taxonomy of this genus is currently being revised.

Non-indigenous species found at the HO include four species of Ichneumonidae, two very small parasitoids and infrequent specimens of yellow-jackets.

Butterflies and Moths – Order Lepidoptera

Five species of Lepidoptera were found at the HO site, all endemic to Hawaiʻi. These include three endemic species in the genus *Agrotis*, the common *Agrotis epicremna*, the uncommon *A. baliopa*, and the infrequent *A. mesotaxa*.

The Haleakalā flightless moth (*Thyrocopa apatela*), uncommon at the HO site, was also observed.

Other Lepidoptera included the infrequent endemic Hawaiian Blue (*Udara blackburni*).

Other Species

Two species of brown lacewings (family Hemerobiidae) were found at the HO.

Other invertebrates found at the HO site include an unknown centipede, the common woodlouse, *Porcellio scaber*, and the garlic snail (*Oxychilus alliarius*).

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. Conditions had been dry at the summit, and leaf litter was noticeably less moist than in previous sampling years, which seemed to correspond to lower abundance of arthropods in the soil.

DKIST CONSTRUCTION SITE

Construction was started on the DKIST in December 2012 and was ongoing during the Summer 2017 sampling session. Excavation was completed in 2014 and with one exception, earth-moving equipment has been removed from the site.

Sixty-two species of arthropods were collected at the DKIST site during the Summer 2017 sampling session. The species included sixteen endemic Hawaiian arthropods, thirty-four non-indigenous arthropods, and twelve species of unknown status.

Spiders and Mites - Arachnida

Five species of spiders and mites were found at the DKIST site. Two unknown mites were uncommon. Juvenile and adult Lycosid spiders, *Hogna hawaiiensis* Simon, were common in pitfall traps at the DKIST site, and were seen actively foraging among rocks. A small Linyphiidae spider and another spider (family Theridiidae) were uncommon.

Beetles – Order Coleoptera

Nine species of beetles were observed at the DKIST site, all non-indigenous. The species included five ladybird beetles, two leaf beetle (family Chrysomelidae), a non-indigenous Carabid beetle, and a single specimen of the eucalyptus snout beetle (*Gonipterus scutellatus*).

The convergent ladybird beetle (*Hippodemia convergens*) was common on vegetation in HO sampling.

Flies - Order Diptera

Ten species of flies were detected at the DKIST site. Only one endemic species of fly (family Tephritidae) was observed. *Trupanea cratericola* was uncommon on pukiawe and *Dubautia.* All other species were non-indigenous in Hawai'i.

The non-indigenous species include common species such as the blue bottle fly, *Calliphora latifrons* and small flies of the family Sciaridae, and uncommon species such as the three hover flies (family Syrphidae), *Allograpta exotica*, *Eristalis tenax* and *Toxomerus marginatus*.

True Bugs – Orders Heteroptera and Homoptera

Thirteen species of true bugs (Order Heteroptera) were observed at the

DKIST site. These include seven Hawaiian endemic species.

Three species of the Hawaiian endemic seed bug genus *Nysius* were found at the DKIST site. *Nysius coenosulus* was common on *Dubautia* and *pukiawe*. Two other endemic species (*N. lichenicola* and *N. palor*) were infrequent in litter and on vegetation.

The common Hawaiian endemic species *Engytates hawaiiensis* (family Miridae) was observed feeding on *Dubautia* and *Trigonotylus hawaiiensis* was found on grasses. *Hyalopeplus pelucidus* is known from all major Hawaiian Islands and ranges from the seashore to several thousand feet.

***Trigonotylus hawaiiensis* was found on grasses at the DKIST site.**

The non-indigenous species *Geocoris pallens*, was common throughout the site.

The assassin bug, *Zelus renardii*, was infrequent at the site.

The assassin bug, *Zelus renardii.*

Six 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.

Bees and Wasps – Order Hymenoptera

Eight species of bees and wasps were observed at the DKIST site. These species include a species of endemic yellow-faced bees, a small parasitoid, *Sierola sp.*, and an endemic wasp, *Odynerus nubicola*.

A small endemic parasitoid, *Sierola sp.* was present at the DKIST site.

Other Hymenoptera observed include small non-indigenous parasitic wasps.

Moths – Order Lepidoptera

Four species of Lepidoptera were collected, three endemic species and one non-indigenous species. Three large moths in the genus *Agrotis* were captured in light traps. *Agrotis epicremna* were quite abundant at both HO and DKIST, and were seen actively flying during the daytime, as well as abundant in the light traps. On one night, 62 A. epicremna (and nothing else) were collected in the DKIST light trap.

The endemic *Agrotis epicremna* was very abundant.

Haleakalā flightless moths (*Thyrocopa apatela*) caterpillars were observed in leaf litter beneath vegetation.

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.

HALEAKALĀ ENTRANCE STATION

Sampling in HALE occurred near the Entrance Station (HALE ES) at 6,250 feet elevation. Seventy-six species of arthropods were collected and observed there. The species included twenty-two endemic Hawaiian arthropods, forty-one non-indigenous arthropods, and thirteen species of unknown status.

Spiders and Mites - Arachnida

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

Two jumping spiders (family Salticidae) were observed at the HALE ES. *Phidippus audax* was commonly encountered at HALE-ES, primarily as juveniles.

Phidippus audax encountered at HALE-ES.

A non-indigenous hunting spider (*Cheiracanthium mordax* L. Koch) was common 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.

Beetles – Order Coleoptera

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

Non-indigenous beetles include two species of ladybird beetles and a leaf beetle (family Chrysomelidae) was observed feeding on Eucalyptus trees near the entrance station. *Paropsistrna m-fuscum* is an important pest species on Blue Gum trees.

Other non-indigenous species found were *Gonipterus scutellatus*, the gum tree weevil, native to Australia, and occuring around the World where Eucalyptus trees grow. This insect is a specialist on Eucalyptus, and it is likely that it was experiencing an outbreak on Eucalyptus at Hosmer Grove or at lower elevations. It has wings and could disperse from other locations. One individual was collected at DKIST on Dubautia, and is the first time it has been detected at the summit.

The eucalyptus snout beetle (*Gonipterus scutellatus*) on *Dubautia.*

Two other non-indigenous weevils were also observed. *Otiorhynchus cribricollis* Gyllenhal hide in cracks in the soil during the day feed on foliage at night. The Fuller rose beetle, *Pantomorus cervinus* is a leaf-eating weevil, usually feeding on leaf margins giving leaves a ragged, saw-toothed appearance.

Flies – Order Diptera

Nine species of flies were seen at the HALE ES. Seven species were from families of common non-indigenous flies (e.g.: blow flies, and bee flies) previously reported from HALE ES. Two species were of unknown status.

True Bugs – Orders Heteroptera and Homoptera

Nine species of true bugs (Heteroptera) were found, five endemic to Hawai'i. Four endemic species from the family Miridae were collected. Three common plant bugs *Orthotylus coprosmophila*, on *Coprosma*, *O. sophoriodes*, on *manane*, and *Sarona sp.* were found. A fourth endemic, *Hyalopeplus pelucidus*, was uncommon, usually found only at higher elevations.

The non-indigenous *Geocoris pallens* was uncommon at the HALE ES, but was very abundant at the summit.

Six species of Homoptera were observed. Two Hawaiian endemic species of the genus *Nesosydne* (family Delphacidae), were abundant on vegetation. A third endemic species from the genus *Nesophrosyne* (family Cicadellidae), was infrequent. Non-indigenous aphids were also common on vegetation.

Bees and Wasps – Order Hymenoptera

The ten species of Hymenoptera found near the HALE Entrance Station included three infrequent endemic species, a hunting wasp (family

Bethylidae), a yellow-faced bee (genus *Hylaeus*), and a parasite, *Enicospilus sp.*

A female endemic *Hylaeus* bee collected at the HALE ES.

Three ants were found, *Hypoponera opaciceps*, *Linepithema humile,* and *Cardiocondyla kagutsuchi/venestula.* All have been collected during previous sampling sessions. Two non-indigenous parasites were present as well as honey bees.

Butterflies and Moths – Order Lepidoptera

Twelve species of Lepidoptera were observed at the HALE ES, nine endemic to Hawaiʻi. The only common endemic was a fruit worm moth *Carposina sp.* Other endemics such as the mamane moth (*Uresiphita polygonalis virescens*) species of *Eudonia* and *Orthomecyna*, both from the family Crambidae, and larger species of Noctuid moths were uncommon or infrequent.

The non-indigenous species were a large noctuid moth, *Pseudaletia unipunctata*, and the common lantana biocontrol, *Stenoptilodes littoralis rhynchophora*.

Other Observations

A new species to the HALE ES site was the brown lace wing *Sympherobius californicus*. This species was also found at the HO and DKIST sites and was reared from cocoons. 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. 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.

There are three 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 invasive non-indigenous arthropod species detected at the HO and DKIST sites that are potentially harmful to Hawaiian native arthropods. No new invasive arthropod species were discovered at the HALE ES site.

There were three species that have not been previously collected at the HO site. They are a brown lacewing, *Sympherobius californicus,* and two parasitoids (family Ichneumonidae), *Pimpla punicipes* and *Calliephialtes grapholithae*. The brown lacewing is a purposely introduced biological control species, and the two parasitoids are adventive species. All are known from other Hawaiian Islands.

There were three species collected at the DKIST not previously recorded from that site. They are a brown lacewing, *Sympherobius californicus* (discussed above), a small leaf beetle, *Epitrix hirtipennis*, and a parasitoid, *Calliephialtes grapholithae* (discussed above). The leaf beetle occurs on all major Hawaiian Islands. Adults damage plants by chewing small rounded holes through the leaves resulting in a "shot hole" appearance. Larvae feed on roots of host plants and may tunnel into plants.

There were five species observed at the HALE Entrance Station that have not previously been found during Programmatic Monitoring. They are the brown lacewing *Sympherobius californicus* and parasitoid *Calliephialtes grapholithae* (discussed above), as well as a spider, *Neoscona theisi,* a ladybird beetle, *Diomus sp.*, and a bottle fly, *Pollenia rudis*. The spider typically builds a small orb web between branches of shrubs. While this spider is known to occur in Hawaiʻi, its distribution in Hawaiʻi is unknown. The ladybird beetle and bottle fly are likely an adventive species and are known from other Hawaiian Islands.

Annual Inspection

One day was allocated to the Annual Inspection during the Summer Programmatic Monitoring session. The inspection took place on September 7, 2017. During the inspection, the interiors of DKIST structures were examined for evidence of non-indigenous invasive species. No new invasive arthropod species that could potentially harm Hawaiian native arthropods 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 Safety Officer’s Trailer
Subcontractor Office 1
Subcontractor Office 2
Reber Circle Storage Containers
Material Storage and Lay-Down Areas

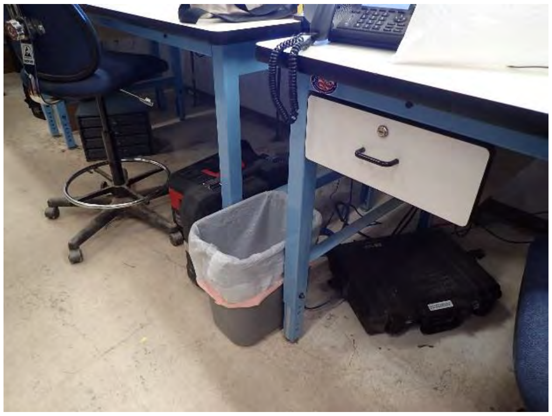
Observatory Buildings

The Observatory, attached support building, and Utility Building were inspected and found to be free of invasive, non-indigenous arthropods. Trash cans used for food waste were lined containers and had proper fitting lids. Trash cans are emptied at least once a week as needed.

The Observatory, attached support building, and Utility Building were free of non-indigenous arthropods.

Rooms inside the Observatory were neat and kept clean. They are swept at least once a day as needed.

Corners and other likely places where non-indigenous arthropods may reside was carefully inspected. There was no evidence of invasive, non-indigenous arthropods.



Trash containers in the Observatory for discarded food were lined and had properly fitting lids. Plastic bags line smaller trash cans where food may be consumed and are removed daily.

The exterior of the Observatory was neat, with no trash or wind-blown debris.

The Utility building was inspected and found to have no signs of invasive, non-indigenous arthropods.

Office Trailers

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

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

Safety Officer's Office was organized, had a lined and covered trash can that is emptied as needed. There was no evidence of any invasive arthropods.

Subcontractor Offices (1 and 2) were clean and no evidence of invasive arthropods were found.

Storage Containers

There were storage containers on the DKIST construction site, at Reber Circle and in the lower lay-down area. All were locked and not available for interior inspection.

Storage containers at the lower lay-down area were locked and not available for inspection.

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 that could potentially harm Hawaiian native 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. Only some minor material wrapping was loose and capable of being wind-blown.

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

Earth-moving Equipment

There was only one piece of earth-moving equipment left at the site. It has been at the site since the beginning of construction. It is clean and has no visible signs of invasive, non-indigenous arthropods.

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.

Temporary trash container adjacent to the Observatory building. The container is used for temporary daily waste storage and is dumped into the larger drop-off containers daily.

Sanitary Control

Food waste is disposed of in special lined trash cans with tight fitting lids. No outdoor food waste containers were found.

ANNUAL INSPECTION DISCUSSION

The DKIST site is kept clean and neat.

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 within the HO and DKIST sites that could potentially harm Hawaiian native species.

There are three 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 invasive, 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 invasive, non-indigenous arthropods found within the DKIST construction site, lay-down and staging areas 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?

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. Trash receptacles for food waste have attached lids and 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.

Trash containers inside the Observatory and Utility buildings used for food waste were clean and lined with plastic bags. 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. There were a few small pieces of wind-blown trash in the habitat surrounding the site. Some tarps were loose and held down with pieces of lumber.

As required by the HO Management Plan, large trucks, tractors, and other heavy equipment and construction materials were inspected before entering the Park. Inspections were conducted by HALE personnel in coordination with the DKIST Construction Administrator. A log of the inspections are maintained by HALE and was not reviewed for this inspection. A log of DKIST inspection requests is maintained by the DKIST Construction Administrator at DKIST offices in Pukalani.

The Construction Site Manager and his crew do an excellent job ensuring that the mitigation measures are implemented, that the construction site is a safe place to work, and DKIST construction 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 2017 sampling at the HO site.

Class	Order	Family	Genus	Species	Authority	Status
Arachnida	Acari		SP1			unknown
Arachnida	Acari		SP2			unknown
Arachnida	Araneae	Linyphiidae				unknown
Arachnida	Araneae	Lycosidae	Hogna	hawaiiensis	Simon	endemic
Arachnida	Araneae	Salticidae				unknown
Arachnida	Araneae	Theridiidae				unknown
CHILOPODA	Lithobiomorpha					unknown
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous
Gastropoda	Stylommatophora	Zonitidae	Oxychilus	alliarius	(J.S. Miller)	non-indigenous
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Insecta	Coleoptera	Chrysomelidae	Altica	carinata	(Germar)	non-indigenous
Insecta	Coleoptera	Chrysomelidae	Diachus	auratus	(Fabricius)	non-indigenous
Insecta	Coleoptera	Chrysomelidae	Paropsisterna	m-fuscum		non-indigenous
Insecta	Coleoptera	Coccinellidae	Coccinella	californica	(Mannerheim)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous
Insecta	Coleoptera	Coccinellidae	Diomus	notescens	(Blackburn)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Harmonia	conformis	(Boisduval)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Hippodemia	convergens	Gurein-Meneville	non-indigenous
Insecta	Coleoptera	Coccinellidae	Hyperaspis	pantherina or sylvestrii		non-indigenous
Insecta	Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Rhyzobius	forestieri	(Mulsant)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Rodolia	cardinalis	(Mulsant)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Scymnus	loewii	Mulsant	non-indigenous
Insecta	Coleoptera	Staphylinidae	Philonthus	sp.		non-indigenous
Insecta	Coleoptera	Staphylinidae				unknown
Insecta	Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Insecta	Diptera	Chamaemyiidae	Leucopis	albipuncta	Zetterstedt	non-indigenous
Insecta	Diptera	Drosophilidae	Drosophila	melanogaster	Meigen	non-indigenous
Insecta	Diptera	Sciaridae				unknown

Class	Order	Family	Genus	Species	Authority	Status
Insecta	Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous
Insecta	Diptera	Syrphidae	Eristalis	tenax	(Linneaus)	non-indigenous
Insecta	Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous
Insecta	Diptera	Tachinidae	Chaetogaedia	monticola	(Bigot)	non-indigenous
Insecta	Diptera	Tephritidae	Trupanea	cratericola	(Grimshaw)	endemic
Insecta	Diptera	Tephritidae	Trupanea	limpidapex	(Grimshaw)	endemic
Insecta	Heteroptera	Anthocoridae				unknown
Insecta	Heteroptera	Geocoridae	Geocoris	pallens	Stål	non-indigenous
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	palor	Ashlock	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	rubescens	White	endemic
Insecta	Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous
Insecta	Heteroptera	Miridae	Engytatus	hawaiiensis	(Kirkaldy)	endemic
Insecta	Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic
Insecta	Heteroptera	Miridae	Taylorilygus	apicalis	(Fieber)	non-indigenous
Insecta	Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic
Insecta	Heteroptera	Nabidae	Nabis	capsiformis	Germar	non-indigenous
Insecta	Heteroptera	Reduviidae	Zelus	renardii	Kolenati	non-indigenous
Insecta	Heteroptera	Rhyparochromidae	Brentiscerus	putoni (= australis)	(White)	non-indigenous
Insecta	Homoptera	Aphididae	SP1			non-indigenous
Insecta	Homoptera	Cercopidae	Clastoptera	xanthocephala	Germar	non-indigenous
Insecta	Homoptera	Cicadellidae	SP1			unknown
Insecta	Homoptera	Delphacidae	Nesosydne	sp.		endemic
Insecta	Homoptera	Pseudococcidae	SP 1			unknown
Insecta	Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous
Insecta	Hymenoptera	Bethylidae	Sierola	spp.		endemic
Insecta	Hymenoptera	Braconidae	Meteorus	laphygmae	Viereck	non-indigenous
Insecta	Hymenoptera	Chalcidae	Brachymeria	obscurata	(Walker)	non-indigenous
Insecta	Hymenoptera	Colletidae	Hylaeus	sp.		endemic
Insecta	Hymenoptera	Eulophidae				unknown
Insecta	Hymenoptera	Ichneumonidae	Barichneumon	californicus	(Ashmead)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Calliephialtes	grapholithae	(Cresson)	non-indigenous

Class	Order	Family	Genus	Species	Authority	Status
Insecta	Hymenoptera	Ichneumonidae	Gelis	tenellus	(Say)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Pimpla	punicipes	Cresson	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Spilichneumon	superbus	(Provancher)	non-indigenous
Insecta	Hymenoptera	Vespidae	Vespula	pensylvanica	(Saussure)	non-indigenous
Insecta	Lepidoptera	Lycaenidae	Udara	blackburni	(Tuely)	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	giffardi (or mesotoxa)		endemic
Insecta	Lepidoptera	Xyloryctidae	Thyrocopa	apatela	(Walsingham)	endemic
Insecta	Neuroptera	Hemerobiidae	SP1			unknown
Insecta	Neuroptera	Hemerobiidae	Sympherobius	californicus	Banks	non-indigenous
Insecta	Psocoptera					unknown

APPENDIX B
DKIST ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Summer 2017 sampling at the DKIST site.

Class	Order	Family	Genus	Species	Authority	Status
Arachnida	Acari		SP1			unknown
Arachnida	Acari		SP2			unknown
Arachnida	Araneae	Linyphiidae				unknown
Arachnida	Araneae	Lycosidae	Hogna	hawaiiensis	Simon	endemic
Arachnida	Araneae	Theridiidae				unknown
CHILOPODA	Lithobiomorpha					unknown
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous
Gastropoda	Stylommatophora	Zonitidae	Oxychilus	alliarius	(J.S. Miller)	non-indigenous
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Insecta	Coleoptera	Chrysomelidae	Altica	carinata	(Germar)	non-indigenous
Insecta	Coleoptera	Chrysomelidae	Epitrix	hirtipennis	(Melsheimer)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Coccinella	californica	(Mannerheim)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous
Insecta	Coleoptera	Coccinellidae	Harmonia	conformis	(Boisduval)	non-indigenous
Insecta	Coleoptera	Coccinellidae	Hippodemia	convergens	Gurein-Meneville	non-indigenous
Insecta	Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous
Insecta	Coleoptera	Curculionidae	Gonipterus	scutellatus		non-indigenous
Insecta	Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Insecta	Diptera	Chamaemyiidae	Leucopis	albipuncta	Zetterstedt	non-indigenous
Insecta	Diptera	Dolichopodidae	Chrysosoma	globiferum	(Wiedemann)	non-indigenous
Insecta	Diptera	Drosophilidae	Drosophila	melanogaster	Meigen	non-indigenous
Insecta	Diptera	Sciaridae				unknown
Insecta	Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous
Insecta	Diptera	Syrphidae	Eristalis	tenax	(Linneaus)	non-indigenous
Insecta	Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous
Insecta	Diptera	Tephritidae	Trupanea	cratericola	(Grimshaw)	endemic
Insecta	Heteroptera	Anthocoridae				unknown
Insecta	Heteroptera	Geocoridae	Geocoris	pallens	Stål	non-indigenous
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic

Class	Order	Family	Genus	Species	Authority	Status
Insecta	Heteroptera	Lygaeidae	Nysius	lichenicola	Kirkaldy	endemic
Insecta	Heteroptera	Lygaeidae	Nysius	palor	Ashlock	endemic
Insecta	Heteroptera	Miridae	Coridromius	variegatus	(Montrouzier)	non-indigenous
Insecta	Heteroptera	Miridae	Engytatus	hawaiiensis	(Kirkaldy)	endemic
Insecta	Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic
Insecta	Heteroptera	Miridae	Koanoa?			endemic?
Insecta	Heteroptera	Miridae	Taylorilygus	apicalis	(Fieber)	non-indigenous
Insecta	Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic
Insecta	Heteroptera	Pentatomidae	Nezara	viridula	Linnaeus	non-indigenous
Insecta	Heteroptera	Reduviidae	Zelus	renardii	Kolenati	non-indigenous
Insecta	Homoptera	Aphididae	SP1			non-indigenous
Insecta	Homoptera	Cercopidae	Clastoptera	xanthocephala	Germar	non-indigenous
Insecta	Homoptera	Cicadellidae	SP1			unknown
Insecta	Homoptera	Delphacidae	Nesosydne	sp.		endemic
Insecta	Homoptera	Pseudococcidae	SP 1			unknown
Insecta	Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous
Insecta	Hymenoptera	Bethylidae	Sierola	spp.		endemic
Insecta	Hymenoptera	Colletidae	Hylaeus	sp.		endemic
Insecta	Hymenoptera	Eulophidae				unknown
Insecta	Hymenoptera	Ichneumonidae	Barichneumon	californicus	(Ashmead)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Calliephialtes	grapholithae	(Cresson)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Gelis	tenellus	(Say)	non-indigenous
Insecta	Hymenoptera	Vespidae	Odynerus	nubicola	Perkins	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Pseudaletia	unipunctata	(Haworth)	non-indigenous
Insecta	Lepidoptera	Xyloryctidae	Thyrocopa	apatela	(Walsingham)	endemic
Insecta	Neuroptera	Hemerobiidae	SP1			unknown
Insecta	Neuroptera	Hemerobiidae	Sympherobius	californicus	Banks	non-indigenous
Insecta	Psocoptera					unknown

APPENDIX C
HALE ES ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Summer 2017 sampling at the HALE Entrance Station.

Class	Order	Family	Genus	Species	Authority	Status
Arachnida	Acari		SP1			unknown
Arachnida	Acari		SP2			unknown
Arachnida	Araneae	Araneidae	Neoscona	theisi	(Walckenaer)	non-indigenous
Arachnida	Araneae	Clubionidae	Cheiracanthium	mordax	L. Koch	non-indigenous
Arachnida	Araneae	Linyphiidae				unknown
Arachnida	Araneae	Salticidae	Phidippus	audax	(Hentz)	non-indigenous
Arachnida	Araneae	Salticidae				unknown
Arachnida	Araneae	Theridiidae	Steatoda	grossa	(C. L. Koch)	non-indigenous
Arachnida	Araneae	Theridiidae				unknown
Arachnida	Araneae	Thomisidae	Mecaphesa	sp. nr. kanakanus	(Karsch)	endemic
CHILOPODA	Lithobiomorpha					unknown
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous
DIPLOPODA	Julida	Cylindroiulus	latistriatus		(Curtis)	non-indigenous
Gastropoda	"Slugs"					non-indigenous
Gastropoda	Stylommatophora	Zonitidae	Oxychilus	alliarius	(J.S. Miller)	non-indigenous
Insecta	Coleoptera	Carabidae	Mecyclothorax	spp.		endemic
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous
Insecta	Coleoptera	Chrysomelidae	Paropsisterna	m-fuscum		non-indigenous
Insecta	Coleoptera	Coccinellidae	Diomus	sp.		non-indigenous
Insecta	Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous
Insecta	Coleoptera	Curculionidae	Gonipterus	scutellatus		non-indigenous
Insecta	Coleoptera	Curculionidae	Otiorhynchus	cribricollis	Gyllenhal	non-indigenous
Insecta	Coleoptera	Curculionidae	Pantomorus	cervinus	(Boheman)	non-indigenous
Insecta	Coleoptera	Staphylinidae				unknown
Insecta	Dermaptera	Forficulidae	Forficula	auricularia	Linnaeus	non-indigenous
Insecta	Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous
Insecta	Diptera	Calliphoridae	Pollenia	rudis	(Fabricius)	non-indigenous
Insecta	Diptera	Chamaemyiidae	Leucopis	albipuncta	Zetterstedt	non-indigenous

Class	Order	Family	Genus	Species	Authority	Status
Insecta	Diptera	Sciaridae				unknown
Insecta	Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous
Insecta	Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous
Insecta	Diptera	Tipulidae	SP1			unknown
Insecta	Heteroptera	Geocoridae	Geocoris	pallens	Stål	non-indigenous
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic
Insecta	Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous
Insecta	Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic
Insecta	Heteroptera	Miridae	Orthotylus	coprosmaphila	Polhemus	endemic
Insecta	Heteroptera	Miridae	Orthotylus	sophoriodes	Polhemus	endemic
Insecta	Heteroptera	Miridae	Sarona	sp.		endemic
Insecta	Heteroptera	Nabidae	Nabis	capsiformis	Germar	non-indigenous
Insecta	Heteroptera	Rhyparochromidae	Brentiscerus	putoni (= australis)	(White)	non-indigenous
Insecta	Homoptera	Aphididae	SP1			non-indigenous
Insecta	Homoptera	Cicadellidae	Nesophrosyne	sp. 1		endemic
Insecta	Homoptera	Delphacidae	Nesosydne	sp.		endemic
Insecta	Homoptera	Delphacidae	Nesosydne	sp. 2		endemic
Insecta	Homoptera	Pseudococcidae	SP 1			unknown
Insecta	Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous
Insecta	Hymenoptera	Bethylidae	Sierola	spp.		endemic
Insecta	Hymenoptera	Colletidae	Hylaeus	sp.		endemic
Insecta	Hymenoptera	Eulophidae				unknown
Insecta	Hymenoptera	Formicidae	Cardiocondyla	kagutsuchi/venestula		non-indigenous
Insecta	Hymenoptera	Formicidae	Hypoponera	opaciceps	(Mayr)	non-indigenous
Insecta	Hymenoptera	Formicidae	Linepithema	humile	(Mayr)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Calliephialtes	grapholithae	(Cresson)	non-indigenous
Insecta	Hymenoptera	Ichneumonidae	Enicospilus			endemic
Insecta	Hymenoptera	Ichneumonidae	Gelis	tenellus	(Say)	non-indigenous
Insecta	Lepidoptera	Carposinidae	Carposina	sp. A		endemic
Insecta	Lepidoptera	Crambidae	Eudonia	spp.		endemic
Insecta	Lepidoptera	Crambidae	Nomophila	noctuella	(Denis & Schiffermüller)	non-indigenous
Insecta	Lepidoptera	Crambidae	Udea	heterodoxa	(Meyrick)	endemic

Class	Order	Family	Genus	Species	Authority	Status
Insecta	Lepidoptera	Crambidae	Udea	pyranthes	(Meyrick)	endemic
Insecta	Lepidoptera	Crambidae	Uresiphita	polygonalis	(Butler)	endemic
Insecta	Lepidoptera	Geometridae	Eupithecia	monticolans	Butler	endemic
Insecta	Lepidoptera	Geometridae	Scotorythra	sp.		endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Agrotis	xiphias	Meyrick	endemic
Insecta	Lepidoptera	Noctuidae	Pseudaletia	unipunctata	(Haworth)	non-indigenous
Insecta	Lepidoptera	Pterophoridae	Stenoptilodes	littoralis	(Meyrick)	non-indigenous
Insecta	Neuroptera	Hemerobiidae	SP1			unknown
Insecta	Neuroptera	Hemerobiidae	Sympherobius	californicus	Banks	non-indigenous
Insecta	Odonata	Aeshnidae	Anax	junius	(Drury)	non-indigenous
Insecta	Orthoptera	Gryllidae	Trigonidomorpha	sjostedti	Chopard	non-indigenous
Insecta	Psocoptera					unknown

Programmatic Arthropod Monitoring at the Haleakalā High Altitude Observatories and Haleakalā National Park Maui, Hawaiʻi

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

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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 shrub land vegetation type and resources along the Park road corridor are grouped into alpine and subalpine shrub land 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, 2014, 2015, 2016, and 2017.

This report presents the results of the Winter 2017 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 year that inspection will occur in September.

Programmatic arthropod monitoring was conducted April 8 - 16, 2017. The pitfall traps (10 per site) were installed Saturday April 8, 2017 and picked up Sunday April 16, 2017. Light traps were set the nights of April 8 – 14, 2017 with the exception of April 13 due to rainy weather (a total of 6 trap nights at each site). Baiting for ants was done at all three sites on April 9, 2017 (50 cards at HO/DKIST, 14 cards at HALE-ES). Weather was good at the beginning and end of the monitoring period, but there were several days of cold, wet weather from Tuesday April 10 to Friday April 13, 2017, and this made it difficult to sample vegetation or flying insects, so sampling focused on leaf and detritus litter sampling during those days.

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 Winter 2017 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 shrub land 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 shrub land habitat zones, depending upon the elevation. These habitats contain several native and non-native species of plants, animals, and arthropods. The subalpine shrub land 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 (Krushelnycky 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 Status

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 April 2017, 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 (Endorsement Number: I1014), effective date February 1, 2017 – February 1, 2018, and the National Park Service (Permit # HALE-2010-SCI-0001) issued on March 22, 2010. Sampling began on April 8, 2017 and was completed on April 16, 2017.

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 Haleakalā 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.

Monitoring Procedures

The selection of a trapping technique used in this 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 (Krushelnycky et al. 2007) 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. 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.

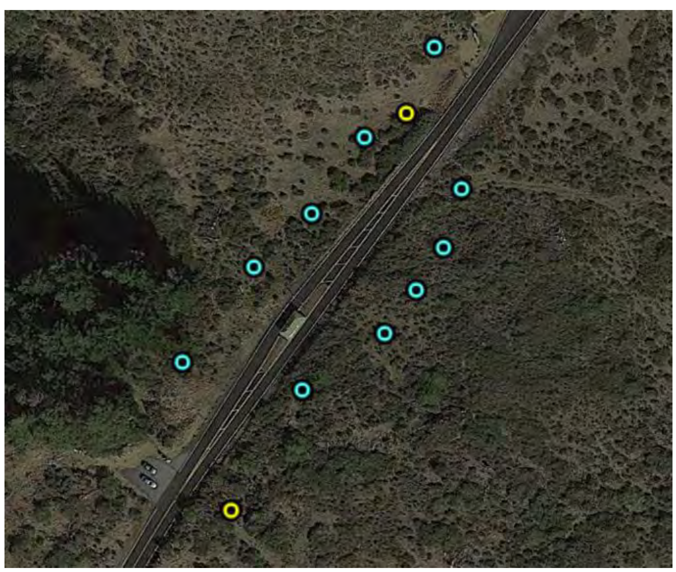
All pitfall traps were installed on April 8, 2017 and their contents collected on April 16, 2017.

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. Light traps were set at each sampling site near sunset, and were allowed to run overnight or until batteries failed. An additional night of sampling was suspended due to weather conditions.

Locations of pitfall traps (blue dots) and light traps (yellow dots) at the HO and DKIST Winter 2017.



Locations of pitfall traps (blue dots) and light traps (yellow dots) at the HALE Entrance Station Winter 2017.

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 beaten 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 open overnight in order to avoid attracting unwanted pests.

On April 9, 2017, fifty baited ant traps were deployed at the HO/DKIST sites and fourteen baited traps were deployed at the HALE ES site.

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), population estimates 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).

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. Specimens were deposited at the UH Manoa Arthropod Collection.

Schedule/Start and End Dates

Sampling was conducted over eight days and seven nights beginning on April 8, 2017 and ending on April 16, 2017.

VI. RESULTS and DISCUSSION

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. Sixty-nine species of arthropods were detected at the HO site (excluding the Air Force Facility and the DKIST site). The species included seventeen endemic species, thirty-nine non-indigenous species, and thirteen species of unknown status.

Spiders and Mites - Arachnida

Juvenile and adult Lycosid spiders, *Hogna (Lycosa) hawaiiensis* Simon, were common. Small spiders of the family Linyphiidae were uncommon and may represent more than one species. A single specimen from the spider family Theridiidae was observed. This family includes the ‘Happy-faced spider’ in Hawai‘i.

Springtails - Collembola

At least one species of Collembola was observed at the HO site. From the family Entomobryidae, these small insects were uncommon in leaf litter under plants.

Beetles – Order Coleoptera

Thirteen beetle species were observed at the HO site, eleven are non-indigenous.

Coccinella septempunctata **was abundant on vegetation at the HO site.**

Lady-bird beetles (family Coccinellidae) were the most common beetles at the HO site, represented by nine species. All are non-indigenous species and most are predacious on insects and mites.

Trechus obtusus Erichson, an introduced ground beetle, was uncommon, found under rocks and in pitfall traps. A similar-looking Hawaiian endemic species of *Mecyclothorax* was found infrequently at the HO site.

Two other uncommon non-indigenous beetles were found. These species have been collected at the HO site in past studies.

Flies - Order Diptera

Twelve species of flies were detected at the HO site, none that are known to be native to Hawai'i. These species have been collected in previous sampling efforts. No native fruit flies (genus *Trupanea*) were observed and may have been absent due to seasonal changes in abundance.

True Bugs – Orders Heteroptera and Homoptera

Thirteen species of true bugs (order Heteroptera) were observed including five Hawaiian endemic species. The most abundant true bug at the HO site is *Nysius coenosulus* Stål, an endemic seed bug, which was common on both *Dubautia* and *pukiawe*.

***Pachybrachius nr. fracticollis*, a ground seed bug, is well camouflaged in leaf-litter.**

Species from the family Miridae included the Hawaiian endemic insects *Engytates hawaiiensis* (Kirkaldy) and *Hyalopeplus pelucidus* Stål.

Geocoris pallens Stål were uncommon on vegetation at the HO site. The assassin bug, *Zelus renardii* was an infrequent capture. This bug preys on the bean capsid and has successfully reduced insect damage to crops in Hawai'i.

Six species of Homoptera were found, including an endemic species of plant hopper of the genus *Nesosydne*, abundant on *Dubautia*. Non-indigenous Acacia psyllids, *Acizzia uncatoides* (Ferris & Klyver) were abundant on vegetation at the HO site. An unknown green leafhopper was common also on vegetation.

Bees and Wasps – Order Hymenoptera

Five species of wasps were found at the HO site. Three small parasitic wasps were common around vegetation. Two other small wasps were infrequently observed.

Butterflies and Moths – Order Lepidoptera

Twelve species of Lepidoptera were found at the HO site. These include two endemic species in the genus *Agrotis* and three species of endemic grass moths (family Crambidae). One other endemic moth was observed, Thyrocopa apatela

(Walsingham), the Haleakalā flightless moth. Larvae were found in leaf-litter and adults appeared in pitfall traps. The non-indigenous cabbage looper, *Pieris rapae* (Linnaeus), was common 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 storage and staging site near the FAA facility was clear of wind-blown debris.

DKIST CONSTRUCTION SITE

Construction was started on the DKIST in December 2012 and was ongoing during the Winter 2017 sampling session.

Fifty-eight species of arthropods were collected at the DKIST site during the Winter 2017 sampling session. The species included nineteen endemic Hawaiian arthropods, thirty-one non-indigenous arthropods, and eight species of unknown status.

Spiders and Mites - Arachnida

Lycosid spiders, *Hogna hawaiiensis* Simon, were common. A small Linyphiidae spider was uncommon under rocks.

Endemic Lycosid spiders, *Hogna hawaiiensis*, are common at the DKIST site.

Springtails - Collembola

One species of Collembola was observed at the DKIST site. These small insects were uncommon in leaf litter under plants.

Beetles – Order Coleoptera

Eight species of beetles were observed at the DKIST site, all non-indigenous. The species included six ladybird beetles, a non-indigenous Carabid beetle, and a single specimen of the non-indigenous vegetable weevil, *Listroderes costirostris* Germain was found in litter under *Dubautia*. The latter species is originally from South America, and has spread to many parts of the world including Hawaiʻi.

Flies - Order Diptera

Twelve species of flies were detected at the DKIST site. Only one endemic species, *Trupanea cratericola* (Grimshaw), was observed. All other fly were common, non-indigenous species observed previously at the DKIST site.

True Bugs – Orders Heteroptera and Homoptera

Nine species of true bugs (Order Heteroptera) were observed at the DKIST site, six endemic to Hawaiʻi. *Nysius coenosulus* Stål was the most common true bug at the DKIST site, occurring on vegetation. Another endemic true bug, *N. lichenicola* Kirkaldy, was uncommon in leaf litter under plants.

Three other Hawaiian endemic species include the abundant *Engytates hawaiiensis* (Kirkaldy) and infrequent *Hyalopeplus pelucidus* Stål. Both are known from other Hawaiian Islands. Two other endemic species were collected at the DKIST site, *Trigonotylus hawaiiensis* (Kirkaldy), found on grasses and *Nysius communis* Usinger, on vegetation at the DKIST site.

Five species of Homoptera were collected, including a species of the endemic genus Nesosydne that was abundant on Dubautia, Non-indigenous species include a green planthopper common on *pukiawe* and the abundant Acacia psyllid.

Acacia psyllids are abundant on *Dubautia* at the DKIST site.

Bees and Wasps – Order Hymenoptera

Seven species of bees and wasps were observed at the DKIST site. These species include three species of endemic yellow-faced bees, small parasitic wasps and honey bees. No ants were found at the DKIST site.

Moths – Order Lepidoptera

Nine species of Lepidoptera were collected, six endemic species and three non-indigenous species. Two large moths in the genus *Agrotis* were captured in light traps. Caterpillars of the genus *Agrotis* were found in pitfall traps. Larvae of the Haleakalā flightless moth (*Thyrocopa apatela* (Walsingham)) were frequently observed in leaf litter and two adults were captured in pitfall traps.

Non-indigenous white cabbage butterflies (*Pieris rapae* (Linnaeus)) were common flying around the DKIST site on sunny days.

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.

HALEAKALĀ ENTRANCE STATION

Sampling in Haleakalā National Park occurred near the park Entrance Station (HALE ES) at 6,250 feet elevation. Ninety-six species of arthropods were collected and observed there. The species included thirty-four endemic Hawaiian arthropods, forty-two non-indigenous arthropods, and twenty 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.

The non-indigenous Garden Sac spider (*Cheiracanthium mordax* L. Koch) was common in sweep net sampling over grasses. The False Black Widow spider (*Steatoda grossa* (C. L. Koch)) was common under rocks and in low-growing vegetation. This spider is similar in appearance to the black widow, lacking the red hourglass pattern on the underside of the abdomen. Both of these species have been reported from HALE in the past. The endemic crab spider, *Mecaphesa kanakanus*, was uncommon at HALE ES. This species is known from Haleakalā above 7,000 ft. (2,100 m) (Suman 1967).

Two species of mites of unknown status were also observed.

Collembola - Springtails

One species of Collembola was observed at the HALE ES 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.

Trechus obtusus Erichson, an uncommon resident of the habitat near the HALE ES.

Specimens of the Apple Weevil, *Otiorhynchus cribricollis*, was uncommon at the site. Other non-indigenous beetles include two species of ladybird beetles and two specimens of a very small unidentified Carabid beetle collected under rocks.

Flies – Order Diptera

Eleven species of flies were seen at the HALE ES. Seven species were from families of common non-indigenous flies (e.g.: blow flies, and bee flies) previously reported from HALE ES. Four species were of unknown status.

True Bugs – Orders Heteroptera and Homoptera

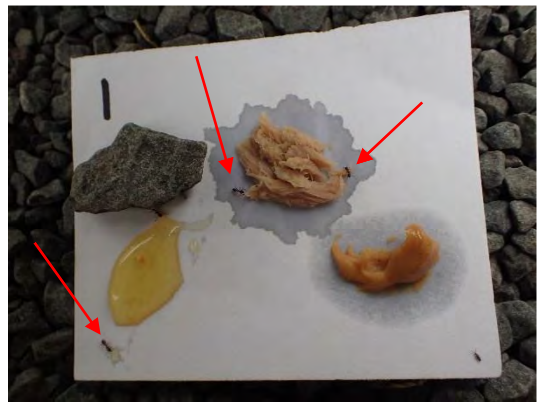
Eleven species of true bugs (Heteroptera) were found. Endemic Hawaiian species include two seed bugs, two common species of small green plant bugs of the genus *Orthotylus*, and two species of plant bugs from the genus *Sarona* one pale-orange in color found on *mamane*.

The non-indigenous Hyaline Grass Bug, *Liorhyssus hyalinus*, occurred infrequently and the non-indigenous *Pachybrachius nr. fracticollis*, was uncommon at the HALE ES.

Six species of Homoptera were observed, including three Hawaiian endemic species of *Nesophrosyne* (family Cicadellidae), that were common on vegetation.

Bees and Wasps – Order Hymenoptera

The nine species of Hymenoptera found near the HALE Entrance Station included two species of endemic yellow-faced bee (genus *Hylaeus*), honey bees, two non-indigenous wasps, and an unknown parasitoid.



Red arrows point to Argentine ants on ant bait card at HALE ES.

Three ants were found. The Argentine ant, *Linepithema humile*, the Tramp ant, *Cardiocondyla kagutsuchi/venestula*, and *Hypoponera opaciceps*, all previously known from the HALE ES. The latter species is also known from upper elevations in the park where it forms small colonies (Krushelnycky et al. 2007).

Butterflies and Moths – Order Lepidoptera

Thirty-two species of Lepidoptera were observed at the HALE ES, nineteen endemic to Hawai'i. Common endemics include small moths from the

Carposinidae, Cosmopterigidae, Crambidae families, and larger moths from the Geometridae and Noctuidae families.

The most common non-indigenous species included two large noctuid moths, *Agrotis ipsilon* (Hufnagel) and *Pseudaletia unipunctata* (Haworth), and the lantana biocontrol moth, *Stenoptilodes littoralis rhynchophora* (Meyrick).

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 single specimen of the non-indigenous cricket, *Trigonidomorpha sjostedti* Chopard was collected as well.

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.

Discussion

The arthropods that were found during this sampling are characteristic of the fauna found during previous monitoring. No new invasive arthropods were detected at the DKIST site, the larger HO site, and HALE ES 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.

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 invasive non-indigenous arthropod species detected at the HO and DKIST sites. No new invasive arthropod species were discovered at the HALE ES site, the species observed there have been detected in previous sampling sessions.

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APPENDIX A
HO ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Winter 2017 sampling at the HO site.

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Arachnida	Araneae	Lycosidae	Hogna	hawaiiensis	Simon	endemic	C
Arachnida	Araneae	Linyphiidae				unknown	U
Arachnida	Araneae	Theridiidae				unknown	U
CHILOPODA	Lithobiomorpha					unknown	U
Collembola	Entomobryidae					endemic	U
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous	I
Gastropoda	Stylommatophora	Zonitidae	Oxychilus	alliarius	(J.S. Miller)	non-indigenous	U
Insecta	Coleoptera	Carabidae	Mecyclothorax	spp.		endemic	I
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous	U
Insecta	Coleoptera	Chrysomelidae	Altica	carinata	(Germar)	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Coccinella	californica	(Mannerheim)	non-indigenous	I
Insecta	Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous	A
Insecta	Coleoptera	Coccinellidae	Cryptolaemus	montrouzieri	Mulsant	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Diomus	notescens	(Blackburn)	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Harmonia	conformis	(Boisduval)	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Hippodemia	convergens	Gurein-Meneville	non-indigenous	I
Insecta	Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous	C
Insecta	Coleoptera	Coccinellidae	Rhyzobius	forestieri	(Mulsant)	non-indigenous	I
Insecta	Coleoptera	Coccinellidae	Rhyzobius	lophanthae	(Blaisdale)	non-indigenous	I
Insecta	Coleoptera	Staphylinidae				unknown	U
Insecta	Diptera	Anthomyiidae	Delia	platura	(Meigen)	non-indigenous	U
Insecta	Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous	C
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous	C
Insecta	Diptera	Chamaemyiidae	Leucopis	albipuncta	Zetterstedt	non-indigenous	C
Insecta	Diptera	Drosophilidae	Drosophila	melanogaster	Meigen	non-indigenous	U
Insecta	Diptera	Sarcophagidae				non-indigenous	U
Insecta	Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous	C
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous	U
Insecta	Diptera	Syrphidae	Eristalis	tenax	(Linneaus)	non-indigenous	U
Insecta	Diptera	Drosophilidae				unknown	I
Insecta	Diptera	Muscidae				unknown	C
Insecta	Diptera	Tipulidae	SP1			unknown	I
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic	C
Insecta	Heteroptera	Lygaeidae	Nysius	communis	Usinger	endemic	U
Insecta	Heteroptera	Lygaeidae	Nysius	palor	Ashlock	endemic	I
Insecta	Heteroptera	Miridae	Engytates	hawaiiensis	(Kirkaldy)	endemic	A
Insecta	Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic	I
Insecta	Heteroptera	Geocoridae	Geocoris	pallens	Stål	non-indigenous	U
Insecta	Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous	U
Insecta	Heteroptera	Miridae	Coridromius	variegatus	(Montrouzier)	non-indigenous	I

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Insecta	Heteroptera	Nabidae	Nabis	capsiformis	Germar	non-indigenous	I
Insecta	Heteroptera	Reduviidae	Zelus	renardii	Kolenati	non-indigenous	I
Insecta	Heteroptera	Rhyparochromidae	Brentiscerus	putoni	(White)	non-indigenous	U
Insecta	Heteroptera	Anthocoridae				unknown	I
Insecta	Heteroptera	Nabidae				unknown	I
Insecta	Homoptera	Delphacidae	Nesosydne	sp.		endemic	A
Insecta	Homoptera	Aphididae	SP1			non-indigenous	U
Insecta	Homoptera	Cercopidae	Clastoptera	xanthocephala	Germar	non-indigenous	I
Insecta	Homoptera	Cicadellidae	Draeculacephala	minerva	Ball	non-indigenous	I
Insecta	Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous	A
Insecta	Homoptera	Cicadellidae	SP1			unknown	C
Insecta	Hymenoptera	Ichneumonidae	Barichneumon	californicus	(Ashmead)	non-indigenous	I
Insecta	Hymenoptera	Ichneumonidae	Gelis	tenellus	(Say)	non-indigenous	C
Insecta	Hymenoptera	Ichneumonidae	Spilichneumon	superbus	(Provancher)	non-indigenous	I
Insecta	Hymenoptera	Braconidae				unknown	C
Insecta	Hymenoptera	Eulophidae				unknown	C
Insecta	Lepidoptera	Crambidae	Eudonia	spp.		endemic	U
Insecta	Lepidoptera	Crambidae	Omiodes	continuatalis	(Wallengren)	endemic	I
Insecta	Lepidoptera	Crambidae	Omiodes	monogona	Meyrick	endemic	I
Insecta	Lepidoptera	Lycaenidae	Udara	blackburni	(Tuely)	endemic	I
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic	U
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic	C
Insecta	Lepidoptera	Noctuidae	larva			endemic	U
Insecta	Lepidoptera	Xyloryctidae	Thyrocopa	apatela	(Walsingham)	endemic	U
Insecta	Lepidoptera	Lycaenidae	Lampides	boeticus	(Linnaeus)	non-indigenous	U
Insecta	Lepidoptera	Noctuidae	Agrotis	ipsilon	(Hufnagel)	non-indigenous	I
Insecta	Lepidoptera	Nymphalidae	Vanessa	cardui	(Linnaeus)	non-indigenous	I
Insecta	Lepidoptera	Pieridae	Pieris	rapae	(Linnaeus)	non-indigenous	C
Insecta	Psocoptera					unknown	C

APPENDIX B
DKIST ARTHROPOD SPECIES LIST

A list of Arthropod species detected during the Winter 2017 sampling at the DKIST site.

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Arachnida	Araneae	Linyphiidae				unknown	U
Arachnida	Araneae	Lycosidae	Hogna	hawaiiensis	Simon	endemic	C
CHILOPODA	Lithobiomorpha					unknown	U
Collembola	Entomobryidae					endemic	U
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous	I
Gastropoda	"Slugs"					non-indigenous	I
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Coccinella	californica	(Mannerheim)	non-indigenous	I
Insecta	Coleoptera	Coccinellidae	Coccinella	septempunctata	Linnaeus	non-indigenous	A
Insecta	Coleoptera	Coccinellidae	Diomus	notescens	(Blackburn)	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Harmonia	conformis	(Boisduval)	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Olla	v-nigrum	(Mulsant)	non-indigenous	C
Insecta	Coleoptera	Coccinellidae	Rodolia	cardinalis	(Mulsant)	non-indigenous	I
Insecta	Coleoptera	Curculionidae	Listroderes	difficilis	Germain	non-indigenous	I
Insecta	Diptera	Anthomyiidae	Delia	platura	(Meigen)	non-indigenous	U
Insecta	Diptera	Calliphoridae	Calliphora	latifrons	Hough	non-indigenous	C
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous	C
Insecta	Diptera	Chamaemyiidae	Leucopis	albipuncta	Zetterstedt	non-indigenous	C
Insecta	Diptera	Drosophilidae	Drosophila	melanogaster	Meigen	non-indigenous	U
Insecta	Diptera	Muscidae				unknown	C
Insecta	Diptera	Sarcophagidae				non-indigenous	U
Insecta	Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous	C
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous	U
Insecta	Diptera	Syrphidae	Eristalis	tenax	(Linneaus)	non-indigenous	U
Insecta	Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous	U
Insecta	Diptera	Tephritidae	Trupanea	cratericola	(Grimshaw)	endemic	I
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic	C
Insecta	Heteroptera	Lygaeidae	Nysius	communis	Usinger	endemic	U
Insecta	Heteroptera	Lygaeidae	Nysius	lichenicola	Kirkaldy	endemic	I
Insecta	Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous	U
Insecta	Heteroptera	Miridae	Engytates	hawaiiensis	(Kirkaldy)	endemic	A
Insecta	Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic	I
Insecta	Heteroptera	Miridae	Trigonotylus	hawaiiensis	(Kirkaldy)	endemic	I
Insecta	Heteroptera	Rhopalidae	Liorhyssus	hyalinus	(Fabricius)	non-indigenous	I
Insecta	Heteroptera	Rhyparochromidae	Brentiscerus	putoni	(White)	non-indigenous	U
Insecta	Homoptera	Aphididae	SP1			non-indigenous	U
Insecta	Homoptera	Cicadellidae	SP1			unknown	C
Insecta	Homoptera	Delphacidae	Nesosydne	sp.		endemic	A
Insecta	Homoptera	Pseudococcidae	SP 1			unknown	I
Insecta	Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous	A

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous	I
Insecta	Hymenoptera	Braconidae				unknown	C
Insecta	Hymenoptera	Colletidae	Hylaeus	nivicola	Meade-Waldo	endemic	C
Insecta	Hymenoptera	Colletidae	Hylaeus	sp.		endemic	C
Insecta	Hymenoptera	Colletidae	Hylaeus	volcanicus	(Perkins)	endemic	I
Insecta	Hymenoptera	Eulophidae				unknown	C
Insecta	Hymenoptera	Ichneumonidae	Gelis	tenellus	(Say)	non-indigenous	C
Insecta	Lepidoptera	Crambidae	Omiodes	monogona	Meyrick	endemic	I
Insecta	Lepidoptera	Lycaenidae	Lampides	boeticus	(Linnaeus)	non-indigenous	U
Insecta	Lepidoptera	Lycaenidae	Udara	blackburni	(Tuely)	endemic	I
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic	U
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic	C
Insecta	Lepidoptera	Noctuidae	larva			endemic	U
Insecta	Lepidoptera	Noctuidae	Pseudaletia	unipunctata	(Haworth)	non-indigenous	U
Insecta	Lepidoptera	Pieridae	Pieris	rapae	(Linnaeus)	non-indigenous	C
Insecta	Lepidoptera	Xyloryctidae	Thyrocopa	apatela	(Walsingham)	endemic	U
Insecta	Neuroptera	Hemerobiidae	Hemerobius	pacificus	Banks	non-indigenous	I
Insecta	Psocoptera					unknown	C

APPENDIX C
HALE ES ARTHROPOD SPECIES LIST

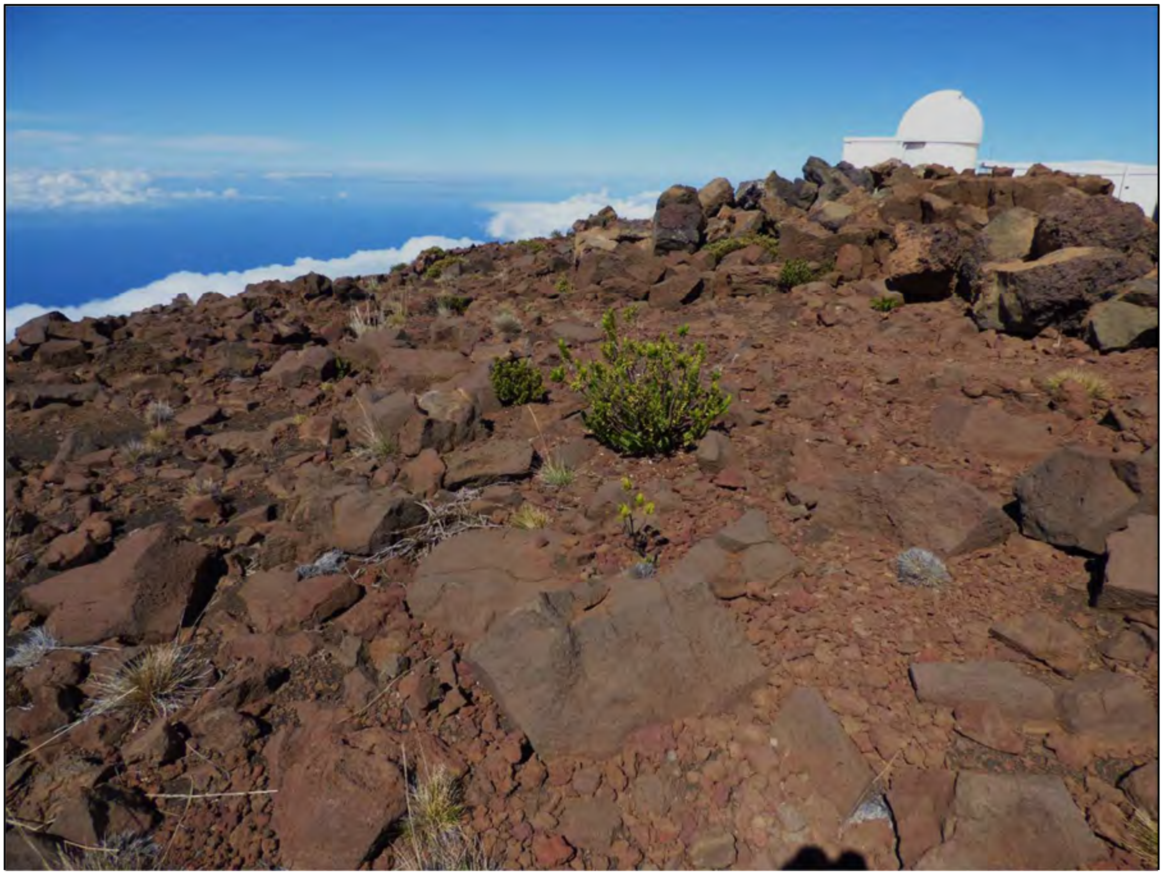
A list of Arthropod species detected during the Winter 2017 sampling at the HALE Entrance Station.

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Arachnida	Acari		SP1			unknown	U
Arachnida	Acari		SP2			unknown	U
Arachnida	Araneae	Thomisidae	Mecaphesa	sp. nr. kanakanus	(Karsch)	endemic	U
Arachnida	Araneae	Clubionidae	Cheiracanthium	mordax	L. Koch	non-indigenous	C
Arachnida	Araneae	Theridiidae	Steatoda	grossa	(C. L. Koch)	non-indigenous	C
Arachnida	Araneae	Linyphiidae				unknown	U
Arachnida	Araneae	Salticidae				unknown	U
Arachnida	Araneae	Theridiidae				unknown	C
CHILOPODA	Lithobiomorpha					unknown	C
Collembola	Entomobryidae					endemic	C
Crustacea	Isopoda	Porcellionidae	Porcellio	scaber	Latreille	non-indigenous	C
DIPLOPODA	Julida	Allajulus	latistriatus		(Curtis)	non-indigenous	A
Gastropoda	"Slugs"					non-indigenous	C
Gastropoda	Stylommatophora	Zonitidae	Oxychilus	alliarius	(J.S. Miller)	non-indigenous	C
Insecta	Coleoptera	Carabidae	Mecyclothorax	spp.		endemic	I
Insecta	Coleoptera	Apionidae	Exapion	ulicis	(Forster)	non-indigenous	I
Insecta	Coleoptera	Carabidae	Trechus	obtusus	Erichson	non-indigenous	U
Insecta	Coleoptera	Coccinellidae	Cryptolaemus	montrouzieri	Mulsant	non-indigenous	I
Insecta	Coleoptera	Coccinellidae				non-indigenous	I
Insecta	Coleoptera	Curculionidae	Otiorhynchus	cribricollis	Gyllenhal	non-indigenous	U
Insecta	Coleoptera	Carabidae				unknown	I
Insecta	Coleoptera	Ptiliidae				unknown	I
Insecta	Coleoptera	Staphylinidae				unknown	U
Insecta	Dermaptera	Forficulidae	Forficula	auricularia	Linnaeus	non-indigenous	C
Insecta	Diptera	Anthomyiidae	Delia	platura	(Meigen)	non-indigenous	U
Insecta	Diptera	Calliphoridae	Calliphora	vomitoria	(Linnaeus)	non-indigenous	C
Insecta	Diptera	Chamaemyiidae	Leucopis	albipuncta	Zetterstedt	non-indigenous	U
Insecta	Diptera	Drosophilidae	Drosophila	melanogaster	Meigen	non-indigenous	U
Insecta	Diptera	Sepsidae	Sepsis	thoracica	(Robineau-Desvoidy)	non-indigenous	C
Insecta	Diptera	Syrphidae	Allograpta	exotica	(Weidemann)	non-indigenous	U
Insecta	Diptera	Syrphidae	Toxomerus	marginatus	(Say)	non-indigenous	U
Insecta	Diptera	Drosophilidae				unknown	I
Insecta	Diptera	Muscidae				unknown	C
Insecta	Diptera	Sciaridae				unknown	C
Insecta	Diptera	Tipulidae	SP1			unknown	C
Insecta	Heteroptera	Lygaeidae	Nysius	coenosulus	Stål	endemic	U
Insecta	Heteroptera	Lygaeidae	Nysius	palor	Ashlock	endemic	I

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Insecta	Heteroptera	Miridae	Hyalopeplus	pelucidus	Stål	endemic	I
Insecta	Heteroptera	Miridae	Orthotylus	coprosmaphila	Polhemus	endemic	C
Insecta	Heteroptera	Miridae	Orthotylus	sophoriodes	Polhemus	endemic	C
Insecta	Heteroptera	Miridae	Sarona	sp.		endemic	C
Insecta	Heteroptera	Miridae	Sarona	sp. 2		endemic	I
Insecta	Heteroptera	Lygaeidae	Pachybrachius	nr. fracticollis		non-indigenous	U
Insecta	Heteroptera	Rhopalidae	Liorhyssus	hyalinus	(Fabricius)	non-indigenous	I
Insecta	Heteroptera	Rhyparochromidae	Brentiscerus	putoni (= australis)	(White)	non-indigenous	U
Insecta	Heteroptera	Miridae	SP1			unknown	I
Insecta	Homoptera	Cicadellidae	Nesophrosyne	sp. 1		endemic	C
Insecta	Homoptera	Delphacidae	Nesosydne	sp.		endemic	C
Insecta	Homoptera	Delphacidae	Nesosydne	sp. 2		endemic	A
Insecta	Homoptera	Aphididae	SP1			non-indigenous	C
Insecta	Homoptera	Psyllidae	Acizzia	uncatoides	(Ferris & Klyver)	non-indigenous	C
Insecta	Homoptera	Pseudococcidae	SP 1			unknown	U
Insecta	Hymenoptera	Colletidae	Hylaeus	sp.		endemic	U
Insecta	Hymenoptera	Colletidae	Hylaeus	volatilis	(F. Smith)	endemic	I
Insecta	Hymenoptera	Apidae	Apis	mellifera	Linneaus	non-indigenous	C
Insecta	Hymenoptera	Formicidae	Cardiocondyla	kagutsuchi/venestula		non-indigenous	I
Insecta	Hymenoptera	Formicidae	Hypoponera	opaciceps	(Mayr)	non-indigenous	U
Insecta	Hymenoptera	Formicidae	Linepithema	humile	(Mayr)	non-indigenous	U
Insecta	Hymenoptera	Vespidae	Polistes	aurifer	de Saussure	non-indigenous	I
Insecta	Hymenoptera	Vespidae	Vespula	pensylvanica	(Saussure)	non-indigenous	I
Insecta	Hymenoptera	Braconidae				unknown	C
Insecta	Lepidoptera	Carposinidae	Carposina	sp. A		endemic	C
Insecta	Lepidoptera	Carposinidae	Carposina	sp. B		endemic	U
Insecta	Lepidoptera	Cosmopterigidae	Hyposmocoma	sp.1		endemic	C
Insecta	Lepidoptera	Crambidae	Eudonia	spp.		endemic	U
Insecta	Lepidoptera	Crambidae	Omiodes	monogona	Meyrick	endemic	U
Insecta	Lepidoptera	Crambidae	Orthomecyna	sp.		endemic	C
Insecta	Lepidoptera	Crambidae	Udea	heterodoxa	(Meyrick)	endemic	I
Insecta	Lepidoptera	Crambidae	Udea	pyranthes	(Meyrick)	endemic	C
Insecta	Lepidoptera	Crambidae	Uresiphita	polygonalis	(Butler)	endemic	U
Insecta	Lepidoptera	Geometridae	Eupithecia	monticolans	Butler	endemic	C
Insecta	Lepidoptera	Geometridae	Eupithecia	sp.		endemic	C
Insecta	Lepidoptera	Geometridae	Scotorythra	paludicola	(Butler)	endemic	I
Insecta	Lepidoptera	Geometridae	Scotorythra	rara	(Butler)	endemic	C
Insecta	Lepidoptera	Geometridae	Scotorythra	sp.		endemic	C
Insecta	Lepidoptera	Noctuidae	Agrotis	baliopa	Meyrick	endemic	U
Insecta	Lepidoptera	Noctuidae	Agrotis	epicremna	Meyrick	endemic	U
Insecta	Lepidoptera	Noctuidae	Agrotis	giffardi (or mesotoxa)		endemic	I
Insecta	Lepidoptera	Noctuidae	Agrotis	xiphias	Meyrick	endemic	C
Insecta	Lepidoptera	Torticidae	Cydia	sp. 1		endemic	U
Insecta	Lepidoptera	Crambidae	Spoladea	recurvalis	(Fabricius)	non-indigenous	I
Insecta	Lepidoptera	Lycaenidae	Lampides	boeticus	(Linnaeus)	non-indigenous	I

Class	Order	Family	Genus	Species	Authority	Status	Abundance
Insecta	Lepidoptera	Noctuidae	Agrotis	ipsilon	(Hufnagel)	non-indigenous	C
Insecta	Lepidoptera	Noctuidae	Athetis	thoracica	(Moore)	non-indigenous	U
Insecta	Lepidoptera	Noctuidae	Chrysodeixis	eriosoma	(Doubleday)	non-indigenous	U
Insecta	Lepidoptera	Noctuidae	Megalographa	biloba	(Stephens)	non-indigenous	U
Insecta	Lepidoptera	Noctuidae	Pseudaletia	unipunctata	(Haworth)	non-indigenous	C
Insecta	Lepidoptera	Nymphalidae	Vanessa	cardui	(Linnaeus)	non-indigenous	I
Insecta	Lepidoptera	Pieridae	Pieris	rapae	(Linnaeus)	non-indigenous	C
Insecta	Lepidoptera	Pterophoridae	Stenoptilodes	littoralis	(Meyrick)	non-indigenous	C
Insecta	Lepidoptera	Microlepidoptera	SP1			unknown	C
Insecta	Lepidoptera	Noctuidae	Hypena	sp.		unknown	U
Insecta	Lepidoptera	Tortricidae				unknown	U
Insecta	Neuroptera	Hemerobiidae	Hemerobius	pacificus	Banks	non-indigenous	U
Insecta	Orthoptera	Gryllidae	Trigonidomorpha	sjostedti	Chopard	non-indigenous	I
Insecta	Psocoptera					unknown	C

BOTANICAL SURVEY
& ANNUAL INSPECTION
HALEAKALĀ OBSERVATORIES
FALL 2017



Prepared for:
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Maui, Hawaii

November 2017

OVERVIEW

The Daniel K. Inouye Solar Telescope (DKIST) is an optical telescope facility nearing completion. It is 41.5 meters (136 ft) tall, and will house a 4-meter (13.1 ft) telescope designed to provide insights about the sun.

In accordance with the Final Environmental Impact Statement (FEIS) (NSF 2009), semi-annual programmatic monitoring has been implemented during construction, which began in 2012. In addition to the semi-annual surveys required by the FEIS during construction, pursuant to the DKIST approved Habitat Conservation Plan (HCP) (NSF 2010) and published Biological Opinion (BO) (USFWS 2011), an annual inspection for invasive species in the DKIST interior facilities and grounds within 100 ft (30 m) of the buildings will be conducted and will continue after construction, to ensure impacts on biological resources from DKIST are minimized.

BOTANICAL SURVEY

Monitoring includes semi-annual botanical surveys at Haleakalā High Altitude Observatories Site (HO) and along the Haleakalā National Park (HALE) road corridor, including characterization of types, diversity, stage of development, coverage, and health of endangered Haleakalā Silverswords (*Argyroxiphium sandwicense* subsp. *macrocephalum*), and non-endangered endemic or alien invasive species at HO and within selected areas of the Park road corridor.

This document reports on the botanical surveys within HO.

ANNUAL INSPECTION

In accordance with the DKIST HCP and BO, an annual inspection for invasive species will be conducted.

DKIST facilities and grounds within 30 m (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.

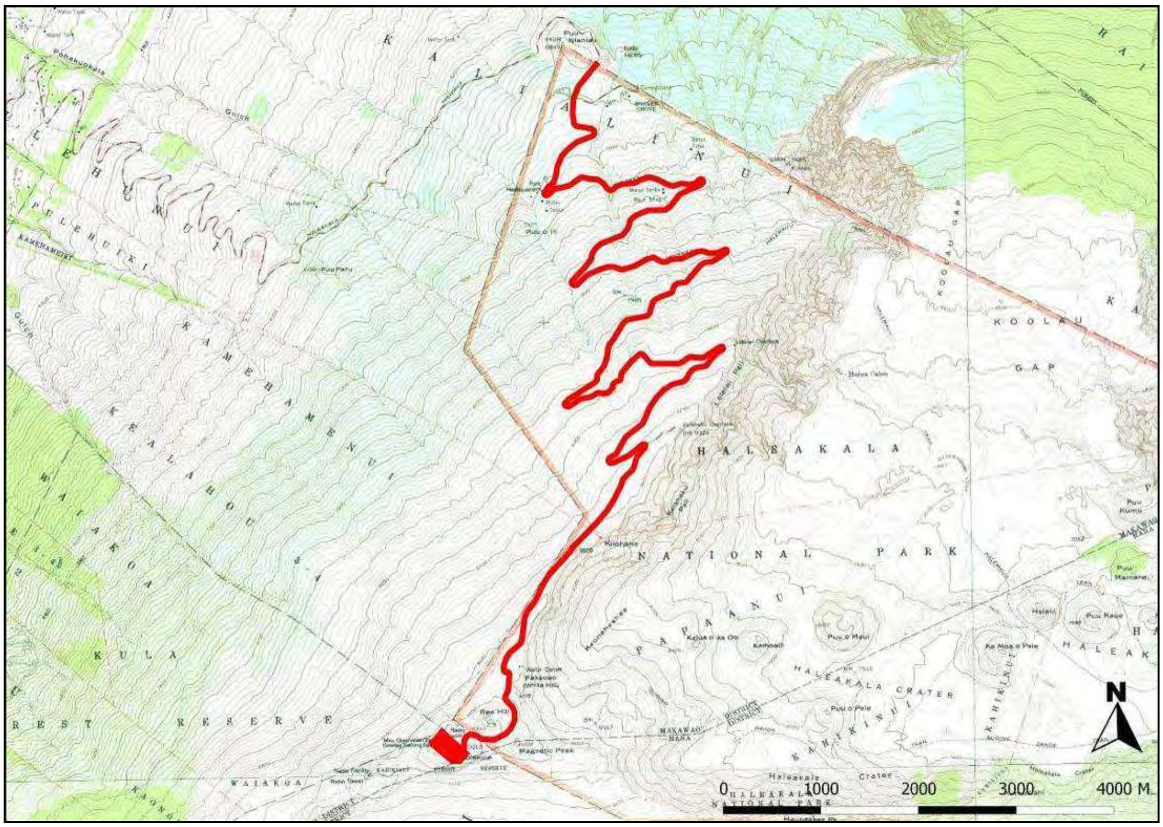
This document also reports on the floral inspection of HO.

PROJECT LOCATION

The DKIST construction site is approximately 0.75 acres on TMK 22-200-7008 (HO), an 18.166 acre parcel located near the summit of Haleakalā, largely within Pu`u Kolekole.

Additionally, about 17 km (11 miles) of paved road utilized for construction and operation of DKIST travels through HALE.

HO is the focus of this survey.



HO and road through HALE.

BIOLOGICAL SETTING

HO is located near the summit of Haleakalā, at 2999-3052 m (9840-10,012 ft) elevation.

Average annual rainfall is a moderate 1037 mm (41 in), occurring primarily during the winter months from November through March (Giambelluca et al. 2013).

Temperatures can be cold at the site, and occasionally dip below freezing, with average annual temperature at the summit of Haleakalā ranging from 43-50 degrees F (6-10 degrees C), and once every few years it will snow (County of Maui 1998).

The soils are volcanic, a mixture of ash, cinders, pumice, and lava (RTS 2002).

Vegetation at HO is relatively sparse, a mix of native and non-native plants.

Open terrain, with sparse, low growing vegetation at entrance to HO.

METHODOLOGY

HO was surveyed on November 2, 2017.

BOTANICAL SURVEY

A walk-through survey method is used. Focus is placed on areas that could harbor rare or invasive plants. All plants and their abundance are noted. Species identification are made in the field. Images are taken of any unknown or new plants. Care is taken during surveys to avoid disturbing the facilities, native vegetation, native insects, petrel burrows, archeological sites, and construction activities.

ANNUAL INSPECTION

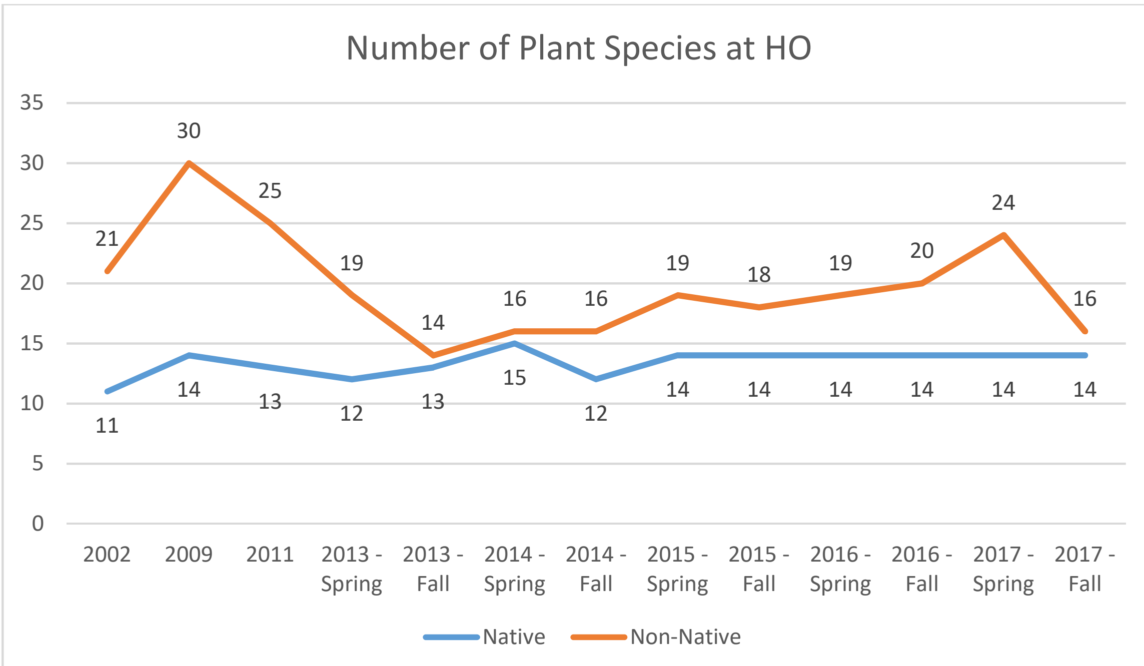
To minimize the likelihood of an invasive species introduction, DKIST interior facilities and grounds within 100 ft (30 m) of the buildings are thoroughly inspected on an ongoing annual basis for non-native species that may have eluded the cargo and luggage (load) inspections. Any newly-discovered non-native, invasive plant or animal will be photo documented, mapped, and described.

Surveying plants at HO.

RESULTS & DISCUSSION

CHANGES IN VEGETATION OVER TIME

During the survey, we observed 14 native and 16 non-native plant species.



Number of species observed at HO in recent surveys

NATIVES

There were the same number of native species present this survey as in the spring.

A few small, less than 10 cm tall, plants of native catchfly (*Silene struthioloides*) continue to persist and get larger in lava cracks near Mees Observatory.

Ena ena (*Pseudognaphalium sandwicensium* var. *sandwicensium*), continues to be found in a few disturbed sites, such as near drainages and the retention basin.

NON-NATIVES

The number of non-native species was lower this year. This appeared to be from ongoing weed control and construction activities.

Species not found this survey included annual bluegrass (*Poa annua*), veronica (*Veronica arvensis*), and hairy cats ear (*Hypochoeris radicata*). No new non-native plants species were found at HO during this survey.

Some non-native plants appear to germinate from a seedbank and continue to persist in very limited distribution in the same locations, such as cheeseweed (*Malva neglecta*), ripgut (*Bromus diandrus*), and evening primrose (*Oenothera stricta* subsp. *stricta*).

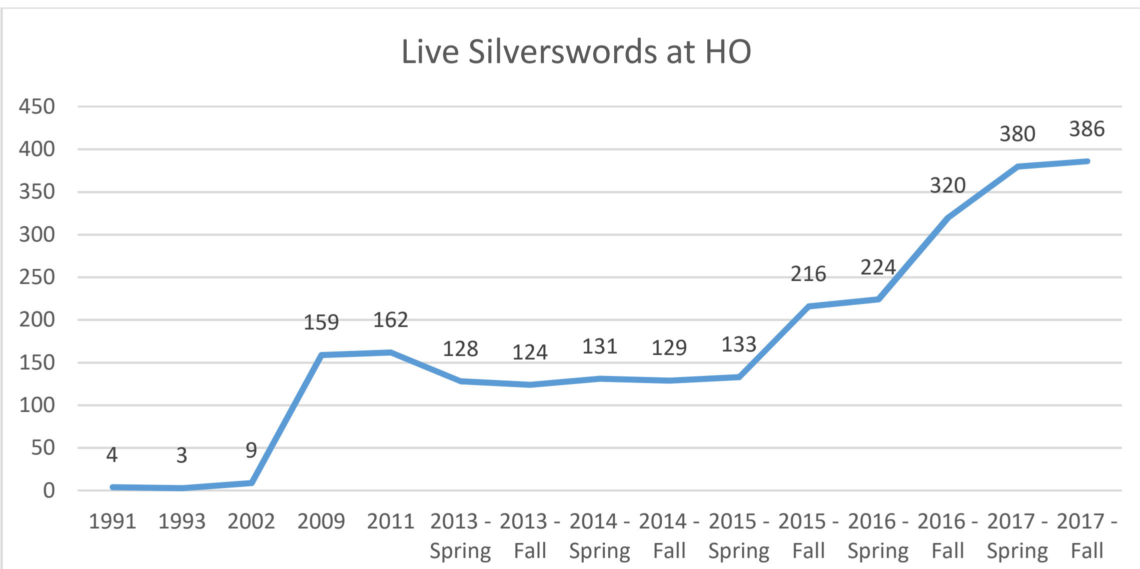
SILVERSWORDS


Haleakalā Silversword

Haleakalā silverswords (*Argyroxiphium sandwicense* subsp. *macrocephalum*) are federally listed as "Threatened", meaning they may become endangered throughout all or a significant portion of their range if no protection measures are taken.

There were 386 silverswords observed at HO this survey, two of which were in flower. This is the largest number of silverswords recorded within HO, and about the same number as were observed during the spring 2017 survey. Most of these were seedlings near plants that flowered in previous years.

All live silversword plants at HO are located on or near MSSS, on land that has undergone heavy construction activities in the past. The silverswords do not appear affected by recent construction activities at HO.



Number of live silverswords at HO.

CONSTRUCTION

The biggest changes at HO continue to be associated with construction.

The main area affected is where the DKIST telescope is being built. Other areas of HO that have been affected include a corridor running from the Advanced Electro-Optical System (AEOS) over Pu`u Kolekole to Mees.

These areas received much ground disturbance and many native and non-native plants were removed in the process. There are also large piles of rocks and soil that have been staged on the margin of the retention basin.

No Threatened or Endangered plants appear to have been impacted by construction. As construction wanes, it is likely that native and non-native vegetation will re-colonize much of the site, as has happened at HO in the past.

ANNUAL INSPECTION

No new non-native, invasive plants were found during the annual inspection. Most of the area within 30 m (100 ft) of the DKIST is unvegetated due to ongoing construction.

PLANT CHECKLIST

The following is a checklist of vascular plant species observed during recent botanical surveys of HO. Plants are listed alphabetically by species. Taxonomy and nomenclature follow Wagner *et al.* (1999), Palmer (2003) and Bishop Museum (2013). Native species are noted by an asterisk (*). The relative abundance of each species observed is also noted, the following abbreviations / definitions are used:

- **D = Dominant** - Forming a major part of the vegetation within the project area.
- **C = Common** - Widely scattered throughout area or locally abundant within a portion of it.
- **O = Occasional** - Scattered sparsely throughout area or in a few small patches.
- **R = Rare** - Only a few isolated individuals within the project area.

Native	Scientific name	2017 - Fall	2017 - Spring	2016 - Fall	2016 - Spring	2015 - Fall	2015 - Spring	2014 - Fall	2014 - Spring	2013 - Fall	2013 - Spring
	Ageratina adenophora			R							
*	*Agrostis sandwicensis*	C	C	C	C	C	C	C	C	C	C
	Anthoxanthum odoratum										R
	Arenaria serpyllifolia	O	C	C	C	C	C	O/C	C	C	C
*	*Argyroxiphium sandwicense* subsp. *macrocephalum*	C	C	C	C	C	C	C	C	C	C
*	*Argyroxiphium x Dubautia*	R/O	R/O	R	R	R	R	R	R		
*	*Asplenium adiantum-nigrum*	O/C	O/C	O/C	C	O/C	O/C	O	O/C	O	O/C
*	*Asplenium trichomanes* subsp. *densum*	O	O	O	O	R/O	R/O	R/O	O	O	R/O
	Axonopus sp.										
	Bidens pilosa										
	Bromus catharticus	R	O	R	O	R	R	R	R		R
	Bromus diandrus	R	R	R	R		R		R		
	Conyza bonariensis	R/O	O	O		R	R	R	R		
	Conyza canadensis var. *pusilla*		R								
	Cryptomeria japonica										
	Cynodon dactylon										
	Dactylis glomerata										
*	*Deschampsia nubigena*	D	D	D	D	D	D	D	D	D	D
*	*Dryopteris wallichiana*								R	R	
*	*Dubautia menziesii*	D	D	D	D	D	D	D	D	D	D

Native	Scientific name	2017 - Fall	2017 - Spring	2016 - Fall	2016 - Spring	2015 - Fall	2015 - Spring	2014 - Fall	2014 - Spring	2013 - Fall	2013 - Spring
	Erodium cicutarium	C	C	C	C	C	C	C	C	C	C
	Festuca rubra		R		R		R				R
	Foeniculum vulgare										
	Gamochaeta sp.	R	R	R	R						
*	*Geranium cuneatum* subsp. *tridens*										
	Gutierrezia sarothrae										
	Holcus lanatus		R	R	R	R	R		R	R	R
	Hypochoeris radicata		C	R	R	R/O	R/O	R	O/C	O	C
	Lepidium virginicum	R	C	R	O	R/O	O	O	C	O/C	C
*	*Leptecophylla tameiameiae*	O	O/C	O	O	R/O	R/O	R/O	O	O	C
	Lobularia maritima		R								
*	*Lythrum maritimum*										
	Malva neglecta	R	R			R	R	R			R
	Medicago lupulina	O	O	O	O	O	O	O	O	O	O
	Oenothera stricta subsp. *stricta*	R	O	R	R		R	R		R	R
*	*Pellaea ternifolia*	O	O/C	O	O	O	O	O	O	O	O
	Pennisetum clandestinum										
	Pinus sp.										
	Plantago lanceolata	O	O	O	O	O	O	O	O	O	O/C
	Poa annua		R			R	R	R	R		R
	Poa pratensis	O	C	O	O	O/C	O/C	O	C	O	C
	Polycarpon tetraphyllum	R			R	R		R	R	R	
*	*Pseudognaphalium sandwicensium* var. *sandwicensium*	R/O	O	O	R	R	R		R		
*	*Pteridium aquilinum* var. *decompositum*								R	R	R
	Rumex acetosella							R	R	R	R
	Senecio madagascariensis	R/O	O/C	O	O	R	R				R
	Senecio sylvaticus		O	R	R	R					
	Senecio vulgaris										
*	*Silene struthioloides*	R	R	R	R	R	R				
	Sonchus oleraceus		R								R
	Taraxacum officinale	R	C	R/O	O	O	O/C	O	C	O	C

Native	Scientific name	2017 - Fall	2017 - Spring	2016 - Fall	2016 - Spring	2015 - Fall	2015 - Spring	2014 - Fall	2014 - Spring	2013 - Fall	2013 - Spring
*	*Tetramolopium humile* subsp. *haleakalae*	O	C	O	O	O/C	O/C	O	O/C	C	C
	Trifolium repens		R							R	
*	*Trisetum glomeratum*	C	C	C	C	C	C	C	C	C	C/D
*	*Vaccinium reticulatum*	R/O	R/O	R/O	R/O	R/O	R/O	R/O	O	O	O
	Veronica arvensis				R	R	R				
	Vicia sativa										
	Vulpia bromoides										
	Vulpia myuros										
	Vulpia spp.	O	O	O	O	O	O/C	O	O/C	O	O/C

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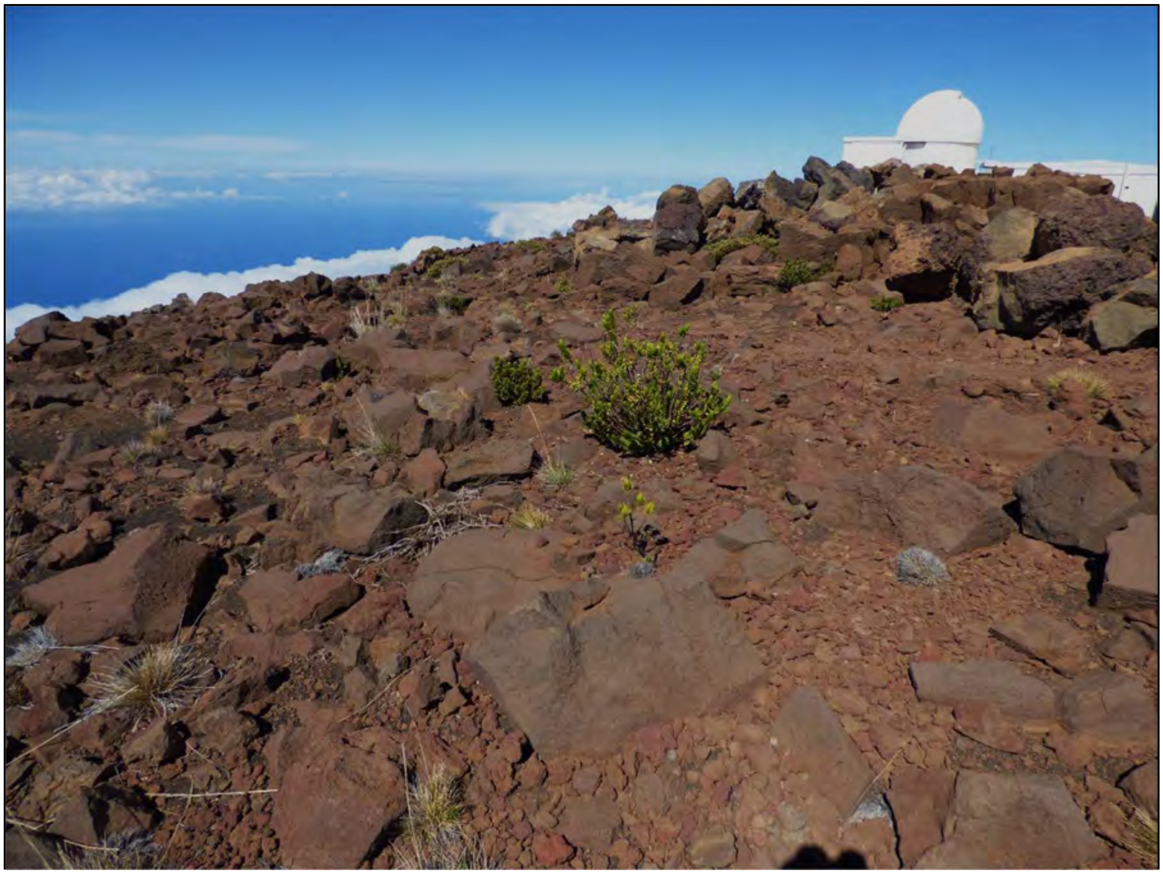
BOTANICAL SURVEY
HALEAKALĀ OBSERVATORIES
SPRING 2017



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May 2017

OVERVIEW

The Daniel K. Inouye Solar Telescope (DKIST) is an optical telescope facility nearing completion. It is 41.5 meters (136 ft) tall, and will house a 4-meter (13.1 ft) telescope designed to provide insights about the sun.

In accordance with the Final Environmental Impact Statement (NSF 2009), Habitat Conservation Plan (NSF 2010), and Biological Opinion (USFWS. 2011), programmatic monitoring has been implemented during construction, which began in 2012.Annual inspection for invasive species in the DKIST interior facilities and grounds within 100 ft (30 m) of the buildings will continue after construction, to ensure impacts on biological resources from DKIST are minimized.

BOTANICAL SURVEY

Monitoring includes semi-annual botanical surveys at Haleakalā High Altitude Observatories Site (HO) and along the Haleakalā National Park (HALE) road corridor, including characterization of types, diversity, stage of development, coverage, and health of endangered Haleakalā Silverswords (*Argyroxiphium sandwicense* subsp. *macrocephalum*), and non-endangered endemic or alien invasive species at HO and within selected areas of the Park road corridor.

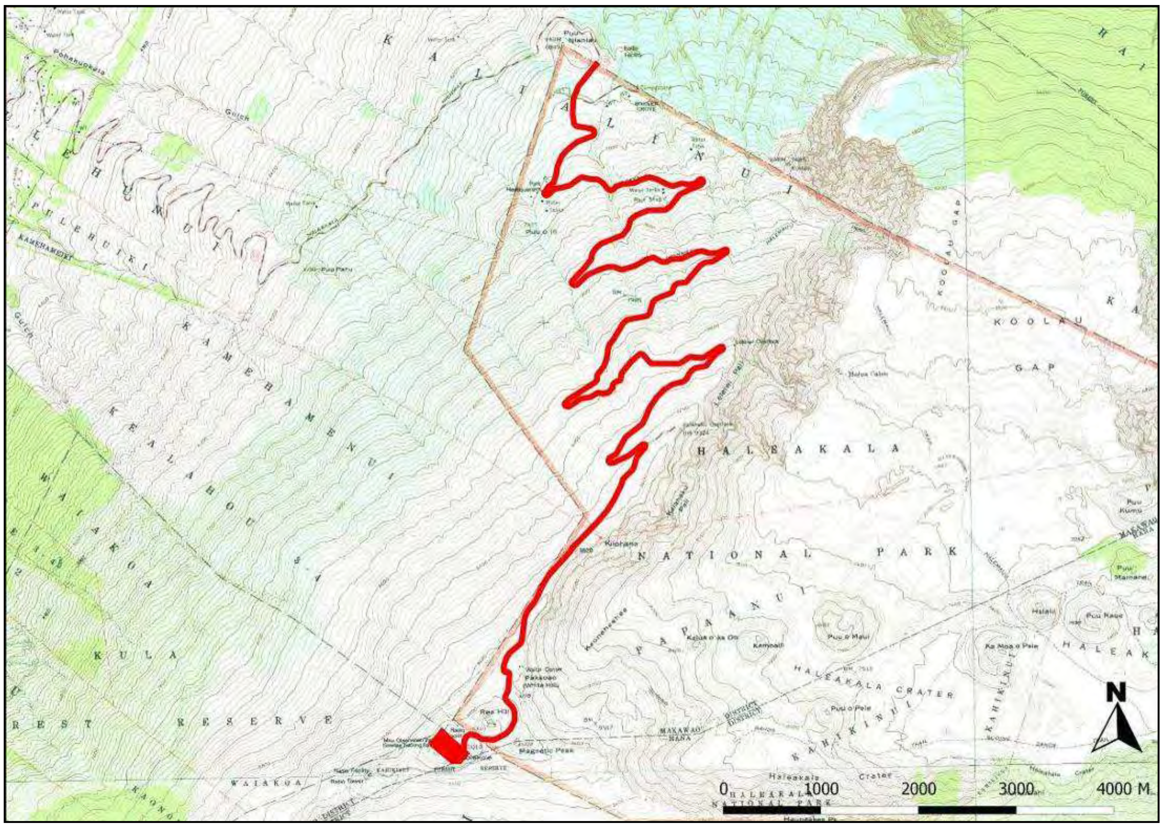
This document reports on the botanical surveys within HO.

PROJECT LOCATION

The DKIST construction site is approximately 0.75 acres on TMK 22-200-7008 (HO), an 18.166 acre parcel located near the summit of Haleakalā, largely within Pu`u Kolekole.

Additionally, about 17 km (11 miles) of paved road utilized for construction and operation of DKIST travels through HALE.

HO is the focus of this survey.



HO and road through HALE.

BIOLOGICAL SETTING

HO is located near the summit of Haleakalā, at 2999-3052 m (9840-10,012 ft) elevation.

Average annual rainfall is a moderate 1037 mm (41 in), occurring primarily during the winter months from November through March (Giambelluca et al. 2013).

Temperatures can be cold at the site, and occasionally dip below freezing, with average annual temperature at the summit of Haleakalā ranging from 43-50 degrees F (6-10 degrees C), and once every few years it will snow (County of Maui 1998).

The soils are volcanic, a mixture of ash, cinders, pumice, and lava (RTS 2002).

Vegetation at HO is relatively sparse, a mix of native and non-native plants.

Open terrain, with sparse, low growing vegetation at entrance to HO.

METHODOLOGY

HO was surveyed on May 3, 2017.

BOTANICAL SURVEY

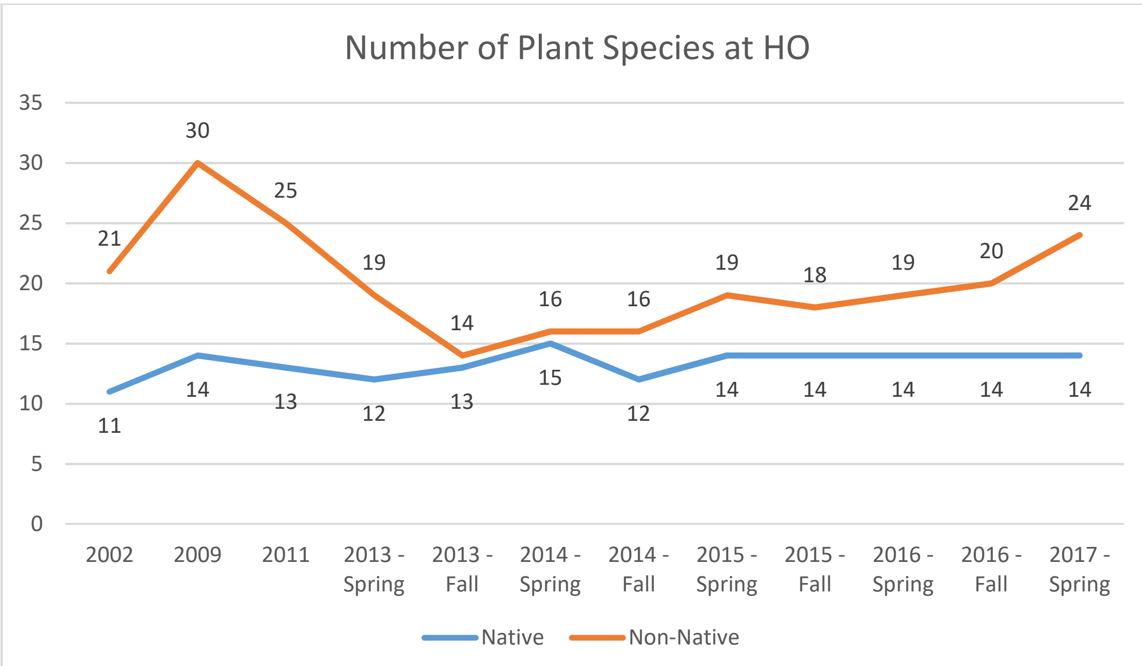
A walk-through survey method is used. All plants are noted and their locations recorded using a Garmin eTrex LegendH GPS (Global Positioning System). Where plants are continuous a point is recorded every 3 m. All plants and their abundance are noted. Species identifications are made in the field. Images are taken of any unknown or new plants. Care is taken during surveys to avoid disturbing the facilities, native vegetation, native insects, petrel burrows, archeological sites, and construction activities.

Surveying plants at HO.

RESULTS & DISCUSSION

CHANGES IN VEGETATION OVER TIME

During the survey, we observed 14 native and 24 non-native plant species. This is the same number of native species observed in recent surveys, and a slight increase in number of non-native species.



Number of species observed at HO in recent surveys

NATIVES

There were the same number of native species present this survey as in recent surveys.

Of note, Haleakalā silverswords (*Argyroxiphium sandwicense* subsp. *macrocephalum*) are becoming more abundant and widespread at HO, though they are still only located on the Air Force leased property.

A few small, less than 10 cm tall, plants of native catchfly (*Silene struthioloides*) continue to persist and get larger in lava cracks near Mees Observatory.

Ena ena (*Pseudognaphalium sandwicensium* var. *sandwicensium*), continues to be found in a few disturbed sites, such as near drainages and the retention basin.

NON-NATIVES

The number of non-native species increased slightly. Two new non-native plant species previously not found at the site were horseweed (*Conyza canadensis* var. *pusilla*) and sweet alyssum (*Lobularia maritima*).

Other non-native plants seen this year, not observed last year, but seen in prior years included: red fescue (*Festuca rubra*), common mallow (*Malva neglecta*), annual ryegrass (*Poa annua*), sow thistle (*Sonchus oleraceus*), and clover (*Trifolium repens*).

Some non-native plants continue to persist in very limited distribution in the same locations, such as Yorkshire fog (*Holcus lanatus*), ripgut (*Bromus diandrus*), evening primrose (*Oenothera stricta* subsp. *stricta*), and hairy horseweed (*Conyza bonariensis*).

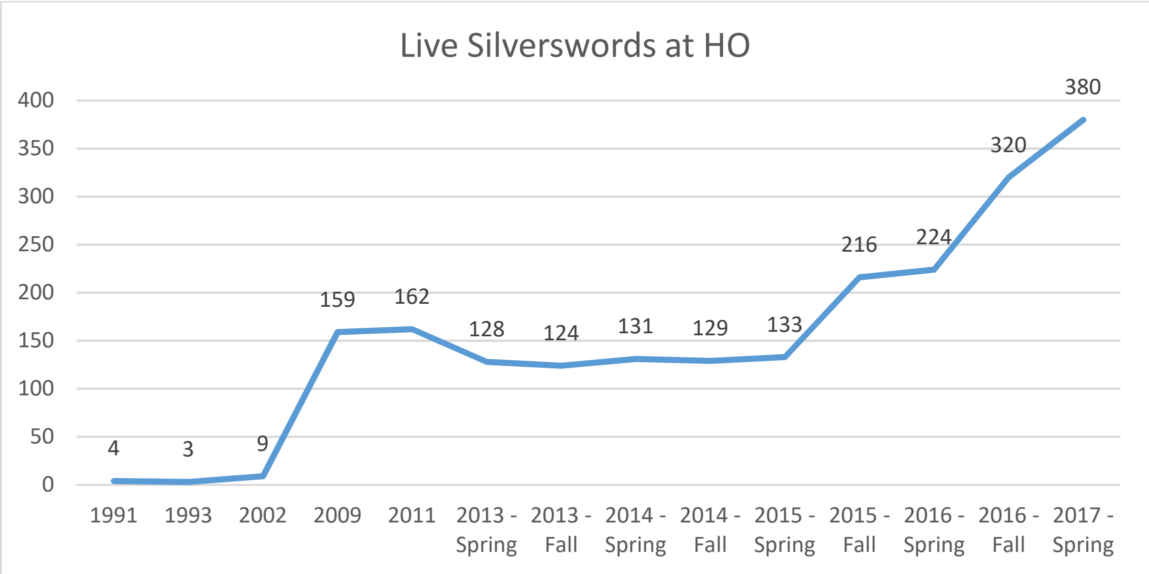
SILVERSWORDS

Haleakalā silverswords (*Argyroxiphium sandwicense* subsp. *macrocephalum*) are federally listed as "Threatened", meaning they may become endangered throughout all or a significant portion of their range if no protection measures are taken.

There were 380 silverswords observed at HO this survey, one of which was in flower. This is the largest number of silverswords recorded within HO, and continues a recent trend to increasing numbers of silverswords.

All live silversword plants at HO are located on or near MSSS, on land that has undergone heavy construction activities in the past. The silverswords do not appear affected by recent construction activities at HO.

Haleakalā Silversword



Number of live silverswords at HO.

CONSTRUCTION

The biggest changes to the topography and number of plants at HO continue to be associated with construction.

The main area affected is where the DKIST telescope is being built. Other areas of HO that have been affected include a corridor running from the Advanced Electro-Optical System (AEOS) over Pu`u Kolekole to Mees.

These areas received much ground disturbance and many native and non-native plants were removed in the process. There are also large piles of rocks and soil that have been staged on the margin of the retention basin.

No Threatened or Endangered plants appear to have been impacted by construction. As construction wanes, it is likely that native and non-native vegetation will re-colonize much of the site, as has happened at HO in the past.

PLANT CHECKLIST

The following is a checklist of vascular plant species observed during recent botanical surveys of HO. Plants are listed alphabetically by species. Taxonomy and nomenclature follow Wagner *et al.* (1999), Palmer (2003) and Bishop Museum (2013). Native species are noted by an asterisk (*). The relative abundance of each species observed is also noted, the following abbreviations / definitions are used:

- **D = Dominant** - Forming a major part of the vegetation within the project area.
- **C = Common** - Widely scattered throughout area or locally abundant within a portion of it.
- **O = Occasional** - Scattered sparsely throughout area or in a few small patches.
- **R = Rare** - Only a few isolated individuals within the project area.
- **X = Observed** - Present during survey. No abundance estimate.

Native	Scientific name	2017 - Spring	2016 - Fall	2016 - Spring	2015 - Fall	2015 - Spring	2014 - Fall	2014 - Spring	2013 - Fall	2013 - Spring
	Ageratina adenophora		R							
*	*Agrostis sandwicensis*	C	C	C	C	C	C	C	C	C
	Anthoxanthum odoratum									R
	Arenaria serpyllifolia	C	C	C	C	C	O/C	C	C	C
*	*Argyroxiphium sandwicense* subsp. *macrocephalum*	C	C	C	C	C	C	C	C	C
*	*Argyroxiphium x Dubautia*	R/O	R	R	R	R	R	R		
*	*Asplenium adiantum-nigrum*	O/C	O/C	C	O/C	O/C	O	O/C	O	O/C
*	*Asplenium trichomanes* subsp. *densum*	O	O	O	R/O	R/O	R/O	O	O	R/O
	Axonopus sp.									
	Bidens pilosa									
	Bromus catharticus	O	R	O	R	R	R	R		R
	Bromus diandrus	R	R	R		R		R		
	Conyza bonariensis	O	O		R	R	R	R		
	Conyza canadensis var. pusilla	R								
	Cryptomeria japonica									
	Cynodon dactylon									
	Dactylis glomerata									
*	*Deschampsia nubigena*	D	D	D	D	D	D	D	D	D
*	*Dryopteris wallichiana*							R	R	

Native	Scientific name	2017 - Spring	2016 - Fall	2016 - Spring	2015 - Fall	2015 - Spring	2014 - Fall	2014 - Spring	2013 - Fall	2013 - Spring
*	*Dubautia menziesii*	D	D	D	D	D	D	D	D	D
	Erodium cicutarium	C	C	C	C	C	C	C	C	C
	Festuca rubra	R		R		R				R
	Foeniculum vulgare									
	Gamochaeta sp.	R	R	R						
*	*Geranium cuneatum* subsp. *tridens*									
	Gutierrezia sarothrae									
	Holcus lanatus	R	R	R	R	R		R	R	R
	Hypochoeris radicata	C	R	R	R/O	R/O	R	O/C	O	C
	Lepidium virginicum	C	R	O	R/O	O	O	C	O/C	C
*	*Leptecophylla tameiameiae*	O/C	O	O	R/O	R/O	R/O	O	O	C
	Lobularia maritima	R								
*	*Lythrum maritimum*									
	Malva neglecta	R			R	R	R			R
	Medicago lupulina	O	O	O	O	O	O	O	O	O
	Oenothera stricta subsp. *stricta*	O	R	R		R	R		R	R
*	*Pellaea ternifolia*	O/C	O	O	O	O	O	O	O	O
	Pennisetum clandestinum									
	Pinus sp.									
	Plantago lanceolata	O	O	O	O	O	O	O	O	O/C
	Poa annua	R			R	R	R	R		R
	Poa pratensis	C	O	O	O/C	O/C	O	C	O	C
	Polycarpon tetraphyllum			R	R		R	R	R	
*	*Pseudognaphalium sandwicensium* var. *sandwicensium*	O	O	R	R	R		R		
*	*Pteridium aquilinum* var. *decompositum*							R	R	R
	Rumex acetosella						R	R	R	R
	Senecio madagascariensis	O/C	O	O	R	R				R
	Senecio sylvaticus	O	R	R	R					
	Senecio vulgaris									
*	*Silene struthioloides*	R	R	R	R	R				
	Sonchus oleraceus	R								R
	Taraxacum officinale	C	R/O	O	O	O/C	O	C	O	C

Native	Scientific name	2017 - Spring	2016 - Fall	2016 - Spring	2015 - Fall	2015 - Spring	2014 - Fall	2014 - Spring	2013 - Fall	2013 - Spring
*	*Tetramolopium humile* subsp. *haleakalae*	C	O	O	O/C	O/C	O	O/C	C	C
	Trifolium repens	R							R	
*	*Trisetum glomeratum*	C	C	C	C	C	C	C	C	C/D
*	*Vaccinium reticulatum*	R/O	R/O	R/O	R/O	R/O	R/O	O	O	O
	Veronica arvensis			R	R	R				
	Vicia sativa									
	Vulpia bromoides									
	Vulpia myuros									
	Vulpia spp.	O	O	O	O	O/C	O	O/C	O	O/C

ANNOTATED PLANT CHECKLIST

The following annotated checklist is designed to record the history of all plant species reported from HO, and to provide an identification guide and maps to assist with management of the botanical resources.

Each plant has the scientific name, common name, family name, nativity status, an image (images not always from HO), a history of the plant from previous botanical surveys, the current status of the species at HO, and locations for species observed during botanical surveys that include GPS mapping.

Maps are only included for years in which the species was observed. The native plants *Deschampsia nubigena* and *Dubautia menziesii* are not GPS'd each year as they are abundant throughout HO.

The annotated checklist includes all plant species ever recorded from HO, resulting in species included that were not observed in the most recent survey.

Ageratina adenophora (Asteraceae)
Maui pamakani (Non-native)

Not observed during this survey nor since 2009 when one small infertile plant was found and pulled. Perhaps pulling the lone sterile plant in 2009 prevented it from establishing. It could possibly show up from time to time in the moister areas of HO, germinating from seed blown up from lower elevations.

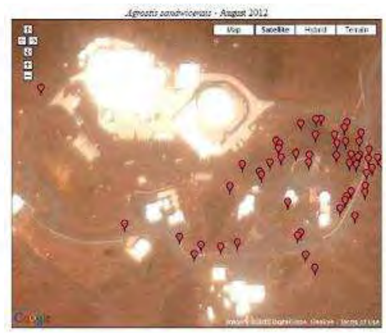
2009

Agrostis sandwicensis (Poaceae)
Bentgrass (Native: Endemic)

This native clumping grass is present in the same general areas of HO it has been known from, especially in less disturbed areas. The exception being active construction areas around DKIST, Pan-STARRS, and the former Reber Circle telescope site where the native grass is now absent. It may recolonize some of these areas when construction is completed.

2009

2011



2012

2013

2014

2015

2016

2017

Anthoxanthum odoratum (Poaceae)
Sweet vernal grass (Non-native)

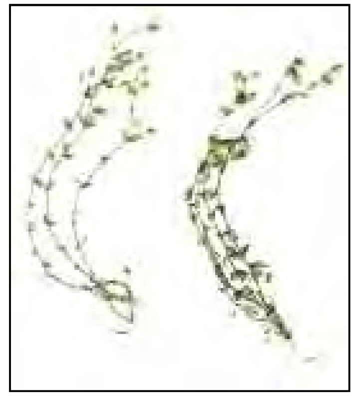
Not observed this survey.

Occasionally recorded in previous surveys. It is common lower down the mountain.

2013

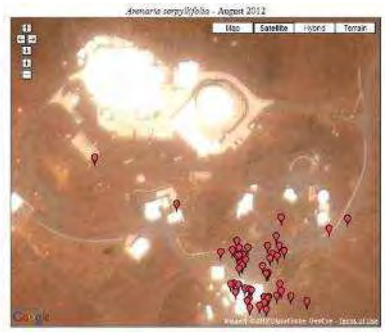
Arenaria serpyllifolia (Caryophyllaceae)
Thyme-leaved sandwort (Non-native)

This small herbaceous plant had a similar distribution as previous years, it remains common around buildings, near the MSSS and the Mees Solar Observatory.



2009

2011



2012

2013

2014

2015

2016

2017

Argyroxiphium sandwicense subsp. *macrocephalum* (Asteraceae) ʻĀhinahina, silversword (Native: Endemic)

There were 380 silverswords found during this survey, an increase from the 224 observed in fall 2016, and located in the same general areas. Most of these were small seedlings. The bulk of the silverswords at HO occur around the MSSC buildings and parking areas in cinder planter boxes. There are also a few on the north edge of the property, in a jumble of rocks.

2009

2011

2013

2014

2015

2016

2017

Argyroxiphium x *Dubautia* (Asteraceae)
Silversword Dubautia hybrid
(Native: Endemic)

A total of five small plants of this spontaneous hybrid between Haleakala silverswords (*Argyroxiphium sandwicense* subsp. *macrocephalum*) and kupaoa (*Dubautia menziesii*) were observed this survey.

The plants have spread in distribution, but are all still located in planter boxes at the MSSC.

2014

2015

2016

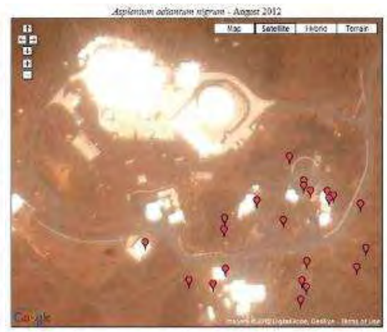
2017

Asplenium adiantum-nigrum (Aspleniaceae) ‘Iwa‘iwa (Native: Indigenous)

This small native fern continues to persist in mostly undisturbed rocky areas of HO, and was found in the same general areas as previous surveys.

2009

2011



2012

2013

2014

2015

2016

2017

Asplenium trichomanes subsp. *densum* (Aspleniaceae)
Maidenhair spleenwort (Native: Endemic)

This small native fern persists in the same general location it has in previous surveys, rocky crevices in the least disturbed areas.

2009

2011

2012

2013

2014

2015

2016

2017

Axonopus sp. (Poaceae)
Carpet grass (Non-native)

Not observed during this survey.

A small infertile plant was first observed in 2009 in a road crack near the Mees parking lot area and was pulled. It has not been found again since then.

2009

Bidens pilosa (Asteraceae)
Spanish needles (Non-native)

Not observed during this survey.

This herbaceous plant was first found at HO in 2011 at the edge of the concrete near the buildings at MSSC. At the time a single plant that had not yet gone to seed was found and pulled. It has not been observed since.

2011

Bromus catharticus (Poaceae)
Rescue grass (Non-native)

First collected at the site in 1982, surveys since then have resulted in a few plants found in the same general areas, with the most found in 2009. It likely continues to germinate from a seed bank.

2009

2011

2012

2013

2014

2015

2016

2017

Bromus diandrus (Poaceae)
Ripgut grass (Non-native)

A few plants were again found near the Airglow Facility near Pan-STARRS. This grass was first found in 2009 in the same location and continues to germinate from a seed bank.

2009

2011

2014

2015

2016

2017

Conyza bonariensis (Asteraceae)
Hairy horseweed (Non-native)

A widespread wind dispersed plant elsewhere on Maui, it occasionally germinates in road cracks and other sites at HO.

2009

2011

2014

2015

2017

Conyza canadensis var. *pusilla* (Asteraceae) Horseweed (Non-native)

Observed for the first time at HO this survey, in three widely scattered sites.

A widespread wind dispersed plant elsewhere on Maui, it will likely behave similarly to hairy horseweed at HO, occasionally germinating in road cracks and other disturbed sites.

2017

Cryptomeria japonica (Taxodiaceae)
Japanese tsugi pine (Non-native)

Not observed since 2005, when a lone possibly cultivated tree was found near the former LURE facility and was later removed.

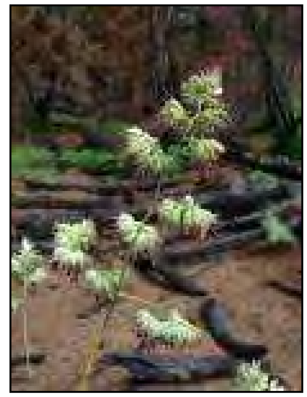
Cynodon dactylon (Poaceae)
Bermuda grass (Non-native)

Not observed this survey.

Previously found during the 2002 and 2009 surveys from a small patch near Mees, though not seen during more recent surveys.

2009

Dactylis glomerata (Poaceae)
Cocksfoot (Non-native)



Not observed this survey.

One plant was found in 2009 on the west side of the Mees building and has not been observed since.

2009

Deschampsia nubigena (Poaceae)
Hairgrass (Native: Endemic)

Not mapped this survey.

Still a dominant component of the vegetation at HO. It was displaced in the current construction areas, but may recolonize the area once the project is completed.

2009

2011

Dryopteris wallichiana (Dryopteridaceae) Laukahi (Native: Indigenous)

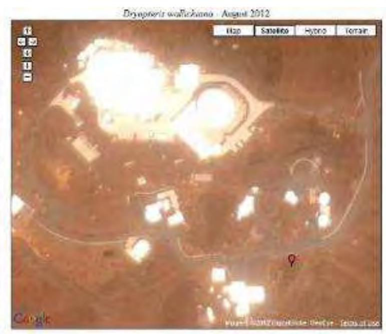
Not observed this survey.

In 2014, one small plant was found along a concrete crack by the Las Cumbres Observatory Telescope. Previously, it was known from an area among the rocks that are in the DKIST construction zone.

Elsewhere on Maui, this fern is typically found in moist mesic forested areas.

2009

2011



2012

2014

Dubautia menziesii (Asteraceae)
Kūpaoa (Native: Endemic)

Not mapped this survey.

This native shrub is still dominant over much of the site, but now displaced from the construction disturbed sites. It may return once construction is completed.

2009

2011

Erodium cicutarium (Geraniaceae)
Pin clover, storksbill (Non-native)

A small herbaceous plant that remains common in disturbed areas and near the buildings over most of HO.

2009

2011

2012

2013

2014

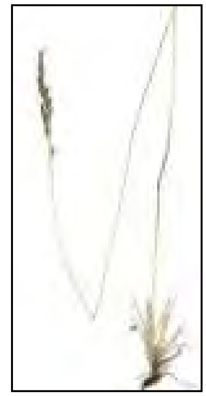
2015

2016

2017

Festuca rubra (Poaceae)
Red fescue (Non-native)

A few small clumps observed by Pan-STARRS. Occasionally found in low numbers in previous surveys.



2009

2011

2012

2013

2015

2016

2017

Foeniculum vulgare (Apiaceae)
Fennel (Non-native)

Not observed since a single small sterile plant was found near Mees in 2011 and was pulled.

2011

Gamochaeta sp. (Asteraceae)
Gamochaeta (Non-native)

A few small plants were present near the Airglow Facility and MSSC.

First observed during the spring 2016 survey, when a single tiny sterile plant was found near Pan-Starrs. This herbaceous plant has also been found sparingly in other areas of subalpine East Maui.

2016

2017

Geranium cuneatum subsp. *tridens* (Geraniaceae)
Hinahina (Native: Endemic)

Not observed during this survey.

Reported from the site in 1994. Not seen since.

Gutierrezia sarothrae (Asteraceae)
Broom snakeweed (Non-native)

Not observed this survey.

The area where it was previously located has been disturbed due to construction activities. There was no sign of broom snakeweed found.

This small herb was found for the first time in the State of Hawai‘i during the 2009 survey near Pan-STARRS.

2009

2011

Holcus lanatus (Poaceae)
Yorkshire fog (Non-native)

Yorkshire fog continues to persist near the Airglow Facility. Despite repeated control efforts, this grass persists by germinating from a well established seed bank.

In the past it has also been observed on the southwest side of Mees.

2009

2011

2012

2013

2014

2015

2016

2017

Hypochoeris radicata (Asteraceae)
Hairy cat's ear (Non-native)

Widely scattered over the same general areas it has been present in previous surveys.

There seems to be less than in the early years of surveys, perhaps from a combination of weed control, construction, and dry conditions.

2009

2011

2012

2013

2014

2015

2016

2017

Lepidium virginicum (Brassicaceae)
Virginia pepperweed (Non-native)

Present, especially around the Air Force property. Much less abundant than it used to be.

2009

2011

2012

2013

2014

2015

2016

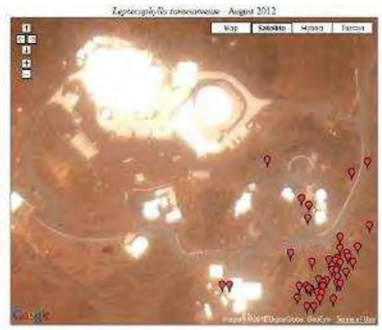
2017

Leptecophylla [*Styphelia*] *tameiameiae* (Ericaceae)
Pūkiawe (Native: Indigenous)

This native shrub remains locally common in the least recently disturbed portions of HO.

2009

2011



2012

2013

2014

2015

2016

2017

Lobularia maritima (Brassicaceae)
Sweet Alyssum (Non-native)

A single plant was observed near the Zodiacal Light Observatory, the first record of this species from HO.

Cultivated as a bedding plant and naturalized over a wide range of habitats in Hawai‘i.

2017

Lythrum maritimum (Lythraceae)
Lythrum (Native: Questionably Indigenous)

Not observed this survey.

This herbaceous sprawling plant is usually found in moister areas. It was first recorded from the site in 2005 where a small patch was found near the Airglow Facility, but has not been seen since.

Malva neglecta (Malvaceae)
Common mallow (Non-native)

Observed in the same area, near the Airglow Facility, where it was previously known.

First observed in 2002, this species has been observed in the same area on and off for the past several years.

2009

2013

2015

2017

Medicago lupulina (Fabaceae)
Black medic (Non-native)

This mat forming herb with yellow flowers continues to be locally common around Mees, and a few plants were again present in the retention basin.

2009

2011

2012

2013

2014

2015

2016

2017

Oenothera stricta subsp. *stricta* (Onagraceae)
Evening primrose (Non-native)

A few plants found in the same areas where it was once much more common. This species has greatly decreased in abundance.

2009

2011

2012

2013

2015

2016

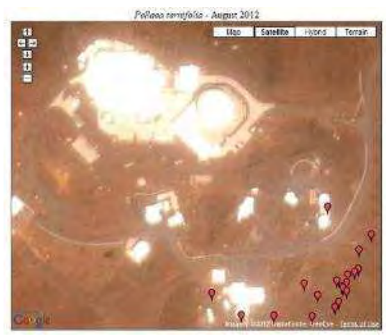
2017

Pellaea ternifolia (Pteridaceae)
Kalamoho (Native: Indigenous)

Found mostly around the eastern flank of the DKIST site tucked into rock crevices in the least disturbed areas of HO.

2009

2011



2012

2013

2014

2015

2016

2017

Pennisetum clandestinum (Poaceae)
Kikuyu grass (Non-native)

Not observed this survey.

First found in 2009, when a single small sterile plant was found and pulled. It has not been seen since.

2009

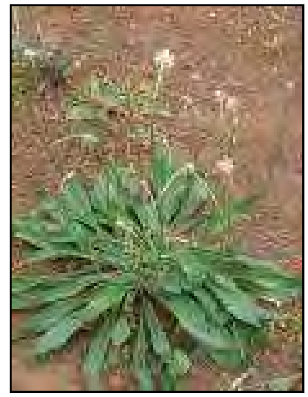
Pinus sp. (Pinaceae)
Pine (Non-native)

Not observed this survey.

Previously two cultivated plants were found and removed in 2002. Then in 2009 a small wild pine seedling was found in a road crack near the retention basin and pulled.

2009

Plantago lanceolata (Plantaginaceae)
Narrow-leaved plantain (Non-native)



Locally common around Mees. A few plants observed near MSSC.

2009

2011

2012

2013

2014

2015

2016

2017

Poa annua (Poaceae)
Annual bluegrass (Non-native)

Observed in the same location it has previously been recorded from, near the northwest side of MSSC.

2016

2009

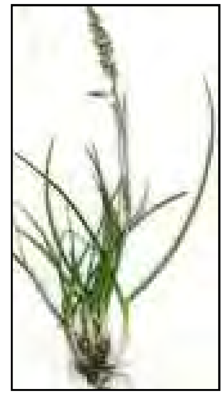
2012

2014

2015

2017

Poa pratensis (Poaceae)
Kentucky bluegrass (Non-native)



This patch forming grass continues to be common throughout most of the site. It prefers somewhat moist sites and is most abundant by buildings and other areas that catch moisture.

2009

2011

2012

2013

2014

2015

2016

2017

***Polycarpon tetraphyllum*
(Caryophyllaceae)
Polycarpon (Non-native)**

Not observed in 2017.

A few plants were first observed at the MSSC, where it has persisted in low numbers in the same general area.

2009

2011

2014

2016

Pseudognaphalium sandwicensium var. *sandwicensium* (Asteraceae)
Ena ena (Native: Endemic)

Observed in multiple locations this survey.

The retention basin location continues to persist. Elsewhere at HO this silver herb appears more ephemeral.

2014

2015

2016

2017

Pteridium aquilinum var. *decompositum* (Hypolepidaceae)
Bracken fern (Native: Endemic)

Not observed this survey.

It had previously been growing near the Faulkes telescope (now operated by Las Cumbres Observatory). First recorded in 2009, where it was growing under a concrete ledge in a moist protected spot. It has not been observed since 2014.

2009

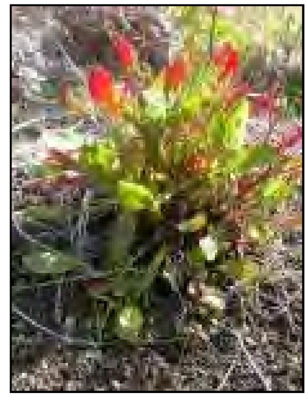
2011

2012

2013

2014

Rumex acetosella (Polygonaceae)
Sheep sorrel (Non-native)



Not observed this survey.

In the past, a small patch of this plant was persisting near Mees.

2009

2013

2014

Senecio madagascariensis (Asteraceae)
Fireweed (Non-native)

Fireweed continues to be more abundant at HO than in the early survey years.

A similar increase in fireweed over the past few years has also occurred in nearby Haleakala National Park.

2011

2013

2015

2016

2017

Senecio sylvaticus (Asteraceae)
Common groundsel (Non-native)

As with the related fireweed, common groundsel has increased in abundance in recent years.

2011

2016

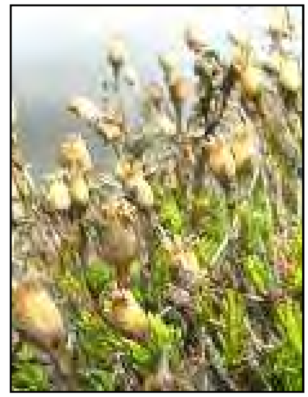
2017

Senecio vulgaris (Asteraceae)
Common groundsel (Non-native)

Not observed this survey.

Similar to the related *Senecio sylvaticus*.

Silene struthioloides (Caryophyllaceae) Catchfly (Native: Endemic)



Seven plants were observed this survey, an increase from previous years. All were very small, and found in the same spot where a lone plant was first observed near Mees in 2009.

2009

2015

2016

2017

Sonchus oleraceus (Asteraceae)
Sow thistle (Non-native)

One plant observed this survey, near the Neutron Monitoring Station.

This short-lived species has been sporadically found in low numbers over the years at HO.

2009

2011

2013

2017

Taraxacum officinale (Asteraceae)
Common dandelion (Non-native)

This cosmopolitan herb remains common around MSSS and to a lesser extent other areas of HO, mostly near buildings and other areas where the plant is likely getting extra moisture.

2009

2011

2012

2013

2014

2015

2016

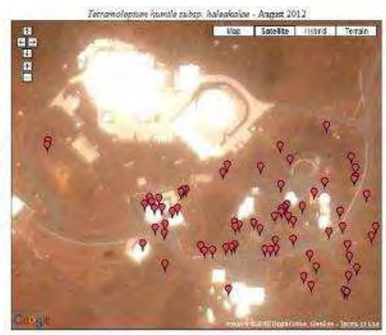
2017

Tetramolopium humile subsp. *haleakalae* (Asteraceae)
Tetramolopium (Native: Endemic)

Still present over most of the site, though less abundant now in areas affected by construction. This hearty native herb may return to some of these sites when construction is completed.

2009

2011



2012

2013

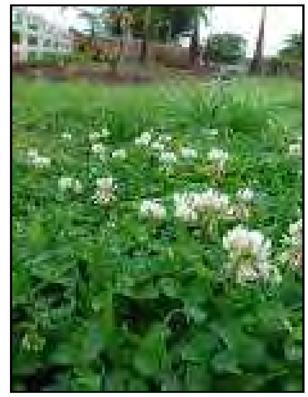
2014

2015

2016

2017

Trifolium repens (Fabaceae)
White clover (Non-native)



Observed near Mees, in the same general area it has occurred before.

First observed at HO in 2009.

2009

2011

2012

2016

2017

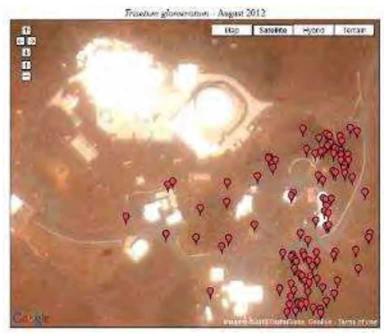
Trisetum glomeratum (Poaceae)
Pili uka (Native: Endemic)

This native grass remains common over much of the site, in the least disturbed areas.

There has been some decrease in abundance due to construction, though this hardy grass many recolonize some of the areas once construction is completed.

2009

2011



2012

2013

2014

2015

2016

2017

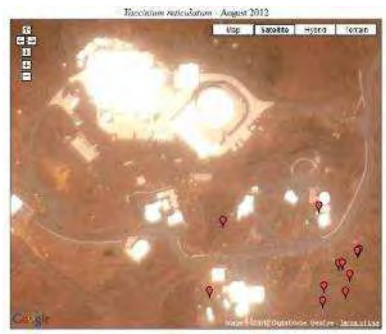
Vaccinium reticulatum (Ericaceae)
‘Ōhelo (Native: Endemic)

Occasionally found in the less disturbed rocky outcrops near Mees and Pan-STARRS.

The distribution has remained rather stable over the past few years.

2009

2011



2012

2013

2014

2015

2016

2017

Veronica arvensis (Plantaginaceae)
Corn speedwell (Non-Native)

Not observed in 2017.

Previously, dozens of small plants were observed on the northern part of the Air Force property, located in a cinder planter near the buildings.

Observed for the first time at HO in the MSSC area in 2015.

2015

2016

Vicia sativa (Fabaceae)
Vetch (Non-native)

Not observed this survey.

First observed in 2005 near Mees. The area has been affected by construction activities and the species has not been observed in recent surveys.

2009

2011

Vulpia spp. (Poaceae) Non-Native
Vulpia bromoides (Brome fescue)
Vulpia myuros (Rat tail fescue)

Present around MSSC and Mees.

Vulpia bromoides is similar to *V. myuros*, which also occurs at HO, and is virtually indistinguishable without a microscope, especially when young. Because of this, the two species are lumped for mapping and management purposes.

2009

2011

2012

2013

2014

2015

2016

2017

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YEARLY REPORT
THREATENED AND ENDANGERED PLANT SPECIES
PERMIT P-200

Prepared by:
Forest Starr & Kim Starr

Prepared for:
Department of Land and Natural Resources

November 2017

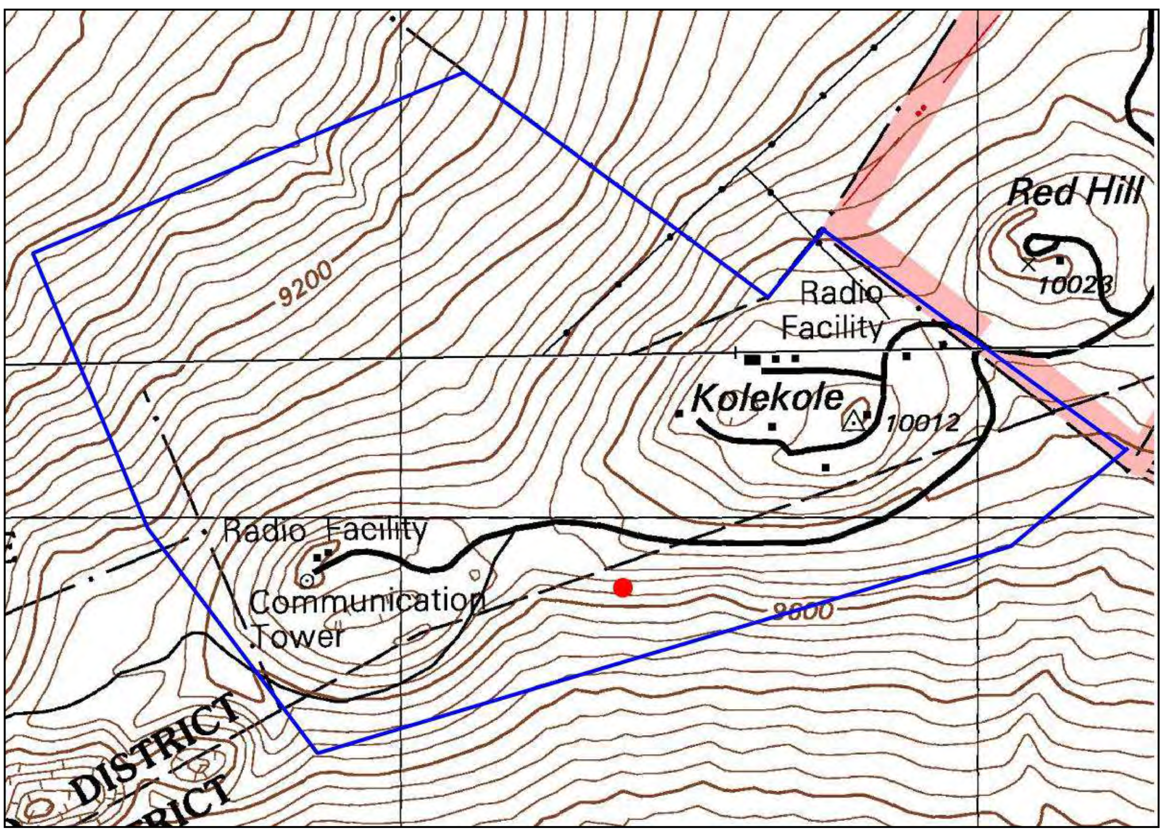
OVERVIEW

This report details recent activity for the Threatened and Endangered Plant Species Permit P-200 (to collect, possess, propagate, and outplant for the purpose of conservation *Argyroxiphium sandwicense* subsp. *macrocephalum* - Haleakalā Silversword) obtained from the Department of Land and Natural Resources Division of Forestry and Wildlife.

Activities over the past year (November 2016 - November 2017) included monitoring planted silverswords.

LOCATION

The seed collection and outplanting site (red dot) resides within the recently fenced Daniel K. Inouye Solar Telescope (DKIST) conservation area (blue line) near the summit of Haleakalā, at about 9,650 ft. elevation.



Silversword seed collection and outplanting site (red dot), within recently fenced conservation area (blue line).

SEED COLLECTION

Seed was collected in 2014 from the only known wild population of silverswords within the DKIST Conservation Exclosure, a cluster of just a few plants near Skyline Drive.

Thankfully numerous plants were in flower, which allowed for cross-pollination between plants resulting in higher seed viability rates.

About 800 seeds were collected, which, despite some native insect damage, were enough to propagate 300+ silversword plants.

Detailed information about the seed collection event can be found in the Hawaii Rare Plant Group (HRPRG) field data form submitted with the 2014 annual report.

Seeds collected on November 18, 2014 for propagation and outplanting.

PROPAGATION

Seeds were transferred to HALE staff who propagated and grew them in the high-elevation greenhouse within HALE at 7000 ft. Germination rates were good, the plants were well cared for, and the roots had filled out the four inch pots by the time of planting. Pre-planting sanitation measures were taken before planting.

Plants not utilized in the DKIST planting were planted by HALE staff in previously developed areas of high visitation sites within HALE, such as overlooks and visitor centers. Park rangers included school groups and other members of the public during planting, to foster support for this species and conservation in general.

Silverswords ready for planting, HALE greenhouse. December 8, 2015.

OUTPLANTING

Outplanting of 306 silverswords occurred on December 8, 2015. The silverswords were planted in the same location the seeds were collected from. We were assisted by two DKIST staff and one HALE staff.

Plants were placed in clusters, with a meter or so between plants. This planting pattern should help maximize potential for cross pollination, viable seeds, and future plant recruitment. All plants were watered, tagged, measured, and had GPS points taken.

Detailed information about each plant can be found in the HRPRG field data form for the 2015 planting event.

Planting silverswords in DKIST conservation exclosure. December 8, 2015.

MONITORING

The planted silverswords were monitored on November 2, 2017. At the two year mark, 79% (243) of the planted silverswords remain alive, similar to outplantings in HALE.

Detailed information on the status of each of the silverswords can be found in the HRPRG field data form for the 2017 monitoring event.

Silverswords in conservation exclosure, one year after planting. November 2, 2016.

FUTURE

Renewal of permit is requested for the coming year.

Future activities will include the final monitoring in fall 2018. Along with identifying any threats that arise, a portion of the monitoring data (live crown diameter) will be incorporated into similar data being collected within HALE, to compare outplanting survival and growth rates in different parts of subalpine East Maui.

FAUNAL SURVEY
& ANNUAL INSPECTION
HALEAKALĀ OBSERVATORIES
FALL 2017

Prepared for:
KC Environmental
Maui, Hawaii

Prepared by:
Forest Starr & Kim Starr
Starr Environmental
Maui, Hawaii

November 2017

OVERVIEW

The Daniel K. Inouye Solar Telescope (DKIST) is an optical telescope facility nearing completion. It is 41.5 meters (136 ft) tall, and will house a 4-meter (13.1 ft) telescope designed to provide insights about the sun.

In accordance with the Final Environmental Impact Statement (FEIS) (NSF 2009), semi-annual programmatic monitoring has been implemented during construction, which began in 2012. In addition to the semi-annual surveys required by the FEIS during construction, pursuant to the DKIST approved Habitat Conservation Plan (HCP) (NSF 2010) and published Biological Opinion (BO) (USFWS 2011), an annual inspection for invasive species in the DKIST interior facilities and grounds within 30 m (100 feet) of the buildings will be conducted and will continue after construction to ensure impacts on biological resources from DKIST are minimized.

FAUNAL SURVEY

Monitoring includes field observations at Haleakalā High Altitude Observatories Site (HO) and selected areas of the Haleakalā National Park (HALE) Park road corridor for faunal presence, e.g., scat, tracks, eaten plants, etc.

This document reports on the faunal surveys within HO.

ANNUAL INSPECTION

In accordance with the DKIST HCP and BO, an annual inspection for invasive species will be conducted.

DKIST facilities and grounds within 30 m (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.

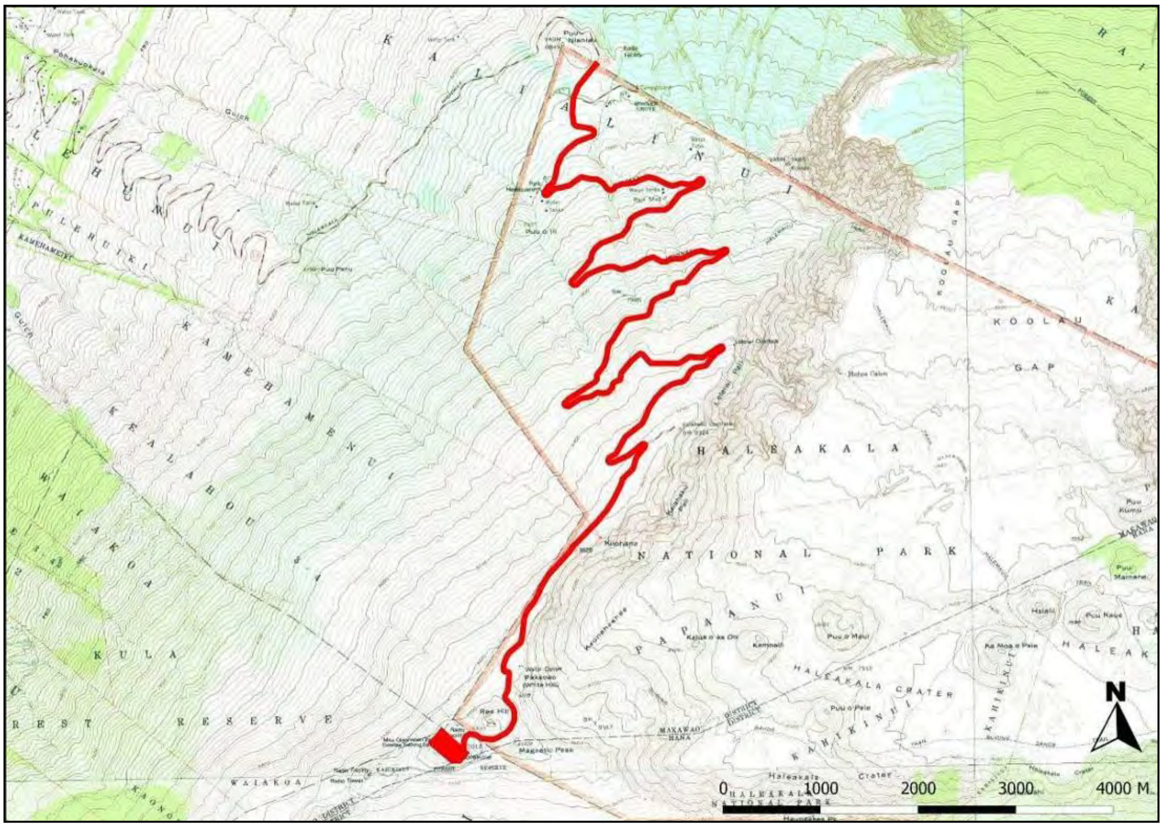
This document also reports on the faunal inspection of HO.

PROJECT LOCATION

The DKIST construction site is approximately 0.75 acres on TMK 22-200-7008 (HO), an 18.166 acre parcel located near the summit of Haleakalā, largely within Pu`u Kolekole.

Additionally, about 17 km (11 miles) of paved road utilized for construction and operation of DKIST travels through HALE.

HO is the focus of this survey.



HO and road through HALE.

BIOLOGICAL SETTING

HO is located near the summit of Haleakalā, at 2999-3052 m (9840-10,012 ft) elevation.

Average annual rainfall is a moderate 1037 mm (41 in), occurring primarily during the winter months from November through March (Giambelluca et al. 2013).

Temperatures can be cold at the site, and occasionally dip below freezing, with average annual temperature at the summit of Haleakalā ranging from 43-50 degrees F (6-10 degrees C), and once every few years it will snow (County of Maui 1998).

The soils are volcanic, a mixture of ash, cinders, pumice, and lava (RTS 2002).

Vegetation at HO is relatively sparse, a mix of native and non-native plants.

Open terrain, with sparse, low growing vegetation at entrance to HO.

METHODOLOGY

HO was surveyed on November 2, 2017.

FAUNAL SURVEY

Five point count stations were established within the survey area, at prominent locations with good visibility. Counts last ten minutes. All birds observed or heard for an unlimited distance are recorded. Signs of native and non-native mammals are searched for, such as scat, tracks, carcasses, or browsing. Mammals are also listened for. Additionally, any incidental sightings within HO are recorded.

ANNUAL INSPECTION

To minimize the likelihood of an invasive species introduction, DKIST interior facilities and grounds within 100 ft (30 m) of the buildings are thoroughly inspected on an ongoing annual basis for non-native species that may have eluded the cargo and luggage (load) inspections. Any newly-discovered non-native, invasive plant or animal will be photo documented, mapped, and described.

BATS

An ultrasonic bat detector was placed near the cinder parking lot at the entrance to HO from November 2-10, 2017

Monitoring point count station at HO.

RESULTS / DISCUSSION

BIRDS

Though we did not personally observe them, we did see pictures taken of two Red-billed Leiothrix (*Leiothrix lutea*) at HO. We also heard reports from numerous workers on site of the birds. They had been at HO for about a week.

This appears to happen annually this time of year, with young Red-billed Leiothrix dispersing from their normal forest habitat and ending up at the summit.

Hawaiian Petrel (*Pterodroma sandwichensis*) burrows continue to be present at the site, and resource management personnel informed us the birds were in the process of fledging.

PREDATORS

No predators or signs of their presence were observed at HO.

A number of predator control stations maintained by DKIST resource management personnel were observed at and near HO.

UNGULATES

No new scat or other signs of ungulates were observed.

Old ungulate scat, likely goat (*Capra hircus*), is still present at HO, mostly on the steep northern slope of the property. It continues to decay and become less prevalent, now that an ungulate fence has been erected around HO as part of the HCP and BO.

BATS

No bat calls were detected during eight nights of monitoring.

ANNUAL INSPECTION

No signs of non-native invasive animal species were found inside or within 30 m (100 ft) of the DKIST buildings.

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FAUNAL SURVEY
HALEAKALĀ OBSERVATORIES
SPRING 2017

Prepared for:
KC Environmental
Maui, Hawai'i

Prepared by:
Forest Starr & Kim Starr
Starr Environmental
Maui, Hawai'i

May 2017

OVERVIEW

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In accordance with the Final Environmental Impact Statement (NSF 2009), programmatic monitoring has been implemented during construction, which began in 2012. Annual inspection for invasive species in the DKIST interior facilities and grounds within 30 m (100 feet) of the buildings will continue after construction to ensure impacts on biological resources from DKIST are minimized.

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This document reports on the faunal surveys within HO.

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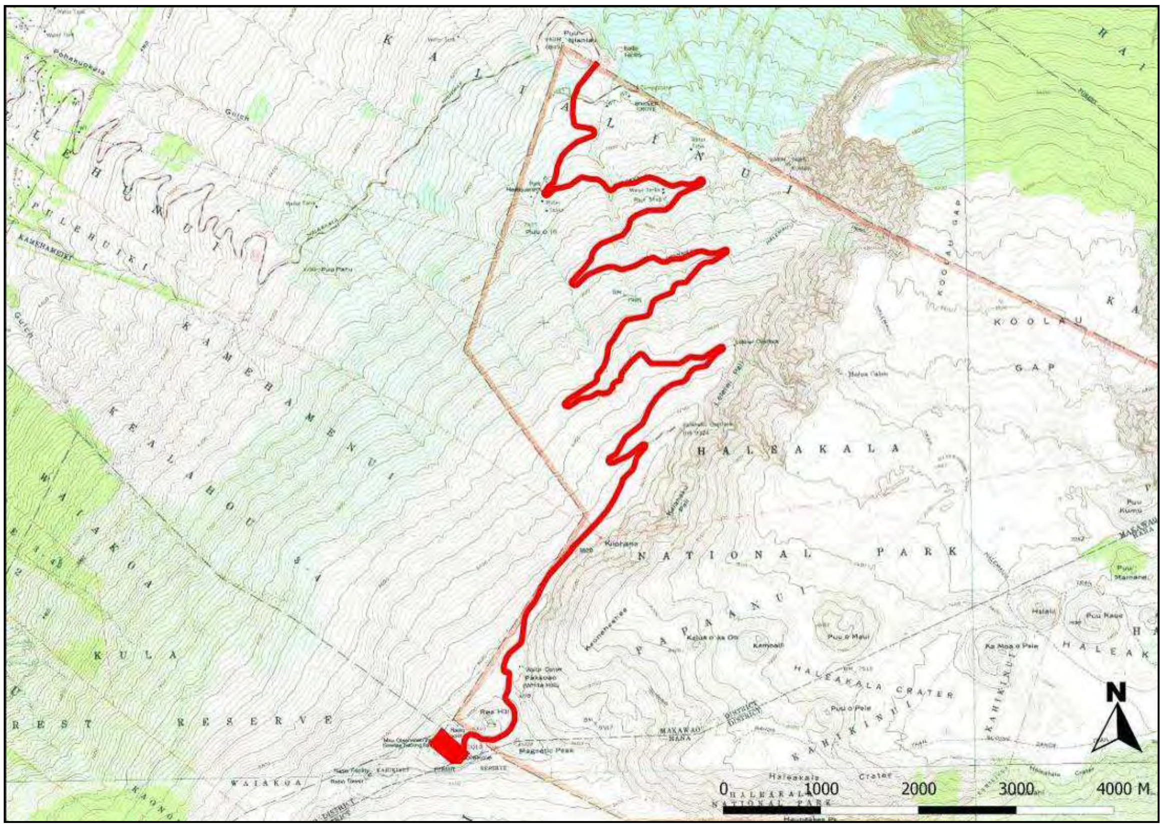
The DKIST construction site is approximately 0.75 acres on TMK 22-200-7008 (HO), an 18.166 acre parcel located near the summit of Haleakalā, largely within Pu`u Kolekole.

Additionally, about 17 km (11 miles) of paved road utilized for construction and operation of DKIST travels through HALE.

HO is the focus of this survey.



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Temperatures can be cold at the site, and occasionally dip below freezing, with average annual temperature at the summit of Haleakalā ranging from 43-50 degrees F (6-10 degrees C), and once every few years it will snow (County of Maui 1998).

The soils are volcanic, a mixture of ash, cinders, pumice, and lava (RTS 2002).

Vegetation at HO is relatively sparse, a mix of native and non-native plants.

Open terrain, with sparse, low growing vegetation at entrance to HO.

METHODOLOGY

HO was surveyed on May 3, 2017.

FAUNAL SURVEY

Five point count stations were established within the survey area, at prominent locations with good visibility. Counts last ten minutes. All birds observed or heard for an unlimited distance are recorded. Signs of native and non-native mammals are searched for, such as scat, tracks, carcasses, or browsing. Mammals are also listened for. Additionally, any incidental sightings within HO are recorded.

BATS

An ultrasonic bat detector was placed near the cinder parking lot at the entrance to HO from May 3-5, 2017

Monitoring point count station at HO.

RESULTS / DISCUSSION

BIRDS

No birds were observed or heard at HO this survey.

Hawaiian Petrel (*Pterodroma sandwichensis*) burrows continue to be observed at the site, as part of our survey, along with fresh scat.

PREDATORS

No predators or signs of their presence were observed at HO.

UNGULATES

No new scat or other signs of ungulates were observed.

Old ungulate scat, likely goat (*Capra hircus*), is still present at HO, mostly on the steep northern slope of the property. It continues to decay and become less prevalent, now that an ungulate fence has been in place around HO since November 2013, as part of the compliance for the HCP and BO.

BATS

Four bat pulses were detected near HO on one night.

The pulses were predominantly long, horizontal, and lower frequency, suggesting a bat transiting through the area, located in the saddle between two cinder cones.

REFERENCES

Giambelluca, T.W., Q. Chen, A.G. Frazier, J.P. Price, Y.-L. Chen, P.-S. Chu, J.K. Eischeid, and D.M. Delparte, 2013: Online Rainfall Atlas of Hawaiʻi. *Bull. Amer. Meteor.* Soc. 94, 313-316, doi: 10.1175/BAMS-D-11-00228.1. (April 2013) http://rainfall.geography.hawaii.edu/.

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Invasive plant control at Haleakala High Altitude Observatory Site (HO) for 2017

Arthur C. Medeiros Ph.D. (artcmedeiros@gmail.com)

Report submitted: May 31, 2017

This year, utilizing low-pressure backpack sprayers, approximately 7 gallons of 1.0% glyphosate-water mix was selectively applied to invasive plant species at the Haleakala High Altitude Observatory Site (HO) on Saturday May 27, 2017. Weather conditions were near ideal, being sunny, cloudless, and with low wind speeds shifting over the day from southwest to north. All identifiable invasive plants located in close-spaced multiple sweeps were removed or treated. It is estimated that 98-99% of all invasive plants within the project site were located this year and treated.

The Haleakala High Altitude Observatory Site (HO) consists of relatively intact native shrublands and rocklands as well as a variety of disturbed habitats. Native shrublands and rocklands of HO currently support low levels of invasive plant species, both in abundance and species diversity. After multiple years of invasive plant control, native shrublands and rocklands of HO are now more weed-free than equivalent areas of adjacent Haleakala National Park especially in regard to Chilean evening primrose (*Oenothera stricta stricta*), gosmore (*Hypochoeris radicata*), and various non-native grasses.

Disturbed areas of HO, especially compacted sites, however often have significant cover and marked diversity of invasive plant species. The most problematic of these are: *Oxalis corniculata, Poa pratensis, Erodium cicutarium, Bromus catharticus, Hypochoeris radicata*, and *Vulpia* sp. I estimate that at least 60% of all individuals controlled in invasive plant species management efforts this year belong to the single species redstem filaree (*Erodium cicutarium*).

Diversity of invasive plant species at HO also appears to be increasing through propagule ingress, whether natural or human-assisted. For example, this year (2017) was the first time I encountered *Conyza canadensis* commonly at the HO site with several sizeable individuals treated in scattered locales.

Worthy of note, at the southern boundary of the HO site, in an area formerly dominated by the non-native *Medicago lupulina* is a naturally occurring and expanding population of the rare endemic subshrub *Silene struthiolodes*. I was surprised by this successful recovery trajectory considering the steady decline of this uncommon species elsewhere on upper Haleakala.

Silene struthioloides (Caryophyllaceae), rare Hawaiian subshrub increasing at HO.

In terms of my efforts this year, all persons engaged in mechanical and herbicidal control this year were experienced, then briefed, trained, and field-tested in regional flora of upper elevations of Haleakala volcano to be able to confidently differentiate between native and non-native species. All participants have completed Safety and Environmental Compliance coursework. Boots, work equipment, and personal gear were cleaned and brushed prior to arrival on-site to ensure gear was free of seeds of imported non-native plants.

DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY
(AFMC)

20 Dec 2017

Memorandum for the Record

SUBJECT: Maui Space Surveillance Complex located within the Haleakalā High Altitude Observatory (HO) Invasive Plant Control Report (Reporting Period 1 Nov 2016 to 31 Oct 2017)

1. The Air Force Research Laboratory (AFRL) Directed Energy Directorate, Detachment 15, Maui HI occupies 4.4 acres within the HO. The AFRL manages this property IAW Lease Agreement, AF instructions and guidance AFI 32-7064 and incompliance with DoD, State and Federal laws. Detachment 15 follows an Integrated Natural Resources Management Plan and Integrated Pest Management Plan to assist the installation commander with the conservation and rehabilitation of natural resources where practical. The specific requirements of the INRMP are:

a. Ensure populations of threatened and endangered species on or near the site are protected and managed in compliance with the Endangered Species Act of 1973, as amended (ESA);

b. Foster an atmosphere of coordination and cooperation with the U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and Hawaii Department of Land and Natural Resources (DLNR) to inventory, map, and preserve endangered species on or near the site;

c. Prevent the introduction or spread of invasive species to the summit area. The sparse vegetation of the site limits grounds maintenance to periodic cleanup and removal of noxious weeds growing around buildings and paved areas. AFRL does not use herbicides for invasive species control, relying only one mechanical treatment methods and there is a semi-annual pickup of loose trash around the site.

d. Any contractor working at the MSSC is required to take the following measures to prevent construction or repair activities from introducing new species:

1) Any equipment, supplies, and containers with construction materials that originate from elsewhere (e.g., the other islands or the mainland) must be checked for infestation by unwanted species by a qualified biologist or agricultural inspector prior to being transported to the summit. All construction vehicles that will be used off paved surfaces must be steam cleaned/pressure washed before they travel or are transported through Haleakalā National Park. All construction and maintenance contracts include provisions for the contractors to comply with IfA HOMP and site environmental requirements.

2) Importation of fill material to the site is prohibited, unless such fill (e.g., sand) is sterilized to remove seeds, larvae, insects, and other biota that could survive at HO and propagate. All material obtained from excavation is to remain on Haleakalā. Surplus excavated cinders, soil, etc., is to be offered to other agencies located at the summit or Haleakalā National Park.

3) Contractors are required to participate in HO-approved pre-construction briefings to inform workers of the damage that can be done by unwanted introductions. Satisfactory fulfillment of this requirement can be evidenced by a signed certification from the contractor.

4) Parking of heavy equipment and storage of construction materials outside the immediate confines of HO property is prohibited.

5) Contractors are required to remove construction trash frequently, particularly materials that could serve as a food source that would increase the population of mice and rats that prey on native species.

2. During this reporting period AFRL conducted an Environmental Compliance Assessment of the MSSC site. The Integrated Natural Resource Management Plan (INRMP) for the Maui Space Surveillance Complex (MSSC) dated July 2016, the Draft Integrated Pest Management Plan and the controls for invasive procedures were evaluated. No findings related to improper management of natural resources or invasive species were discovered.

3. If you have any questions regarding AFRL/Det 15 invasive species control please contact Mr. Jim Gardner at 808-891-7748 or Mr. Joe Volza at 505-846-4050.

MICHELLE L. HEDRICK, DR-IV
Lead Test & Environmental Engineer