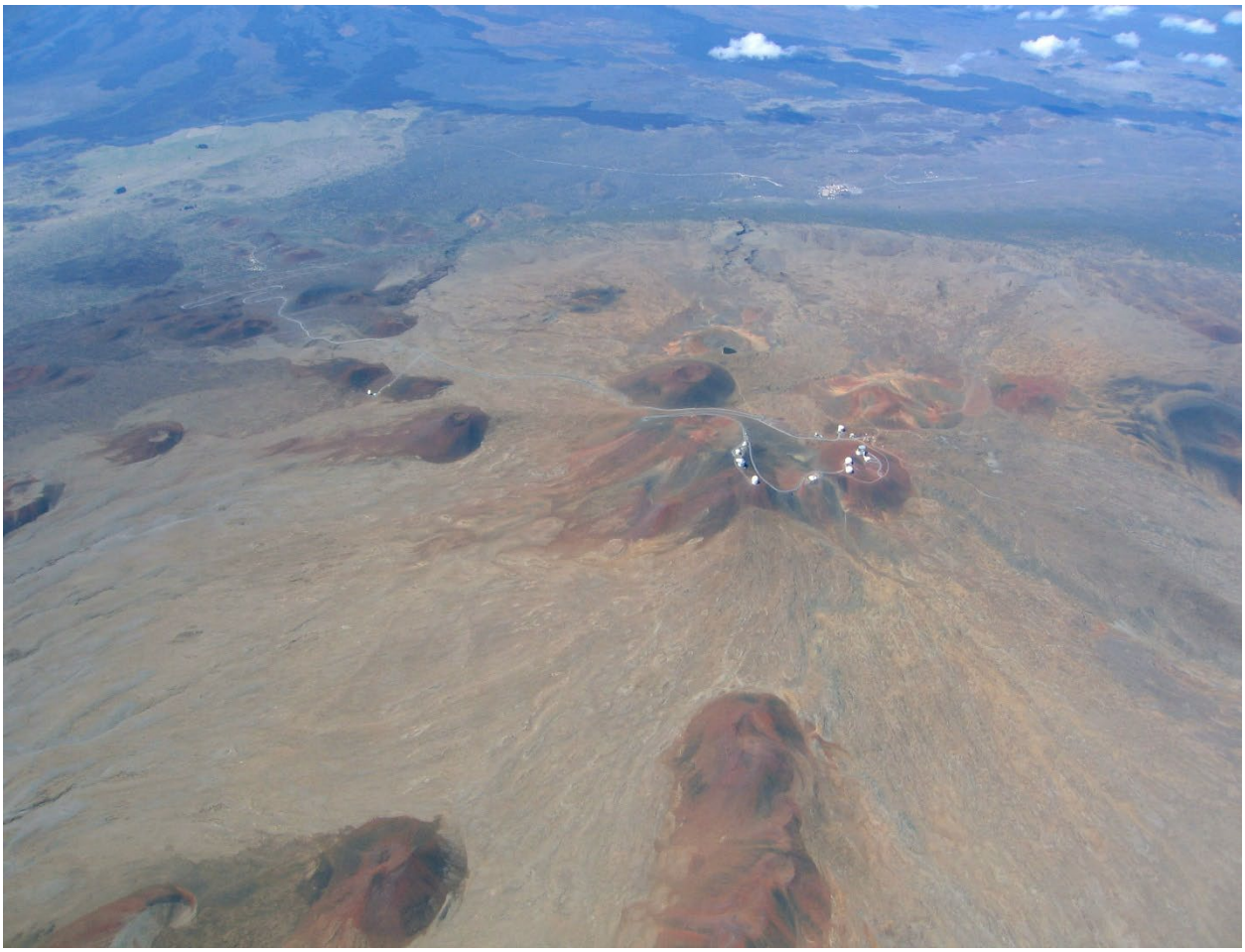
2015 Invasive & Native Species Monitoring Report



Prevention, early detection, monitoring, rapid response, & control

OFFICE OF MAUNAKEA MANAGEMENT

Prepared By: Darcy Yogi, Jessica Kirkpatrick, & Fritz Klasner

August 20, 2021

TABLE OF CONTENTS

Executive Summary 5
Introduction 6
Prevention 6
Delivery & Equipment Inspections 6
Study Area 6
Methods 6
Results & Discussion 7
Routine Site Inspections 7
Study Area 8
Methods 8
Results & Discussion 8
Early Detection Monitoring 9
Facility Surveys 10
Study Area 10
Methods 10
Results & Discussion 10
Conclusion 19
Rotating Panel Surveys 20
Study Area 20
Methods 20
Results & Discussion 20
Conclusion 23
Annual Alien Invertebrate Monitoring 24
Introduction 24
Study Area 24
Methods 24
Results & Discussion 25
Conclusion 40
Incidental Early Detection 41
Introduction 41
Study Area 41
Methods 41

Results and Discussion 41
Native & Established Species Monitoring 42
Annual Wēkiu Bug Monitoring 42
Introduction 42
Study Area 43
Methods 43
Results and Discussion 43
Analysis 46
Conclusion 47
Honey Bee Monitoring 48
Introduction 48
Study Site 48
Methods 48
Results and Discussion 48
Vertebrate Monitoring 49
Introduction 49
Study Site 49
Methods 49
Results and Discussion 50
Rapid Response 51
Case 1: Ochetellus glaber 52
Management Recommendations 52
Case 2: Ochetellus glaber, Tapinoma melanocephalum, & Cardiocondyla kagutsuchi 52
Management Recommendations 53
Case 3: Invasive Arthropod Inspection for Concrete Barriers at HP 53
Management Recommendations 53
Control 53
Vegetation Control 54
Introduction 54
Study Area 54
Methods 54
Results and Discussion 54
Conclusion 56

Arthropod Control....57
Cardiocondyla kagutsuchi....57
Introduction....57
Study Area....57
Methods....57
Results & Discussion....57
Acknowledgements....57
References....59
Appendices....60
Appendix A: UH Management Areas....61
Appendix B: 2015 Annual Survey Maps....62
Appendix C: 2015 Annual Survey Trap Locations*....73
Appendix D: 2015 Wēkiu Bug Capture Data....76
Appendix E: Wēkiu Bug Abundance Map....79
Appendix F: Wēkiu Bug Capture Rate Map....80
Appendix G: 2015 Annual Survey Capture List....81
Appendix H: Introduction and Distribution of *Ochetellus glaber* in the Maunakea Forest Reserve on Maunakea, Hawaii- Report – 2015....84
Appendix I: Introduction and Distribution of *Ochetellus glaber*, *Tapinoma melanocephalum*, & *Cardiocondyla kagutsuchi* at Halepōhaku on Maunakea, Hawaii – Report – 2015....92
Appendix J: Invasive Arthropod Inspection Report for Concrete Barriers at Halepōhaku....102

EXECUTIVE SUMMARY

The Office of Maunakea Management (OMKM) manages State of Hawai'i owned lands leased to the University of Hawai'i (UH) on Maunakea, Hawai'i. This management area includes the Mauna Kea Science Reserve (MKSR), Astronomy Precinct, mid-level facilities at Halepōhaku (HP), and the Summit Access Road Corridor, encompassing a total of 11,288 acres (Appendix A). The 2009 Comprehensive Management Plan (CMP) is the guiding management document and provides policy framework for UH to address measures to protect the cultural, natural, research, and recreational resources on UH managed lands. The Natural Resources Management Plan (NRMP), a sub-plan of the CMP, addresses the threats from and potential impacts of non-native plants, animals, and diseases to the natural resources on Maunakea. The NRMP requires an Invasive Species Management Program/plan (ISMP) to prevent, detect, monitor, respond to, and control any new and established invasive species within the Management Area. This report documents invasive species actions conducted under the ISMP as well as native species monitoring in the 2015 calendar year.

Sections in this report include *Prevention*, *Early Detection*, *Native & Established Species Monitoring*, *Rapid Response*, and *Control*. During the 2015 year, 60 invasive species inspections were conducted for equipment and supplies traversing to UH managed lands; 111 sites were monitored for invasive and native species (3,151 arthropods were captured, 1,606 of which were wēkiu bugs that were captured and released); over 300 invasive species facility traps were placed and retrieved; and 155 historic property sites (rotating panel surveys) were monitored for invasive species and trash.

NOTE

The Thirty Meter Telescope (TMT) Conservation District Use Permit (CDUP) requires monitoring of invasive species at the TMT site, its access way, the Batch Plant parking lot, and Halepōhaku locations where TMT activity occurs. TMT contracted the Big Island Invasive Species Committee (BIISC) to implement prevention efforts and monitor invasive species at TMT activity locations. As specified in the CDUP, monitoring efforts are conducted frequently at TMT activity locations and mirror OMKM's prevention and monitoring methods. Data from BIISC/ TMT CDUP compliance efforts are included in this report but are displayed as separate tables in most cases.

INTRODUCTION

The Maunakea Invasive Species Management Plan (ISMP) was approved by the Maunakea Management Board [MKMB) in February 2015. Although the plan was approved in 2015, OMKM began implementation in 2013. Thus, 2015 is the third full year of ISMP implementation. This report documents implementation of protocols that have been finalized and protocols that are under final review.

Sections in this report emphasize plant, vertebrate, and invertebrate threats. These threats are explained in detail in *SOP D: Maunakea Plant Threats, Identification, Collection, & Processing Guide*; *SOP B: Maunakea Vertebrate Threats, Identification, Collection, & Processing Guide*; and *SOP C: Maunakea Invertebrate Threats, Identification, Collection, & Processing Guide,* respectively. Wēkiu bug and alien invertebrate monitoring are a continuation of work previously conducted by the Bernice Pauahi Bishop Museum.

PREVENTION

Preventative measures are the first line of defense for invasive species management on Maunakea. Prevention procedures for plants and arthropods are part of a comprehensive effort to identify and analyze the risk associated with potential invasion pathways. Management actions include inspection requirements and strict sanitation procedures for contractors and staff throughout UH managed lands. The main purpose of these inspections is to reduce the risk of introducing new invasive species on Maunakea. This section documents, in summary, all delivery and equipment inspections and all site inspections conducted in 2015. Sanitation guidelines are found in the ISMP. Rapid response activities, described later in this report, ensure that new invasive species are treated swiftly and appropriately when found.

Delivery & Equipment Inspections

Delivery and equipment inspections are conducted to ensure that the delivery, materials, supplies, and vehicle(s) are clean and free of animal (including arthropods), plant, and earthen materials.

Study Area

A little over 50% of all inspections occurred in or around Hilo at delivery base yards and facility warehouses. All other inspections occurred in Kona, Waimea, or were conducted online via email. Examples of inspected items include low-boy trailers, solar panels, various lifts (fork or scissor), chillers, and general research supplies and equipment.

Methods

Inspections are done by visual observation and, in some cases, baiting. Specific inspection methods vary depending on the item. For example, pallets and crates require a closer look at the underside, corners, and crevices. Larger vehicles, machinery, and equipment inspections focus on dirt-collecting areas such as wheel wells, tires, mudflaps, and inside the cab underneath the floor mat. Bait is used when delivery item(s) are stored outdoors for more than four days. Peanut butter, jelly, and spam on index cards are left out for at least 15 minutes and observed for invertebrate activity. After an inspection is completed, concerns are reported to the entity that requested the inspection.

Most concerns can be handled on site by staff and only require subsequent self-inspection, but some situations require a re-inspection after remediations are completed.

Results & Discussion

A total of 60 inspections were conducted in 2015 by Department of Land and Natural Resources (DLNR)-approved biological inspectors. All inspections were conducted by OMKM except for one TMT inspection, which was completed by BIISC. Of the 60 inspections, 18 required remediation, and 3 were rejected until more extensive remediation could be carried out. Most remediations were due to evidence of ants, spiders, or earthen materials on the inspected cargo or machinery. For all inspections that required remediation, corrective action was taken (pressure wash, vacuum, pesticide treatment, etc.) and subsequent inspection was passed. Below is a table that displays the number of inspections for each facility for 2015. Some facilities did not require inspections this year.

2015 Invasive Species Inspections

Facility	Inspection Area	Inspection Locations	Number of Inspections
MKSS/VIS	Kona	Kona Lua, Island Top Soil, Lowe's	5
	Hilo	Hawai'i Petroleum, AirGas	
Gemini	Hilo	Allied Machinery, Conen's Royal Hawaiian Movers, Foreign Trade Zone	9
IRTF	NA	NA	0
CFHT	Waimea	CFHT facility	3
	Hilo	Aloha Air Cargo	
Keck	Waimea	Keck facility (in person & virtual)	14
	Hilo	Conen's	
Subaru	Hilo	Subaru facility	17
SMA	NA	NA	0
CSO	Hilo	CSO facility, Air Freight Services, Aloha Air Cargo, KonaTrans	4
JCMT	NA	NA	0
UKIRT	NA	NA	0
UH88	Hilo	IFA building	1
UH24	NA	NA	0
VLBA	Hilo	Conen's, Allied Machinery	4
TMT	Hilo	Hawai'i Petroleum, Island Wide Fencing	3
	Kona	Goodfellows Bros, DeLuz Trucking	

Routine Site Inspections

Site inspections are conducted to ensure that entities that make regular deliveries to UH managed lands (i.e. Kona Lua, water truck, etc.) are effectively controlling invasive species throughout their baseyard (where equipment or materials are stored for delivery). OMKM also confirms that these entities understand the invasive species protocols and requirements for deliveries to Maunakea. Unlike delivery and equipment inspections, a DLNR inspection is not required for each individual delivery from these entities.

Study Area

Site inspections occur at any locations where equipment for entities that make regular deliveries to Maunakea is stored. In 2015, site inspections were conducted for Island Top Soil in Kawaihae, Kona Lua in Kona, Hawai'i Petroleum in Hilo, and Airgas in Hilo.

Methods

Site inspections are more comprehensive than delivery and equipment inspections. These inspections include documentation of vegetation and invertebrates around the site and discussion of sanitation, landscaping and invasive species policies with site managers. OMKM staff place attractant baits and conduct visual inspections throughout the premises (which may include warehouses, parking lots, trash receptacles, vehicles, equipment, etc.) to document invertebrates, vegetation, general cleanliness, facility upkeep, and any other potential concerns. About 20 index cards baited with peanut butter, jelly, and spam are placed throughout each site. Baited cards are retrieved after ~20 minutes and are observed for invertebrate activity. Analogous to delivery and equipment inspections, vehicles and equipment within the site are also inspected for animal, plant, and earthen materials. OMKM also takes the opportunity to educate site managers about standard operating procedures and policies for routine deliveries to Maunakea.

Once the site inspection is complete, OMKM staff compile a report that is provided to the site manager. Site inspection reports include the purpose of the site inspection, general site notes, issues with the site (if any), and management recommendations for any issues observed during the inspection. Site inspections typically occur annually for all entities that make routine deliveries to Maunakea. All management recommendations provided in the site inspection report are examined for implementation during future site re-inspections.

Results & Discussion

This was the first year of implementation for routine site inspections and, therefore, practices and policies are still evolving. A total of four site inspections were conducted by OMKM staff in 2015 (these inspections are included under the MKSS/VIS facility in the *2015 Invasive Species Inspections* table above). It was not possible to visit every relevant site in 2015, but OMKM will inspect additional sites next year and will continue annual re-inspections.

Six different ant species were detected during these site inspections, with the tropical fire ant, *Solenopsis geminate*, being the most common. Vegetation was observed at each site but did not pose a high threat as populations were low and manageable. Below is a table that displays general observations and management recommendations for each site.

2015 Routine Site Inspections

Observations	Island Top Soil, Kawaihae	Kona Luas, Kona	Hawai'i Petroleum, Hilo	Airgas, Hilo
Baseyard	Unpaved, high salt concentration	Paved, mostly weed-free	Gravel, mostly weed-free	Paved, mostly un-vegetated, clean and organized
Sanitation policies	Vehicles are pressure washed & cleaned inside with each trip	Vehicles and luas are cleaned with each trip	Drivers responsible for vehicle cleaning with raise incentive	Strict sanitation policies, vehicles cleaned regularly
Current treatments	None	Monthly treatment for pests and weeds	Regular treatment for weeds	Regular Orkin treatment
Observed vegetation (threats)	Kiawe trees (*Prosopis pallida*)	False koa (*Leucaena leucocephala*), Fountain grass (*Pennisetum cetaceum*)	Common grasses, Christmas berry (*Schinus terebinthifolius*)	Sporadic non-native herbs and mosses
Observed arthropods (threats)	Singapore ant (*Trichomyrmex destructor)*	Black house ant (*Ochetellus glaber*), Tropical fire ant (*Solenopsis geminata)*	*Pheidole morens*, *Brachymyrmex obscurior,* Tropical fire ant (*Solenopsis geminata)*	Little fire ant (*Wasmannia auropunctata*)
Potential impacts of arthropod threats	Pest to electrical systems, will nest inside power sources	Black house ant will bite humans and nest in buildings; the tropical fire ant stings and can damage irrigation	*P.morens* and *B.obscurior* are widespread pest species; the tropical fire ant stings and can damage irrigation systems	Tramp ant, nest anywhere, highly invasive, stings animals and humans
Recommendations	Periodic treatment for ants using Amdro or Talstar® insecticide (or similar)	Continue current treatments	Continue current treatment, also add regular treatment for arthropod pests	Continue current treatments, also add treatment for little fire ant using granular baits, seek further education from Hawai'i Ant Lab

EARLY DETECTION MONITORING

An early detection monitoring system provides the opportunity to prevent wide-spread establishment of new invasive species on UH managed lands, whether they are new to the island or encroaching from lower elevations. In the case of species new to the island, early detection decreases the likelihood of dispersal out of UH managed lands. Early detection methods directed toward management activities are linked to regular monitoring activities (see the *Monitoring* section below) and are necessary for effective management. The goals of the early detection program are to detect and prioritize control for new invasive plant and animal species before they become established on UH managed lands. In 2015, early detection efforts emphasize the following taxonomic groups: invertebrates, plants, and vertebrates. In future years we anticipate refining our focus within these existing taxa. Early Detection monitoring is divided into 4 main sections: *Facility Surveys, Rotating Panel Surveys, Annual Alien Arthropod Surveys,* and *Incidental Early Detection*.

Facility Surveys

Study Area

Facility monitoring occurred in all facilities on UH managed lands. In the Maunakea Science Reserve (MKSR), traps were placed in all 12 telescope facilities (most facilities have 2 or more traps), the Summit Lunchroom, the Batch Plant parking lot, and the Thirty Meter Telescope construction site (surveys conducted by BIISC). At Halepōhaku (HP), traps were placed in the commons building (including the kitchen), dorm buildings, maintenance building, parking lots, the Visitor Information Station (VIS), the ranger station, and the VIS storage warehouse and presentation room.

Methods

The main purpose of facility trap surveys is to detect new invertebrate species in or around facilities, the primary concern being ants. Identifications of all arthropod specimens collected during the 2015 year were made to the lowest possible taxonomic unit necessary to determine whether the species was a threat.

Facility monitoring includes indoor and outdoor sticky traps and perimeter searches. OMKM uses HoyHoy® cockroach sticky traps that are cut in half and baited with Spam® (protein), jelly (carbohydrate), and peanut butter (lipid). Baited sticky traps are placed in areas such as lounge rooms, loading bays, near dumpsters and trash or recycling bins, parking lots, and any other areas with human activity and food. Outdoor traps are placed outside facilities with a plastic container placed over the trap for weather protection. Six facility traps in the HP commons and kitchen areas are present throughout the year, replaced monthly, while all other HP and MKSR facility traps (63 traps total) are placed quarterly and retrieved within one week whenever possible.

In 2015, quarterly facility traps were placed in February, May, August, and November. Perimeter searches are conducted to augment our invasive species detection efforts and occur on a quarterly basis concurrent with facility trapping. These searches are conducted around all HP facilities and parking lots and include hand searches, invasive weed pulls, and baiting with peanut butter, jelly, and spam vials. The removal of invasive plants along with the placement of baited vials is an effective way to detect ants. See *SOP 10: Invasive Invertebrate Early Detection Surveys of Facilities* for more details on facility trapping.

Thirty Meter Telescope (TMT) biological monitoring compliance surveys occurred weekly and monthly using facility trap methods and annual arthropod monitoring methods (see the *Monitoring* section below for annual monitoring methods).

Results and Discussion

In 2015, 300 facility traps were placed and retrieved. Inside and outside facility traps captured around 3,626 arthropod individuals in 16 taxonomic orders[1]. Outside traps also captured two house mice (*Mus musculus*) and a single flea (Siphonaptera). 2015 perimeter searches detected 25 arthropod taxa (18 potential threats), 1 mollusk, and 7 invasive plant species (some plants have

[1] Some upper-level taxonomy has changed; all arthropod taxonomic groups displayed in this report are consistent with the State of Hawai'i arthropod resource list (Nishida 2002).

been established for quite some time). Four arthropod threat species, *C. kagutsuchi, O. glaber, T. melanocephalum,* and *A. mellifera*, required further management action (see *Arthropod Control, Rapid Response*, and *Honey bee Monitoring* sections, respectively). No new threats were identified during TMT compliance surveys. See http://www.malamamaunakea.org/ for the TMT biological moniotoring report.

Below is a summary table followed by a list of arthropods captured in the MKSR, at HP, and at the TMT site as part of its monitoring compliance[2]. Invertebrate threats are identified in **bold** font and shaded rows identify new records[3]. New record threats are **shaded with bold font**. Nativity can either be non-native, native, or non-native & native within that taxonomic group.

Facility Trap Summary Table

Facility type and location	Arthropod Individuals Captured	Unique Taxonomic Orders Identified
Inside Facilities -MKSR	166	6
Outside Facilities- MKSR	446	9
Inside Facilities- HP	1,190	14
Outside Facilities- HP	1,824	14
Totals	**3,626**	**16**

Mauna Kea Science Reserve Facilities- Capture List

Inside Facility Traps			
Order	**Family**	***Genus & Species***	**Nativity**
Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**
Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
Diptera	Calliphoridae	*Unknown*	Non-Native
Diptera	Chloropidae	*Unknown*	Non-Native
Diptera	Drosophilidae	*Unknown*	Non-Native & Native
Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
Diptera	Phoridae	*Unknown*	Non-Native & Native
Diptera	Sciaridae	*Unknown*	Non-Native & Native
Diptera	Sepsidae	*Unknown*	Non-Native
Hemiptera	Lygaeidae	*Geocoris pallens*	Non-Native
Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
Hemiptera	Lygaeidae	*Nysius terrestris*	Native
Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
Hemiptera	Miridae	*Lygus elisus*	Non-Native
Homoptera	Aphididae	*Unknown*	Non-Native
Homoptera	Psyllidae	*Unknown*	Non-Native & Native
Hymenoptera	**Encyrtidae**	***Unknown***	**Non-Native & Native**
Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Outside Facility Traps			
Order	**Family**	***Genus & Species***	**Nativity**

[2] TMT Compliance results are summarized separately in this report.
[3] New record captures to the Management Area.

Araneae	**Clubionidae**	***Unknown***	**Non-Native**
Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**
Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
Coleoptera	Tenebrionidae	*Tribolium sp.*	Non-Native
Collembola	Entomobryidae	*Unknown*	Non-Native & Native
Collembola	Unknown	*Unknown*	Non-Native & Native
Diptera	Agromyzidae	*Unknown*	Non-Native & Native
Diptera	Calliphoridae	*Unknown*	Non-Native
Diptera	Chloropidae	*Unknown*	Non-Native
Diptera	Drosophilidae	*Unknown*	Non-Native & Native
Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
Diptera	Phoridae	*Unknown*	Non-Native & Native
Diptera	Psychodidae	*Unknown*	Non-Native & Native
Diptera	Sciaridae	*Unknown*	Non-Native & Native
Diptera	Sepsidae	*Unknown*	Non-Native
Diptera	Unknown	*Unknown*	Non-Native & Native
Hemiptera	Lygaeidae	*Geocoris pallens*	Non-Native
Hemiptera	Lygaeidae	*Geocoris sp.*	Non-Native
Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	Non-Native
Hemiptera	Lygaeidae	*Nysius blackburni*	Native
Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
Hemiptera	Lygaeidae	*Nysius terrestris*	Native
Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
Hemiptera	Miridae	*Lygus elisus*	Non-Native
Hemiptera	Unknown	*Unknown*	Non-Native & Native
Homoptera	Aphididae	*Unknown*	Non-Native
Homoptera	Psyllidae	*Unknown*	Non-Native & Native
Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
Hymenoptera	**Encyrtidae**	***Unknown***	**Non-Native & Native**
Hymenoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**
Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Thysanoptera	Thripidae	*Unknown*	Unknown

Halepōhaku Facilities- Capture List

Inside Facility Traps			
Order	**Family**	***Genus & Species***	**Nativity**
Acari	Unknown	*Unknown*	Non-Native & Native
Acari	Bdellidae	*Unknown*	Non-Native & Native
Araneae	**Agelenidae**	***Unknown***	**Non-Native**
Araneae	**Clubionidae**	***Unknown***	**Non-Native**
Araneae	**Corinnidae**[4]	***Unknown***	**Unknown**
Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**
Araneae	**Unknown**	***Unknown***	**Non-Native & Native**

[4] The State of Hawai'i arthropod resource list (Nishida 2002) does not list the family Corinnidae; however, taxonomy for the family Corinnidae has changed and some species that were in the family Clubionidae are now in Corinnidae.

Blattodea	Blattellidae	*Blattella germanica*	Non-Native
Coleoptera	**Carabidae**	***Laemostenus complanatus***	**Non-Native**
Coleoptera	Cerambycidae	*Plagithmysus blackburni*	Native
Coleoptera	**Cryptophagidae**	***Henoticus serratus***	**Non-Native**
Coleoptera	**Tenebrionidae**	***Tribolium***	**Non-Native**
Coleoptera	**Unknown**	***Unknown***	**Non-Native & Native**
Collembola	Entomobryidae	*Unknown*	Non-Native & Native
Collembola	Neanuridae	*Unknown*	Unknown
Collembola	Unknown	*Unknown*	Non-Native & Native
Dermaptera	Forficulidae	*Forficula auricularia*	Non-Native
Diptera	Calliphoridae	*Unknown*	Non-Native
Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
Diptera	Phoridae	*Unknown*	Non-Native & Native
Diptera	Psychodidae	*Unknown*	Non-Native & Native
Diptera	Sarcophagidae	*Unknown*	Non-Native
Diptera	Sciaridae	*Unknown*	Non-Native & Native
Diptera	Unknown	*Unknown*	Non-Native & Native
Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
Hemiptera	Lygaeidae	*Nysius coenosulus*	Native
Homoptera	Aphididae	*Unknown*	Non-Native
Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
Hymenoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**
Lepidoptera	Noctuidae	*Agrotis spp.*	Non-Native & Native
Lepidoptera	Tineidae	*Unknown*	Non-Native
Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Thysanoptera	Thripidae	*Unknown*	Unknown
Outside Facility Traps			
Order	**Family**	***Genus & Species***	**Nativity**
Acari	Unknown	*Unknown*	Non-Native & Native
Araneae	**Agelenidae**	***Unknown***	**Non- Native**
Araneae	**Clubionidae**	***Unknown***	**Non- Native**
Araneae	**Corinnidae**	***Unknown***	**Unknown**
Araneae	**Gnaphosidae**	***Unknown***	**Non- Native**
Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**
Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
Coleoptera	**Anobiidae**	***Lasioderma serricorne***[5]	**Non- Native**
Coleoptera	**Carabidae**	***Trechus obtusus***	**Non- Native**
Coleoptera	**Carabidae**	***Laemostenus complanatus***	**Non- Native**
Coleoptera	Coccinellidae	*Hippodamia convergens*	Non- Native
Coleoptera	**Tenebrionidae**	***Tribolium sp.***	**Non- Native**
Collembola	Entomobryidae	*Unknown*	Non-Native & Native
Collembola	Neanuridae	*Unknown*	Non-Native & Native
Collembola	Unknown	*Unknown*	Non-Native & Native
Dermaptera	Forficulidae	*Forficula auricularia*	Non- Native
Diptera	Agromyzidae	*Unknown*	Non-Native & Native
Diptera	Calliphoridae	*Unknown*	Non- Native
Diptera	Drosophilidae	*Unknown*	Non-Native & Native

[5] The family Anobiidae has been captured on UH managed lands, but had not been identified to the species level until 2015.

Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
Diptera	Sciaridae	*Unknown*	Non-Native & Native
Diptera	Unknown	*Unknown*	Non-Native & Native
Hemiptera	Geocoridae	*Geocoris sp.*	Non- Native
Hemiptera	Lygaeidae	*Nysius palor*	Non- Native
Hemiptera	Lygaeidae	*Nysius terrestris*	Native
Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
Hemiptera	Miridae	*Coridromius variegatus*	Non- Native
Hemiptera	Miridae	*Orthotylus sophoricola*	Native
Homoptera	Aphididae	*Unknown*	Non- Native
Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
Hymenoptera	**Unknown**	***Unknown***	**Non-Native & Native**
Lepidoptera	Tortricidae	*Cydia sp.*	Non-Native & Native
Lithobiomorpha	Lithobiidae	*Lithobius sp.*	Non-Native & Native
Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Siphonoptera	Unknown	*Unknown*	Non- Native

The table below displays invertebrate species not commonly observed during facility perimeter searches that were seen in 2015. Species that are common or frequently observed were not recorded during perimeter searches. The invertebrate table shows the order, family, genus & species, and the locality in which they were found, as well as their nativity. Invertebrate threats are identified in **bold** font and shaded rows identify new records[6]. New record threats are **shaded with bold font**. Nativity can either be non-native, native, or non-native & native within the taxonomic group.

Invertebrates Observed During Perimeter Searches

Order	Family	*Genus & Species*	Locality	Nativity
Araneae	**Araneidae**	***Neoscona spp.***	Halepōhaku	Non- Native
Araneae	**Clubionidae**	***Unknown***	Halepōhaku	Non- Native
Araneae	**Corinnidae**	***Corinna spp.***	Halepōhaku	Non- Native
Araneae	**Theridiidae**	***Steatoda spp.***[7]	Halepōhaku	Non- Native
Araneae	**Unknown**	***Unknown***	Halepōhaku	Non-Native & Native
Araneae	**Gnaphosidae**	***Unknown***	Halepōhaku	Non- Native
Araneae	**Linyphiidae**	***Unknown***	Halepōhaku	Non-Native & Native
Coleoptera	**Carabidae**	***Laemostenus complanatus***	Halepōhaku	Non- Native
Coleoptera	**Carabidae**	***Trechus obtusus***	Halepōhaku	Non- Native
Coleoptera	**Unknown**	***unknown***	Halepōhaku	Non-Native & Native
Hemiptera	Geocoridae	*Geocoris pallens*	Halepōhaku	Non- Native
Hemiptera	Lygaeidae	*Unknown*	Halepōhaku	Non-Native & Native
Hemiptera	Lygaeidae	*Nysius communis*	Halepōhaku	Native
Hemiptera	Rhopalidae	*Liorhyssus hyalinus*	Halepōhaku	Non- Native
Hymenoptera	**Apidae**	***Apis mellifera***	Halepōhaku	Non- Native
Hymenoptera	**Braconidae**	***Unknown***	Halepōhaku	Non-Native & Native
Hymenoptera	**Ichneumonidae**	***Unknown***	Halepōhaku	Non-Native & Native

[6] New record captures to the Management Area.
[7] The family Theridiidae has been captured on UH managed lands, but has not been identified to the genus level until 2015.

Hymenoptera	**Formicidae**	***Cardiocondyla kagutsuchi***	Halepōhaku	Non- Native
Hymenoptera	**Formicidae**	***Ochetellus glaber***	Maunakea Forest Reserve	Non- Native
Hymenoptera	**Formicidae**	***Tapinoma melanocephalum***	Halepōhaku	Non- Native
Hymenoptera	**Vespidae**	***Vespula pensylvanica***	Halepōhaku	Non- Native
Isopoda	Unknown	*Unknown*	Halepōhaku	Non-Native & Native
Lithobiomorpha	**Lithobiidae**	***Lithobius spp.***	Halepōhaku	Non-Native & Native
Odonata	Aeshnidae	*Anax junius*	Halepōhaku	Native
Stylommatophora	Vitrinidae	*Vitrina tenella*	Halepōhaku	Native

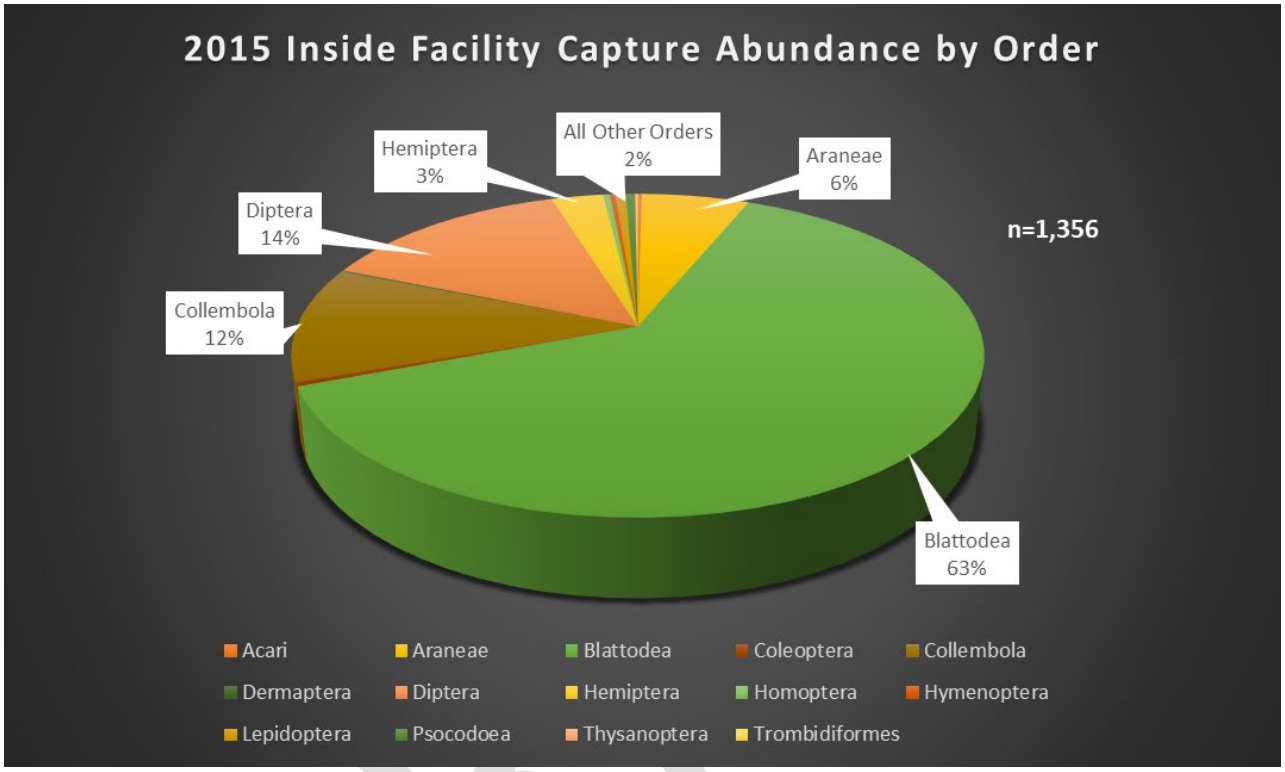
The table below displays vegetation observed during facility perimeter searches that is new or is of "high risk" (defined as a score >7 as determined by the Hawai'i Pacific Weed Risk Assessment [HPWRA]) to the UH management area. The vegetation table shows the genus and species, common name, and area in which they were found. Common vegetation of low HPWRA risk was not recorded. See *SOP D: Maunakea Plant Threats, Identification, Collection and Processing Guide* for plants on UH managed lands. All non-established plant threats at Halepōhaku (*B. pilosa, F. vulgare, G. pulchella,* and *M. parviflora*) were removed, and all plant threats in the Maunakea Science Reserve (MKSR) were removed.

New and High-Risk Vegetation Observed During Perimeter Searches

Genus & Species	Common Name	HPWRA Score	Halepōhaku	MKSR
Bidens pilosa	Spanish needle	23	X	
Foeniculum vulgare	Fennel	19	X	
Gaillardia pulchella	Indian blanket	None	X	
Malva parviflora	Cheeseweed	None	X	
Rumex acetosella	Sheep sorrel	18	X	
Senecio madagascariensis	Fireweed	23	X	X
Taraxacum officinale	Common dandelion	20		X

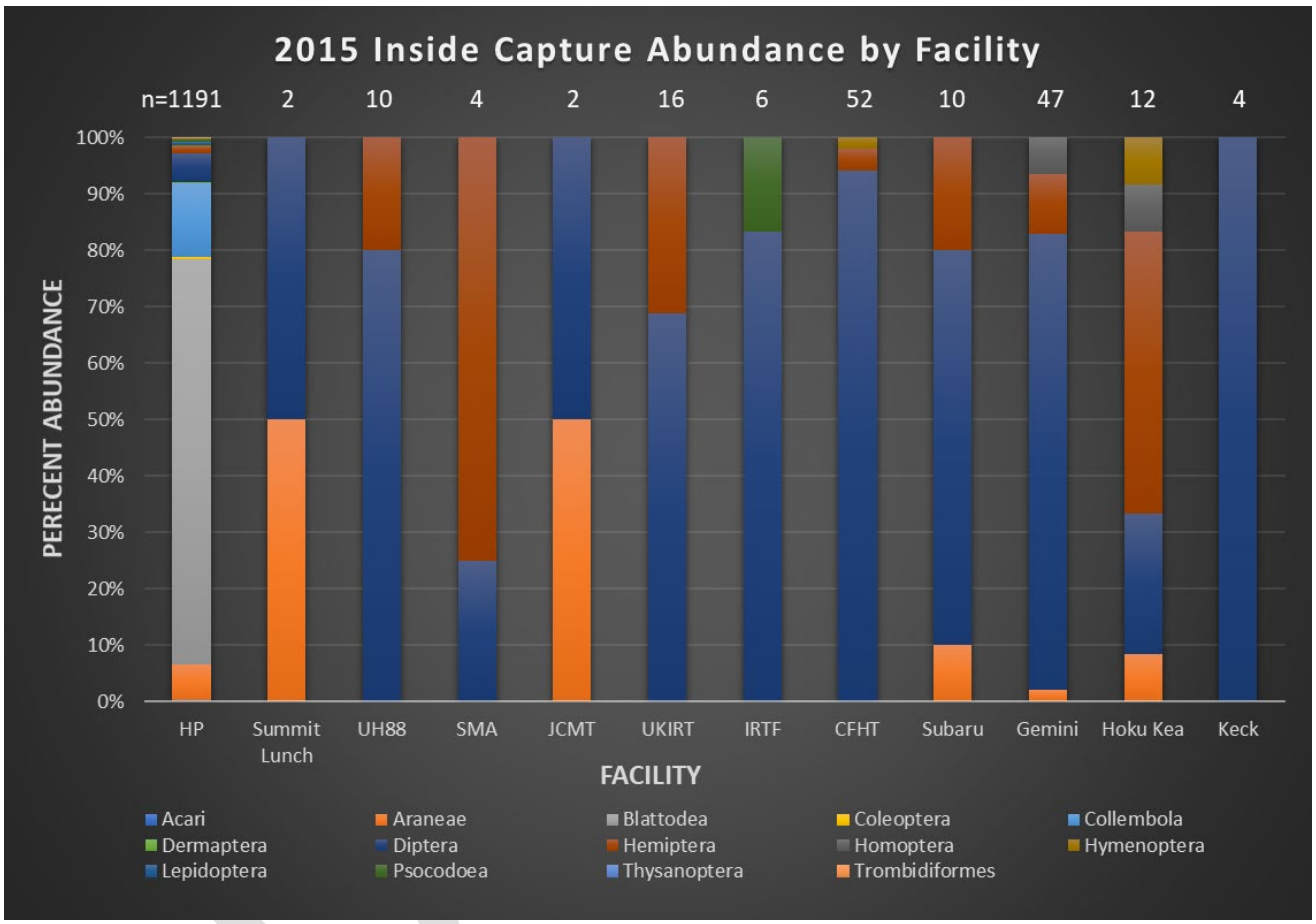
Inside Facility Capture Abundance by Order

The pie chart below shows the capture abundance by order for all traps placed inside facilities in the MKSR and HP. The majority of individuals captured inside facilities were cockroaches (Blattodea), flies (Diptera), and springtails (Collembola). All cockroaches (854) were captured at HP. The "n" in the upper right is the total number of individuals captured inside facilities (1,356).



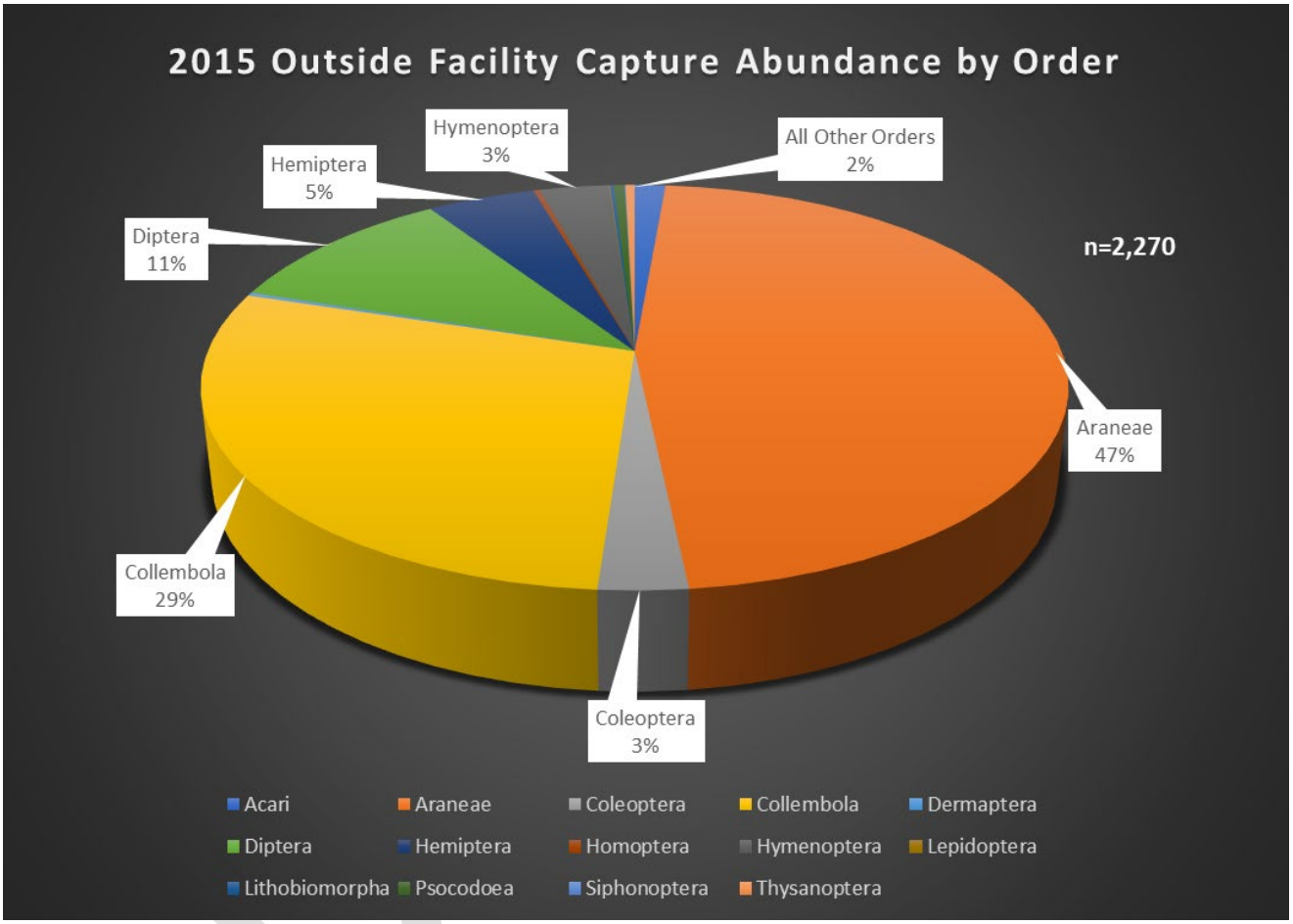
Inside Facility Capture Abundance by Facility

The graph below shows the percentage of individuals (displayed as arthropod orders) captured in each facility. HP facilities captured the most individuals and had the greatest diversity of orders (13 orders) compared to the MKSR (6 orders). Cockroaches (Blattodea), accounted for about 70% of all captures at HP. The most common orders in MKSR facilities were true bugs (Hemiptera), flies (Diptera), and spiders (Araneae). The number of individuals, "n", for each facility is displayed above each bar. No arthropods were captured at CSO or VLBA in 2015.



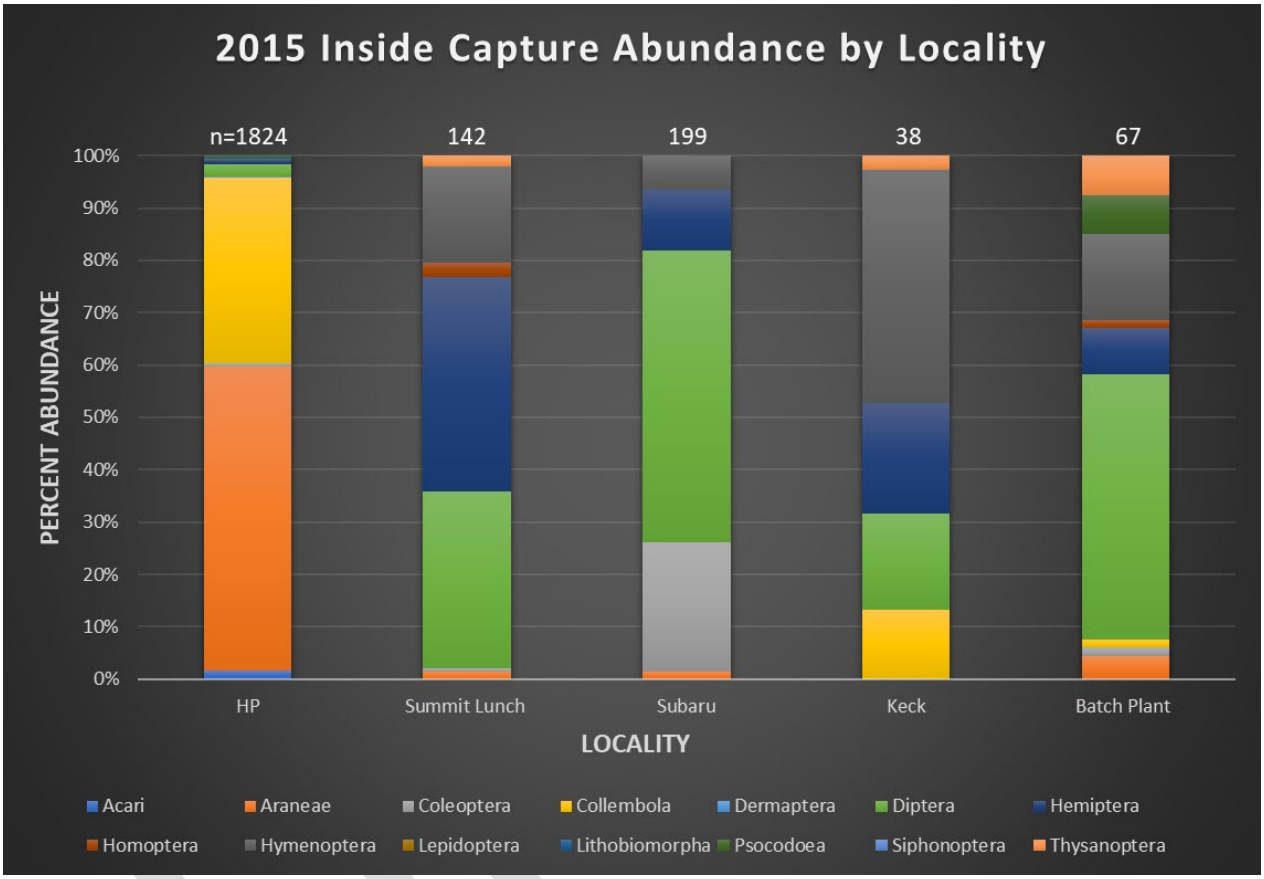
Outside Facility Capture Abundance by Order

The pie chart below shows the capture abundance by order for all traps placed outside facilities in the MKSR and HP. The majority of individuals captured outside facilities were spiders (Aranae), though 1,000 of these were newly hatched spiderlings found on a single trap (August HP trap near the Common Building propane tank). Springtails (Collembola) and flies (Diptera) were also quite abundant. The "n" in the upper right of the chart is the total number of individuals captured outside facilities.



Outside Facility Capture Abundance by Locality

The graph below shows the percentage of individuals (displayed as arthropod orders) captured outside at each locality (most traps are outside of facilities; batch plant is a parking lot). The majority of arthropods captured outside HP were mites (Acari) and springtails (Collembola) whereas the MKSR localities mainly captured flies, true bugs (Hemiptera), and wasps (Hymenoptera). The number of individuals, "n" for each locality is displayed above each bar.



Conclusion

Inside facility traps captured a total of 1,356 arthropod individuals in 14 orders; the majority of captures were cockroaches, flies, and springtails. Outside facility traps captured a total of 2,270 arthropod individuals in 14 orders; the majority of captures were spiders, springtails, and flies. Halepōhaku traps captured the greatest diversity and highest abundance of arthropods when compared to facilities in the Maunakea Science Reserve. Perimeter searches detected four arthropod species threats that required further management action (see *Arthropod Control, Rapid Response*, and *Honey bee Monitoring* sections), and four new plant species threats were removed.

Rotating Panel Surveys

Study Area

Plant and invertebrate early detection surveys are conducted concurrently with State-mandated historic property monitoring; these surveys occur on a rotating panel basis. Rotating panel sites are monitored yearly, every 3 years, or every 5 years. In 2015, a total of 155 historic property sites were monitored for invasive species in the Astronomy Precinct, Maunakea Science Reserve and Halepōhaku parcels. The 2015 surveys included the yearly sites and the 3-year sites, which were not visited in 2014 as planned, due to health and safety concerns. Specific site locations are not disclosed for cultural resource protection. The map below shows the 2015 rotating panel monitoring locations[8] that were surveyed for invasive plants and invertebrates.

Methods

The 2015 rotating panel surveys occurred from July 13th-17th, August 10th-18th, and September 21st-24th. The main purpose of plant and invertebrate early detection surveys is to detect, document, and monitor invasive species threats at historic properties. All collected invertebrates were identified to the lowest possible taxonomic unit necessary to determine if the species was a threat.

Invertebrates

At each site, four vials baited with Spam®, jelly, and peanut butter were placed and a 5-10 minute hand search (overturning rocks and visual inspection) was conducted within a 5 meter radius of each historic property site. Vials were placed in four opposing directions around the site for 5-15 minutes and then observed for invertebrates. All known invertebrates observed were recorded and released and unknown specimens were collected and identified in the lab.

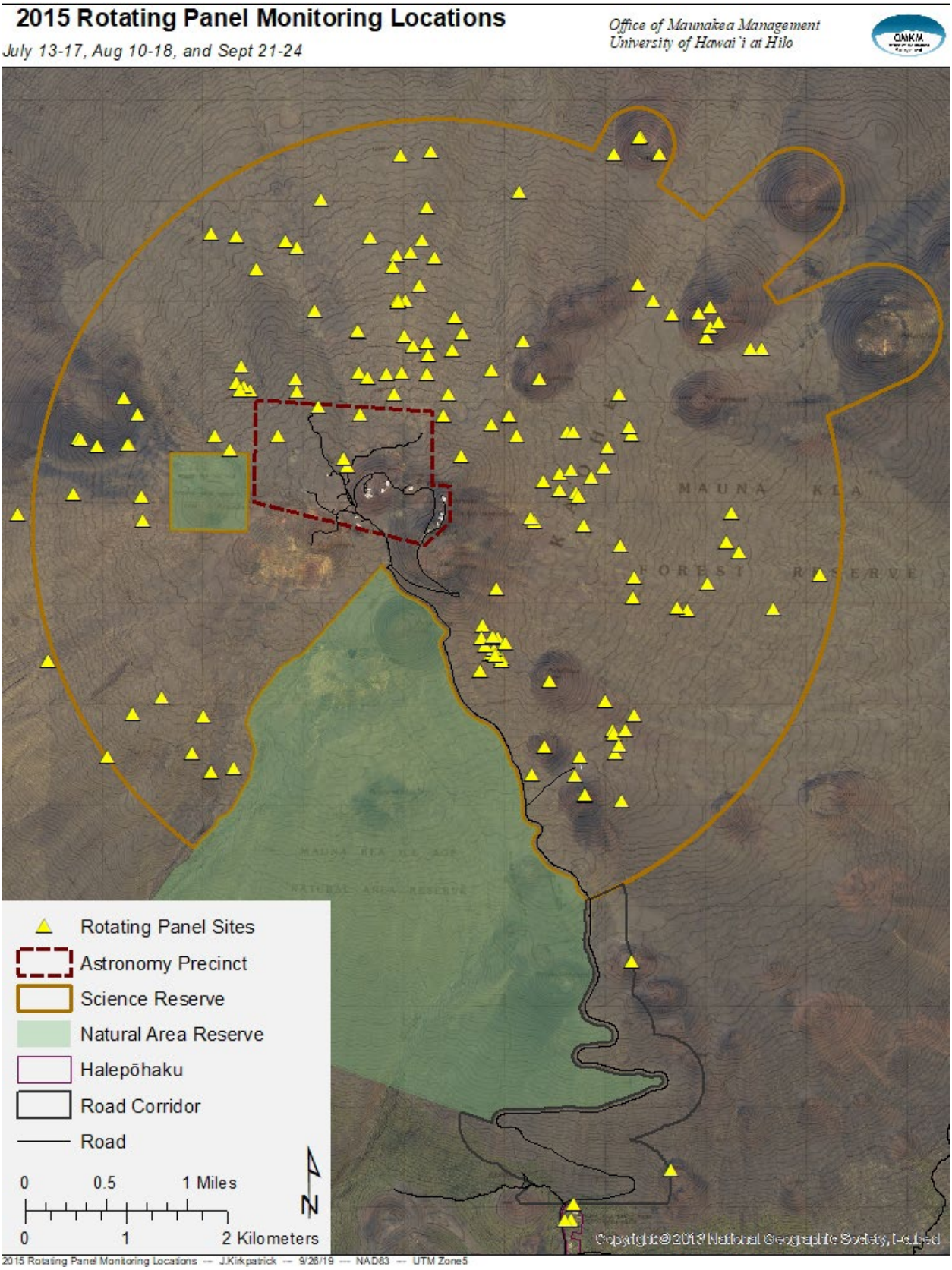
Vegetation

Vegetation within a 5 meter radius of each site was observed and recorded. Invasive vegetation was pulled, documented, and disposed of off-site. The roots of pulled plants were carefully inspected for ants and other potential invertebrate threats. All vegetation, including native plants, lichens[9], and mosses, were recorded.

Results & Discussion

During the 2015 rotating panel surveys, one new-record non-threat invertebrate (Pyralidae, snout moth) was observed in the Science Reserve. No new vegetation or invertebrate threats were identified. The majority of invertebrates observed during the rotating panel surveys include bottle and hover flies (Calliphoridae, Syrphidae), ladybeetles (*H. convergens & C. septempunctata)*, Hawaiian wolf spiders (*L. hawaiiensis*), and seed bugs (*N. palor*). Most of the vegetation observed were native species including Hawai'i bentgrass (*A. sandwicensis)*, Pili uka (*T. glomeratum*), 'iwa'iwa (*A. adiantum-nigrum*), and Douglas' bladderfern (*C. douglasii*). Fireweed (*S. madagascariensis*) was the most common invasive species observed, and these individuals were removed along with other invasive weeds when observed.

[8] There were 5 Site ID numbers on the field datasheets that could not be confirmed. The species observed for those unidentifiable sites are included in the data set shown below. There may also be up to 5 additional sites that were monitored that are not displayed on the map.
[9] Lichen and moss color was recorded in the field because we do not have the expertise to confidently identify lichen or moss species.


2015 Rotating Panel Monitoring Locations
July 13-17, Aug 10-18, and Sept 21-24
Office of Maunakea Management
University of Hawai`i at Hilo
Rotating Panel Sites
Astronomy Precinct
Science Reserve
Natural Area Reserve
Halepōhaku
Road Corridor
Road
0 0.5 1 Miles
0 1 2 Kilometers
N
2015 Rotating Panel Monitoring Locations -- J.Kirkpatrick -- 9/26/19 -- NAD83 -- UTM Zone5

Below are species lists of invertebrates and vegetation observed during the rotating panel surveys. Invertebrate observations include both hand search and baited vial observations. Invertebrate and vegetation threats are identified in **bold** font and shaded rows identify new records[10].

2015 Observed Invertebrate List

Order	Family	*Genus & Species*	Nativity
Acari	Unknown	*Unknown*	Non-Native & Native
Araneae	**Clubionidae**	***Unknown***	**Non-Native**
Araneae	**Gnaphosidae**	***Unknown***	**Non-Native**
Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**
Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
Araneae	Lycosidae	*Unknown*	Native
Araneae	**Salticidae**	***Unknown***	**Non-Native & Native**
Araneae	**Theridiidae**	***Unknown***	**Non-Native & Native**
Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
Coleoptera	**Carabidae**	***Necrobia rufipes***	**Non-Native**
Coleoptera	**Carabidae**	***Trechus obtusus***	**Non-Native**
Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
Coleoptera	**Scarabaeidae**	***Onthophagus nigriventris***	**Non-Native**
Collembola	Unknown	*Unknown*	Non-Native & Native
Diptera	Calliphoridae	*Unknown*	Non-Native
Diptera	Chloropidae	*Unknown*	Non-Native
Diptera	Drosophilidae	*Unknown*	Non-Native & Native
Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
Diptera	Phoridae	*Unknown*	Non-Native & Native
Diptera	Sarcophagidae	*Unknown*	Non-Native
Diptera	Sciaridae	*Unknown*	Non-Native & Native
Diptera	Sepsidae	*Unknown*	Non-Native
Diptera	Syrphidae	*Unknown*	Non-Native
Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	Non-Native
Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
Hemiptera	Lygaeidae	*Nysius terrestris*	Native
Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
Hemiptera	Miridae	*Lygus elisus*	Non-Native
Hemiptera	Miridae	*Orthotylus sophoricola*	Native
Hemiptera	Nabidae	*Nabis capiformis*	Non-Native
Hemiptera	Rhopalidae	*Unknown*	Non-Native & Native
Hemiptera	Unknown	*Unknown*	Non-Native & Native
Homoptera	Aphididae	*Unknonwn*	Non-Native
Homoptera	Pseudococcidae	*Unknown*	Non-Native & Native
Homoptera	Psyllidae	*Unknown*	Non-Native & Native
Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
Hymenoptera	**Encyrtidae**	***Unknown***	**Non-Native & Native**
Lepidoptera	Geometridae	*Unknown*	Non-Native & Native

[10] New record captures to the Management Area.

Lepidoptera	Noctuidae	*Agrotis spp.*	Non-Native & Native
Lepidoptera	Noctuidae	*Unknown*	Non-Native & Native
Lepidoptera	Pieridae	*Pieris rapae*	Non-Native
Lepidoptera	Pyralidae	*Unknown*	Non-Native & Native
Lepidoptera	Tineidae	*Unknown*	Non-Native
Lithobiomorpha	Lithobiidae	*Lithobius spp.*	Non-Native & Native
Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Thysanoptera	Thripidae	*Unknown*	Non-Native & Native

2015 Observed Vegetation List

Family	*Genus & Species*	Nativity	Vegetation type
Aspleniaceae	*Asplenium adiantum-nigrum*	Native	Fern
Aspleniaceae	*Asplenuim trichomanes*	Native	Fern
Asteraceae	***Hypochaeris radicata***	**Non-Native**	**Herb**
Asteraceae	***Senecio madagascariensis***	**Non-Native**	**Herb**
Asteraceae	***Taraxicum officinale***	**Non-Native**	**Herb**
Asteraceae	*Tetramolopium humile humile*	Native	Herb
Woodsiaceae[11]	*Cystopteris douglasii*	Native	Fern
Caryophyllaceae	*Silene struthioloides*	Native	Herb
Dryopteridaceae	*Dryopteris wallichiana*	Native	Fern
Ericaceae	*Leptecophylla tameiameiae*	Native	Shrub
Ericaceae	*Vaccinium reticulatum*	Native	Shrub
Poaceae	*Agrostis sandwicensis*	Native	Grass
Poaceae	*Rytidosperma semiannulare*	Non-Native	Grass
Poaceae	*Trisetum glomeratum*	Native	Grass
Polygonaceae	***Rumex acetosella***	**Non-Native**	**Herb**
Pteridaceae	*Pellaea ternifolia*	Native	Fern
Scrophulariaceae	***Verbascum thapsus***	**Non-Native**	**Herb**
Unknown	*Unknown Lichen*[12]	Native	Lichen
Unknown	*Unknown Moss*[13]	Unknown	Moss

Conclusion

During the 2015 rotating panel surveys, over 550 invertebrate individuals were observed via hand searches and with baited vials. The most common invertebrates observed include bottle and hover flies, Hawaiian wolf spiders, and seed bugs. Over 1,400 plant individuals, not including lichen, were observed and approximately 150 invasive plants were removed. Most of the vegetation observed were native species, with grasses (>900) and ferns (>240) being the most prevalent vegetation type. No new vegetation or invertebrate threats were identified.

[11] Family was formerly Athyriaceae

[12] Lichen colors observed include black, green, white, yellow, red, and brown.

[13] Moss color observed include black and green.

Annual Alien Invertebrate Monitoring

Introduction

The Bishop Museum was contracted by OMKM in previous years (2007-2012) to conduct biological surveys that monitor native and non-native (established) species and detect new invertebrate threats. Since 2013, OMKM has been conducting these surveys internally. Trapping methods and locations for 2015 are consistent with 2013 and 2014 survey efforts, with the addition of three locations (Burns cone, Puʻukeonehehe‘e and the puʻu east of Keonehehe‘e) in the MKSR. This section includes results for all species captured during the annual 2015 survey effort. Detailed wēkiu bug (*Nysius wekiuicola)* data and analysis is in the *Native & Established Species Monitoring* section below.

Study Area

Alien invertebrate surveys were conducted concurrently with wēkiu bug monitoring surveys to reduce impacts to the environment. Survey areas included Halepōhaku (2,850 m), the Mauna Kea Ice Age Natural Area Reserve (NAR), the road corridor, the MKSR, and puʻu (cinder cones) within the Astronomy Precinct extending to the summit (4,205 m).

Trap site coordinates and elevations were derived from GPS field units (WGS 84 datum). Puʻu names were derived from USGS geology maps and the Geographic Names Information System (GNIS) when available. Not all pu'u have been given official names, or their traditional names have been lost. In this report, such unnamed puʻu are identified by nearby landmarks or distinctive features to allow us to identify specific areas of the vast summit region of Maunakea more easily. Maps and tables in the *Appendices* contain GPS coordinates, elevations, and trap types for survey locations.

Methods

The objectives for 2015 fieldwork were to document established species found within and neighboring UH managed lands (especially the NAR) and to detect new species that could potentially threaten cultural and natural resources or human health and safety. All arthropod specimens were identified by comparison to previous catches and were identified to the lowest possible taxonomic unit necessary to determine if the species was a threat.

To accomplish our objectives, we sampled a broad range of habitats including undisturbed wēkiu bug habitat, nearby disturbed habitat types that are associated with past or present human activities, and various pathways whereby alien arthropods might first become introduced. Each trapping location had between 1 and 12 sites, with each site containing at least one trap type. Trap locations (usually puʻu) were defined using Natural Resources Conservation Service (NRCS) soil survey data. Exceptions were made to designate logical management areas such as the road corridor and TMT site.

A variety of trap types were used to monitor established species and detect new potential threats. Trap types included yellow pans; baited pitfalls; un-baited wet pitfalls; and peanut butter, jelly, and Spam® sticks (PBJS sticks). Additionally, hand searches were conducted at trap sites and vegetation was recorded. All specimens captured in traps were kept for further analysis except for

live wēkiu bugs and other live native arthropods, which were captured, recorded, and released. All traps were retrieved within 3-4 days.

Yellow Pan Traps
Yellow pan traps were used to capture flying insects that are attracted to the color yellow. Pan traps were placed on the substrate and filled with 50% food-grade propylene glycol and 50% water. Propylene glycol is safe for the environment, prevents freezing during nighttime temperatures, slows evaporation, and preserves captured specimens. A mid-sized dense rock was placed inside each trap to prevent it from blowing away or being overturned.

Un-baited Wet Pitfall Traps
Un-baited wet pitfall traps were used to capture crawling arthropods. To reduce wēkiu bug mortality, these traps were not placed in wēkiu bug habitats. A small hole was dug in the substrate and a plastic cup was placed in the hole. The lip of the cup was placed level with the surface substrate and the substrate around the cup was made flat. Once set, about 1/4 of the cup was filled with the 50% propylene glycol-water mixture. A cap rock was placed over each trap to prevent rain or snow from filling it.

Baited Pitfall Traps
Baited pitfall traps were used to capture crawling arthropods that are attracted to the smell of putrid bait. These traps keep arthropods alive by providing them with food and water until they are retrieved. Traps were baited with canned tuna and were placed in all habitats. A small hole was dug in the substrate and a plastic cup was placed in the hole. The lip of the cup was placed level with the surface substrate and the substrate around the cup was made flat. Once the cup was set, about 1 cm of water was poured in and a second cup with a premade hole and a wick was nested into the bottom cup. A few rocks were placed inside to provide shelter. The rim of the cup and the cap rock were baited with tuna and the baited cap rock placed over the trap to provide shelter and prevent rain or snow from filling it.

Peanut Butter, Jelly, & Spam (PBJS) Sticks
PBJS sticks are used to survey for ants; the use of different baits allows for attraction of different ant species. Chopsticks were baited with small amount of peanut butter, jelly, and Spam® and were encompassed by a wire cylinder to keep the trap secure.

Hand Search
Hand searching is practiced on the ground level and includes turning over rocks and brushing one's hand over the substrate in search of arthropods.

Vegetation
All vegetation within a 10 m radius of each trap site in the MKSR and NAR was recorded. Invasive vegetation was removed and the roots of pulled plants were carefully observed for ants and other invasive arthropods.

Results & Discussion
OMKM annual alien invertebrate surveys occurred from June 19th – July 2nd, 2015. One hundred and eleven sites were surveyed using ~335 traps. Traps captured a total of 3,151 arthropod

individuals in 12 taxonomic orders. These numbers do not reflect specimens observed during hand searches, as these specimens are not captured in traps. Hand searches at these sites revealed 373 indiviudals in 13 taxonomic orders, both living and dead. Wēkiu bug abundance was average this year and higher than wēkiu abundance in 2014 (52 bugs captured), with 1,586 wēkiu bugs captured in the baited pitfall traps used for this purpose.

Several new invertebrate taxa were captured in the Management Area in 2015, including a non-native agricultural pest, *Bagrada hilaris* (Pentatomidae, https://hdoa.hawaii.gov/pi/files/2013/01/Bagrada-hilaris-NPA4-5-16.pdf), an unknown stink bug, and two non-native spiders, *Steatoda spp.* (Theridiidae) and *Corinna spp.* (Clubionidae). The spider families Theridiidae and Clubionidae have been identified on UH managed lands before, but this is the first time specimens were identified to genus. As indicated in the ISMP, all spiders (except the native Hawaiian wolf spider, *Lycosa hawaiiensis*) are considered potential threats to the management area and have a low feasibility for control. Both spiders were found at Halepōhaku, and once they are identified to species by an Arachnologist, a formal threat assessment and literature review can be completed.

The table below identifies a number of additional species (shaded in red) that, though they have likely been captured in the management area before, had not previously been identified to species. These include several wasps (Hymenoptera), which, like spiders, are considered according to the ISMP as threats unless determined to be native.

Clothes moths (Tineidae) were documented for the first time in alpine habitat in 2015. However, it is not likely that they are established at high elevations; they probably made it to the summit via aeolian processes.

Below is a list of invertebrates captured during the 2015 annual survey, organized by location and trap type. If a trap type is not listed, then that trap type was not used at that location. Invertebrate threats are identified in **bold font**. New species records[14] are shaded in red, and species that may have expanded their range on UH managed lands is shaded in green. Species that are both threats and new records are **shaded red with bold font**. Nativity[15] can either be non-native, native, or non-native & native within that taxonomic group.

2015 Alien Invertebrate List by Sample Type & Location

Trap Location	Sample Type	Order	Family	*Species*	Nativity
Batch Plant	Baited Pitfall	**Araneae**	**Salticidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Calliphoridae	*Eucalliphora lilaea*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native

[14] New records to the Management Area. Some of these may have appeared in the UH Management area before but had not previously been identified to species.
[15] Nativity was determined using the HI Insect Database State of Hawai'i arthropod resource list (Nishida 2002).

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Diptera	Chironomidae	*Unknown*	Non-Native & Native
		Diptera	Drosophilidae	*Unknown*	Non-Native & Native
		Diptera	Lonchopteridae	*Lonchoptera furcata*	Non-Native
		Diptera	**Muscidae**	***Haematobia irritans***	**Non-Native**
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Tachinidae	*Unknown*	Non-Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Miridae	*Coridromius spp.*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
	Un-Baited PF	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Diptera	Tachinidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Thysanoptera	Thripidae	*Unknown*	Non-Native & Native
	PBJS Stick	Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Drosophilidae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
	Yellow Pan	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Agromyzidae	*Liriomyza spp.*	Non-Native
		Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Chamaemyiidae	*Unknown*	Non-Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Diptera	**Muscidae**	***Haematobia irritans***	**Non-Native**
		Diptera	Mycetophilidae	*Unknown*	Unknown
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Psychodidae	*Unknown*	Non-Native & Native

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Diptera	Tachinidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Apanteles spp.***	**Non-Native**
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Encyrtidae**	***Dicarnosis ripariensis***	**Non-Native**
		Hymenoptera	**Encyrtidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Eulophidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Ichneumonidae**	***Pristomerus spinator***	**Non-Native**
		Hymenoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Hymenoptera	**Pteromalidae**	***Pachyneuron spp.***	**Non-Native**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Scelionidae**	***Telenomus spp.***	**Non-Native**
		Hymenoptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Thysanoptera	Thripidae	*Unknown*	Non-Native & Native
	Hand Search	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Tachinidae	*Unknown*	Non-Native
		Hemiptera	Nabidae	*Unknown*	Non-Native & Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
Burns Cone	Baited Pitfall	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Noctuidae	*Agrotis spp.*	Native
	Un-baited PF	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
	PBJS Stick	None	None	*None*	None
	Yellow Pan	None	None	*None*	None
	Hand Search	Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Coleoptera	**Scarabaeidae**	***Onthophagus nigriventris***	**Non-Native**
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	Non-Native
Halepōhaku	Baited Pitfall	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Araneae	**Theridiidae**	***Steatoda spp.*[16]**	**Non-Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Agromyzidae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
		Lithobiomorpha	Lithobiidae	*Lithobius spp.*	Non-Native & Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	Un-baited PF	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Hemiptera	Unknown	*Unknown*	Non-Native & Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Sphecidae**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	PBJS Stick	Homoptera	Aphididae	*Unknown*	Non-Native
	Yellow Pan	Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Hemiptera	Geocoridae	*Geocoris spp.*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
	Hand Search	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	**Clubionidae**	***Corinna spp.*[17]**	**Non-Native**
		Araneae	**Salticidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Dermaptera	Forficulidae	*Forficula auricularia*	Non-Native
		Diptera	Sarcophagidae	*Unknown*	Non-Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Isopoda	Unknown	*Unknown*	Non-Native & Native
		Lithobiomorpha	Lithobiidae	*Lithobius spp.*	Non-Native & Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Poi Bowl	Baited Pitfall	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
	Hand Search	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**

[16] The family Theridiidae has been identified on UH managed lands before but this is the first time a specimen has been identified to genus.

[17] Taxonomic change- the genus *Corinna* was previously in the family Corinnidae. The family Clubionidae has been identified on UH managed lands before but this is the first time a specimen has been identified to genus.

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
Pu'uhaukea	Baited Pitfall	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Coleoptera	**Staphylinidae**	***Unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
		Hemiptera	Pentatomidae	*Bagrada hilaris*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	Hand Search	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Araneae	**Salticidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	**Chrysomelidae**	***Altica torquata***	**Non-Native**
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Coleoptera	**Scarabaeidae**	***Unknown***	**Non-Native**
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Oestridae	*Hypoderma bovis*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius terrestris*	Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Hemiptera	Pentatomidae	*Bagrada hilaris*	Non-Native
		Hemiptera	Pentatomidae	*Nezara viridula*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Geometridae	*Scotorythra paludicola*	Native
		Lepidoptera	Noctuidae	*Unknown*	Non-Native & Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
Pu'uhauoki	Baited Pitfall	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	Hippodamia convergens	Non-Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Lepidoptera	Nymphalidae	*Vanessa spp.*[18]	Non-Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
		Thysanoptera	Thripidae	*Unknown*	Non-Native & Native
	PBJS Stick	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
	Yellow Pan	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Agromyzidae	*Liriomyza spp.*	Non-Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Miridae	*Coridromius variegatus*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Homoptera	Psyllidae	*Unknown*	Non-Native & Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Ichneumonidae**	***Pristomerus spinator***	**Non-Native**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Scelionidae**	***Unknown***	**Non-Native & Native**
	Hand Search	Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Tachinidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Lepidoptera	Noctuidae	*Agrotis spp.*	Native
Pu'ukea	Baited Pitfall	Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native

[18] The species of *Vanessa* collected was not the native species, *V.tameatamea.*

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
	Un-baited PF	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Diptera	Agromyzidae	*Unknown*	Non-Native & Native
		Diptera	Chamaemyiidae	*Unknown*	Non-Native
		Diptera	Ephydridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
	PBJS Stick	Diptera	Syrphidae	*Unknown*	Non-Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
	Yellow Pan	Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native & Native
		Diptera	Chloropidae	*Unknown*	Non-Native
		Diptera	Drosophilidae	*Unknown*	Non-Native & Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Eulophidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
	Hand Search	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Vespidae**	***Vespula pensylvanica***	**Non-Native**
Pu'ukeone[19]	Baited Pitfall	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	**Clubionidae**	***Unknown***	**Non-Native**

[19] Pu'ukeone is a shortened form of Pu'ukeonehehe'e.

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Lepidoptera	Noctuidae	*Unknown*	Non-Native & Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	Un-Baited PF	None	None	*None*	None
	PBJS Stick	None	None	*None*	None
	Yellow Pan	None	None	*None*	None
	Hand Search	Acari	Unknown	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Lepidoptera	Noctuidae	*Agrotis spp.*	Native
Pu'ukeone E	Baited Pitfall	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Diptera	Sarcophagidae	*Unknown*	Non-Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
	Un-baited PF	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
	Yellow Pan	**Hymenoptera**	**Braconidae**	**Unknown**	**Non-Native & Native**
	PBJS Stick	None	None	None	None
	Hand Search	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Hemiptera	Nabidae	*Unknown*	Non-Native & Native
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
Pu'upōhaku	Baited Pitfall	**Araneae**	**Salticidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Hemiptera	Geocoridae	*Geocoris spp.*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Eulophidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	Un-baited PF	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Hemiptera	Miridae	*Coridromius variegatus*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	PBJS Stick	None	None	*None*	None
	Yellow Pan	Diptera	Agromyzidae	*Liriomyza spp.*	Non-Native
		Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Miridae	*Coridromius variegatus*	Non-Native

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Homoptera	Aphididae	*Unknown*	Non-Native
		Homoptera	Cicadellidae	*Unknown*	Non-Native & Native
		Homoptera	Psyllidae	*Acizzia uncatoides*	Non-Native
		Hymenoptera	**Braconidae**	***Apanteles spp.***	**Non-Native**
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Encyrtidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Eulophidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Pachyneuron spp.***	**Non-Native**
		Hymenoptera	**Scelionidae**	***Unknown***	**Non-Native & Native**
	Hand Search	**Araneae**	**Clubionidae**	***Unknown***	**Non-Native**
		Araneae	**Theridiidae**	***Unknown***	**Non-Native & Native**
		Coleoptera	Cleridae	*Necrobia rufipes*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Oestridae	*Hypoderma bovis*	Non-Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
Pu'upoli'ahu	Baited Pitfall	**Araneae**	**Linyphiidae**	***Unknown***	**Non-Native & Native**
		Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Unknown	*Unknown*	Non-Native & Native
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
	PBJS Stick	None	None	*None*	None
	Yellow Pan	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Agromyzidae	*Liriomyza spp.*	Non-Native
		Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native
		Diptera	Ceratopogonidae	*Unknown*	Non-Native & Native
		Diptera	Drosophilidae	*Unknown*	Non-Native & Native
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hemiptera	Lygaeidae	*Nysius terrestris*	Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Diapriidae**	***Trichopria spp.***	**Non-Native & Native**
		Hymenoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**

Trap Location	Sample Type	Order	Family	*Species*	Nativity
	Hand Search	Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Chironomidae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Pentatomidae	*Bagrada hilaris*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
Puʻuwaiʻau	Baited Pitfall	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
	Un-baited PF	**Araneae**	**Linyphiidae**	***Tenuiphantes[20] tenuis***	**Non-Native**
		Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
	PBJS Stick	Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
	Yellow Pan	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
	Hand Search	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Hemiptera	Geocoridae	*Geocoris spp.*	Non-Native
		Lepidoptera	Pieridae	*Pieris rapae*	Non-Native
Puʻuwēkiu	Baited Pitfall	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Lonchopteridae	*Lonchoptera furcata*	Non-Native
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Hemiptera	Miridae	*Coridromius variegatus*	Non-Native
		Hemiptera	Pentatomidae	*Bagrada hilaris*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
	PBJS Stick	None	None	*None*	None
	Yellow Pan	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**

[20] Taxonomic change from *Lepthyphantes* to *Tenuiphantes.*

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
	Hand Search	**Araneae**	**Unknown**	***Unknown***	**Non-Native**
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Drosophilidae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Haematobia irritans***	**Non-Native**
		Diptera	Sepsidae	*Unknown*	Non-Native
		Lepidoptera	Pieridae	*Pieris rapae*	Non-Native
Road Corr.	Baited Pitfall	**Araneae**	**Theridiidae**	***unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
	Un-baited PF	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Unknown*	Non-Native
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
	PBJS Stick	None	None	*None*	None
	Yellow Pan	Diptera	Chironomidae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Apidae**	***Apis mellifera***	**Non-Native**
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
	Hand Search	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	**Salticidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Collembola	Unknown	*Unknown*	Non-Native & Native
		Diptera	Calliphoridae	*Calliphora vomitoria*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Lepidoptera	Noctuidae	*Unknown*	Non-Native & Native
TMT Site	Baited Pitfall	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Homoptera	Aphididae	*Unknown*	Non-Native
	Un-baited PF	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Collembola	Unknown	*Unknown*	Non-Native & Native

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Tachinidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Eulophidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
	PBJS Stick	Diptera	Sciaridae	*Unknown*	Non-Native & Native
	Yellow Pan	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Agromyzidae	*Liriomyza spp.*	Non-Native
		Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Calliphoridae	*Eucalliphora lilaea*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	Chironomidae	*Unknown*	Non-Native & Native
		Diptera	Chloropidae	*Unknown*	Non-Native
		Diptera	Drosophilidae	*Unknown*	Non-Native & Native
		Diptera	Ephydridae	*Unknown*	Non-Native & Native
		Diptera	Lonchopteridae	*Lonchoptera furcata*	Non-Native
		Diptera	Mycetophilidae	*Unknown*	Unknown
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Phoridae	*Puliciphora lucifera*	Non-Native
		Diptera	Phoridae	*Unknown*	Non-Native & Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Sepsidae	*Unknown*	Non-Native
		Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hemiptera	Lygaeidae	*Nysius terrestris*	Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Hemiptera	Miridae	*Coridromius variegatus*	Non-Native
		Hemiptera	Tipulidae	*Unknown*	Non-Native & Native
		Homoptera	Aphididae	*Unknown*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Eulophidae**	**Unknown**	**Non-Native & Native**
		Hymenoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Pteromalidae**	***Mesopolobus spp.***	**Unkown**
		Hymenoptera	**Pteromalidae**	***Pachyneuron spp.***	**Non-Native**
		Hymenoptera	**Pteromalidae**	***Unknown***	**Non-Native & Native**
		Hymenoptera	**Scelionidae**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Noctuidae	*Agrotis spp.*	Non-Native & Native
		Lepidoptera	Tineidae	*Unknown*	Non-Native
		Thysanoptera	Unknown	*Unknown*	Non-Native & Native
	Hand Search	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native

Trap Location	Sample Type	Order	Family	*Species*	Nativity
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Anthomyiidae	*Delia platura*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Muscidae**	***Unknown***	**Non-Native & Native**
		Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
		Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
		Diptera	Sciaridae	*Unknown*	Non-Native & Native
		Diptera	Syrphidae	*Unknown*	Non-Native
		Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
		Hymenoptera	**Braconidae**	***Unknown***	**Non-Native & Native**
		Lepidoptera	Noctuidae	*Unknown*	Non-Native & Native
VLBA N.	Baited Pitfall	**Araneae**	**Unknown**	***Unknown***	**Non-Native & Native**
		Diptera	Sarcophagidae	*Unknown*	Non-Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
	Un-baited PF	Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
	PBJS Stick	None	None	*None*	None
	Hand Search	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Diptera	**Unknown**	***Unknown***	**Non-Native & Native**
		Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	Non-Native
		Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
		Psocoptera	Psocidae	*Unknown*	Non-Native & Native
VLBA S.	Baited Pitfall	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
		Collembola	Entomobryidae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
		Lepidoptera	Noctuidae	*Agrotis spp.*	Non-Native & Native
		Lepidoptera	Unknown	*Unknown*	Non-Native & Native
	Hand Search	Acari	Unknown	*Unknown*	Non-Native & Native
		Araneae	**Linyphiidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Salticidae**	***Unknown***	**Non-Native & Native**
		Araneae	**Unknown**	***Unknown***	**Non-Native & Native**
		Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
		Diptera	Calliphoridae	*Unknown*	Non-Native & Native
		Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native

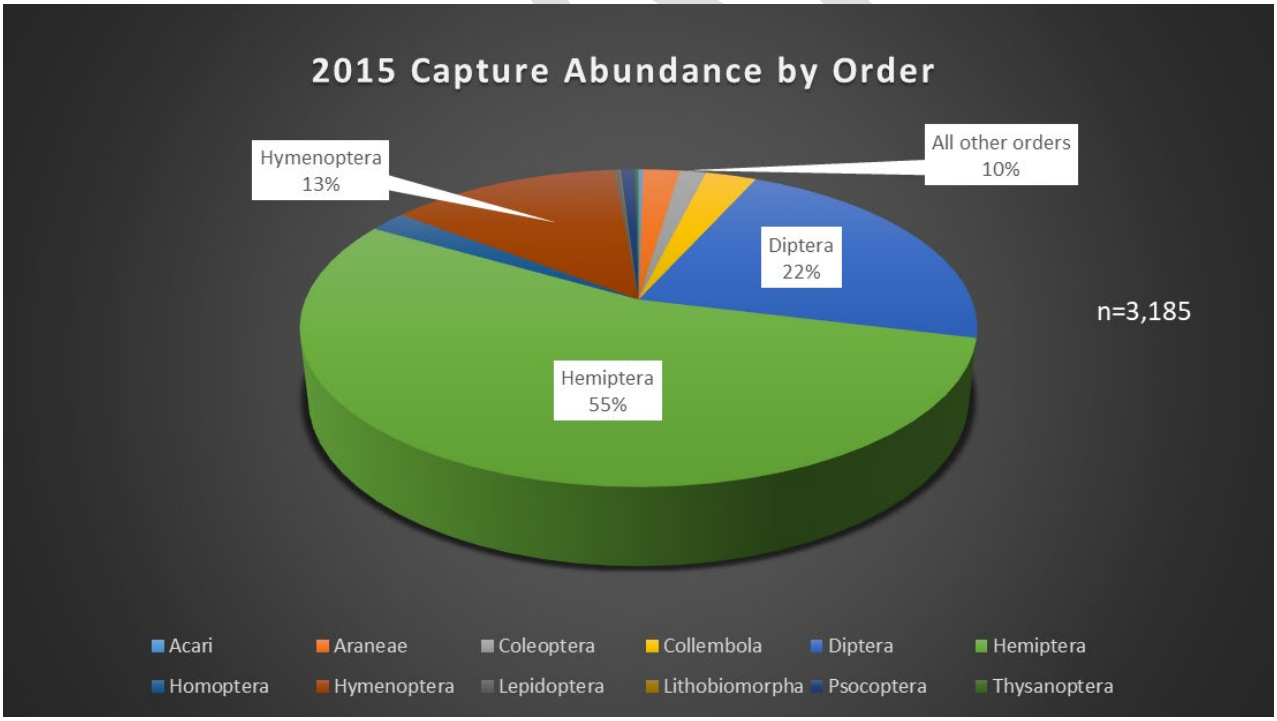
2015 Vegetation at Trap Sites

The table below shows locations where vegetation was observed within 10 meters of trap sites. Vegetation for HP was not recorded because it was not the focus of this survey. Most locations did not have vegetation because many of these sites are on cinder cones. *T. officinale* individuals were removed due to their highly invasive nature and HPWRA score.

Location	Family	Genus & Species	Nativity
Batch Plant	Aspleniaceae	*Asplenium adiantum-nigrum*	Native
	Poaceae	*Trisetum glomeratum*	Native
E of Pu'ukeonehehe'e	Poaceae	*Trisetum glomeratum*	Native
Pu'uwai'au	Asteraceae	*Taraxacum officinale*	Non-Native
	Poaceae	*Agrostis sandwicensis*	Native
	Poaceae	*Poa pratensis*	Non-Native
	Polygonaceae	*Rumex acetesella*	Non-Native
Road Corridor	Poaceae	*Trisetum glomeratum*	Native
Pu'u N of VLBA	Poaceae	*Trisetum glomeratum*	Native
TMT Site	Poaceae	*Trisetum glomeratum*	Native

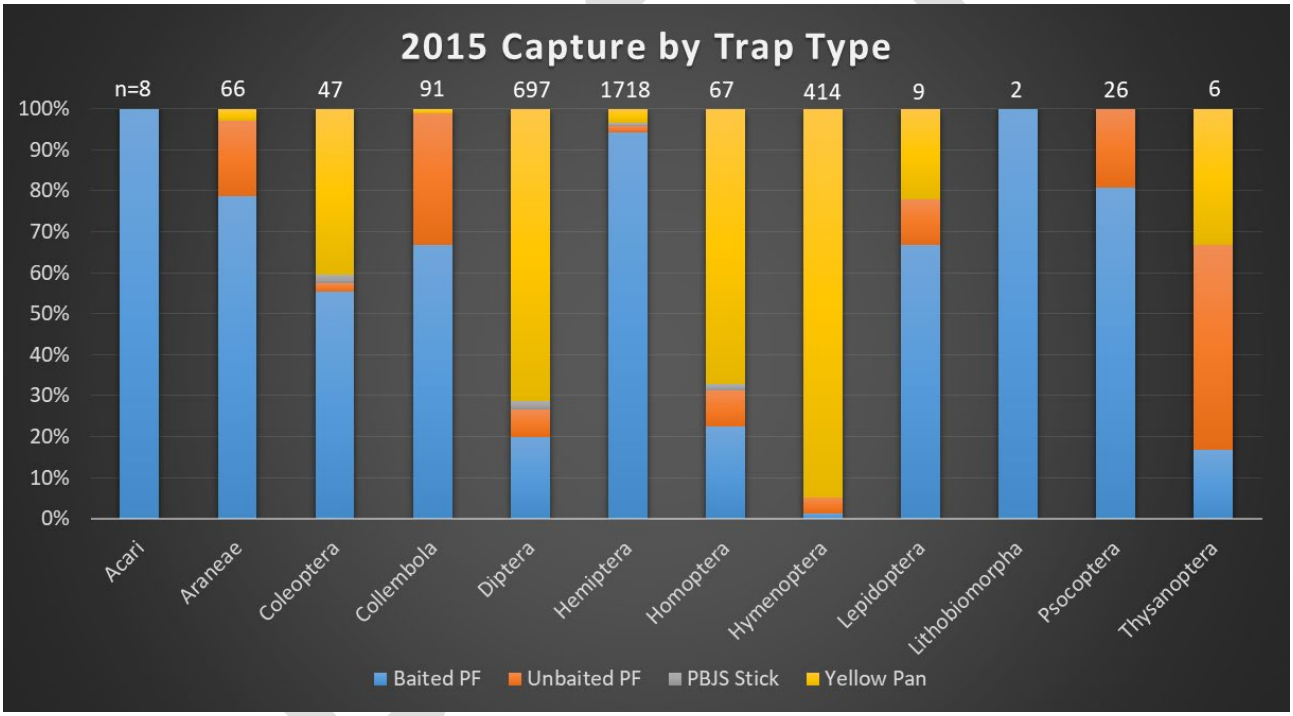
2015 Capture Abundance by Order

The pie chart below shows the capture abundance by order for all trap types combined (does not include hand search data). The majority of individuals captured were true bugs (Hemiptera), flies, and wasps.



2015 Capture Percentage by Trap Type

The graph below shows the percentage of individuals captured in each order by trap type (does not include hand search data). The "n" on top of each bar represents the number of individuals captured within that order. Yellow pan traps mainly captured Hymenoptera (wasps, 95% of all wasps captured throughout the survey), Homoptera (plant bugs, >65% of all plant bugs captured throughout the survey), and Diptera (flies, 70% of all flies captured throughout the survey). The baited pitfall traps captured a variety of crawling insects with the majority of captures being Hemiptera (true bugs, 95% of all true bugs captured throughout the survey) and Araneae (spiders, nearly 80% of all spiders captured throughout the survey). Baited pitfall traps were the only traps that captured Acari (mites) and Lithiobiomorpha (centipedes), though few of these individuals were captured. The unbated pitfall traps mainly captured Collembola (springtails) and did capture the majority of Thysanoptera (thrips) individuals (of which there were only a few). The peanut butter, jelly, and spam sticks attracted very few arthropod orders. Ants were not detected in our 2015 trapping efforts.



Conclusion

The majority of arthropods captured in 2015 were Hemiptera (true bugs) and Diptera (flies). The yellow pan traps and baited pitfall traps captured the majority of taxa. A total of 3,185 arthropod individuals were captured in traps, and most traps captured what was to be expected (i.e. yellow pans captured flying insects).

Identifications of the two new taxa threats (*Staetoda spp.* and *Corinna spp.* spiders) still need to be confirmed, and literature review completed. See *Annual Wēkiu Bug Monitoring* in the *Native &*

Established Species Monitoring section for wēkiu bug results. Vegetation observed at trapping sites were predominately native grasses (either *T. glomeratum* or *A. sandwicensis).*

Incidental Early Detection

Introduction

Non-native flora and fauna can be potential threats to native ecosystems on Maunakea. Therefore, early detection of non-native species is vital to protect and manage the resources on the mountain. In 2015, OMKM early detection efforts included documenting incidental catches and observations of non-established and potential threat species reported by Maunakea users (observatory staff, Rangers, MKSS staff, etc.). OMKM also collaborated with neighboring land owners about current issues on Maunakea and vice versa.

This *Incidental Early Detection* section identifies potentially new species that have not been previously documented within the Management Area. Additionally, this section highlights potential threat species and their locations in order to provide OMKM with a better understanding of trends within threat populations. Incidental detection allows OMKM to further its knowledge about ranges of rare and unusual species, which can be useful when conducting other management activities.

Study Area

The study site includes all UH managed lands and adjacent lands where OMKM related projects may occur.

Methods

Our method of incidental early detection consists of simple visual observation, reporting, and/or capture by Maunakea users. Maunakea users include OMKM staff, researchers, Mauna Kea Support Services (MKSS) staff, Maunakea Rangers, Visitor Information Station staff, observatory staff, and neighboring landowners (DHHL, MKWA, NARS, DLNR). Maunakea users report anything that seems inappropriate or unusual within UH managed lands to OMKM.

When OMKM receives a report, we follow up with an academic expert or agency for identification and recommendations for potential management actions. Once verified, the incident is recorded and a report generated if necessary. Identified threat species are eradicated if feasible. However, non-native invertebrates require extensive study and planning for eradication or control tactics (see *Arthropod Control* section).

Results and Discussion

No new vertebrate or plant threats were identified through incidental early detection in 2015. Invertebrate early detection included potential threat species within the Araneae, Coleoptera, and Hymenoptera orders. We hypothesize that the identified spider species have been within the managed areas for a while but had not been identified to genus and/or species before. It should also be noted that there is often a lag in species identification due to specialist availability. For more information on *C. kagutsuchi*, please see the *Rapid Response* section of this report. The table below displays all early detection incidental reports for vertebrates, invertebrates, and plants in 2015. All threat species are in **bold** and all new record species are shaded.

2015 Incidental Reports

Vertebrates				
No new vertebrate species reported[21]				
Plants				
No new plants were reported[22]				
Invertebrates				
Order	**Family**	***Genus & Species***	**Nativity**	**Location(s)**
Araneae	**Agelenidae**	***Hololena curta***	**Non-Native**	**TMT Site**
Araneae	**Araneidae**	***Neoscona spp.***	**Non-Native**	**HP Upper Parking Lot**
Araneae	**Theridiidae**	***Parasteatoda spp.***	**Non-Native**	**TMT Site**
Coleoptera	**Scarabaeidae**	***Unknown***	**Non-Native & Native**	**Silversword Enclosure**
Hymneoptera	**Formicidae**	***Cardiocondyla kagutsuchi***	**Non-Native**	**HP Upper Parking Lot**
Hymneoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**	**MKSR**
Hymneoptera	**Ichneumonidae**	***Unknown***	**Non-Native & Native**	**Lake Waiʻau**

NATIVE & ESTABLISHED SPECIES MONITORING

Monitoring of native and established species is important for understanding population and ecosystem changes through time. Monitoring goals include identification of new threats (see *Early Detection Monitoring* section above) and documentation of the current status of established native and non-native species, including the spread of invasive threats (species of threat to cultural and natural resources and human health and safety) to help determine effectiveness of both rapid response and control actions. This section includes monitoring results for wēkiu bugs, honey bees, vegetation, and vertebrates (all other types of monitoring are considered as early detection monitoring and are found in the section above).

Annual Wēkiu Bug Monitoring

Introduction

As part of the continuing long-term study started by Hawaiʻi Biological Survey of the Bishop Museum, the Office of Mauna kea Management (OMKM) continues monitoring populations of wēkiu bug (*Nysius wekiuicola*), a species endemic to the Maunakea summit area of Hawaiʻi Island. The objectives for the 2015 fieldwork were to a) document wēkiu bug abundance within UH managed and neighboring (NAR) lands and b) identify the presence or absence of other native species and arthropod biodiversity threats.

It should also be noted that off-season wēkiu bug monitoring efforts were conducted in winter and spring 2015 by UH Hilo professor Jesse Eiben and in fall 2015 by UH Hilo Tropical Conservation Biology and Environmental Science (TCBES) graduate student Nathan Stephenson. All field work was done in cooperation and collaboration with OMKM staff and according to its policies. Data gathered through these studies is available through DLNR and is predominantly consistent with the results presented in this report, aside from seasonal population variability.

[21] See *Vertebrate Monitoring* section for more information on vertebrate activity.

[22] See *Vegetation Control* section for more information on non-native plant management.

Study Area

Wēkiu bug surveys were done concurrently with the alien invertebrate monitoring surveys to reduce impacts to the environment. See *Early Detection Monitoring* section above for alien species monitoring methods and results. Wēkiu bug monitoring occurs in the alpine zone, including the MKSR and NAR beginning at about 3,410 m and encompassing core wēkiu bug habitat that extends to the summit at 4,205 m. See *Appendix C: 2015 Annual Survey Trap Locations* for survey locations, GPS coordinates, trap dates, and trap types. WGS 84 data was used for recording GPS locations. Altitudes were determined by the GPS unit.

Unless otherwise stated, pu'u names were taken from the U.S. Board on Geographic Names. Many pu'u have not yet been given official names; when possible, these cinder cones are identified by nearby landmarks or distinctive features. These names should not be viewed as official, but instead allow us to identify specific areas of the vast summit region of Maunakea more easily.

Methods

We sampled previous trapping sites, including core wēkiu bug habitats in the alpine region, focusing on various pathways whereby alien invertebrates might first become introduced. We also sampled a wide variety of undisturbed habitat types where wēkiu bugs are historically known to have high concentrations, in addition to disturbed habitat types that are associated with past or present human activities. Each trapping area had between 1 and 12 sites, with each site containing one wēkiu bug trap. Trap locations (see *Appendix D: 2015 Wēkiu Bug Capture Data*) were defined using NRCS Soil Survey data. Exceptions were made to address logical management impacts, such as for the road corridor or TMT site.

All captured wēkiu bugs were recorded and released and all non-native species were collected and kept for further analysis. Identifications were made of all invertebrate species collected during the 2015 field work through comparisons to previous catches, and by-catch was identified to the lowest possible taxonomic unit necessary to determine if the species was a threat.

Baited pitfall traps were used to capture wēkiu bugs. These traps keep wēkiu bugs alive by providing them with food and water until they are retrieved. The traps were constructed as in previous alien invertebrate and wēkiu bug trapping efforts. Traps were baited with tuna. To install a trap, a hole was dug in the determined location and a plastic cup placed in the hole, level with the surface substrate. Once the cup was set, about 1 cm of water was placed into the cup.
A second cup with a wick was then inserted into the first cup. This is to provide a source of water without drowning the bugs. A few rocks (for shelter) were then placed in the cup (no more than ½ full) and the cup rim and cap rock were baited with tuna. The baited cap rock is placed over the trap to prevent rain or snow from filling the traps. Traps were retrieved within 3-4 days.

Results and Discussion

A total of 1,586 wēkiu bugs were captured in baited pitfall traps during the 2015 field survey over a total of 303 trapping days, for an average catch rate of 5.23 wēkiu bugs per day. Locations with the highest wēkiu bug abundances include, Puʻuhauʻoki, Poi Bowl, and Puʻuwēkiu (see table and map below). Captured alien arthropod specimens are shown in the *Early Detection Monitoring* section

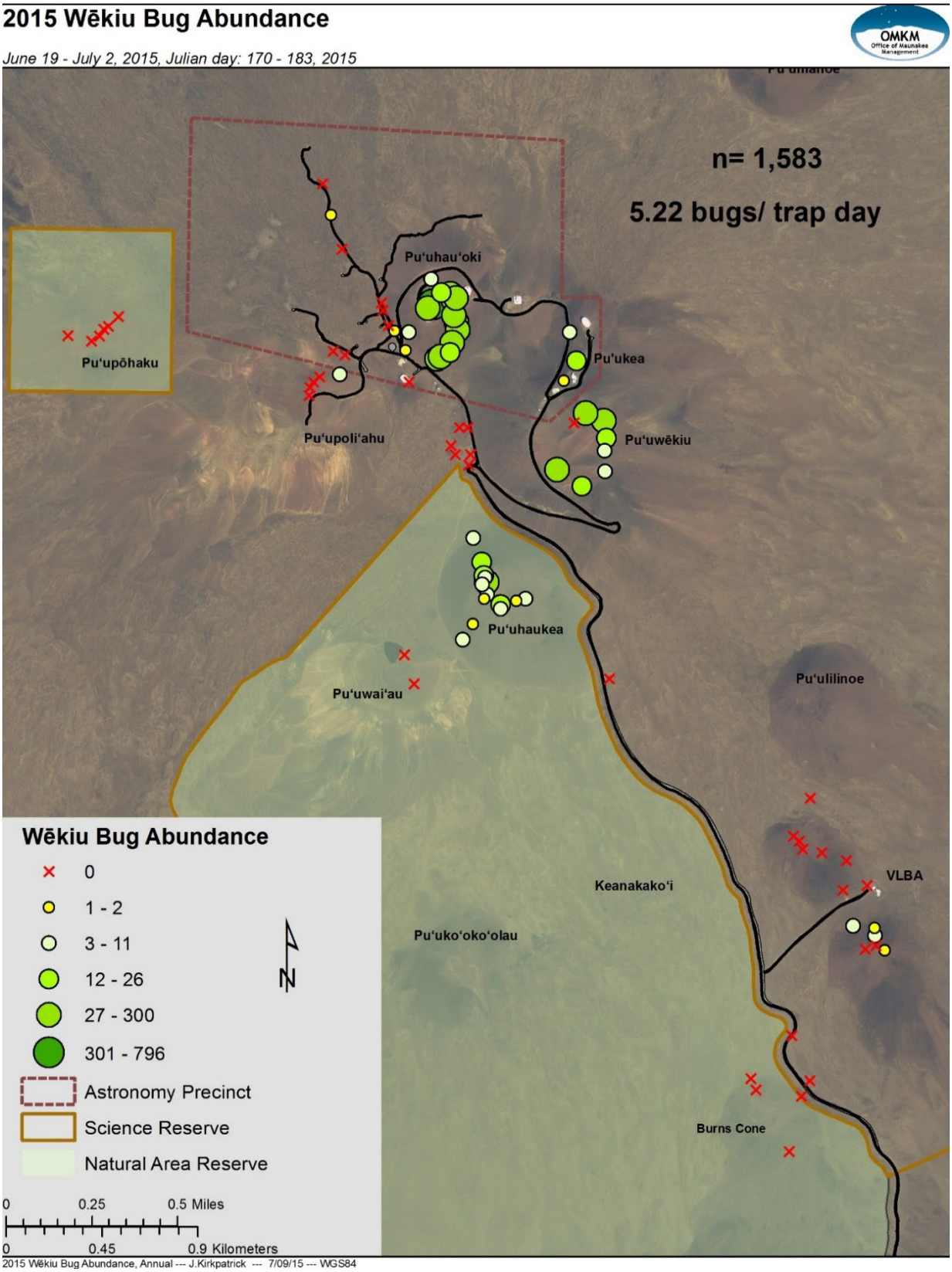
above. See *Appendix D: 2015 Wēkiu Bug Capture Data* table for wēkiu bug concentrations and capture rates per individual trap site.

2015 Wēkiu bug Captures by location

Location	Total Traps	Wēkiu Captures	Trap Dates	Total Trap Days
Poi Bowl	7	452	19 -22 Jun	21
Road Corridor[23]	4	0	19 -22 Jun	12
S. VLBA	6	12	19-22 Jun	18
Puʻuhauʻoki	8	734	23 -26 Jun	24
N. VLBA	7	0	23 -26 Jun	21
Burns Cone	4	0	23 -26 Jun	12
Puʻukeonehehe'e	4	0	23 -26 Jun	12
E. Puʻukeonehehe'e	4	0	23 -26 Jun	12
Puʻuwēkiu	10	227	23 -26 Jun	30
Puʻukea	2	20	26-29 Jun	6
Puʻuhaukea	14	128	28 Jun – 01 Jul	42
Puʻuwaiʻau	2	0	28 Jun – 01 Jul	6
Puʻupōhaku	6	0	29 Jun – 02 Jul	18
Puʻupoliʻahu	7	11	29 Jun – 02 Jul	21
Batch Plant	7	0	29 Jun – 02 Jul	21
TMT Site	9	2	29 Jun – 02 Jul	27
Totals	**101**	**1,586**	**19 Jun – 02 Jul**	**303**

[23] Only listed Road corridor traps within the MKSR in this table.

2015 Wēkiu Bug Abundance Map

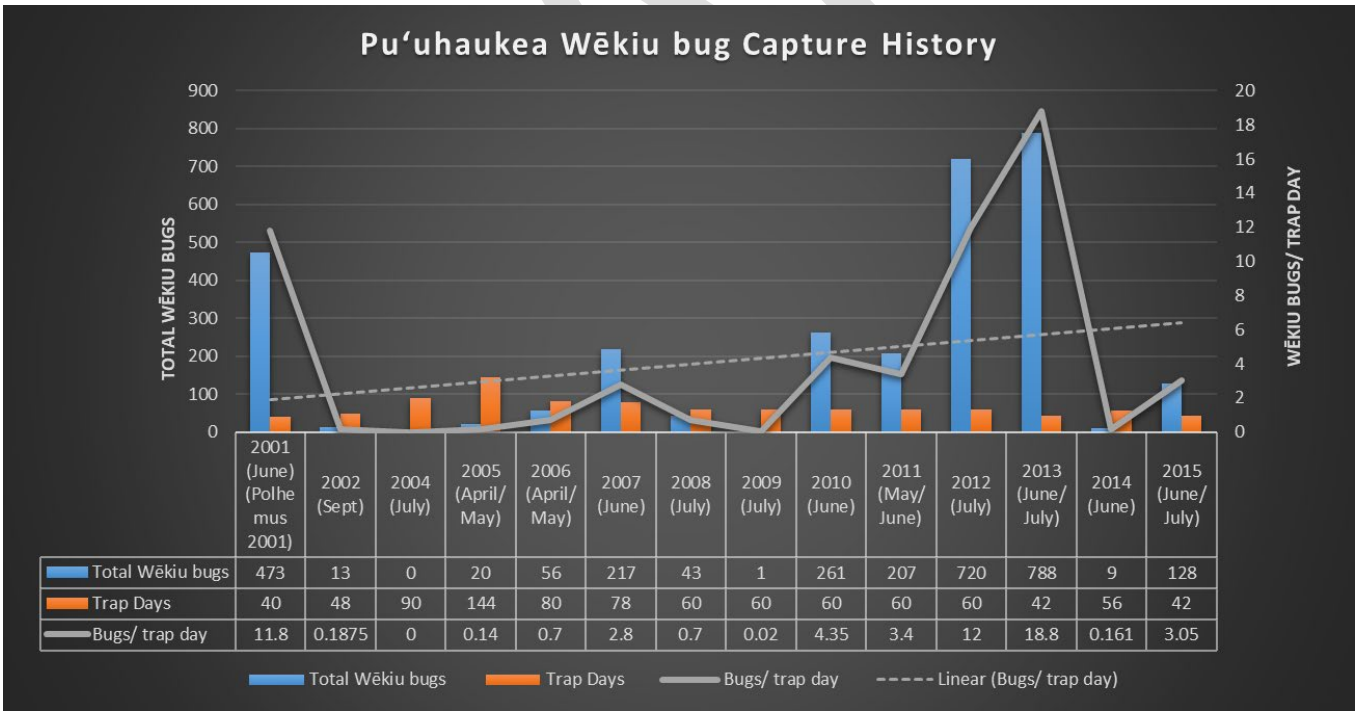


Analysis

Below is a summary of wēkiu bugs captured at Puʻuhaukea (within the Mauna Kea Ice Age Natural Area Reserve) cinder cone from related Bishop Museum studies since 2001. These studies used a combination of glycol (inadvertent capture in invasive species traps) and shrimp-baited pitfall traps for all years except 2007, 2008, 2009, and 2010 when only shrimp paste was used. Beginning in 2011, traps were baited with tuna.

Puʻuhaukea Wēkiu bug Capture History

Year & Month of Trapping event	Total Wēkiu bugs	Trap Days	Bugs/ trap day
2001 (June) (Polhemus 2001)	473	40	11.8
2002 (Sept)	13	48	0.1875
2004 (July)	0	90	0
2005 (April/May)	20	144	0.14
2006 (April/May)	56	80	0.7
2007 (June)	217	78	2.8
2008 (July)	43	60	0.7
2009 (July)	1	60	.02
2010 (June)	261	60	4.35
2011 (May/June)	207	60	3.4
2012 (July)	720	60	12.0
2013 (June/July)	788	42	18.8
2014 (June)	9	56	.161
2015 (June/July)	**128**	**42**	**3.05**



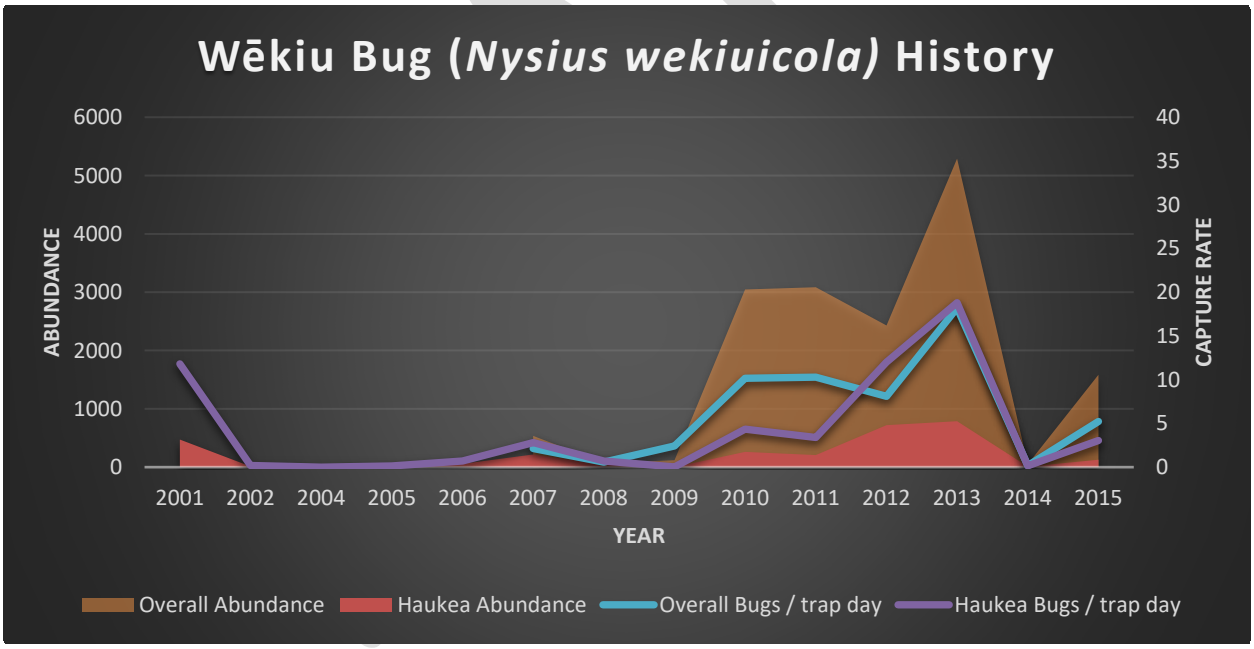
Wēkiu bug Capture History Table- All trap locations[24]

Below is a summary table of wēkiu abundances for the entire summit region since 2007 (when trapping became consistent).

Year of Trapping event	# Wekiu Captured	Trap Days	Bugs / trap day
2007	537	252	2.13
2008	70	120	0.58
2009	118	285	2.42
2010	3,047	300	10.16
2011	3,084	300	10.28
2012	2,430	300	8.1
2013	5,290	290	18.2
2014	52	292	.18
2015	**1,586**	**303**	**5.23**

Wēkiu bug Capture History Chart

The graph below shows wēkiu bug abundances and capture rates (bugs per trap day) for the entire summit since 2007 and for Pu‘uhaukea since 2001. The solid colors show abundance with the scale on the left axis while capture rates are displayed as solid lines with the scale on the right axis. From the chart, it can be seen that abundance and capture rates for both the overall summit and Pu‘uhaukea for the most part follow the same general pattern.



Conclusion

In 2015, wēkiu bug abundance increased from 2014’s low counts. Trapping efforts remain consistent with 2013, and we continue to hypothesize that wēkiu bug population levels maintain extreme variability in (as do other established species on Maunakea). We believe these population variances are a part of a natural cycle influenced by numerous biotic and abiotic (especially climatic) factors. 2015’s results are on the lower end of wēkiu bug abundance trends. Interestingly, a much larger abundance of wēkiu bugs was observed on Pu‘uhau‘oki and Poi Bowl in comparison

[24] The table above shows results starting from 2007, when methods and locations became consistent.

to Puʻuhaukea. We are unsure if the populations migrate or if wēkiu bug life cycles vary between puʻu. These abundance shifts, as well as overall abundance trends, will continue to be an interesting facet of our wēkiu bug surveys and in furthering our understanding of wēkiu bug biology.

Honey bee Monitoring

Introduction

Monitoring honey bee (*Apis mellifera*) activity allows for understanding of the growth and health of the honey bee population on UH managed lands, while also keeping an eye on public safety. Honey bees are not native to Hawaiʻi, but their ecological function as pollinators is essential to many plants that have lost their native pollinators. Conversely, however, honey bees also harvest nectar from some native plants, such as māmane trees, without providing beneficial pollination services. Honey bee populations have been declining due to the varroa mite (*Varroa destructor*) and the small hive beetle (*Aethina tumida*), which harms both the hive and colony. Honey bees on Maunakea are not directly controlled, but their population levels are regulated for public safety reasons.

In May 2012, a honey bee swarm was reported inside of the Visitor Information Station (VIS) facility. The Department of Agriculture relocated the swarm and installed the first two swarm traps within UH managed lands. The purpose of a swarm trap is to attract the honey bees away from areas of human activity. Once a swarm trap becomes populated, the UH Hilo farm is contacted for help with removal and relocation to the Panaʻewa farm. OMKM conducts at minimum quarterly monitoring of swarm traps at HP for honey bee activity.

Study Site

The study site includes five swarm traps mounted to māmane trees around HP: (1) upslope from Utilities, (2) near Dorm A, (3) near Dorm D, (4) near the Ranger cabins, and (5) downslope from the VIS.

Methods

Honey bee swarm traps are constructed of a molded fiber material, with a large basin and a lid. A vial of pheromones is placed in each swarm trap to attract honey bees. The traps are fastened to māmane trees with zipties, and the bottom exit hole blocked to prevent rodent or bird entrance. Swarm traps were monitored monthly for bee activity by visual and auditory observation. All OMKM and incidental user observations were documented in a log. If a trap had activity, OMKM then conducted weekly monitoring to allow for the swarm to become established and then ensure timely trap removal. Traps were removed within 3 weeks of sustained bee activity. The swarm traps were only removed at night or early morning by a certified bee-keeper with OMKM supervision. After proper hive relocation and trap cleaning, the swarm trap was re-installed into the same location within 2 weeks of removal.

Results and Discussion

In 2015, bee activity peaked in the fall, with little to no activity in the winter, spring, and summer. It may be that activity did not peak in the summer, as it did in 2014, due to the rainy weather. As indicated in the tabled below, Trap 4 was the most active swarm trap in 2015 and Trap 1 seemed to be the least active. Environmental factors that could play a role in bee attraction include the vegetative composition, topographical relief, and the arthropod community in the immediate area.

This year, swarming did continually occur behind the VIS in the space below the old boarded-up window seat. The high activity in Trap 4 may have been due to its proximity to the VIS infestation. Trap 4 was removed in November due to the high bee activity within the trap. The colony was relocated to the UH Hilo Pana'ewa farm, and the UH Hilo general beekeeping class was able to harvest over 5 pounds of honey and comb from the trap. Trap 5 is the newest swarm trap, installed near the VIS in November in an effort to divert the honey bees away from the building. However, this trap did not see much activity this year. The 2015 swarm trap activity log can be seen below.

2015 Swarm Trap Activity Log

Month	TRAP 1	TRAP 2	TRAP 3	TRAP 4	TRAP 5
FEB	No bees observed	No bees observed	No bees observed	No bees observed	NA
MAY	No bees observed	No bees observed	No bees observed	No bees observed	NA
JUN	No bees observed	Low bee activity	Low bee activity	No bees observed	NA
JUL	No bees observed	No bees observed	No bees observed	No bees observed	NA
AUG	No bees observed	No bees observed	No bees observed	No bees observed	NA
OCT	No bees observed	No bees observed	No bees observed	High bee activity	NA
NOV	Low bee activity	Low bee activity	Low bee activity	Extreme levels of bee activity, relocated colony, re-installed trap	First installed, no bees observed
DEC	No bees observed	No bees observed	No bees observed	No bees observed	No bees observed

Vertebrate Monitoring

Introduction

OMKM documents incidental vertebrate catches and observations that are reported by Maunakea users. OMKM also collaborates with neighboring land owners about current issues on Maunakea and vice versa. Vertebrates include ungulates, cats, mongoose, dogs, rodents, rabbits, birds, reptiles, and amphibians. Any species not previously documented will be considered a threat and appear in the *Vertebrate, Early Detection Monitoring* section. This section only covers species that are already known to occur.

Study Site

The study site includes all UH managed lands and neighboring land managed by various State entities: Natural Area Reserves System (NARS), Department of Land and Natural Resources (DLNR), and the Department of Hawaiian Home Lands (DHHL).

Methods

Survey methods and reporting are not consistent throughout vertebrate types. All evidence of scat and other signs of vertebrate activity are reported to OMKM.

Ungulates

Ungulates including mouflon sheep (*Ovis musimon*), domesticated sheep (*Ovis aries*), goats (*Capra hircus*), cattle (*Bos taurus*), and feral pigs (*Sus scrofa*) are sparse on UH managed lands, but are occasionally observed.

Cats
Feral cats (*Felis catus*) are sparse at ~9,200 ft. and above but are occasionally observed. When cats are observed, it is recorded in our vertebrate log and MKSS staff put out live traps that are checked daily for cat activity. Captured cats are documented and taken to the Hawai'i Island Humane Society.

Dogs
Feral or loose dogs (*Canis familiaris*) are occasionally observed. From time to time, hunting dogs will get lost. Feral dog sightings are reported to DOFAW, DHHL, and BIISC. Domesticated dogs (*Canis lupus familiaris*) are occasionally seen when brought up in vehicles as pets. Sightings of domesticated dogs are documented but not reported.

Rodents
Rodents include mice and rats. There are two known established rodent species on UH managed lands: the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*). Rats are occasionally observed. Mice seem to be more common on UH managed lands and are observed in seasonal cycles, likely related to food availability (seeds). When rodent sightings increase, VIS/MKSS staff put out peanut butter- or granola-baited snap traps around the inside of their facility. Snap traps are checked daily and carcasses are disposed of in the rubbish can. Snap trap or automated trap captures are not currently being documented by OMKM. All other incidental rodent observations and captures by Maunakea users were documented.

Mongoose & Rabbits
Mongoose (*Herpestes auropuntatus)* and rabbits (*Lepus curpaeums*) are not common and are rarely observed on UH managed lands on Maunakea. When mongoose or rabbits are observed, they are reported to DOFAW, DHHL, and BIISC.

Birds
See *SOP B: Maunakea Vertebrate Threats Identification, Collection, and Processing Guide* for bird species commonly found on UH managed lands. The occasional dead bird is not typically documented. Large mortality events of non-native birds are reported to DOFAW. All dead native or banded birds are collected in a ziploc bag and reported to OMKM and DOFAW.

Reptiles & Amphibians
Reptiles are not known to be established, but the occasional coqui frog, gecko, or lizard does come up on a vehicle. Reported sightings are documented by OMKM.

Results and Discussion
In 2015, OMKM received reports of every vertebrate type except mongoose and rabbits. This year there were more reports of birds than anything else. Birds are not considered threats as they are found everywhere on Maunakea and are difficult to control. There were fewer reports of rodents, but this could be due to lack of reporting by Maunakea users and facility staff rather an actual reduction of their presenece. All other reports are not uncommon; it is typical to have occasional reports of most vertebrate types. Most vertebrate threats reported on UH managed lands were controlled (or control was attempted) using traps if the reported threat was not already dead. The

only non-controlled threat was the stray brown dog, about which reports ceased after the second sighting. 2015 incidental vertebrate reporting results are shown below. Location names have been shortened for simplification.

2015 Incidental Vertebrate Reports

Vertebrate	Species Reported	Reporter	Date	Location	Report
Ungulates	Feral sheep	OMKM	2/17/15	Humu'ula sheep station	Thousands of sheep across station around 3:00 pm
	Feral pig	Ranger	7/20/15	Summit	Wild pig being displayed by a hunter during sunset at summit
Cats	Feral cat	OMKM, MKSS	9/10/15 9/21/15 9/22/15 10/18/15	HP	Grey cat observed across VIS and near HP kitchen in the evening hours, the cat was eventually caught in a trap at HP
	Feral cat	MKSS	10/4/15	HP	Small striped cat was caught in trap
Dogs	Domestic dog	Ranger, VIS, SMA	5/5/15 5/10/15	Pu'uhaukea Pu'upoli'ahu	Stray brown dog seen
Rodents	Mouse	OMKM	8/20/15	SMA facility	Single dead mouse observed during perimeter search
Mongoose & Rabbits	None	NA	NA	NA	NA
Birds	Chukar	Ranger	2/17/15	UH '88 facility	Three chukars observed on summit
	Chukar	Ranger	4/25/15	JCMT facility	Single chukar observed on summit
	Kalij pheasant	Ranger	6/5/15	CSO facility	Single female kalij pheasant observed foraging at CSO facility
	Chukar	Ranger	6/19/15	IRTF facility	Single chukar observed on summit
	'Apapane	Researcher	7/29/15	HP	Dead 'apapane collected while doing field work
	Finch	OMKM	8/20/15	IRTF facility	Dead finch observed during perimeter search
	Mynah bird	OMKM	9/10/15	HP	Dead mynah bird in HP handicap stall around 8:00 am
Birds	'Apapane	OMKM, Ranger	9/16/15 9/30/15 10/1/15 10/5/15	HP	'Apapane observed in māmane tree close to Ranger parking lot and silversword enclosure
	Chukar	Ranger	10/13/15	VLBA	Single chukar observed on road
	Red-billed leiothrix	Ranger	11/2/15	Subaru facility	Pair of leiothrixes observed
Reptiles & Amphibians	Gecko	OMKM	2/7/15	HP gravel parking	Dead gecko near lower picnic benches

RAPID RESPONSE

Rapid response plans outline basic procedures to facilitate an efficient response to a new invasive species threat. While it would be impossible to anticipate every contingency, we can be prepared. Rapid response procedures require identifying and understanding the background of the targeted species, delimiting the invasion, generating a management plan, compiling information from experts and literature, and finally organizing an efficient reporting structure. When procedures are

timely, control and eradication are more feasible, with threats to cultural and natural resources reduced. This section discusses rapid response cases for the 2015 year. Several previously unreported arthropod species were identified in 2015, but based on initial life history reviews it was determined that response actions would focus only on continued monitoring using existing methods (see *Arthropod Early Detection* section for new species encountered in 2015), with the following exceptions.

Case 1: Ochetellus glaber

On April 16, 2015, *Ochetellus glaber* (black house ant) was discovered around the "Hale" located in the Mauna Kea Forest Reserve (MKFR) across the street from the VIS. *O. glaber* was detected using hand search methods, although baited vials and weed pulls were also being conducted. Numerous specimens were found within a non-native fan palm pile that was near the Hale. The fan palms were being used for the roof thatching of the structure. No prior records of this ant species exist for anywhere above the Saddle Road junction. Once the ants were identified, OMKM assited with delimiting surveys on Forest Reserve land. No additional ants or threats were identified during those efforts. OMKM also conducted perimeter searches around the HP facilities as a part of the already scheduled quarterly ant survey. No new ants or threats were found during the perimeter searches either. The area of *O. glaber* detection was not treated with pesticides due to the public's disapproval. Baiting efforts were initially done by DOFAW staff, but were eventually discontinued due to social concerns. For more details on this incident, see *Appendix H* for the full report.

Management Recommendations

Hawai'i Ant Lab (HAL) initially recommended the use of *Enforcer's AntMax* (Abamectin) bait stations around the detection area for several days before foliage removal. HAL recommended that a barrier Talstar® treatment then be applied around the detection area to prevent re-introduction. Additionally, continued baiting of the general vicinity was recommended due to the high influx of traffic. However, barrier treatments were not applied and baiting efforts ceased due to social conditions. OMKM will continue to work with DLNR in the future should they request further assistance in Forest Reserve monitoring efforts.

Case 2: Ochetellus glaber, Tapinoma melanocephalum, and Cardiocondyla kagutsuchi

On September 16, 2015, three ants were detected at HP during OMKM quarterly ant surveys. The three species are *Ochetellus glaber* (black house ant), *Tapinoma melanocephalum* (ghost ant), and *Cardiocondyla kagustsuchi*. All three ants have previously been observed in the area, and the latter two (*T. Melanocephalum and C. kagustsuchi*) have been observed on UH managed lands. *C. kagutsuchi* has a persisting population below the VIS storage warehouse, but this detection of *C. kagutsuchi* was on the upper paved parking lot in front of the HP Commons building. The other two species, *O. glaber* & *T. melanocephalum*, were detected in the HP lower paved parking lot. Only single individuals of *O. glaber* & *T. melanocephalum* were observed, while numerous *C. kagutsuchi* specimens were persent. All three species were observed through hand search methods and were detected on or near the pavement curbs. No further detections of *O. glaber* & *T. melanocephalum* were made after rapid response and quarterly surveys were complete. *C. kagutsuchi* populations in the upper parking lot continued to be observed. However, after pesticide treatments were

complete, no ants or threats were observed in the detection areas. For more details, see *Appendix I* for the full report.

Management Recommendations

Hawai'i Ant Lab suggested focused hand searches near buildings since *T. melanocephalum* and *O. glaber* are typically found in association with building interiors. Therefore, OMKM continued to conduct quarterly perimeter searches within the HP area in order to detect any further invasions or spread. Extra transect surveys were also completed by OMKM staff as part of an extensive detection effort and to check for additional *C. kagutsuchi*. OMKM treated the HP upper and lower parking areas with Talstar® insecticide in detection areas for 3 months in order to eradicate any residual populations. Finally, OMKM deployed bait plates filled with *Terro* and/or *Maxforce Complete* ant baits outside of the HP Commons building. Baiting also continued for 3 months. Pesticide and baiting efforts were completed by the end of 2015.

Case 3: Invasive Arthropod Inspection for Concrete Barriers at HP

An inspection for invasive arthropods of Department of Transportation (DOT) concrete barriers staged at HP was conducted on November 19, 2015. The un-inspected barriers arrived at HP on November 17, 2015 and were placed at the gravel staging area below the VIS and Ranger offices. Members of UHH Entomology lab and BIISC conducted a visual inspection accompanied by a baited survey of the barriers after they arrived on the mountain. The barriers and surrounding area (~20' buffer) were treated with Talstar®. For more details on this case, see *Appendix J* for the full report.

Management Recommendations

OMKM will work with the DOT, State Attorney General, and DLNR staff to increase awareness of OMKM and the Maunakea ISMP requirements. DLNR and BIISC staff will be notified of 'ōhi'a plant product movement with road barriers such that they can work with DOT to minimize risk as appropriate. OMKM quarterly monitoring will continue. Should the TMT project resume, monitoring frequency will be weekly.

CONTROL

Control may be applicable to invasive species that are too widespread to eradicate. The goal of control and management efforts is to reduce invasive species populations to more acceptable levels with effective management that prevents their spread or re-emergence. Once control and management efforts are implemented, monitoring must be documented to understand the effectiveness of management efforts.

Arthropods are difficult to control because of their size and mobility. The most common control methods for arthropods include chemical treatment and biological control. Plants are also difficult to control once they have seeded and spread. Common vegetation control methods include physical removal and chemical treatment. In 2015, OMKM controlled multiple invasive herbs and one ant species (*C. kagutsuchi*). Our control methods are still in development and may change in the future.

Vegetation Control

Introduction

Vegetation was controlled mechanically by OMKM staff, volunteers, and Maunakea rangers around HP and the MKSR. Removing weeds reduces habitat for invasive arthropods (such as *C. kagutsuchi),* helps in detecting new arthropods threats, and helps to reduce the spread of invasive species on UH managed lands. Investigation into long-term management options is ongoing.

Study Area

Vegetation control focused on human pathways and traffic areas. Sites included parking areas around HP and the VIS, along the Access Road, and around facilities in the MKSR and Astronomy Precinct.

Methods

OMKM Staff controls targeted non-native plants monthly throughout the HP area. Invasive trees are pruned each month in order to prevent further growth and spread, until weakened to an extent that the plant can be removed entirely. Smaller non-established plants are completely removed by hand-pulling. Most plant debris is hauled out in trash bags, as the County of Hawai‘i requires invasive species to be sent to the landfill rather than to greenwaste.

Volunteers with community weed pull events are provided with invasive plant identification guides, invasive arthropod reporting information, and instructions on proper weed removal/disposal methods. OMKM staff supervises all volunteer activities. Hand tools such as trowels, picks, and weeders are used to remove vegetation. All pulled vegetation is inspected for ants and cleared of soil before disposal into a trash bag. Trash bags are taken to the South Hilo Sanitary Landfill. When volunteers report ants, the location is flagged and documented for future survey and control (if applicable).

OMKM Rangers observe and remove invasive weeds in the MKSR and Astronomy precinct throughout the year. When weeds are observed they are hand-pulled and the species, number of individuals, and location are documented in a ranger report sent daily to OMKM staff.

Results and Discussion

OMKM Staff Vegetation Control

Every month, approximately two bags of vegetation debris were disposed of. Fennel, broom, eucalyptus, and apple plants were regularly controlled by pruning. The apple and broom individuals seem to be in decline, but the fennel and eucalyptus individuals remain resilient in re-growth. The other species noted on the table below were only observed during times of high moisture and were subsequently removed. Since their initial removal in the late summer these uncommon species have not been observed again.

Weed Species Pulled or Pruned by OMKM Staff

Family	Genus & Species	Common Name
Apiaceae	*Foeniculum vulgare*	Fennel
Asteraceae	*Bidens pilosa*	Spanish needle
Asteraceae	*Gaillardia pulchella*	Indian blanketflower

Fabaceae	*Cytisus spp.*	Broom
Fabaceae	*Trifolium repens*	White clover
Malvaceae	*Malva parviflora*	Cheeseweed
Myrtaceae	*Eucalyptus spp.*	Eucalyptus
Rosaceae	*Malus domestica*	Apple

Volunteer Vegetation Control

The volunteer program in 2015 engaged 228 volunteers who worked total of 1,710 hours and removed 442 bags of invasive weeds. Groups this year included Waiakea High Interact, UH Hilo Rotaract, UH Hilo Pre-Pharmacy, Hawai'i Army Youth National Guard, and two public events. We had presentations by Doug Simons (CFHT), Alton Okinaka (UH Hilo Sociology), Fritz Klasner (OMKM), Wally Ishibashi (OMKM), Stewart Hunter (MKSS), Jessica Kirkpatrick (OMKM), Heather Stever (UH Hilo TCBES), and Tom Chun (Kahu Kū Mauna). Targeted invasive weed species are shown below.

Weed Species Pulled by Volunteers

Family	Genus & Species	Common Name
Asteraceae	*Heterotheca grandiflora*	Telegraph weed
Asteraceae	*Hypochaeris radicata*	Hairy cat's ear
Asteraceae	*Scenicio madagascarensis*	Fireweed
Asteraceae	*Taraxacum officinale*	Common dandelion
Gerainiaceae	*Erodium cicutarium*	Pin clover, alfilaria
Onagraceae	*Oenothera stricta*	Chilean evening primrose
Polygonaceae	*Rumex acetosella*	Sheep's sorrel
Scrophulariaceae	*Verbascum thapsus*	Common mullein
Scrophulariaceae	*Verbascum virgatum*	Wand mullein

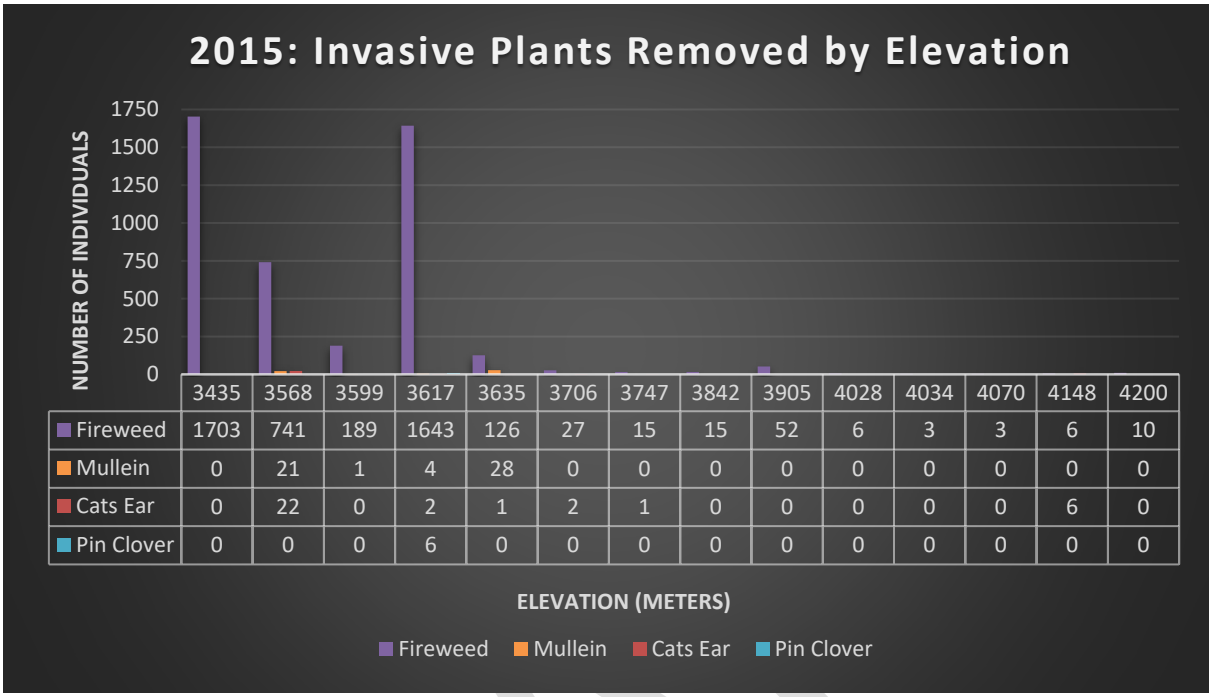
Maunakea Ranger Vegetation Control

Fireweed reports were at an all-time high in 2015 due to the wet summer conditions. From late summer to winter, fireweed reports and pulls continued to remain at unusually high levels. In 2014, fireweed counts totalled around 215 for the year in the MKSR. In 2015, fireweed reports neared 2,300 individuals in October alone. All other weed species remained around or less than 10 individuals per month, with small outbursts in August and November. When plotted by month, fireweed populations spiked in October 2015 (see graph below). When plotted by elevation, most of the weeds were reported around the 6th bend (3,435 m) on the Access Road, around Park 1 (3,617 m), and near Mile Marker 4.5 (3,568 m) (see graph below). Although the general trend of fireweed reports decreases with elevation, these areas may have the highest number of reports due to high ranger visitation and visibility. Nonetheless, all weed species pulled by Maunakea Rangers were at increased levels compared to 2014, especially for the MKSR.

Weed Species Pulled by Maunakea Rangers

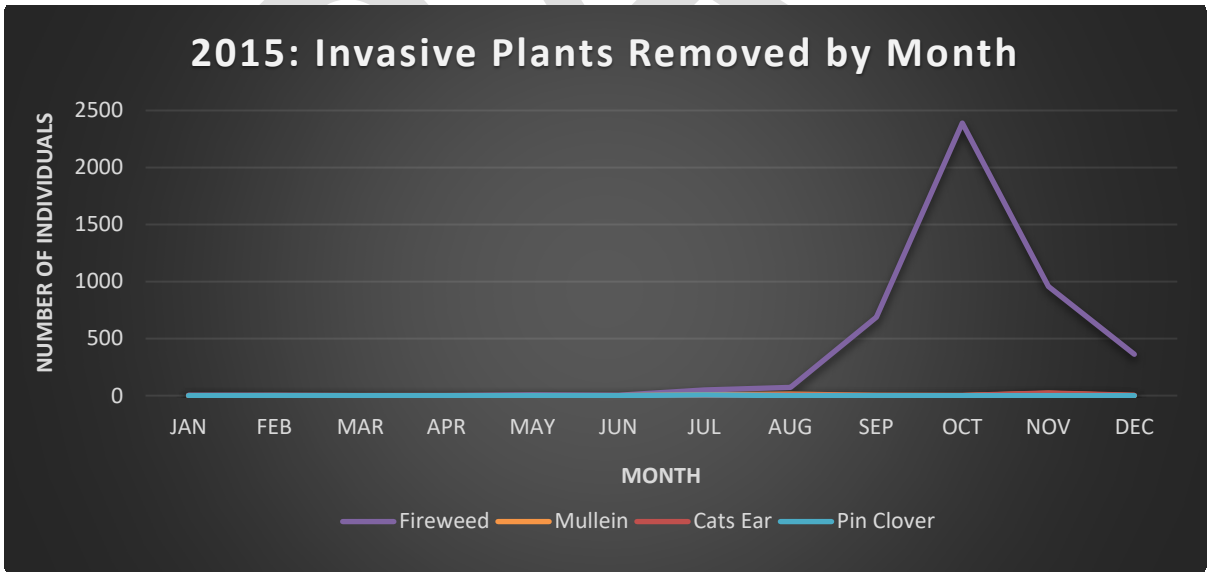
Family	Genus & Species	Common Name
Asteraceae	*Hypochaeris radicata*	Hairy cat's ear
Asteraceae	*Scenicio madagascarensis*	Fireweed
Asteraceae	*Taraxacum officinale*	Common dandelion
Geraniaceae	*Erodium cicutarium*	Pin clover; alfilaria
Scrophulariaceae	*Verbascum thapsus*	Common mullein

Number of Non-Native Weed Individuals Pulled Monthly



	3435	3568	3599	3617	3635	3706	3747	3842	3905	4028	4034	4070	4148	4200
Fireweed	1703	741	189	1643	126	27	15	15	52	6	3	3	6	10
Mullein	0	21	1	4	28	0	0	0	0	0	0	0	0	0
Cats Ear	0	22	0	2	1	2	1	0	0	0	0	0	6	0
Pin Clover	0	0	0	6	0	0	0	0	0	0	0	0	0	0

Elevation of Non-Native Weed Individuals Pulled



Conclusion

Invasive weed pulls reduce the risk of seed dispersal by Maunakea users and decrease potential ant habitat. All three parties (OMKM, volunteers, Rangers) are necessary for vegetation control and early detection efforts on UH managed lands. However, this year's weed populations have been overwhelming for all staff. Therefore, long-term options need to be developed to more effectively control non-native vegetation, especially within the higher elevations of the MKSR. In the future,

other vegetation control methods may be developed for OMKM- and Ranger-targeted weed species and a complementary restoration plan created for the HP area.

Arthropod Control
Cardiocondyla kagutsuchi

Introduction

As explained in the introductory paragraph of this section, arthropods are difficult to control and available options are few. In 2015, we continued with *Cardiocondyla kagutsuchi* (a common ant) control. Control for this species is feasible because the ants are confined to one area. We treat the area with spot treatments of Talstar® Professional insecticide, a liquid formulation with Bifenthrin as the active ingredient. All applications are recorded in a detailed pesticide log.

Study Area

Control efforts are focused in the vegetated area below the VIS storage warehouse and presentation room. *C. kagutsuchi* persists in this area. Before applying insecticide, the area is intensely surveyed to determine species range and identify the treatment area.

Methods

Ant Surveys

OMKM conducts quarterly ant surveys throughout HP, along roadways, within parking lots, and around facility perimeters. When ants are observed, an intensive micro-survey is conducted to delimit the necessary treatment area and determine pesticide formulations. Baited vials (peanut butter, jelly, spam) are placed throughout survey areas and observed after 10 minutes for any signs of ant activity. At each survey location, invasive weeds are pulled and observed for ants. Pulling weeds is our most effective method for detecting ants because ants appear to feed on the honeydew of aphids and mealybugs found on the roots. In many cases we found ants only by pulling weeds, even when vials were less than a foot away. Areas that contain ants are flagged for later treatment.

Control

Ant infested areas are spot treated with Talstar® Professional insecticide. Insecticide dilution followed all label requirements and quantities applied were determined by the size of the area to be treated.

Results and Discussion

The *C. kagutsuchi* population continues to persist in the same area. Throughout 2015, *C. kagutsuchi* were observed during every quarterly survey. The detections are typically ant individuals, as staff rarely find colonies, which can be deep within the soil. These ants continue to be detected through hand searches and not through the baited vial method. Treatments were done twice in 2015 in this location. The control of *C. kagutsuchi* continued into 2016 and beyond.

ACKNOWLEDGEMENTS

We thank the Bishop Museum for their years of effort monitoring both invasive species and wēkiu bugs on Maunakea. We appreciate all the hard work that was put into the survey design, making the survey much easier for us. We thank Cynthia B. King with DLNR for the necessary collecting

permits. Additionally, we would like to thank Dr. Jesse A. Eiben for his professional assistance with all OMKM entomological activities. We also have to thank Dr. Eiben's UH Hilo entomology lab for helping with identification requirements. OMKM field assistants in 2015 include: Jessica Kirkpatrick, Darcy Yogi, Amber Stillman, Joy Yoshina, Sage Van Kralingen, Gizelle Geronimo, Nelson Crabbe, Jorden Zarders, Sean Kirkpatrick, Nathan Stephenson, Tisha Pi'ilani-Pelanca, Christian Kapono, and Heather Stever. We would not have the ISMP without Hawai'i Ant Lab's Casper Vanderwoude and BIISC's Springer Kaye. Finally, we need to thank the OMKM Rangers and entire OMKM office for another successful and safe year. Mahalo nui to all!

REFERENCES

Preston, D.J., R. A. Englund, N.L Evenhuis, & C. Imada (2013). Results of the 2012 alien species and Wekiu bug (Nysius Wekiuicola) surveys on the summit of Mauna Kea, Hawaii Island. Final report. Honolulu, Bishop Museum.

Evenhuis, N. L. and L. G. Eldredge (2013). Bishop Museum Occasional Papers: Records of the Hawaii Biological Survey for 2012. N. Evenhuis. Honolulu, Bishop Museum Press. **114:** 57.

Kavanaugh, D. H. and T. Erwin (1985). "*Trechus obtusus* Erichson (Coleoptera: Carabidae), a European Ground Beetle, on the Pacific Coast of North America: Its Distribution, Introduction, and Spread." Pan-Pacific Entomologist **61**(2): 170-179.

Liebher, J. K. and R. Takumi (2002). "Introduction and Distributional Expansion of Trechus obtusus (Coleoptera: Carabidae) in Maui, Hawaii." Pacific Science **56**(4): 365-375.

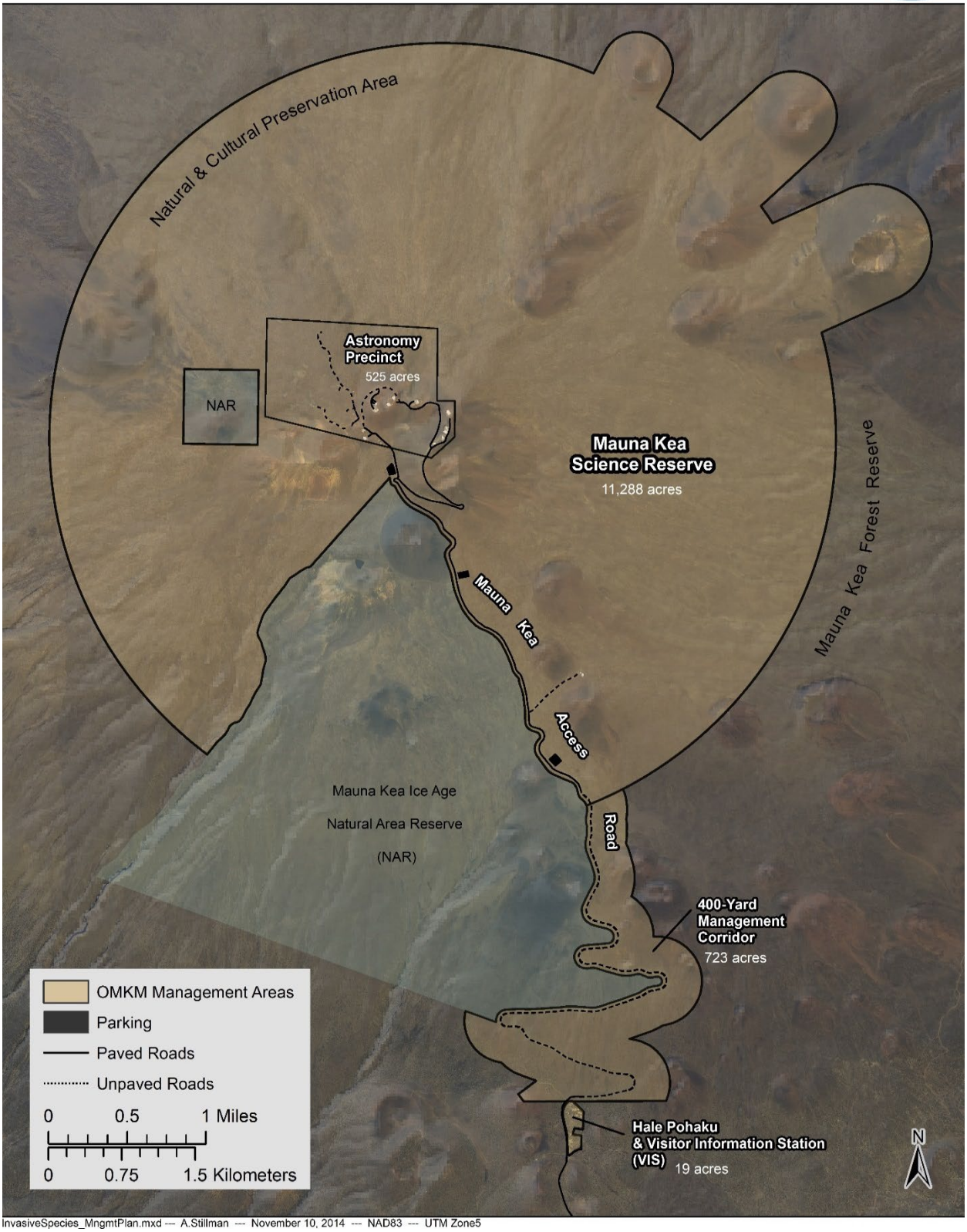
Liebherr, J. and P. Krushelnycky (2007). Unfortunate encounters? Novel interactions of native Mecyclothorax, alien Trechus obtusus (Coleoptera: Carabidae), and Argentine ant (Linepithema humile, Hymenoptera: Formicidae) across a Hawaiian landscape. Beetle Conservation. T. R. New, Springer Netherlands**:** 61-73.

Lovei, G. L. and K. D. Sunderland (1996). "Ecology and Behavior of Ground Beetles (Coleoptera: Carabidae)." Annual Review of Entomology **41**: 231-256.

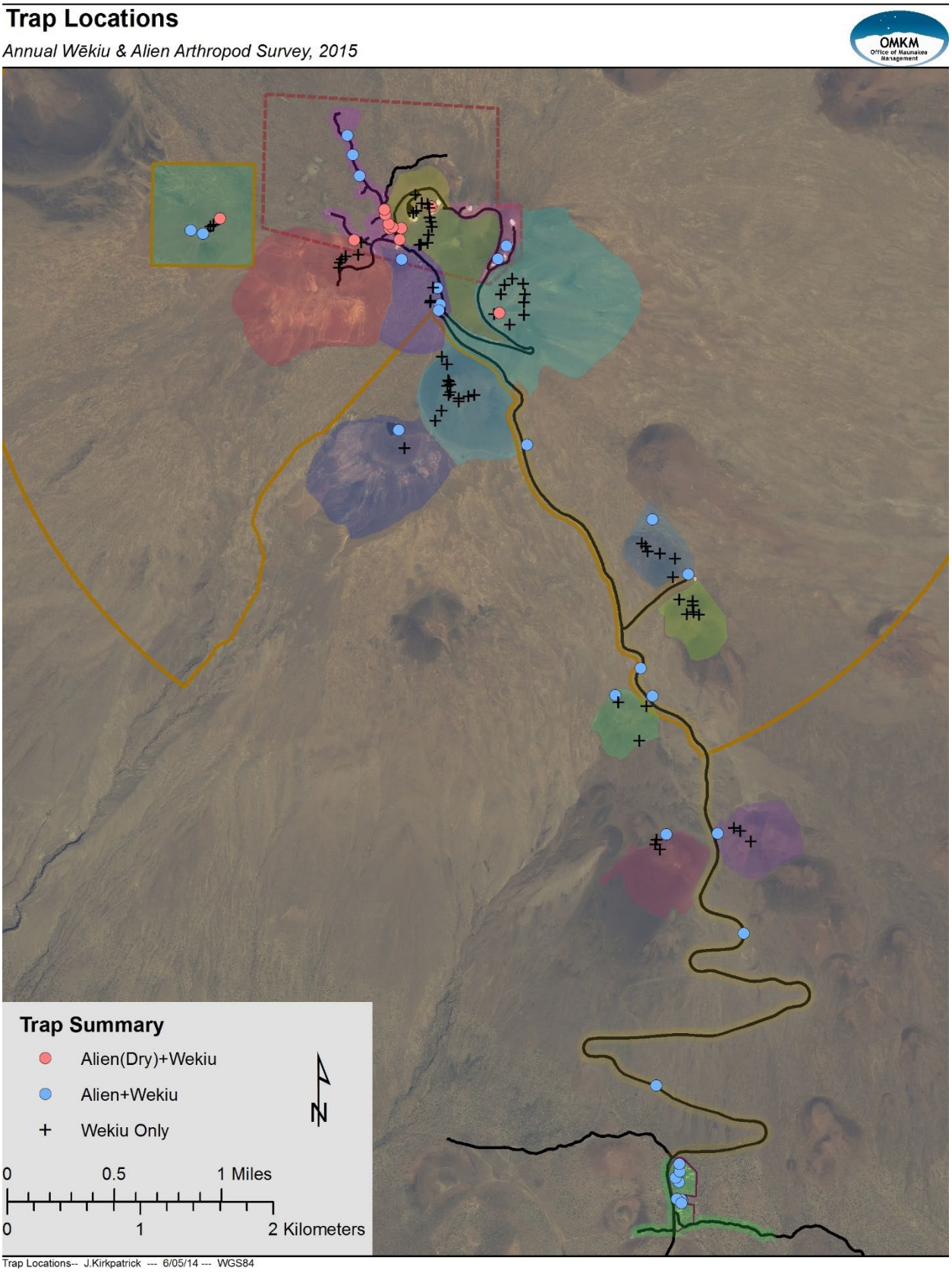
Peck, R. W. and P. C. Banko (2011). Survey of Invasive Ants at Hakalau Forest National Wildlife Refuge, Hawaii Cooperative Studies Unit University of Hawaii at Hilo, Pacific Aquaculture and Coastal Resources Center (PACRC).

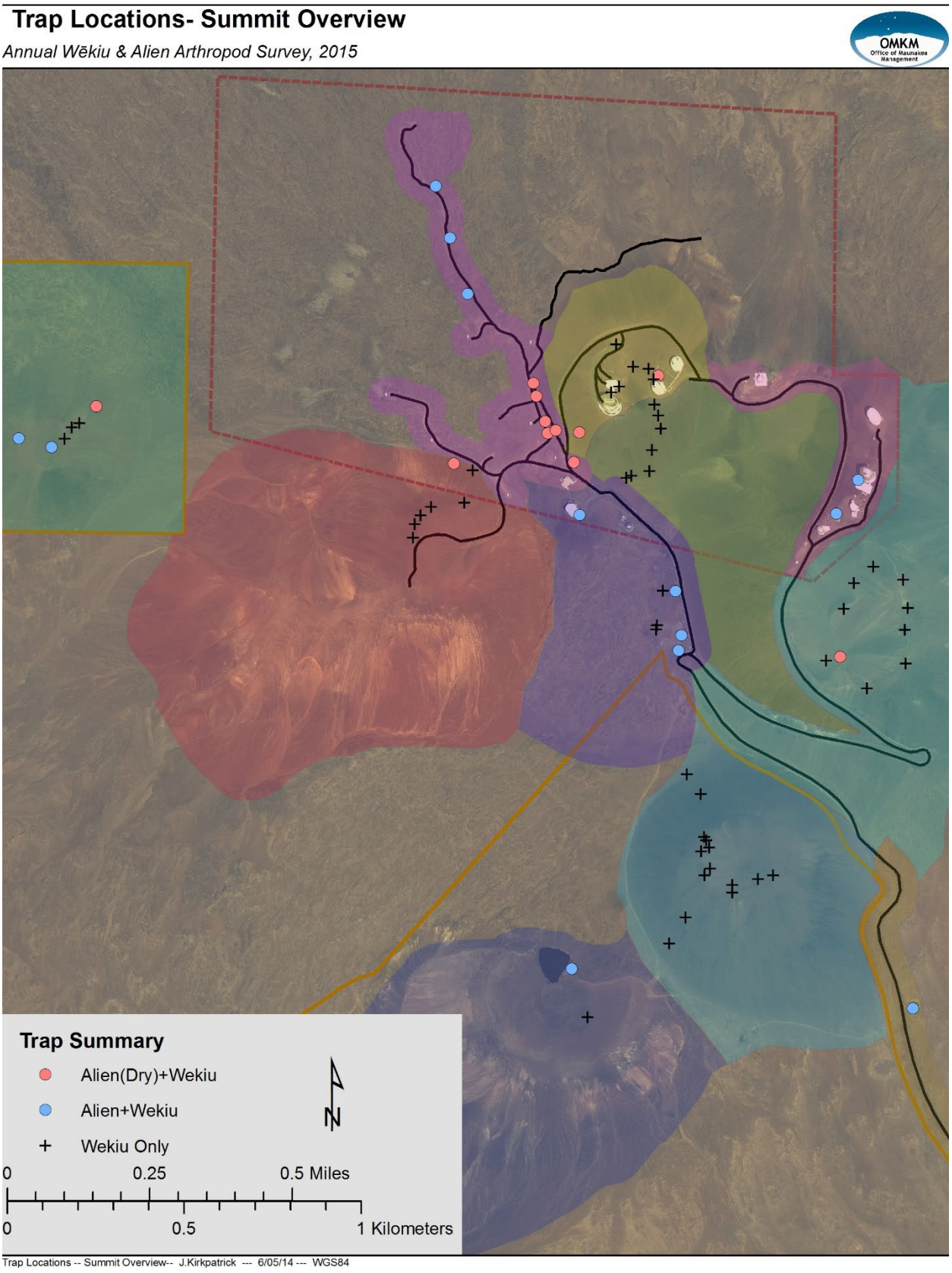
APPENDICES

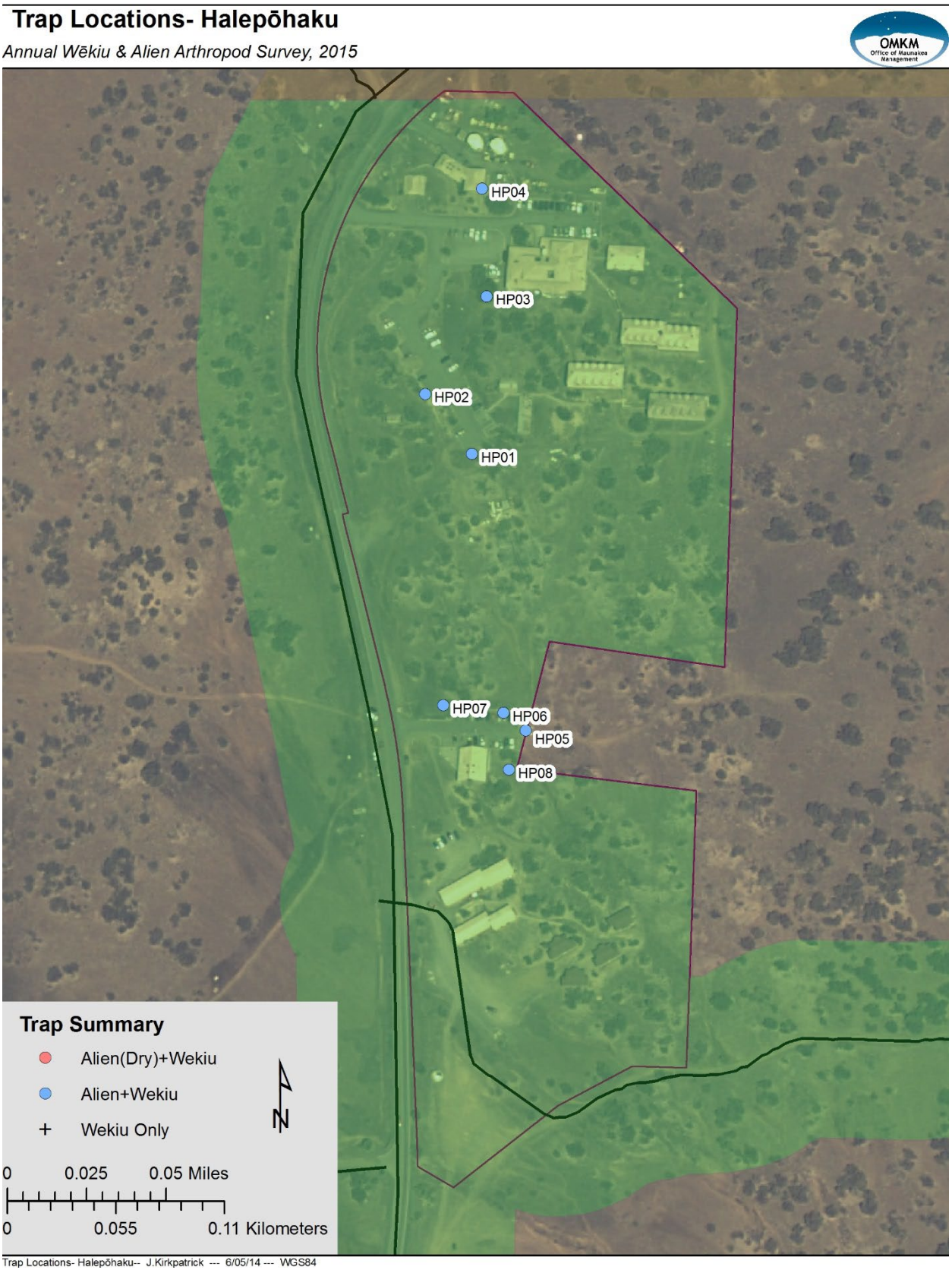
APPENDIX A: UH MANAGEMENT AREAS

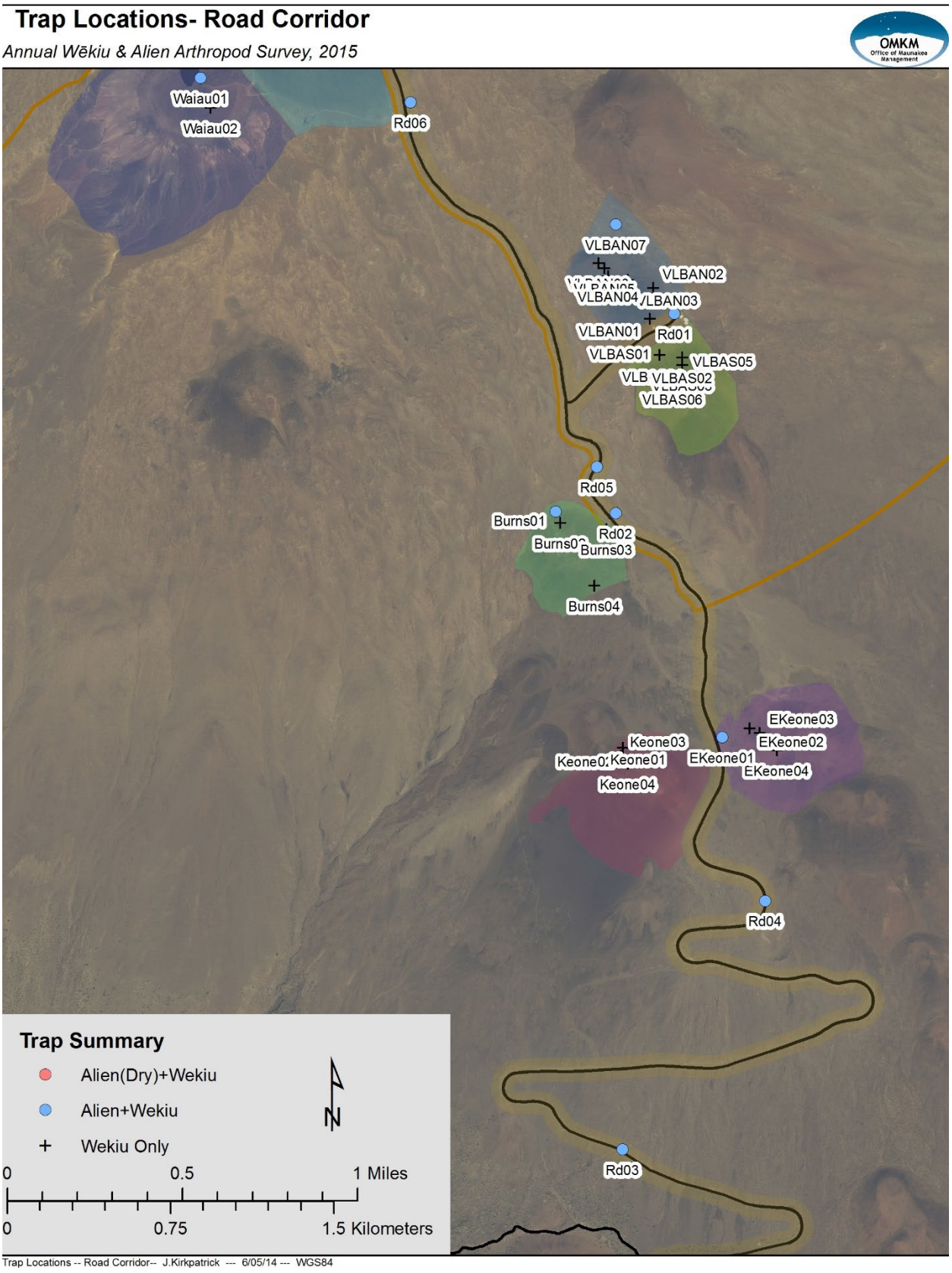


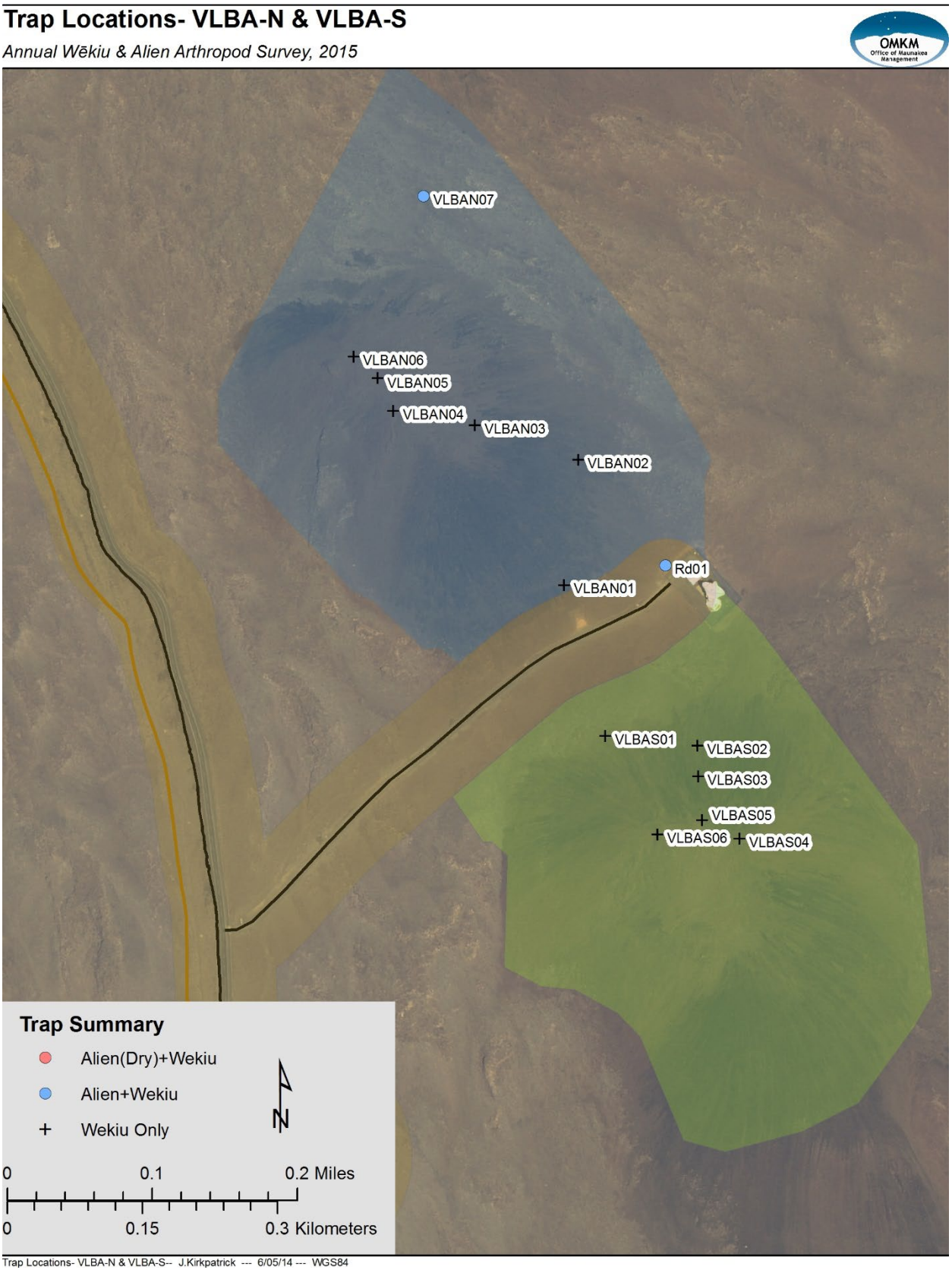
Appendix B: 2015 Annual Survey Maps

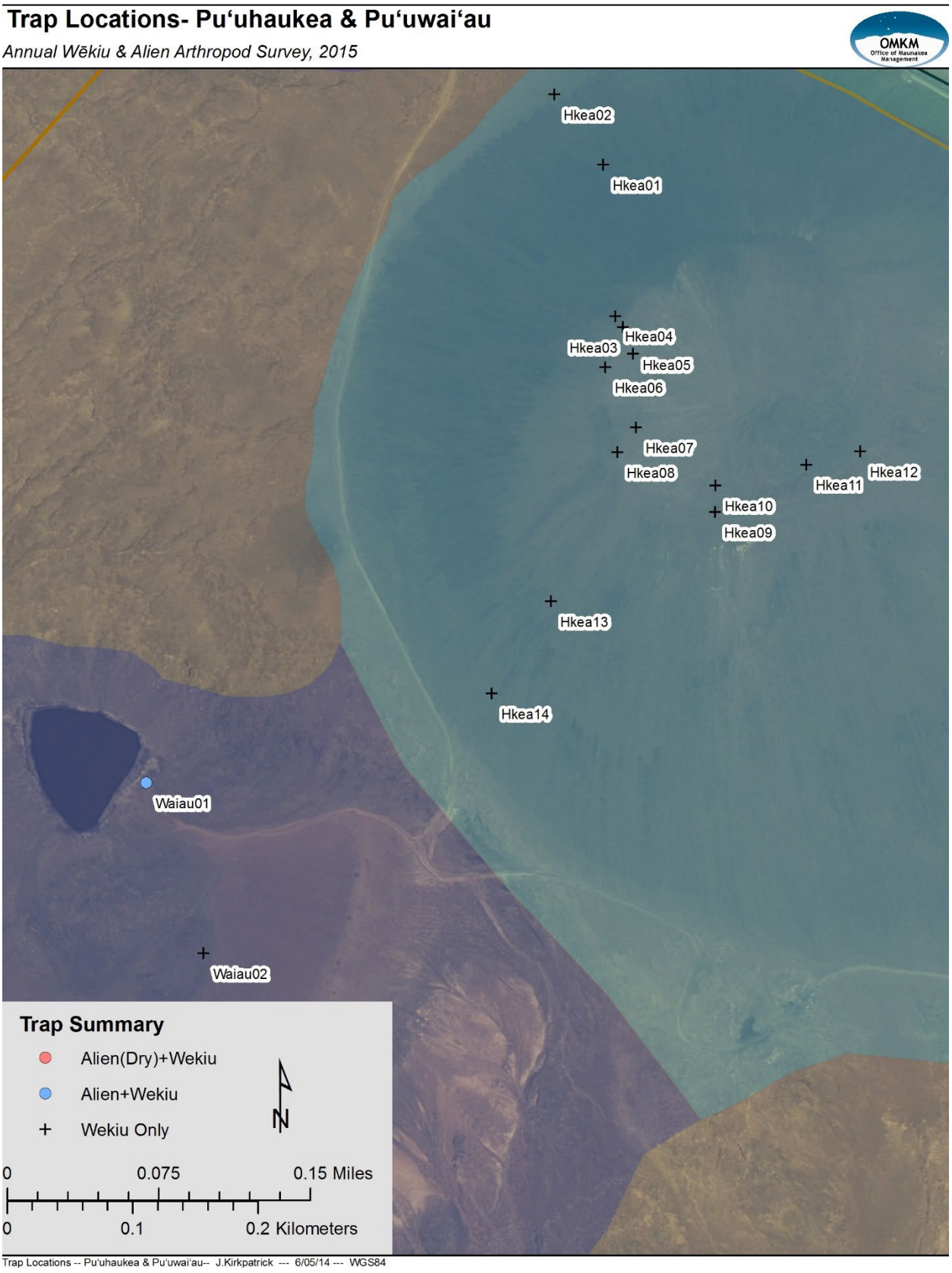


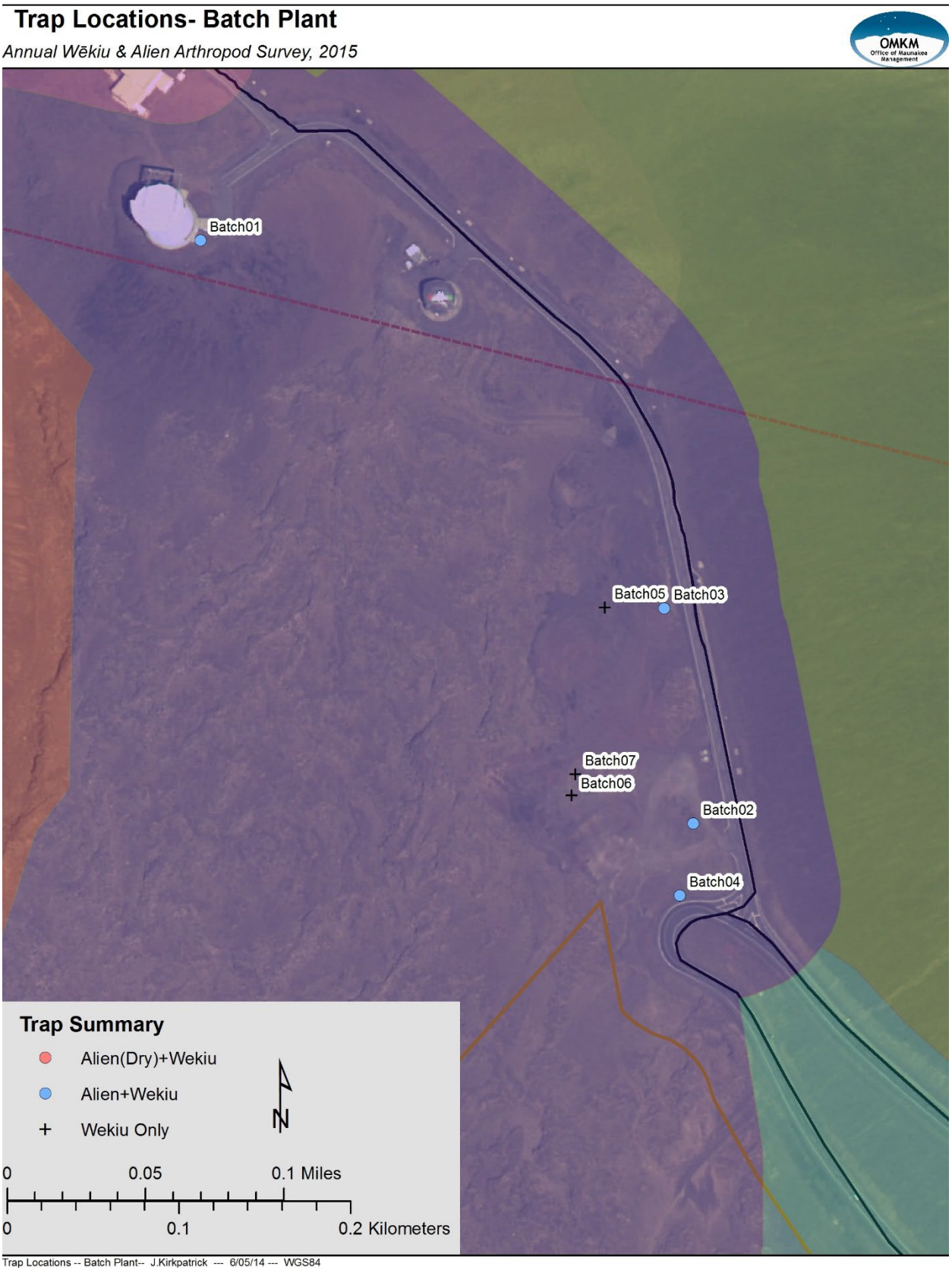

Trap Locations- Summit Overview
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.25
0.5 Miles
0
0.5
1 Kilometers
Trap Locations -- Summit Overview-- J.Kirkpatrick --- 6/05/14 --- WGS84

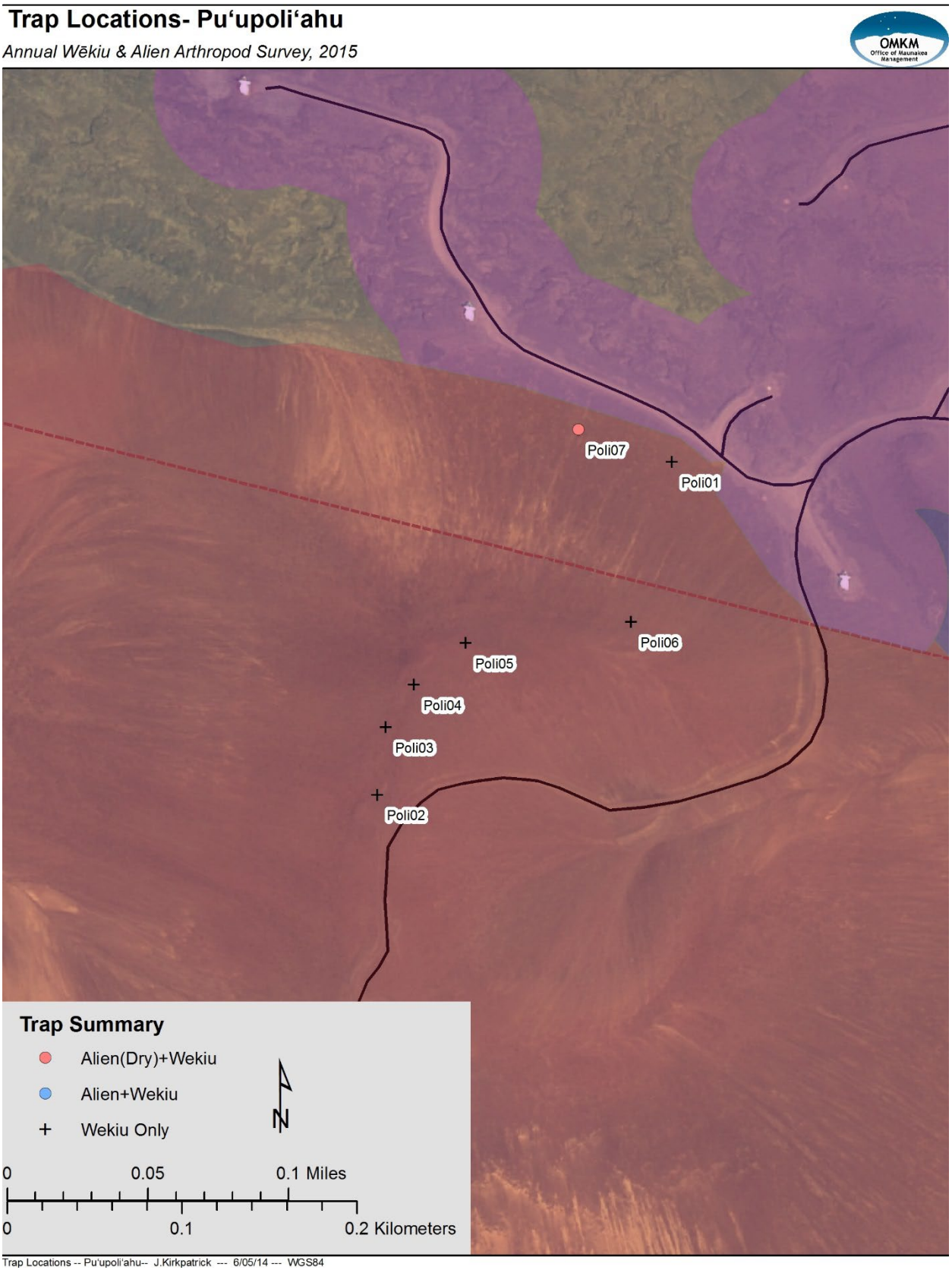

Trap Locations- Halepōhaku
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
HP04
HP03
HP02
HP01
HP07
HP06
HP05
HP08
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0 0.025 0.05 Miles
0 0.055 0.11 Kilometers
Trap Locations- Halepōhaku-- J.Kirkpatrick --- 6/05/14 --- WGS84


Trap Locations- Road Corridor
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Waiau01
Waiau02
Rd06
VLBAN07
VLBAN02
VLBAN04
VLBAN03
VLBAN01
Rd01
VLBAS01
VLBAS05
VLB
VLBAS02
VLBAS06
Rd05
Burns01
Rd02
Burns0
Burns03
Burns04
EKeone03
Keone03
EKeone02
Keone0
Keone01
EKeone01
EKeone04
Keone04
Rd04
Rd03
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.5
1 Miles
0
0.75
1.5 Kilometers
Trap Locations -- Road Corridor-- J.Kirkpatrick --- 6/05/14 --- WGS84

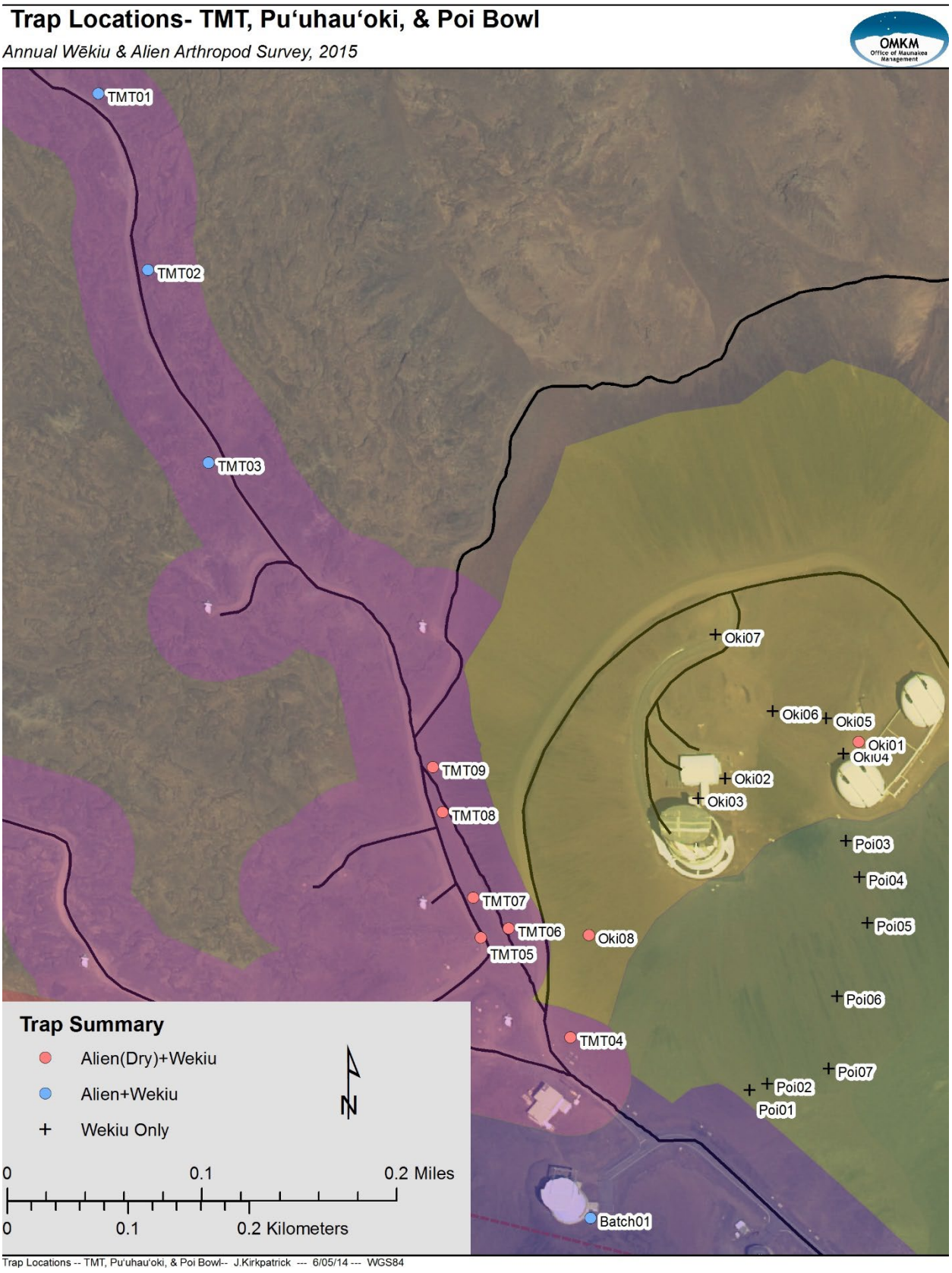

Trap Locations- VLBA-N & VLBA-S
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
VLBAN07
VLBAN06
VLBAN05
VLBAN04
VLBAN03
VLBAN02
Rd01
VLBAN01
VLBAS01
VLBAS02
VLBAS03
VLBAS05
VLBAS06
VLBAS04
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.1
0.2 Miles
0
0.15
0.3 Kilometers
Trap Locations- VLBA-N & VLBA-S-- J.Kirkpatrick --- 6/05/14 --- WGS84

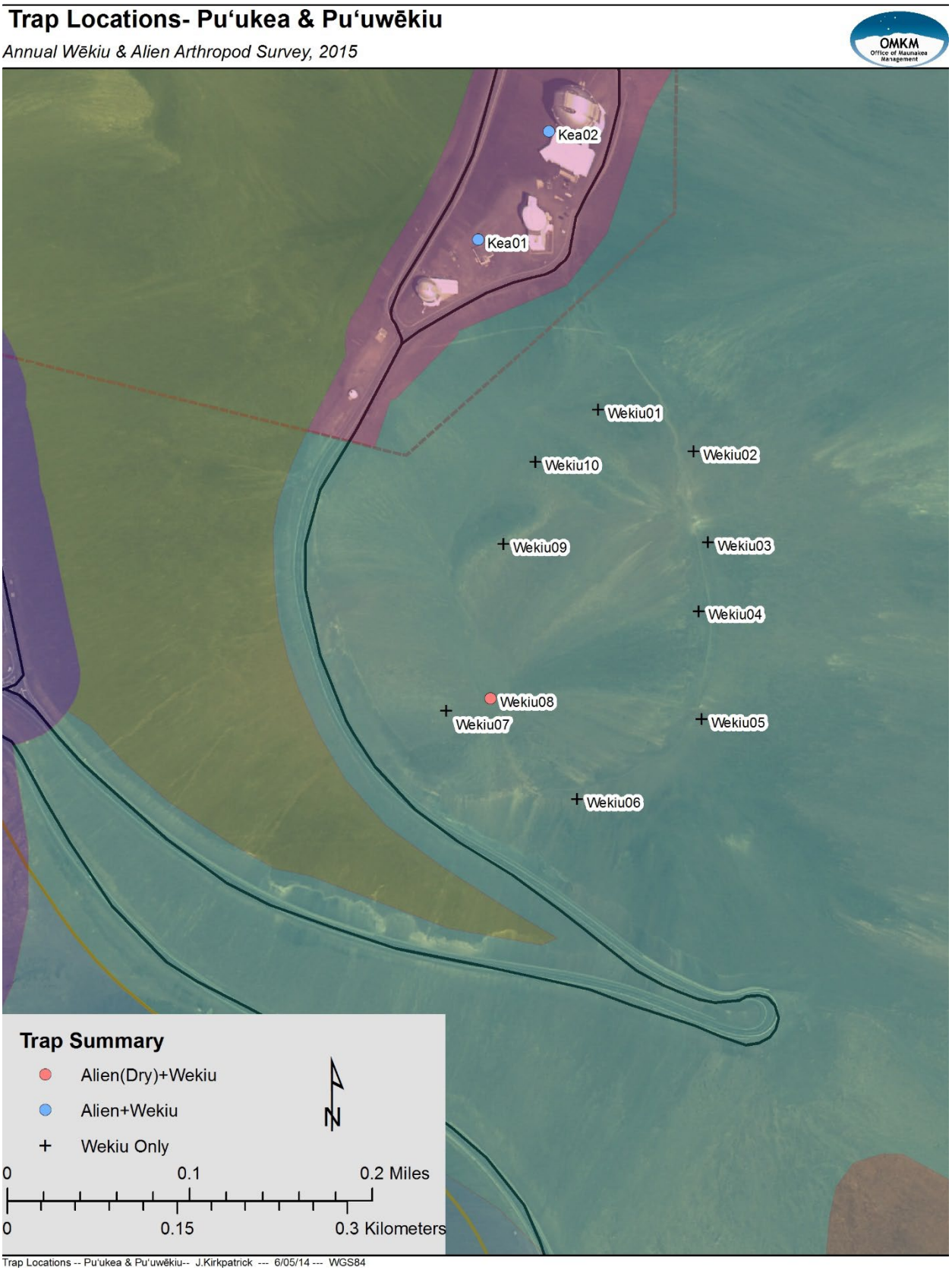

Trap Locations- Pu‘uhaukea & Pu‘uwai‘au
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Hkea02
Hkea01
Hkea04
Hkea03
Hkea05
Hkea06
Hkea07
Hkea08
Hkea12
Hkea11
Hkea10
Hkea09
Hkea13
Hkea14
Waiau01
Waiau02
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.075
0.15 Miles
0
0.1
0.2 Kilometers
Trap Locations -- Pu'uhaukea & Pu'uwai'au-- J.Kirkpatrick --- 6/05/14 --- WGS84


Trap Locations- Batch Plant
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Batch01
Batch05
Batch03
Batch07
Batch06
Batch02
Batch04
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.05
0.1 Miles
0
0.1
0.2 Kilometers
Trap Locations -- Batch Plant-- J.Kirkpatrick --- 6/05/14 --- WGS84


Trap Locations- Pu'upoli'ahu
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Poli07
Poli01
Poli06
Poli05
Poli04
Poli03
Poli02
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.05
0.1 Miles
0
0.1
0.2 Kilometers
Trap Locations -- Pu'upoli'ahu-- J.Kirkpatrick --- 6/05/14 --- WGS84


Trap Locations- Pu'upōhaku
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Poha01
Poha02
Poha03
Poha04
Poha05
Poha06
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.05
0.1 Miles
0
0.1
0.2 Kilometers
Trap Locations -- Pu'upōhaku-- J.Kirkpatrick --- 6/05/14 --- WGS84


Trap Locations- TMT, Pu'uhau'oki, & Poi Bowl
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
TMT01
TMT02
TMT03
TMT09
TMT08
TMT07
TMT06
TMT05
TMT04
Batch01
Oki07
Oki06
Oki05
Oki01
Oki04
Oki02
Oki03
Oki08
Poi03
Poi04
Poi05
Poi06
Poi07
Poi02
Poi01
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.1
0.2 Miles
0
0.1
0.2 Kilometers
Trap Locations -- TMT, Pu'uhau'oki, & Poi Bowl-- J.Kirkpatrick --- 6/05/14 --- WGS84


Trap Locations- Pu'ukea & Pu'uwēkiu
Annual Wēkiu & Alien Arthropod Survey, 2015
OMKM
Office of Maunakea Management
Kea02
Kea01
Wekiu01
Wekiu10
Wekiu02
Wekiu09
Wekiu03
Wekiu04
Wekiu08
Wekiu07
Wekiu05
Wekiu06
Trap Summary
Alien(Dry)+Wekiu
Alien+Wekiu
Wekiu Only
N
0
0.1
0.2 Miles
0
0.15
0.3 Kilometers
Trap Locations -- Pu'ukea & Pu'uwēkiu-- J.Kirkpatrick --- 6/05/14 --- WGS84

APPENDIX C: 2015 ANNUAL SURVEY TRAP LOCATIONS*

Location	Site ID	Trap Date	Altitude (meters)	Latitude	Longitude	Trap Type
Halepōhaku	HP01	23-26-June-2015	2851	19.76058994	-155.45603997	Alien
Halepōhaku	HP02	23-26-June-2015	2853	19.76085992	-155.45626997	Alien
Halepōhaku	HP03	23-26-June-2015	2865	19.76130995	-155.45597996	Alien
Halepōhaku	HP04	23-26-June-2015	2868	19.76179996	-155.45600996	Alien
Halepōhaku	HP05	23-26-June-2015	2832	19.75932998	-155.45575993	Alien
Halepōhaku	HP06	23-26-June-2015	2833	19.75940994	-155.45586999	Alien
Halepōhaku	HP07	23-26-June-2015	2833	19.75943995	-155.45616000	Alien
Halepōhaku	HP08	23-26-June-2015	2831	19.75914993	-155.45583998	Alien
Pu'uhaukea	Hkea01	28-June-01-July-2015	4054	19.81571944	-155.47350000	Wēkiu
Pu'uhaukea	Hkea02	28-June-01-July-2015	4028	19.81621944	-155.47388056	Wēkiu
Pu'uhaukea	Hkea03	28-June-01-July-2015	4124	19.81454996	-155.47332999	Wēkiu
Pu'uhaukea	Hkea04	28-June-01-July-2015	4120	19.81462992	-155.47338992	Wēkiu
Pu'uhaukea	Hkea05	28-June-01-July-2015	4116	19.81435994	-155.47324995	Wēkiu
Pu'uhaukea	Hkea06	28-June-01-July-2015	4125	19.81425994	-155.47346000	Wēkiu
Pu'uhaukea	Hkea07	28-June-01-July-2015	4118	19.81382995	-155.47321994	Wēkiu
Pu'uhaukea	Hkea08	28-June-01-July-2015	4128	19.81364999	-155.47335992	Wēkiu
Pu'uhaukea	Hkea09	28-June-01-July-2015	4124	19.81322997	-155.47260999	Wēkiu
Pu'uhaukea	Hkea10	28-June-01-July-2015	4115	19.81341999	-155.47260999	Wēkiu
Pu'uhaukea	Hkea11	28-June-01-July-2015	4116	19.81357992	-155.47191999	Wēkiu
Pu'uhaukea	Hkea12	28-June-01-July-2015	4126	19.81368000	-155.47150995	Wēkiu
Pu'uhaukea	Hkea13	28-June-01-July-2015	4070	19.81257000	155.47385000	Wēkiu
Pu'uhaukea	Hkea14	28-June-01-July-2015	4043	19.81190000	155.47429000	Wēkiu
Pu'upoli'ahu	Poli01	29-June-02-July-2015	4075	19.82389000	-155.47977000	Wēkiu
Pu'upoli'ahu	Poli02	29-June-02-July-2015	4150	19.82214999	-155.48134997	Wēkiu
Pu'upoli'ahu	Poli03	29-June-02-July-2015	4152	19.82249994	-155.48130998	Wēkiu
Pu'upoli'ahu	Poli04	29-June-02-July-2015	4162	19.82271996	-155.48115995	Wēkiu
Pu'upoli'ahu	Poli05	29-June-02-July-2015	4160	19.82293999	-155.48087999	Wēkiu
Pu'upoli'ahu	Poli06	29-June-02-July-2015	4139	19.82305993	-155.47997994	Wēkiu
Pu'upoli'ahu	Poli07	29-June-02-July-2015	4073	19.82405000	-155.48028333	Alien(Dry)
Pu'u'hau'oki	Oki01	23-26-June-2015	4174	19.82636995	-155.47480999	Alien(Dry)
Pu'u'hau'oki	Oki02	23-26-June-2015	4151	19.82607993	-155.47585999	Wēkiu
Pu'u'hau'oki	Oki03	23-26-June-2015	4164	19.82592998	-155.47606995	Wēkiu
Pu'u'hau'oki	Oki04	23-26-June-2015	4171	19.82627993	-155.47492993	Wēkiu
Pu'u'hau'oki	Oki05	23-26-June-2015	4162	19.82653993	-155.47506999	Wēkiu
Pu'u'hau'oki	Oki06	23-26-June-2015	4117	19.82658997	-155.47548993	Wēkiu
Pu'u'hau'oki	Oki07	23-26-June-2015	4119	19.82715280	-155.47595278	Wēkiu
Pu'u'hau'oki	Oki08	23-26-June-2015	4105	19.82490000	-155.47691667	Alien(Dry)
Pu'uwēkiu	Wēkiu01	23-26-June-2015	4196	19.82157994	-155.46893000	Wēkiu
Pu'uwēkiu	Wēkiu02	23-26-June-2015	4214	19.82125992	-155.46811997	Wēkiu
Pu'uwēkiu	Wēkiu03	23-26-June-2015	4225	19.82054000	-155.46798997	Wēkiu
Pu'uwēkiu	Wēkiu04	23-26-June-2015	4215	19.81998998	-155.46805996	Wēkiu
Pu'uwēkiu	Wēkiu05	23-26-June-2015	4207	19.81912999	-155.46801997	Wēkiu
Pu'uwēkiu	Wēkiu06	23-26-June-2015	4186	19.81847998	-155.46905992	Wēkiu
Pu'uwēkiu	Wēkiu07	23-26-June-2015	4159	19.81916998	-155.47016993	Wēkiu
Pu'uwēkiu	Wēkiu08	23-26-June-2015	4148	19.81926997	-155.46979995	Alien(Dry)
Pu'uwēkiu	Wēkiu09	23-26-June-2015	4178	19.82049993	-155.46970993	Wēkiu
Pu'uwēkiu	Wēkiu10	23-26-June-2015	4183	19.82115992	-155.46944993	Wēkiu

TMT Site/SMA	TMT01	29-June-02-July-2015	4044	19.83111997	-155.48087999	Alien
TMT Site/SMA	TMT02	29-June-02-July-2015	4058	19.82980996	-155.48046995	Alien
TMT Site/SMA	TMT03	29-June-02-July-2015	4068	19.82837993	-155.47996997	Alien
TMT Site/SMA	TMT04	29-June-02-July-2015	4093	19.82413333	-155.47705000	Alien(Dry)
TMT Site/SMA	TMT05	29-June-02-July-2015	4082	19.82486670	-155.47776667	Alien(Dry)
TMT Site/SMA	TMT06	29-June-02-July-2015	4106	19.82494000	-155.47755000	Alien(Dry)
TMT Site/SMA	TMT07	29-June-02-July-2015	4082	19.82516670	-155.47783333	Alien(Dry)
TMT Site/SMA	TMT08	29-June-02-July-2015	4076	19.82580000	-155.47808333	Alien(Dry)
TMT Site/SMA	TMT09	29-June-02-July-2015	4075	19.82613330	-155.47816667	Alien(Dry)
Road Corridor	Rd01	19-22-June-2015	3753	19.80173998	-155.45600996	Alien
Road Corridor	Rd02	19-22-June-2015	3667	19.79344994	-155.45844994	Alien
Road Corridor	Rd03	19-22-June-2015	3032	19.76709992	-155.45774996	Alien
Road Corridor	Rd04	19-22-June-2015	3390	19.77747998	-155.45165992	Alien
Road Corridor	Rd05	19-22-June-2015	3658	19.79534995	-155.45929994	Alien
Road Corridor	Rd06	19-22-June-2015	3932	19.81033998	-155.46769995	Alien
Batch Plant	Batch01	29-June-02-July-2015	4106	19.82278995	-155.47686992	Alien
Batch Plant	Batch02	29-June-02-July-2015	4056	19.81975998	-155.47407992	Alien
Batch Plant	Batch03	29-June-02-July-2015	4082	19.82088994	-155.47425996	Alien
Batch Plant	Batch04	29-June-02-July-2015	4064	19.81937994	-155.47415000	Alien
Batch Plant	Batch05	29-June-02-July-2015	4080	19.82089000	155.47459000	Wēkiu
Batch Plant	Batch06	29-June-02-July-2015	4067	19.81939000	155.47476000	Wēkiu
Batch Plant	Batch07	29-June-02-July-2015	4063	19.82001000	155.47474000	Wēkiu
VLBA, N. Pu'u	VLBAN01	23-26-June-2015	3742	19.80153000	-155.45708000	Wēkiu
VLBA, N. Pu'u	VLBAN02	23-26-June-2015	3776	19.80278998	-155.45694999	Wēkiu
VLBA, N. Pu'u	VLBAN03	23-26-June-2015	3819	19.80311997	-155.45804995	Wēkiu
VLBA, N. Pu'u	VLBAN04	23-26-June-2015	3860	19.80324998	-155.45891999	Wēkiu
VLBA, N. Pu'u	VLBAN05	23-26-June-2015	3858	19.80357997	-155.45908998	Wēkiu
VLBA, N. Pu'u	VLBAN06	23-26-June-2015	3864	19.80378994	-155.45934998	Wēkiu
VLBA, N. Pu'u	VLBAN07	23-26-June-2015	3824	19.80540999	-155.45862998	Alien
VLBA, S. Pu'u	VLBAS01	19-22-June-2015	3742	19.80002000	-155.45662000	Wēkiu
VLBA, S. Pu'u	VLBAS02	19-22-June-2015	3770	19.79993996	-155.45563999	Wēkiu
VLBA, S. Pu'u	VLBAS03	19-22-June-2015	3786	19.79963000	-155.45562993	Wēkiu
VLBA, S. Pu'u	VLBAS04	19-22-June-2015	3811	19.79900999	-155.45517999	Wēkiu
VLBA, S. Pu'u	VLBAS05	19-22-June-2015	3809	19.79918995	-155.45557997	Wēkiu
VLBA, S. Pu'u	VLBAS06	19-22-June-2015	3806	19.79904000	-155.45604994	Wēkiu
Pu'ukea	Kea01	26-29-June -2015	4223	19.82291996	-155.46995996	Alien
Pu'ukea	Kea02	26-29-June -2015	4213	19.82379000	-155.46937994	Alien
Pu'upōhaku	Poha01	29-June-02-July-2015	4001	19.82537996	-155.48993999	Alien(Dry)
Pu'upōhaku	Poha02	29-June-02-July-2015	4026	19.82494997	-155.49038993	Wēkiu
Pu'upōhaku	Poha03	29-June-02-July-2015	4035	19.82482994	-155.49058992	Wēkiu
Pu'upōhaku	Poha04	29-June-02-July-2015	4036	19.82453993	-155.49077994	Wēkiu
Pu'upōhaku	Poha05	29-June-02-July-2015	4033	19.82431998	-155.49112997	Alien
Pu'upōhaku	Poha06	29-June-02-July-2015	4044	19.82453993	-155.49201996	Alien
Poi Bowl	Poi01	19-22-June-2015	4084	19.82376000	-155.47563000	Wēkiu
Poi Bowl	Poi02	19-22-June-2015	4080	19.82381000	-155.47549000	Wēkiu
Poi Bowl	Poi03	19-22-June-2015	4168	19.82562999	-155.47489992	Wēkiu
Poi Bowl	Poi04	19-22-June-2015	4153	19.82535993	-155.47478995	Wēkiu
Poi Bowl	Poi05	19-22-June-2015	4144	19.82501996	-155.47471996	Wēkiu
Poi Bowl	Poi06	19-22-June-2015	4123	19.82446994	-155.47494996	Wēkiu
Poi Bowl	Poi07	19-22-June-2015	4105	19.82392997	-155.47500998	Wēkiu
Pu'uwai'au	Waiau01	28-June-01-July-2015	3990	19.81121999	-155.47690999	Alien

Pu'uwai'au	Waiau02	28-June-01-July-2015	3994	19.80999900	-155.47645400	Wēkiu
Pu'ukeonehehe'e	Keone01	23-26-June-2015	3521	19.78410800	-155.457314000	Alien
Pu'ukeonehehe'e	Keone02	23-26-June-2015	3530	19.78373700	-155.457974000	Wēkiu
Pu'ukeonehehe'e	Keone03	23-26-June-2015	3523	19.78340700	-155.458068000	Wēkiu
Pu'ukeonehehe'e	Keone04	23-26-June-2015	3501	19.78307500	-155.457750000	Wēkiu
E. Pu'ukeonehehe'e	EKeone01	23-26-June-2015	3482	19.78423000	-155.453634000	Alien
E. Pu'ukeonehehe'e	EKeone02	23-26-June-2015	3488	19.78462100	-155.452456000	Wēkiu
E. Pu'ukeonehehe'e	EKeone03	23-26-June-2015	3497	19.78442400	-155.451997000	Wēkiu
E. Pu'ukeonehehe'e	EKeone04	23-26-June-2015	3521	19.78372500	-155.451233000	Wēkiu
Burns cone	Burns01	23-26-June-2015	3647	19.79348500	-155.461087000	Alien
Burns cone	Burns02	23-26-June-2015	3649	19.79301200	-155.460865000	Wēkiu
Burns cone	Burns03	23-26-June-2015	3627	19.79277300	-155.458835000	Wēkiu
Burns cone	Burns04	23-26-June-2015	3629	19.79042400	-155.459337000	Wēkiu

*Alien trap types include all traps, PBJS Sticks, Yellow Pan, Un-baited wet pitfall, and Baited Pitfall.

*Alien(Dry) trap types include 3 traps PBJS Sticks, Yellow Pan, and Baited Pitfall.

*Wēkiu trap types include only Baited Pitfalls.

*Almost all locations were derived from Bishop Museum Monitoring Surveys

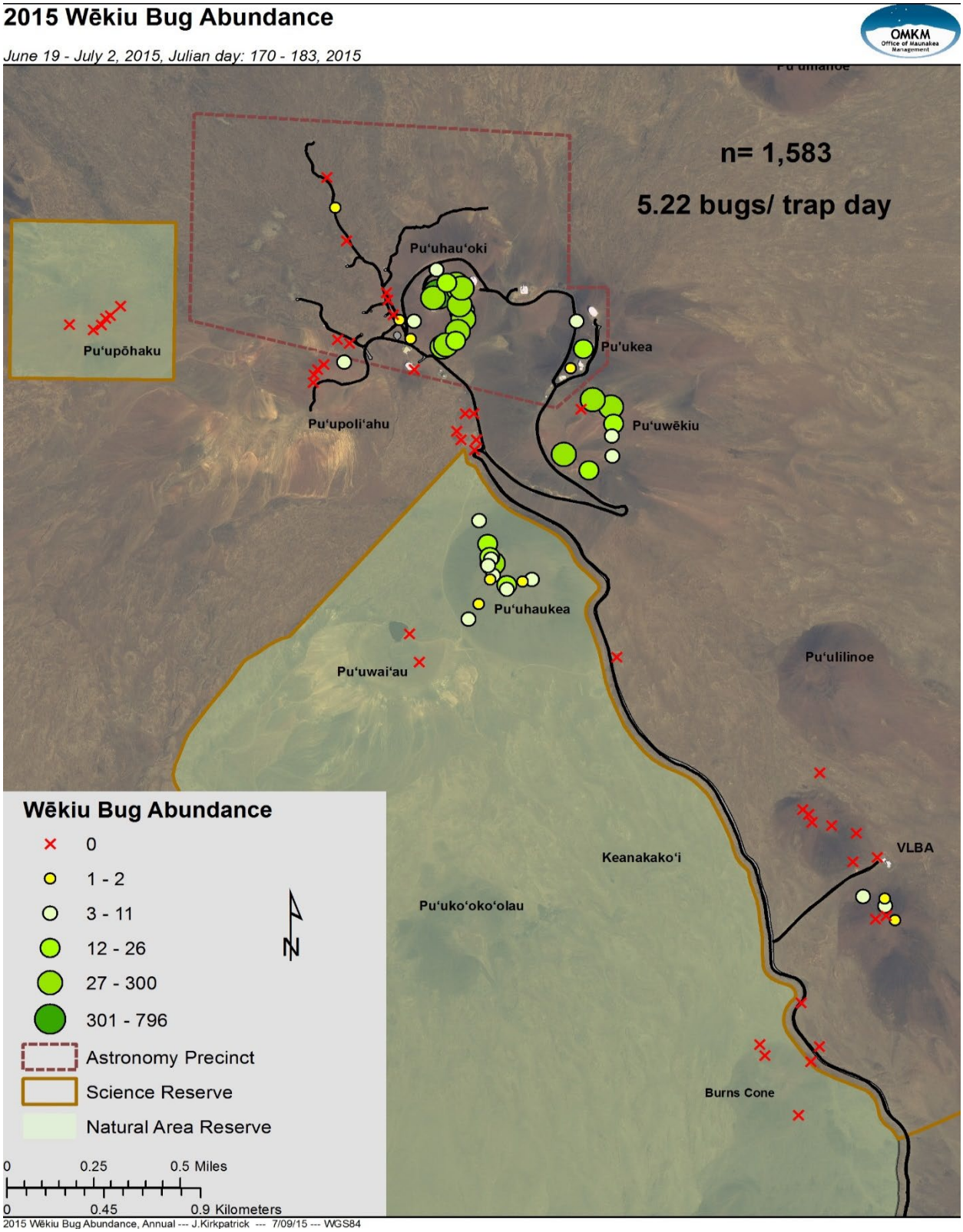
APPENDIX D: 2015 WĒKIU BUG CAPTURE DATA

Location	Site ID	Altitude (meters)	Latitude	Longitude	# Wēkiu Captures	Trap Type
Pu'uhaukea	Hkea01	4054	19.81571944	-155.47350000	19	Wēkiu
Pu'uhaukea	Hkea02	4028	19.81621944	-155.47388056	4	Wēkiu
Pu'uhaukea	Hkea03	4124	19.81454996	-155.47332999	11	Wēkiu
Pu'uhaukea	Hkea04	4120	19.81462992	-155.47338992	18	Wēkiu
Pu'uhaukea	Hkea05	4116	19.81435994	-155.47324995	34	Wēkiu
Pu'uhaukea	Hkea06	4125	19.81425994	-155.47346000	5	Wēkiu
Pu'uhaukea	Hkea07	4118	19.81382995	-155.47321994	9	Wēkiu
Pu'uhaukea	Hkea08	4128	19.81364999	-155.47335992	1	Wēkiu
Pu'uhaukea	Hkea09	4124	19.81322997	-155.47260999	3	Wēkiu
Pu'uhaukea	Hkea10	4115	19.81341999	-155.47260999	12	Wēkiu
Pu'uhaukea	Hkea11	4116	19.81357992	-155.47191999	2	Wēkiu
Pu'uhaukea	Hkea12	4126	19.81368000	-155.47150995	5	Wēkiu
Pu'uhaukea	Hkea13	4070	19.81257000	155.47385000	1	Wēkiu
Pu'uhaukea	Hkea14	4043	19.81190000	155.47429000	4	Wēkiu
Pu'upoli'ahu	Poli01	4075	19.82389000	-155.47977000	0	Wēkiu
Pu'upoli'ahu	Poli02	4150	19.82214999	-155.48134997	0	Wēkiu
Pu'upoli'ahu	Poli03	4152	19.82249994	-155.48130998	0	Wēkiu
Pu'upoli'ahu	Poli04	4162	19.82271996	-155.48115995	0	Wēkiu
Pu'upoli'ahu	Poli05	4160	19.82293999	-155.48087999	0	Wēkiu
Pu'upoli'ahu	Poli06	4139	19.82305993	-155.47997994	11	Wēkiu
Pu'upoli'ahu	Poli07	4073	19.82405000	-155.48028333	0	Alien(Dry)
Pu'u'hau'oki	Oki01	4174	19.82636995	-155.47480999	32	Alien(Dry)
Pu'u'hau'oki	Oki02	4151	19.82607993	-155.47585999	467	Wēkiu
Pu'u'hau'oki	Oki03	4164	19.82592998	-155.47606995	61	Wēkiu
Pu'u'hau'oki	Oki04	4171	19.82627993	-155.47492993	68	Wēkiu
Pu'u'hau'oki	Oki05	4162	19.82653993	-155.47506999	74	Wēkiu
Pu'u'hau'oki	Oki06	4117	19.82658997	-155.47548993	21	Wēkiu
Pu'u'hau'oki	Oki07	4119	19.82715280	-155.47595278	11	Wēkiu
Pu'u'hau'oki	Oki08	4105	19.82490000	-155.47691667	3	Alien(Dry)
Pu'uwēkiu	Wēkiu01	4196	19.82157994	-155.46893000	27	Wēkiu
Pu'uwēkiu	Wēkiu02	4214	19.82125992	-155.46811997	95	Wēkiu
Pu'uwēkiu	Wēkiu03	4225	19.82054000	-155.46798997	14	Wēkiu
Pu'uwēkiu	Wēkiu04	4215	19.81998998	-155.46805996	3	Wēkiu
Pu'uwēkiu	Wēkiu05	4207	19.81912999	-155.46801997	3	Wēkiu
Pu'uwēkiu	Wēkiu06	4186	19.81847998	-155.46905992	23	Wēkiu
Pu'uwēkiu	Wēkiu07	4159	19.81916998	-155.47016993	54	Wēkiu
Pu'uwēkiu	Wēkiu08	4148	19.81926997	-155.46979995	0	Alien(Dry)
Pu'uwēkiu	Wēkiu09	4178	19.82049993	-155.46970993	3	Wēkiu
Pu'uwēkiu	Wēkiu10	4183	19.82115992	-155.46944993	0	Wēkiu
TMT Site/SMA	TMT01	4044	19.83111997	-155.48087999	0	Alien
TMT Site/SMA	TMT02	4058	19.82980996	-155.48046995	1	Alien
TMT Site/SMA	TMT03	4068	19.82837993	-155.47996997	0	Alien
TMT Site/SMA	TMT04	4093	19.82413333	-155.47705000	1	Alien(Dry)
TMT Site/SMA	TMT05	4082	19.82486670	-155.47776667	1	Alien(Dry)
TMT Site/SMA	TMT06	4106	19.82494000	-155.47755000	1	Alien(Dry)
TMT Site/SMA	TMT07	4082	19.82516670	-155.47783333	0	Alien(Dry)
TMT Site/SMA	TMT08	4076	19.82580000	-155.47808333	0	Alien(Dry)

TMT Site/SMA	TMT09	4075	19.82613330	-155.47816667	0	Alien(Dry)
Road Corridor	Rd01	3753	19.80173998	-155.45600996	0	Alien
Road Corridor	Rd02	3667	19.79344994	-155.45844994	0	Alien
Road Corridor	Rd05	3658	19.79534995	-155.45929994	0	Alien
Road Corridor	Rd06	3932	19.81033998	-155.46769995	0	Alien
Batch Plant	Batch01	4106	19.82278995	-155.47686992	0	Alien
Batch Plant	Batch02	4056	19.81975998	-155.47407992	0	Alien
Batch Plant	Batch03	4082	19.82088994	-155.47425996	0	Alien
Batch Plant	Batch04	4064	19.81937994	-155.47415000	0	Alien
Batch Plant	Batch05	4080	19.82089000	155.47459000	0	Wēkiu
Batch Plant	Batch06	4067	19.81939000	155.47476000	0	Wēkiu
Batch Plant	Batch07	4063	19.82001000	155.47474000	0	Wēkiu
VLBA, N. Pu'u	VLBAN01	3742	19.80153000	-155.45708000	0	Wēkiu
VLBA, N. Pu'u	VLBAN02	3776	19.80278998	-155.45694999	0	Wēkiu
VLBA, N. Pu'u	VLBAN03	3819	19.80311997	-155.45804995	0	Wēkiu
VLBA, N. Pu'u	VLBAN04	3860	19.80324998	-155.45891999	0	Wēkiu
VLBA, N. Pu'u	VLBAN05	3858	19.80357997	-155.45908998	0	Wēkiu
VLBA, N. Pu'u	VLBAN06	3864	19.80378994	-155.45934998	0	Wēkiu
VLBA, N. Pu'u	VLBAN07	3824	19.80540999	-155.45862998	0	Alien
VLBA, S. Pu'u	VLBAS01	3742	19.80002000	-155.45662000	4	Wēkiu
VLBA, S. Pu'u	VLBAS02	3770	19.79993996	-155.45563999	1	Wēkiu
VLBA, S. Pu'u	VLBAS03	3786	19.79963000	-155.45562993	6	Wēkiu
VLBA, S. Pu'u	VLBAS04	3811	19.79900999	-155.45517999	1	Wēkiu
VLBA, S. Pu'u	VLBAS05	3809	19.79918995	-155.45557997	0	Wēkiu
VLBA, S. Pu'u	VLBAS06	3806	19.79904000	-155.45604994	0	Wēkiu
Pu'ukea	Kea01	4223	19.82291996	-155.46995996	1	Alien
Pu'ukea	Kea02	4213	19.82379000	-155.46937994	19	Alien
Pu'upōhaku	Poha01	4001	19.82537996	-155.48993999	0	Alien(Dry)
Pu'upōhaku	Poha02	4026	19.82494997	-155.49038993	0	Wēkiu
Pu'upōhaku	Poha03	4035	19.82482994	-155.49058992	0	Wēkiu
Pu'upōhaku	Poha04	4036	19.82453993	-155.49077994	0	Wēkiu
Pu'upōhaku	Poha05	4033	19.82431998	-155.49112997	0	Alien
Pu'upōhaku	Poha06	4044	19.82453993	-155.49201996	0	Alien
Poi Bowl	Poi01	4084	19.82376000	-155.47563000	137	Wēkiu
Poi Bowl	Poi02	4080	19.82381000	-155.47549000	46	Wēkiu
Poi Bowl	Poi03	4168	19.82562999	-155.47489992	57	Wēkiu
Poi Bowl	Poi04	4153	19.82535993	-155.47478995	69	Wēkiu
Poi Bowl	Poi05	4144	19.82501996	-155.47471996	67	Wēkiu
Poi Bowl	Poi06	4123	19.82446994	-155.47494996	55	Wēkiu
Poi Bowl	Poi07	4105	19.82392997	-155.47500998	18	Wēkiu
Pu'uwai'au	Waiau01	3990	19.81121999	-155.47690999	0	Alien
Pu'uwai'au	Waiau02	3994	19.80999900	-155.47645400	0	Wēkiu
Pu'ukeonehehe'e	Keone01	3521	19.78410800	-155.45731400	0	Alien
Pu'ukeonehehe'e	Keone02	3530	19.78373700	-155.45797400	0	Wēkiu
Pu'ukeonehehe'e	Keone03	3523	19.78340700	-155.45806800	0	Wēkiu
Pu'ukeonehehe'e	Keone04	3501	19.78307500	-155.45775000	0	Wēkiu
E. Pu'ukeonehehe'e	EKeone01	3482	19.78423000	-155.45363400	0	Alien
E. Pu'ukeonehehe'e	EKeone02	3488	19.78462100	-155.45245600	0	Wēkiu
E. Pu'ukeonehehe'e	EKeone03	3497	19.78442400	-155.45199700	0	Wēkiu
E. Pu'ukeonehehe'e	EKeone04	3521	19.78372500	-155.45123300	0	Wēkiu
Burns cone	Burns01	3647	19.79348500	-155.46108700	0	Alien

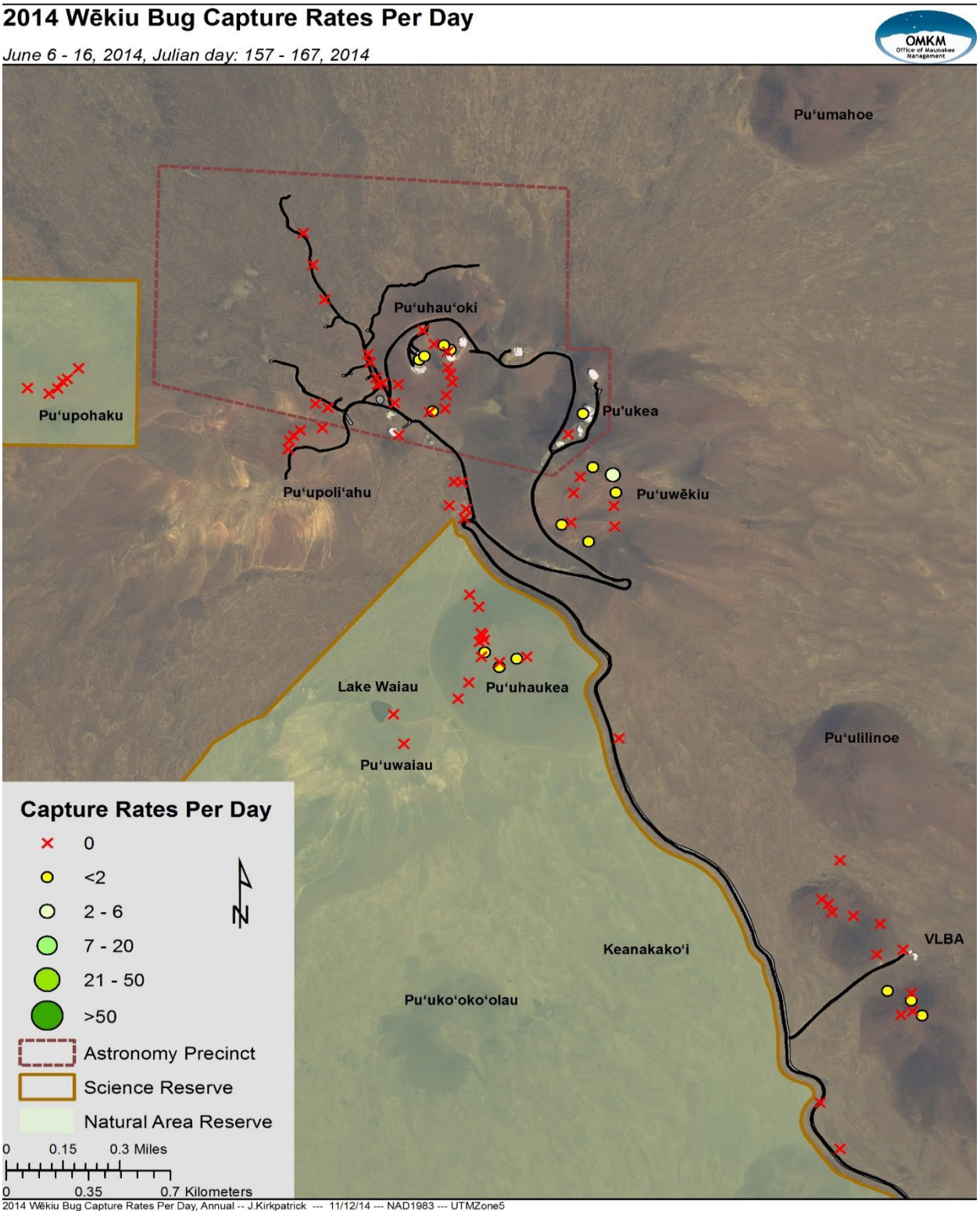
Burns cone	Burns02	3649	19.79301200	-155.46086500	0	Wēkiu
Burns cone	Burns03	3627	19.79277300	-155.45883500	0	Wēkiu
Burns cone	Burns04	3629	19.79042400	-155.45933700	0	Wēkiu

APPENDIX E: WĒKIU BUG ABUNDANCE MAP



*Abundance represents the number of individuals

APPENDIX F: WĒKIU BUG CAPTURE RATE MAP



APPENDIX G: 2015 ANNUAL SURVEY CAPTURE LIST

Arthropod threats are identified in **bold** font. Shaded rows identify new species records to the management area. New record threats are shown in **bold font with shaded** rows. Nativity can either be non-native, native, or non-native & native within that taxonomic group. It should be noted that some species shaded as new records are specimens that, though they may have been found on Maunakea in previous years, have never been identified to species before now. Nativity can either be non-native, native, or non-native & native within that taxonomic group.

Taxa	Order	Family	Genus & species	Nativity
1	Acari	Unknown	*Unknown*	Non-Native & Native
2	Araneae	Clubionidae	*Corinna spp. [2]*	Non-Native
3	Araneae	Clubionidae	*Unknown*	Non-Native
4	Araneae	Linyphiidae	*Tenuiphantes[5] tenuis*	Non-Native
5	Araneae	Linyphiidae	*Unknown*	Non-Native & Native
6	Araneae	Lycosidae	*Lycosa hawaiiensis*	Native
7	Araneae	Salticidae	*Unknown*	Non-Native & Native
8	Araneae	Theridiidae	*Steatoda spp.[1]*	Non-Native
9	Araneae	Theridiidae	*Unknown*	Non-Native & Native
10	Araneae	Unknown	*Unknown*	Non-Native & Native
11	Coleoptera	Chrysomelidae	*Altica torquata*	Non-Native
12	Coleoptera	Cleridae	*Necrobia rufipes*	Non-Native
13	Coleoptera	Coccinellidae	*Coccinella septempunctata*	Non-Native
14	Coleoptera	Coccinellidae	*Hippodamia convergens*	Non-Native
15	Coleoptera	Coccinellidae	*Unknown*	Non-Native
16	Coleoptera	Scarabaeidae	*Onthophagus nigriventris*	Non-Native
17	Coleoptera	Scarabaeidae	*Unknown*	Non-Native
18	Coleoptera	Staphylinidae	*Unknown*	Non-Native & Native
19	Collembola	Entomobryidae	*Unknown*	Non-Native
20	Collembola	Unknown	*Unknown*	Non-Native & Native
21	Dermaptera	Forficulidae	*Forficula auricularia*	Non-Native
22	Diptera	Agromyzidae	*Liriomyza spp.*	Non-Native
23	Diptera	Agromyzidae	*Phytomyza plantaginis*	Non-Native
24	Diptera	Agromyzidae	*Unknown*	Non-Native & Native
25	Diptera	Anthomyiidae	*Delia platura*	Non-Native
26	Diptera	Calliphoridae	*Calliphora vomitoria*	Non-Native
27	Diptera	Calliphoridae	*Eucalliphora lilaea*	Non-Native
28	Diptera	Calliphoridae	*Unknown*	Non-Native & Native
29	Diptera	Ceratopogonidae	*Unknown*	Non-Native & Native
30	Diptera	Chamaemyiidae	*Unknown*	Non-Native
31	Diptera	Chironomidae	*Unknown*	Non-Native & Native
32	Diptera	Chloropidae	*Unknown*	Non-Native
33	Diptera	Drosophilidae	*Unknown*	Non-Native & Native
34	Diptera	Ephydridae	*Hydrellia tritici*	Non-Native
35	Diptera	Ephydridae	*Unknown*	Non-Native & Native
36	Diptera	Lonchopteridae	*Lonchoptera furcata*	Non-Native
37	Diptera	Muscidae	*Haematobia irritans*	Non-Native
38	Diptera	Muscidae	*Unknown*	Non-Native & Native
39	Diptera	Mycetophilidae	*Unknown*	Unknown
40	Diptera	Oestridae	*Hypoderma bovis*	Non-Native

41	Diptera	Phoridae	*Megaselia brunneipalpata*	Non-Native
42	Diptera	Phoridae	*Puliciphora lucifera*	Non-Native
43	Diptera	Phoridae	*Unknown*	Non-Native & Native
44	Diptera	Sarcophagidae	*Unknown*	Non-Native
45	Diptera	Sciaridae	*Bradysia impatiens*	Non-Native
46	Diptera	Sciaridae	*Unknown*	Non-Native & Native
47	Diptera	Sphaeroceridae	*Unknown*	Non-Native & Native
48	Diptera	Syrphidae	*Unknown*	Non-Native
49	Diptera	Tachinidae	*Unknown*	Non-Native
50	Diptera	Unknown	*Unknown*	Non-Native & Native
51	Hemiptera	Geocoridae	*Geocoris pallens*	Non-Native
52	Hemiptera	Geocoridae	*Geocoris spp.*	Non-Native
53	Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	Non-Native
54	Hemiptera	Lygaeidae	*Nysius palor*	Non-Native
55	Hemiptera	Lygaeidae	*Nysius spp.*	Non-Native & Native
56	Hemiptera	Lygaeidae	*Nysius terrestris*	Native
57	Hemiptera	Lygaeidae	*Nysius wekiuicola*	Native
58	Hemiptera	Lygaeidae	*Unknown*	Non-Native & Native
59	Hemiptera	Miridae	*Coridromius spp.*	Non-Native
60	Hemiptera	Miridae	*Coridromius variegatus*	Non-Native
61	Hemiptera	Nabidae	*Unknown*	Non-Native & Native
62	Hemiptera	Pentatomidae	*Bagrada hilaris*	Non-Native
63	Hemiptera	Pentatomidae	*Nezara viridula*	Non-Native
64	Hemiptera	Tipulidae	*Unknown*	Non-Native & Native
65	Hemiptera	Unknown	*Unknown*	Non-Native & Native
66	Homoptera	Aphididae	*Unknown*	Non-Native
67	Homoptera	Cicadellidae	*Unknown*	Non-Native & Native
68	Homoptera	Psyllidae	*Acizzia uncatoides*	Non-Native
69	Homoptera	Psyllidae	*Unknown*	Non-Native & Native
70	Hymenoptera	Apidae	*Apis mellifera*	Non-Native
71	Hymenoptera	Braconidae	*Apanteles spp.*	Non-Native
72	Hymenoptera	Braconidae	*Unknown*	Non-Native & Native
73	Hymenoptera	Diapriidae	*Trichopria spp.*	Non-Native & Native
74	Hymenoptera	Encyrtidae	*Dicarnosis ripariensis*	Non-Native
75	Hymenoptera	Encyrtidae	*Unknown*	Non-Native & Native
76	Hymenoptera	Eulophidae	*Unknown*	Non-Native & Native
77	Hymenoptera	Ichneumonidae	*Pristomerus spinator*	Non-Native
78	Hymenoptera	Ichneumonidae	*Unknown*	Non-Native & Native
79	Hymenoptera	Pteromalidae	*Mesopolobus spp.*	Unkown
80	Hymenoptera	Pteromalidae	*Pachyneuron spp.*	Non-Native
81	Hymenoptera	Pteromalidae	*Unknown*	Non-Native & Native
82	Hymenoptera	Scelionidae	*Telenomus spp.*	Non-Native
83	Hymenoptera	Scelionidae	*Unknown*	Non-Native & Native
84	Hymenoptera	Sphecidae	*Unknown*	Non-Native & Native
85	Hymenoptera	Unknown	*Unknown*	Non-Native & Native
86	Hymenoptera	Vespidae	*Vespula pensylvanica*	Non-Native
87	Isopoda	Unknown	*Unknown*	Non-Native & Native
88	Lepidoptera	Geometridae	*Scotorythra paludicola*	Native
89	Lepidoptera	Noctuidae	*Agrotis spp.*	Non-Native & Native
90	Lepidoptera	Noctuidae	*Unknown*	Non-Native & Native
91	Lepidoptera	Nymphalidae	*Vanessa spp.[3]*	Non-Native

92	Lepidoptera	Pieridae	*Pieris rapae*	Non-Native
93	Lepidoptera	Tineidae	*Unknown*	Non-Native
94	Lepidoptera	Unknown	*Unknown*	Non-Native & Native
95	Lithobiomorpha	Lithobiidae	*Lithobius spp.*	Non-Native & Native
96	Psocoptera	Psocidae	*Unknown*	Non-Native & Native
97	Thysanoptera	Thripidae	*Unknown*	Non-Native & Native
98	Thysanoptera	Unknown	*Unknown*	Non-Native & Native

*****Only includes species from the annual alien arthropod and wēkiu bug survey, does not include TMT compliance surveys.

APPENDIX H: INTRODUCTION AND DISTRIBUTION OF *OCHETELLUS GLABER* IN THE MAUNA KEA FOREST RESERVE ON MAUNAKEA, HAWAIʻI- REPORT – 2015

Prepared by J. Kirkpatrick

Introduction

On April 16, 2015, *Ochetellus glaber*, an invasive ant, was discovered around the "Hale" located in the Mauna Kea Forest Reserve adjacent to the Visitor Information Station (VIS) at Halepōhaku (HP) on Maunakea, Hawaiʻi by Office of Maunakea Management (OMKM) staff Jessica Kirkpatrick and five Big Island Invasive Species Committee (BIISC) staff members. *O. glaber* was found in a residual non-native fan palm pile by visual observation. No ants were found with vial and weed pull methods. Numerous ant specimens were observed within the palm fronds and six specimens were collected on April 16, 2015. The wood of the structure was made from pressure washed bark-stripped ʻŌhiʻa posts from Kalapana (according to the individuals present at the Hale during this initial survey). A ¾ inch thick and 8 inch long branch sample was collected by U.S. Fish & Wildlife Service (USFWS) enforcement officer Paul Chang and examined by Dr. Lisa Keith, Research Pathologist at U.S Department of Agriculture lab. Dr. Keith confirmed that the sample provided was not infected (no symptoms or fungus) with the ʻōhiʻa fungus *Ceratocysis* responsible for the widespread Rapid ʻŌhiʻa Death. OMKM staff also observed a dead gold dust / orange spotted day gecko (*Phelsuma spp)* under the palm fronds and collected an old wasp nest from within the fronds.

Currently, the only other known ant populations within UH managed lands of Maunakea are isolated *Cardiocondyla kagutsuchi* populations along the road corridor shoulder up to Halepōhaku and Halepōhaku parking lots (up to 9,300 ft.) (Unpub. OMKM *C . kagutsuchi* Delimiting Survey, 2013). These populations are spot treated with Talstar® insecticide when observed. The USFWS also found this species present within the Hakalau National Wildlife Refuge and along the Keanakolu- Mana Road from 2009- 2010. The greatest ant threat, *Linepithema humile*, the Argentine ant, is found at the Puʻuhuluhulu parking lot, along Keanakolu- Mana Road, and within the Mauna Kea County Park. However, this species has not been identified above Keanakolu- Mana road (Peck & Banko, 2011 and Wetterer et al., 1998).

The Halepōhaku area has been surveyed at least annually for invasive species since 2007, initially by the Bishop Museum then, starting in 2012, by OMKM staff. This is the first time *O. glaber* has been found in any survey on UH Managed lands, and research in literature produced no records of previous detection of this species within in the Halepōhaku area or anywhere else above the Saddle Road junction (Peck & Banko, 2011; Unpub. OMKM *C .kagutsuchi* Delimiting Survey, 2013; and Wetterer et al., 1998).

Figure 1: "Hale" in process of being built with ʻōhiʻa wood and non-native palm fronds.

Rapid Response is the process of reacting to a new, recent, not previously detected invasive species. Goals in this process include identifying known life-history information, determining if the species presents a threat, delineating the spatial extent of species distribution, and developing and implementing site-specific management recommendations. OMKM initiates rapid response procedures for newly detected, non-native, potential threat species on University-managed lands as outlined in the Maunakea Invasive Species Management Plan (ISMP). This report was prepared using Rapid Response guidelines from the ISMP, with the survey conducted in the Mauna Kea Forest Reserve at the request of Department of Land and Natural Resources (DLNR) staff.

Jurisdiction

O. glaber was found on Forest Reserve land (managed by DLNR) and not within the UH Management area. Even though *O. glaber* was not found within the UH Management area, this incident is a good way for OMKM to test the applicability of and become familiarized with the approved Emergency Rapid Response procedures outlined in the ISMP. OMKM is providing field and technical assistance; however, all management decisions remain with DLNR, and OMKM will assist as requested.

Life History

The genus *Ochetellus* is comprised of 10 described species and subspecies that range throughout the South of Japan, the Philippines, Fiji, New Caledonia, and Australia. The species *O. glaber* probably originated from Australia and Japan (Landcare Research & Leathers, 2015). *O. glaber* was first recorded in the Hawaiian Islands in 1977 (Kirschenbaum & Grace, 2008). It bites, and was identified as an ant pest on Oʻahu (Tenorio & Nishida, 1995).

They are generalist foragers that tend honeydew-producing insects and may consume parasitoids. They can feed on a wide variety of sources including honeydew, insects, or worms, and sometimes forage in houses. *O. glaber* ants like sweets and are known to cluster on fruit trees, on plants bearing fruits, and on plants infested with sap-sucking insects such as aphids. They are aggressive, displacing fire ants and other species, and have been found invading subterranean termite tunnels and nests (Scott & Thomas, 2000). A study in Hawaiʻi showed that *O. glaber* were found in large numbers tending plant-sucking insects on trees and shrubs just outside of or

touching a building (Leong & Grace, 2008). Studies in Maui show that *O. glaber* are common in dry mesic habitats from sea level to 3,000 ft. elevation (Starr & Loope, 2008). The species often nests arboreally, under stones, or in fallen logs, and are adapted for living around the interface of open vegetation and scrub habitat (Leathers, 2015). They can also nest outside against paths, in rock piles, and in other cracks and crevices. The species will also nest indoors, and nests have been found in between walls, ceilings, doors, and fences, but rarely in the soil (Control, 2012).

The worker ants are sterile and maintain the nests, gather food, and feed the larvae (OzAnimals.com). Larvae depend entirely on workers for food (Control, 2012). Colonies have multiple queens and may produce by budding when a queen and some workers move to a new area. This allows ants to be transported long distances when nests or queens are moved in commerce (Leathers, 2015). Should the queen die, the colony will die also (Control, 2012). *O. glaber* are extremely adaptable at establishing smaller colonies within a house or building (Control, 2012). They share attributes of a tramp species such as polygyny, colony reproduction by budding, and the ability to colonize disturbed habitats and relocate nesting sites rapidly. These characteristics make it difficult to control ant infestations (Cornelius, 1996). Their need for moisture is the most common reason for invading kitchens, bathrooms, or other sources of water in a premises. Adults cannot ingest solid food particles, but ingest liquids which are pressed out of food material. They can be vectors of disease organisms such as dysentery, smallpox, and bacteria such as Salmonella. Adults will usually run along distinct trails, which can assist in finding nests (Control, 2012).

Identification

Ochetellus glaber, formerly known as *Iridomyrmex glaber*, are small (2.5mm-3mm) and black. The males have wings and the female has wings until she mates and becomes the reproductive queen. (OzAnimals.com). Workers are shiny black or brown, 2.0-2.5mm long with 12 segmented antennae. Mandibles have 8 teeth and 1 or 2 denticles, with petiolar scale rounded and forming an even arch dorsally (Landcare Research).

Food & Bait Preferences

O. glaber tend to like sweets, but are also attracted to protein (Tenorio & Nishida, 1995) and will eat seeds, plants, fats, and grease (Control, 2012). A study in Hawai'i used tuna, peanut butter, fly pupae, moth larvae, and honey water (soaked paper towel) to determine bait preferences. The study showed that when *O .glaber* foragers were presented with a choice of tuna and sucrose, the foraging rate was always greater on sucrose, regardless of the presence of brood. When presented with fly pupae and sucrose, the foraging rate on pupae was greater than on sucrose for colonies containing brood and the foraging rate on pupae and sucrose was similar for colonies without brood. They also preferred fruit fly pupae and *Plutella* larvae over tuna and peanut butter (Cornelius & Grace, 1997). Other studies in Hawai'i show that they prefer sucrose over maltose and are not attracted to oil. Sucrose based baits would be at least as acceptable to *O. glaber* as the honeydew component melezitose (Cornelius, 1996).

Threat

The Office of Maunakea Management is concerned with the finding of *O.glaber* because ant species are social, predacious insects that have the ability to predate on or out-compete native arthropods (Leathers, 2015). They have been known to cause long-term ecological changes by lowering biodiversity, disrupting natural communities, and altering ecosystem processes (Leathers, 2015).

2015 Activity Timeline

This section includes the timeline of activities, including surveys before and after the initial detection of *O. glaber* on Forest Reserve land.

Activity Type[25]	Lead	Date(s)	Location[26]	Ants?	Spp. obs?
Facility Monitoring- Vials	OMKM	1/16 – 2/6/15	HP	No	NA
Facility Monitoring- Traps	OMKM	2/17 - 24/15	HP & MKSR	No	NA
TMT Compliance- Weekly	BIISC	2/19-26/15	TMT Site, Access Way (AW), HP	No	NA
Facility Monitoring- Traps	OMKM	2/24 – 3/12/15	HP	No	NA
TMT Compliance- Weekly	BIISC	2/26 – 3/4/15	TMT, AW, HP	Yes	*C.kagutsuchi*
Facility Monitoring- Traps	OMKM	3/12 - 4/14/15	HP	No	Yes
UH Entomology Class - HS	UH Faculty	3/17/15	HP & VIS	No	NA
Biodiversity Monitoring	Researcher	3/23 – 27/15	E, NW, N, & NE of HP	No	NA
TMT Compliance- Weekly	BIISC	3/25 – 4/2/15	TMT, AW, HP, Batch Plant (BP)	No	NA
TMT Compliance- Weekly	BIISC	4/2 - 8/15	TMT, AW, HP, BP	No	NA
TMT Compliance- Weekly	BIISC	4/8 - 16/15	TMT, AW, HP, BP	No	NA
Increased Activity Monitoring	OMKM/HAL	4/9/15	Forest Reserve (tent), AW	No	NA
Facility Monitoring- Traps	OMKM	4/14 - 5/13/15	HP	No	NA
TMT Compliance- Weekly	BIISC	4/16 - 23/15	TMT, AW, HP, BP	No	NA
Increased Activity Monitoring	OMKM/BIISC	4/16/15	Forest Reserve (tents)	Yes	*O.glaber*
Ant Check-up	USFWS	4/17/15	Fan palm pile	No	NA
Facility Monitoring- Vials	OMKM/BIISC	4/17 – 5/7/15	HP	Yes	*C.kagutsuchi*
Delimiting Surveys	OMKM	4/20/15	Forest Reserve (W. tents)	No	NA
Ant Control, baiting	DOFAW	4/20/15	Forest Reserve (W. tents)	No	NA
TMT Compliance- Weekly	BIISC	4/23-30/15	TMT, AW, HP, BP	No	NA
TMT Compliance- Weekly	BIISC	4/30 - 12/9/15	TMT, AW, HP, BP	No	NA
Outreach	Researcher & D.Ward	5/1/15	W. of VIS	NA	NA
Ant Control, baiting	DOFAW	5/8/15	Forest Reserve (W. tents)	No	NA
Facility Monitoring- Traps	OMKM	5/13 - 20/15	HP & MKSR	No	NA
Facility Monitoring	OMKM	June-August '15	HP & MKSR	Yes	*C.kagutsuchi*
Facility Monitoring- Traps	OMKM	9/16/15	HP	*Yes	*O.glaber, T.melanocephalum, C.kagutsuchi*

* See "Introduction and Distribution of Ochetellus glaber, Tapinoma melanocephalum, & Cardiocondyla kagutsuchi at Halepōhaku on Maunakea, Hawaii – Report – 2015" in appendix for additional information.

[25] Activity methods can be viewed upon request. OMKM facility monitoring procedures can be found on the OMKM website.

[26] Exact locations provided upon request of the lead agency

Initial Detection

On April 16th, vials were baited with peanut butter, jelly, and spam. A total of 50 vials were placed on the ground about 15 feet apart around the "Hale" site. The vials were left out for about an hour and checked every 15 minutes. Hand searches were conducted around the sampling site and within the construction materials. Hand searching included pulling invasive vegetation and searching around vegetation, under rocks, and within the soil. *O. glaber* was found while hand searching the pile of palm fronds left over from the thatching of the hale. *O. glaber* was not interested in the bait even when directly in their path. The blue line on the map shows the surveyed location; the ant Location is approximate.

Initial Detection Recommendations

OMKM advised the public to not move, disturb, or attempt to treat for ants until an informed decision can be made that minimizes risk of exacerbating invasive species threats. The occupying public have questioned State jurisdiction of the lands and expressed opposition to the use of pesticides.

Initial Detection Notification

The same day the ants were collected on Forest Reserve Land, it was identified as *Ochetellus glaber* by the Hawai'i Ant Lab (HAL). DLNR, Natural Area Reserve (NAR), and Department of Forestry and Wildlife (DOFAW) were notified of the situation within 12 hours of initial detection. The HAL provided initial control and long term eradication and monitoring recommendations. See *Management Recommendations* section below.

Public Relations

The public present at the "hale" area are willing to help resolve this issue and want to stay informed about necessary actions in regard to this situation. The individuals involved in constructing the "Hale" discussed the possibility of removing thatching and soaking future thatching in salt water for ~1 week prior to construction. Jessica Kirkpatrick has the contact information of two members of the occupying public group to formally communicate with regard to the invasive ant issues.

Delimiting Survey

On April 20th, a delimiting survey was conducted on Forest Reserve land by OMKM staff, as requested by DLNR, using the same methods as described above (baited vials and hand searching). A total of 10 baited vials were placed on the ground near the "hale", checked every 10 min., and retrieved after 30 min. No ants and no new threats were detected during this survey. From April 17th thru May 7th, OMKM and BIISC conducted perimeter searches around all Halepōhaku facilities using baited vials and hand search methods. This type of facility monitoring is already ongoing, occurs quarterly, and just so happened to be scheduled around the same time that O. glaber was detected. Therefore, this OMKM routine survey will also be used as the delimiting survey for Halepōhaku. It should be noted that more effort (time and staff) was put into OMKM's delimiting survey on UH managed lands, and some areas (VIS parking lot, VIS building, Ranger

Parking lot) were surveyed twice within this time frame to be confident that ants were not in the area. No ants and no new threats were detected during this survey effort.

Delimiting Survey Locations

The two sampling locations in the delimiting survey include UH managed areas at Halepōhaku and the VIS and the Maunakea Forest Reserve lands adjacent to the VIS. See the map below for exact survey locations. Red identifies areas (perimeters) that were monitored, including hand searches and baited vials. At least 10 vials were placed at each site (perimeter polygon) for no more than 30 min, and hand searches were conducted around each perimeter for at least 10 min.

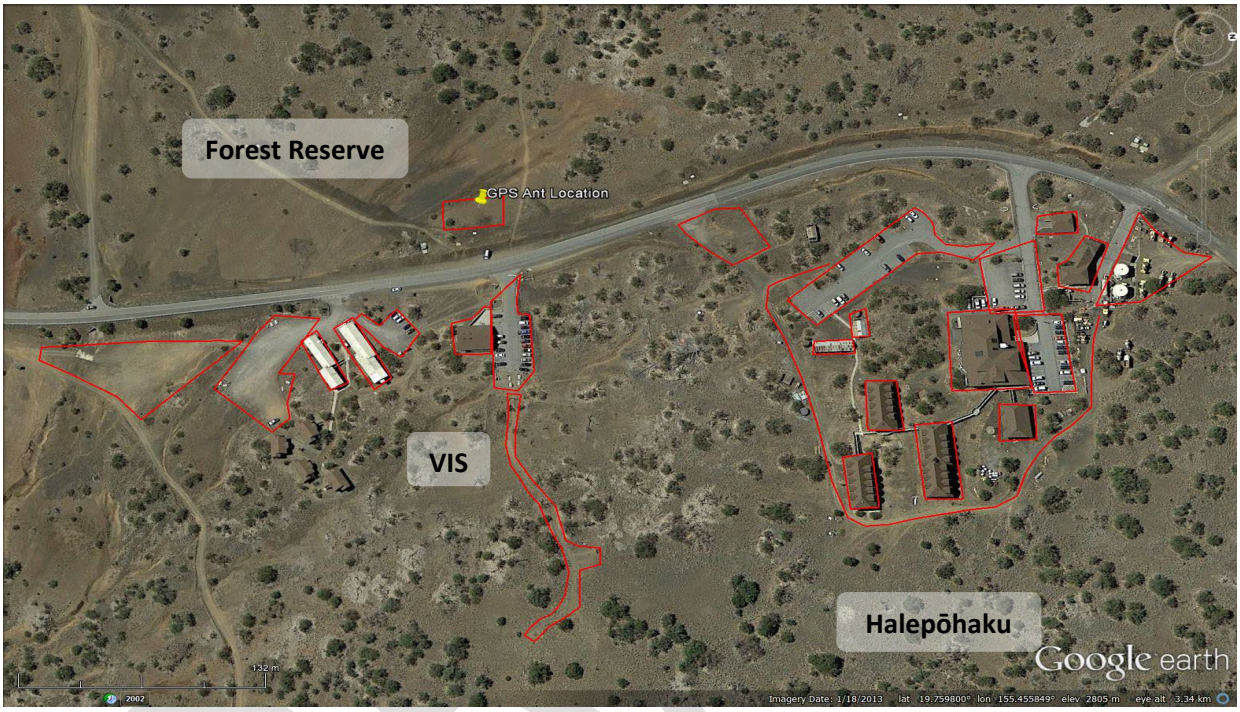


Figure 4: Delimiting Survey Locations conducted April 17th- May 7th

Public Control Efforts

"Hale" camp residents informed Jessica Kirkpatrick about their efforts to manage the ants with organic neem oil applications. Dr. Jesse Eiben responded to this notification with a cautionary warning against the use of neem oil because it is not appropriate for eradication goals. Dr. Eiben cautioned that neem oil is an ant repellant, which could cause the spread of ants away from the initial introduction site. Like most other oil extracts, any mortality will only be due to suffocation by the liquid and therefore type and style of spray must be thoroughly assessed for effectiveness. Nonetheless, Dr. Eiben mentioned that neem oil could be used as a supplementary method along with soapy water soaking for pre-treatment of any further materials brought up to 9,000 ft.

Outreach

The week after initial detection, OMKM made 'A'ole Ant handouts and distributes them when present on the mountain and in public meetings. OMKM also verbally informs the public group about the survey being conducted that day, and invites them to come along and watch how ant surveys are conducted. Deborah Ward (Maunakea Environment Committee) and Dr. Eiben have also been educating groups about ant threats. OMKM held an Open House at Halepōhaku on May 28, 2015 to educate the public and generate valuable discussion. This will allow for OMKM to

show the public what we are doing on the mountain while giving the public a chance to ask questions and talk story.

Management Recommendations

Initial Control Recommendations

After contacting Hawai'i Ant Lab, control recommendations were provided to OMKM. They recommended placing *Enforcer's AntMax* (Abamectin) bait stations around the "hale" area for several days. After the bait stations are extracted, all affected materials are recommended to be removed from the mountain in a tarp in order to contain remaining ants. Finally, a barrier of Talstar® spray should be applied around the area to prevent further introductions. Fifteen bait stations were placed by DOFAW staff Jay & Clem on April 20, 2015 per Hawai'i Ant Lab Recommendation. After two weeks, bait stations were checked and no signs of ant feeding were observed (not all stations were still present as some had been removed). An additional 8 bait stations were placed, but never retrieved due to 'volatile conditions' with protesters as reported by DLNR staff.

Long-term Eradication & Monitoring Recommendations

OMKM will continue to work with DLNR with regard to future surveys in the Forest Reserve . However, surveys will only be conducted if the occupying public is welcoming, as past discussions show the public questions the land manager's authority and motives. Surveys are projected to continue weekly at Halepōhaku and less frequently on the Forest Reserve land with the permission of the occupying public group (surveys in the Forest Reserve were discontinued in May 2015 due to volatile conditions and OMKM has not been asked by Forest Reserve staff to resume surveys).

References

Control, A. P. (2012). "Black Ant (*Ochetellus glaber)*." Retrieved April 20th, 2015, from http://www.amalpest.com.au/LearningCentre/PestFacts/Ants/BlackAnt.

Cornelius, M. L., et al. (1996). "Acceptability of different sugars and oils to three tropical ant species (Hymen., Formicidae)." Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz 69(2): 41-43.

Cornelius, M. L., & J. Kenneth Grace (1997). "Influence of Brood on the Nutritional Preferences of theTropical Ant Species, *Pheidole megacephala* (F.) and *Ochetellus glaber* (Mayr)." J. Entomol. Sci. **32**(4).

Kirschenbaum, R., & J. Kenneth Grace (2007). "Dominant Ant Species in Four Habitats in Hawaii (Hymenoptera: Formicidae)." Sociobiology 50(3).

Kirschenbaum, R. & J. K. Grace (2008). "Agnostic Interactions Among Invasive Ant Species (Hymenoptera: Formicidae) from Two Habitats on Oahu, Hawaii." Sociobiology 51(3): 543-553.

Landcare Research "Ant Factsheets- *Ochetellus glaber*." Retrieved April 20th, 2015, from http://www.landcareresearch.co.nz/publications/factsheets/Factsheets/ochetellus-glaber.

Leathers, J. (2015). "California Pest Rating Proposal- *Ochetellus glaber* (Mayr): An Ant." Retrieved April 7,2015, from http://blogs.cdfa.ca.gov/Section3162/?p=730.

Leong, M. K. H. & J. Kenneth Grace. (2008). "Occurrence and Distribution of Ants (Hymenoptera: Formicidae),Cockroaches (Blattodea), Centipedes (Chilopoda), and Wasps (Hymenoptera: Vespidae) of Public Health Importance on the Island of Oahu." Proc. Hawaiian Entomol. Soc. **40**: 33-39.

Office of Maunakea Management. (2013). "*Cardiocondyla kagutsuchi* Delimiting Surveys: Along the Maunakea Access Road from the 2nd Cattle guard to Halepōhaku." Unpublished data.

OzAnimals.com. "Black Ant (*Ochetellus glaber*)." Retrieved April 20, 2015, from http://www.ozanimals.com/Insect/Black-Ant/Ochetellus/glaber.html.

Peck, R. W., and P. C. Banko. (2011). Survey of invasive ants at Hakalau Forest National Wildlife Refuge. Hawai'i Cooperative Studies Unit Technical Report HCSU-027. University of Hawai'i at Hilo. 25 pp., incl. 12 figures, 1 table.

Scott, S. and C. Thomas (2000). Pests of Paradise: First Aid and Medical Treatment of Injuries from Hawai'i's Animals. Singapore, University of Hawai'i Press.

Starr, F., Kim Starr, & Lloyd L. Loope (2008). Survey for Ants on the Island of Maui, Hawaii, with Emphasison the Little Fire Ant (*Wasmannia auropunctata*).

Tenorio, J. M., & Gordon Nishida (1995). What's Bugging Me? Identifying and Controlling Household Pests in Hawai'i. Singapore, University of Hawai'i Press.

Wetterer, J. K., Paul C. Banko, Leona P. Laniawe, John W. Slotterback, and Greg J. Brenner (1998). "Non-Indigenous Ants at High Elevations on Mauna Kea, Hawai'i." Pacific Science **52**(3): 228-236.

APPENDIX I: INTRODUCTION AND DISTRIBUTION OF *OCHETELLUS GLABER*, *TAPINOMA MELANOCEPHALUM*, & *CARDIOCONDYLA KAGUTSUCHI* AT HALEPŌHAKU ON MAUNAKEA, HAWAIʻI – REPORT – 2015

Prepared by D. Yogi

Introduction

On September 16, 2015, three ants were detected at Halepōhaku (HP) on UH managed lands. The three species include: *Tapinoma melanocephalum* (ghost ant), *Ochetellus glaber* (black house ant), and *Cardiocondyla kagutsuchi* (no common name). One *T. melanocephalum* and one *O. glaber* ant individual were detected during quarterly facility perimeter searches at the HP Lower Parking Lot by OMKM employee Darcy Yogi. Additionally, on September 2, 2015, a new population of *C. kagutsuchi* was observed at the HP Upper Parking Lot during quarterly facility perimeter searches conducted by Darcy Yogi. Approximately 20-30 individuals were observed and 5 were collected at the Upper Parking Lot location. The persisting *C. kagutsuchi* population behind the Visitor Information Station (VIS) Presentation room was also observed that same day. Darcy Yogi observed about 5 individuals at the Presentation room location. Weed pull methods detected the persistent *C. kagutsuchi* population, but all other species were detected with simple visual observation during perimeter searches.

The HP area has been surveyed for invasive species annually since 2007 by the Bishop Museum and monthly starting in 2013 by OMKM. Currently, the only other known ant populations within UH managed lands on Maunakea are isolated *C. kagutsuchi* populations along the road corridor shoulder up to HP and within HP parking lots (up to 9,300 ft.) (Unpub. OMKM *C. kagutsuchi* Delimiting Survey, 2013). However, *C. kagutsuchi* has only been consistently observed near the VIS Presentation Room. The new *C. kagutsuchi* population is near an older population that was observed along the retaining wall below the Utilities workshop. *O. glaber* was recently first detected in the Forest Reserve lands across the street from the VIS in April 2015, but it is unclear whether these detection events are related (see *Appendix H*). *T melanocephalum* was also observed before near Batch Plant in the Maunakea Science Reserve (MKSR). Although none of the detected ant species are completely "new" species, they are not established within UH-managed lands of Maunakea.

Rapid response is the process of reacting to a new, recent, not previously detected invasive species. In this case, we are using rapid response procedures for newly detected invasive populations. Goals in this process include identifying known life-history information, determining if the species presents a threat, delineating the spatial extent of species distribution, and developing and implementing site-specific management recommendations. OMKM initiates rapid response procedures for newly detected, non-native, potential threat species on University-managed lands as outlined in the Maunakea Invasive Species Management Plan (ISMP). This report is prepared using Rapid Response guidelines from the ISMP.

Initial Detection

On September 2nd and 16th, quarterly perimeter searches were conducted in the HP/ VIS area using vials baited with peanut butter, jelly, and spam. At each location, at least 10 baited vials were placed on the ground about 15 feet apart around the perimeter of either a building or parking lot.

The vials were left out for at least 10 minutes while hand searches were conducted. Hand searching included pulling invasive vegetation and searching surrounding vegetation, under rocks, and within the soil. *T. melanocephalum* and *O. glaber* individuals were found near each other on the HP Lower Parking Lot concrete curb while conducting perimeter searches (see Figure 1). *C. kagutsuchi* populations were found in the HP Upper Parking Lot on the edge of the handicap stall (see Figure 1) and continue to be observed in the vegetated area below the VIS presentation room (not shown on map). All of the new ant locations are shown in the map below. The presentation room location is not shown because this is a reoccurring population of *C. kagutsuchi*.

Figure 5: New ant populations at Halepohaku with completed perimeter searches highlighted in blue.

Initial Detection Recommendations

OMKM initially proposed intensive delimiting surveys (see *Delimiting Survey* section) and pesticide application (Talstar®) in areas where ants were observed. Delimiting surveys would be conducted in the Upper and Lower Parking Lots of HP as well as in adjacent areas. Pesticide application was completed for the Upper Parking Lot location on 9/4/15 after initial detection on 9/2/15, but no ants were observed that day. During the delimiting survey on 9/23/15, *C. kagutsuchi* was again observed in the same handicap stall area. Talstar® pesticide application for the Lower Parking Lot and re-application for the Upper Parking Lot was completed on 10/12/15. Another recommendation was to generate a report on this incident with more information on the life history of *T. melanocephalum* with help from UH Hilo TCBES graduate student Jorden Zarders in Dr. Jesse Eiben's lab. Additionally, *O. glaber* information can be added to the 2015 OMKM rapid response

report in regard to this incident. Increasing our knowledge about these ant species within the UH managed lands will allow OMKM to generate more effective control and monitoring methods.

Initial Detection Notification

All ants were identified by Cas Vanderwoude at the Hawai'i Ant Lab (HAL) the day after collection, kept in the freezer for a night. After identification, an email notification was sent out to DLNR entomologist Cynthia King, UH Hilo Entomology professor Dr. Jesse Eiben, HAL Director Cas Vanderwoude, BIISC Director Springer Kaye, OMKM Director Stephanie Nagata, and DOFAW Manager Steve Bergfield. The HAL provided initial control and long term eradication and monitoring recommendations (see *Management Recommendations* section). Kahu Kū Mauna and the Office of Conservation and Coastal Lands (OCCL) were not notified because these ants were previously observed on UH-managed lands.

Life History

Since there are existing rapid response reports for *O. glaber* and *C. kagutsuchi*, this report only includes the life history for *Tapinoma melanocephalum*. For life history information on *Ochetellus glaber,* please see *Introduction and Distribution of Ochetellus glaber in the Maunakea Forest Reserve on Maunakea, Hawaii – Report 2015*. For distribution and life history information on *Cardiocondyla kagutsuchi* see *2013 Invasive Species & Native Arthropod Monitoring Report*, page 32 "Case 3: *Cardiocondyla kagutsuchi*" and Technical Report HCSU-*027 Survey of Invasive Ants at Hakalau Forest National Wildlife Refuge* (Peck & Banko, 2011). Life history information is researched in order to understand the species' physical characteristics, behavior, diet, and distribution for appropriate control methods.

Tapinoma melanocephalum

Distribution

Tapinoma melanocephalum, common name ghost ant, is a tramp ant from the old world tropics, of either African or Oriental origin (Wheeler, 1910). A tramp ant is a highly aggressive, competitive, adaptive, and dispersible group of ants (Commonwealth of Australia, 2012). Tramp ants are known to reduce species diversity, modify habitats, and alter ecosystem processes (Commonwealth of Australia, 2012). Ghost ants are ubiquitous within the tropics and subtropics due to their dispersal through commercial activities (Wetterer, 2009). The first record of *T. melanocephalum* in Hawai'i was in 1887 (Blackburn & Cameron, 1887), but there have not been many studies completed on the local impacts of this species. *T. melanocephalum* is highly adaptable to its environment and can survive in temperate regions, although it is limited to buildings (Francoeur, 1977).

Feeding & Foraging

Ghost ants are opportunistic foragers (Anderson & Reichel, 1994). In the wild, they will typically scavenge for insects (Smith, 1965) and farm sap-sucking insects for their honeydew in hot climates or greenhouses (Harris, n.d.). However, in human environments they will typically forage for sweets and various proteins (Harris, n.d.). This species of ant is a common household nuisance because they often forage in kitchens and bathrooms (Lee, 2002). Forager ants are characterized by their erratic behavior and rotten coconut odor when disturbed (Smith, 1965). Foragers are able to locate food sources and recruit quickly in order to better compete with other ant species (Lee, 2002) because they are easily replaced (Clark et. Al., 1982). This species of ant does not typically trail, except for when workers are transporting brood (Nickerson & Bloomcamp, 2012).

Colony Characteristics

T. melanocephalum colonies tend to be smaller in size, but can be numerous within the same area (polygyne, unicolonial) (Smith, 1965). This is because colony sites may be too small or unstable to support a singular large colony at once (Nickerson & Bloomcamp, 2012). Ghost ants are very common pests insides homes, but will nest both indoors and outdoors (Nickerson & Bloomcamp, 2012). Nests tend to be in small cavities like under loose bark, at the bases of palm fronds, in tufts of dead moist grass, on plant stems, and other small cavities (Oster and Wilson, 1978). Indoor nests will typically be inside of wall voids, between cabinetry, and within baseboards (Nickerson & Bloomcamp, 2012). Colonies are highly mobile as they tend to occupy temporary habitats and are therefore quick to migrate when conditions become poor (Passera, 1994). Each colony has multiple flightless queens and all colony individuals can interchange between the multiple subcolonies using an odor trail (Nickerson & Bloomcamp, 2012). New colonies are formed through budding (Nickerson & Bloomcamp, 2012).

Identification

T. melanocephalum is a tiny monomorphic ant that measures around 1.2-1.9 mm long (Creighton, 1950). They have a dark brown head and thorax with an opaque gaster and legs (Creighton, 1950). They have one petiolar segment with four visible segments on the gaster (Creighton, 1950). Their antennae have 12 segments, which thickens towards the tip (Creighton, 1950). The physical characteristics of the ghost ant make them hard to see as they are small and pale in color (Smith & Whitman, 1992).

Bait Preferences

Ghost ants are known to be attracted to peanut butter and honey (Lee, 2002). Sugar-based attractants in liquid or gel baits have been known to be effective as well (Lee and Kooi, 2004). Boric acid (1%) in sucrose water has been known to kill lab colonies (Klotz et al., 1996) along with liquid fipronil (.05%) insecticide (Ulloa-Chacon & Jaramillo, 2003). However, there is limited success with paste or granular bait such as Maxforce®, which was found to have little to no effect on the colony as it was hardly consumed (Lee, 2002). Nonetheless, this species can be controlled with baiting or contact insecticide (Nickerson & Bloomcamp, 2012).

Arthropod Threat

OMKM is concerned with the finding of *T. melanocephalum*, *C. kagutsuchi*, and *O. glaber* because, in general, ant species are social predaceous insects with the ability to predate on or out-compete native arthropods (Leathers, 2015). All three detected species are tramp ants, which are known to be aggressive, competitive, and easily dispersed by humans (Commonwealth of Australia, 2012). They have been known to reduce biodiversity, alter ecosystem processes, and modify habitat (Commonwealth of Australia, 2012). This concern, along with the approved ISMP which identifies these species as an invertebrate threat, compels us to research and survey UH-managed areas.

Delimiting Survey

From September 23rd-25th, a delimiting survey was conducted around the HP Commons Building by OMKM staff. At each location, vials baited with peanut butter, jelly, and spam were placed around 10 ft. apart from each other and left for at least 10 minutes while hand searches were conducted. The baiting and hand searching process was repeated throughout the designated location in order to cover the entire perimeter area as needed. On Sept. 23rd, the Upper Parking Lot was focused on and *C. kagutsuchi* was detected again in the same area, near the handicap stall (see **Figure 2**). On Sept. 24th, nearby areas were searched along with the Lower Parking Lot site. However, no ants

were observed (see **Figure 3**). On Sept. 25th, the Lower Parking Lot was searched once more outside of the ant detection site, but no other ants or threats were observed (see **Figure 4**). This same hand searching and vial baiting method is used for our quarterly perimeter searches (see **Figure 6**) and is the method of the initial ant detection. Therefore, this OMKM routine survey will also be used as the delimiting survey for Halepōhaku along with additional transect surveys explained in the *Delimiting Survey Locations* section (see **Figure 5**). It should be noted that more effort (time and staff) was put into OMKM's delimiting survey on UH lands and some areas (HP Parking Lots) were surveyed more than once within this time frame to be confident that ants were not in the area.

Delimiting Survey Locations

Initial delimiting surveys occurred at the HP Lower and Upper Parking Lots, around the Utilities water tanks, and along the Maintenance road. At least 10 vials were placed at each site (perimeter polygon) for no more than 30 min and hand searches were conducted around each perimeter for at least 10 min. The secondary delimiting surveys occurred at 100 m intervals latitudinally down the HP region. The transect survey was completed on 10/5/15 in addition to the quarterly perimeter searches, which were completed on 10/1/15. Transect search methods will be the same as above. **Figures 2, 3,** & **4** below display delimiting survey locations by day with locations outlined with a colored polygon (un-filled). **Figure 5** displays delimiting survey transects. **Figure 6** exhibits our quarterly perimeter search locations, which were completed between 9/2/15 and 10/1/15.

Figure 6: Delimiting surveys that occurred on 9/23/15. C. kagutsuchi population observed at HP Upper Parking Lot in the same location even after Talstar® ® pesticide treatment in the area on 9/4/15.

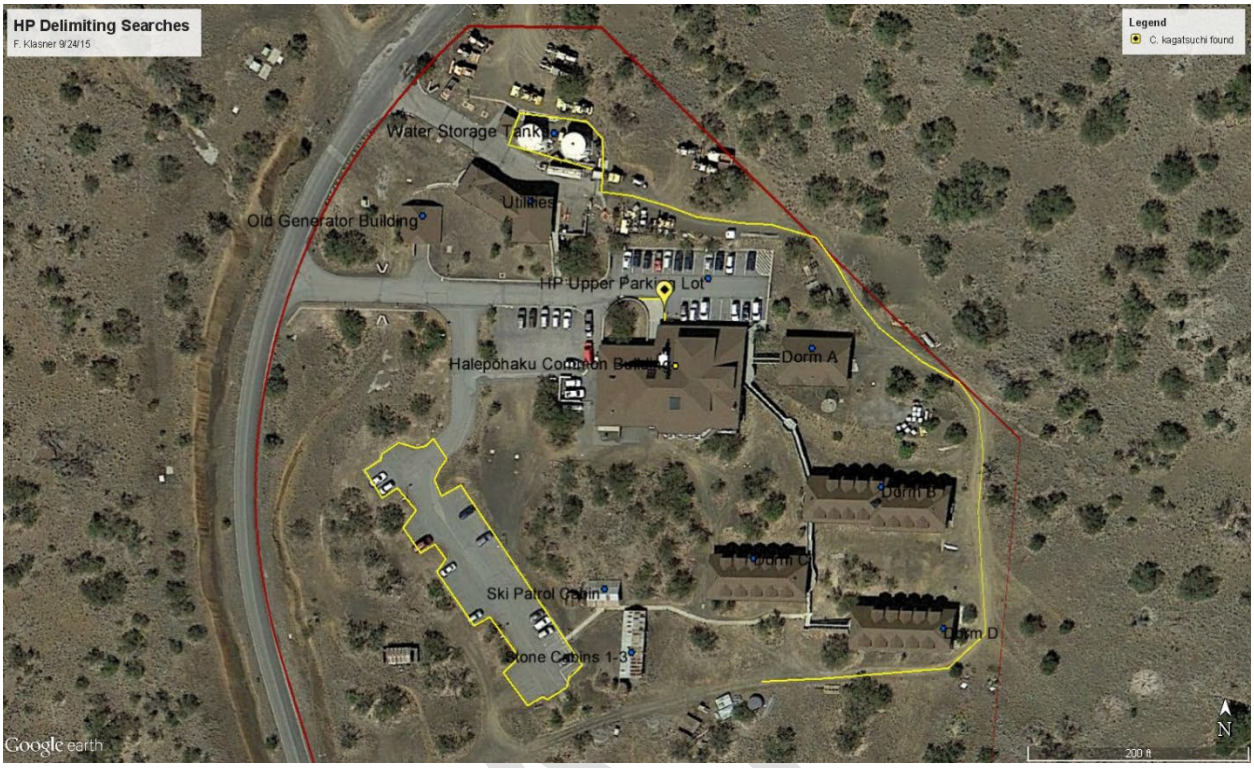


Figure 7: Same C. kagutsuchi population was observed during delimiting surveys completed on 9/24/15.

Figure 8: No ants were observed during delimiting surveys on 9/25/15.

Figure 9: Each transect was approximately 100 m apart and in proximity to buildings and parking lots. The HP managed area is outlined in red.

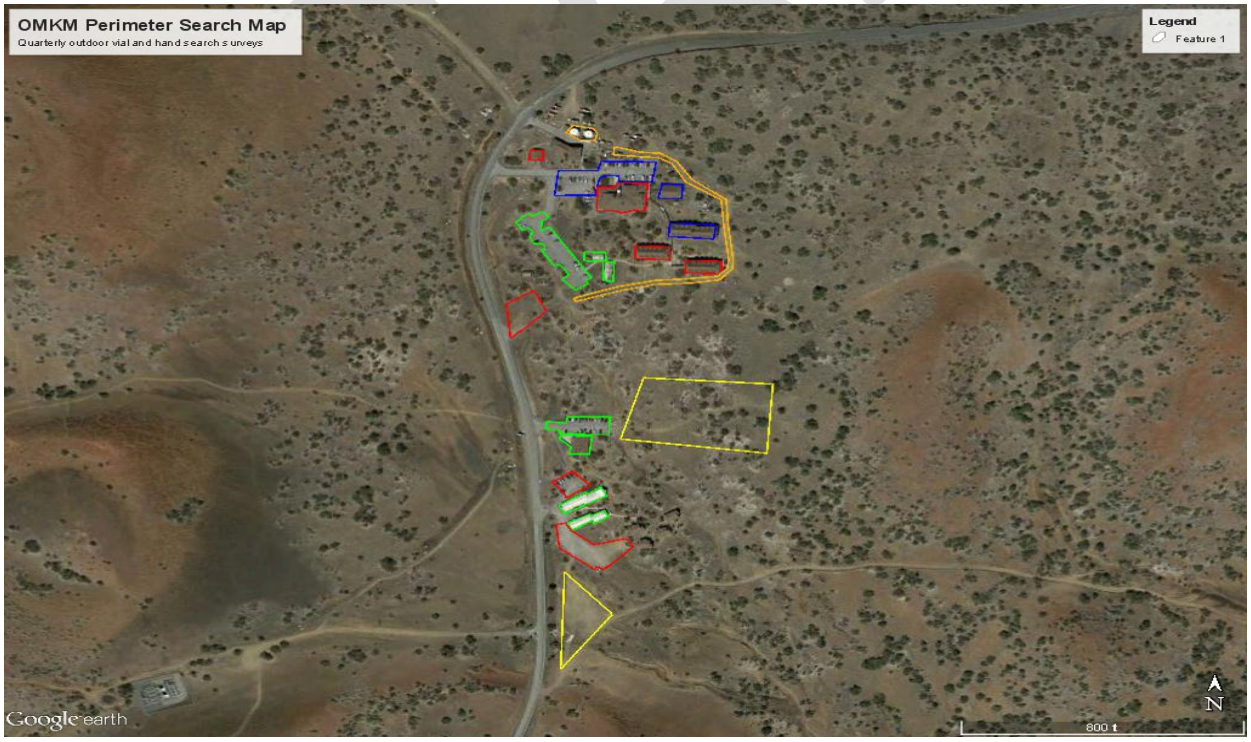


Figure 10: Quarterly perimeter search completion as of 10/1/15 with completion dates designated by color.

Management Recommendations

Initial Control Recommendations

The HAL suggested a focused search near buildings, especially on south facing warmer areas because the *T. melanocephalum* and *O. glaber* are both known to be interior ants. Therefore, completing our facility perimeter searches with extra transect surveying should provide a both intensive and extensive detection effort for these ant species as well as *C. kagutsuchi*. OMKM will conduct monthly Talstar® insecticide treatments in areas of detection until January 2016. OMKM will also continue baiting with Terro® and/or Maxforce® Complete bait plates at HP until January 2016.

Long-term Eradication & Monitoring Recommendations

OMKM will continue to conduct quarterly perimeter searches within the HP and MKSR parcels. Monitoring methods may be edited and enhanced with assistance from other agencies and specialists. Currently, OMKM plans to continue normal monitoring efforts as identified within the ISMP after baiting efforts are completed.

2015 Activity Timeline

This section includes the timeline of activities including surveys before and after the initial detection.

Activity Type[27]	Lead	Date(s)	Location[28]	Ants?	Ant species observed
Quarterly Facility Monitoring (Indoor & Outdoor)	J. Kirkpatrick	2/17-5/7/15	MKSR & HP	Yes	*C.kagutsuchi* (HP) *O.glaber* (HP)
O.glaber Rapid Response	J. Kirkpatrick	4/16-5/8/15	Forest Reserve	No	NA
Quarterly Facility Monitoring (Indoor & Outdoor)	D. Yogi	5/13-7/21/15	MKSR & HP	No	*C.kagutsuchi* (HP)
Pesticide Application	J. Kirkpatrick	5/21/15	VIS	Yes	*C.kagutsuchi*
Quarterly Facility Monitoring (Indoor & Outdoor)	D. Yogi	8/20-9/2/15	MKSR	No	NA
Quarterly Facility Monitoring (Indoor)	D. Yogi	8/20-26/15	HP	No	NA
Quarterly Facility Monitoring (Outdoor)	D. Yogi	9/2/15	HP	Yes	*C.kagutsuchi* (HP Upper Lot)
Pesticide Application	F. Klasner	9/4/15	HP	No	NA
Quarterly Facility Monitoring (Outdoor)	D. Yogi	9/16/15	HP	Yes	*C.kagutsuchi O.glaber, T. melanocephalum*
Monthly Facility Monitoring	D. Yogi	9/16/15	HP	No	NA
Delimiting Surveys – HP Upper	A. Stillman	9/23/15	HP	Yes	*C.kagutsuchi*
Delimiting Surveys – Adjacent areas & HP Upper Lot	F. Klasner	9/24/15	HP	Yes	*C.kagutsuchi*
Delimiting Surveys – HP Lower	A. Stillman	9/25/15	HP	No	NA
Quarterly Facility Monitoring (Outdoor)	D. Yogi	9/30–10/2/15	HP	No	NA
Maxforce & Terro Baiting	OMKM	10/5/15 –1/2/15	HP	No	NA
Transect Surveys	D. Yogi	10/6/15	HP	No	NA
Monthly Facility Monitoring	D. Yogi	10/08/15	HP	No	NA
Pesticide Application	OMKM	10/12/15	HP	Yes	*C.kagutsuchi* (HP Upper Lot)
HDOT Concrete Barrier Inspection	UHH/BIISC	11/19/15	HP	No	NA
Quarterly Facility Monitoring (Indoor & Outdoor)	D. Yogi	11/23-30/15	MKSR	No	NA
Quarterly Facility Monitoring (Indoor)	D. Yogi	11/23-30/15	HP	No	NA
Quarterly Facility Monitoring (Outdoor)	D. Yogi	12/19/15-1/8/15	HP	No	NA
Pesticide Application	D. Yogi	12/8/15	HP	No	NA
Pesticide Application	D. Yogi	1/14/16	HP	No	NA

[27] Activity methods can be viewed upon request. OMKM facility monitoring procedures can be found on the OMKM website. Weekly BIISC TMT monitoring also occurred, but is not noted on this timeline.

[28] Exact locations provided upon request of the lead agency

References

Andersen, A.N. & Reichel, H. (1994). The ant (Hymenoptera: Formicidae) fauna of Holmes Jungle, a rainforest patch in the seasonal tropics of Australia's Northern Territory. *Jorunal of the Australian Entomological Society*, 33, 153-158.

Blackburn, T. & Cameron, P. (1887). On the Hymenoptera of the Hawaiian Islands. *Memoirs of the Manchester Literary & Philosophical Society*, 10, 194-244.

Clark, D.B., Guayasamin, C., Pazmino, O., Donoso, C., Paez de Villacis, Y. (1982). The tramp ant *Wasmannia auropunctata* Autecology and effects on ant diversity and distribution on Santa Cruz Island, Galapagos. *Biotropica*, 14, 196-207.

Creighton, W.S. (1950). The ants of North America*. Bulletin of the Museum of Comparative Zoology*, 104. 13-585.

Francoeur, A. (1977). Synopsis taxonomique et economique des fourmis du Quebec. *Annals of the Entomological Society of Quebec*, 22, 205-212.

Harris, R. (n.d.). Invasive Ant Risk assessment for *Tapinoma melanocephalum.* New Zealand Ministry of Agriculture and Forestry, Biosecurity Authority. Landcare Research: Nelson.

Klotz, J.H., Oi, D.H., Vail, K.M., & Williams D.F. (1996). Laboratory Evaluation of a Boric Acid Liquid Bait on Colonies of *Tapnimoa melanocephalum*, Argentine Ants, and Pharaoh Ants. *Journal of Economic Entomology*, 89(3), 673-677.

Lee, C.Y. (2002). Tropical household ants: pest status, species diversity, foraging behavior, and baiting studies. In: Jones, S.C., Zhai, J., Robinson, W.H. eds Proceedings of the 4th International conference on Urban Pests. Pocahantas Press, Virginia.

Nickerson, J.C. & Bloomcamp, C.L. (2012). "Featured Creatures: Ghost Ant." Retrieved September 30, 2015 from http://entnemdept.ufl.edu/creatures/urban/ants/ghost_ant.htm#desc

Office of Maunakea Management. (2013). "*Arthropod Rapid Response Record – Cardiocondyla kagutsuchi*." Unpublished data.

Office of Maunakea Management. (2013). "*Cardiocondyla kagutsuchi* Delimiting Surveys: Along the Maunakea Access Road from the 2nd Cattle guard to Halepōhaku." Unpublished data.

Office of Maunakea Management. (2015). "*Introduction and Distribution of Ochetellus glaber in the Maunakea Forest Reserve on Maunakea, Hawaii – Report 2015*." Unpublished data.

Oster, G.F. & Wilson, E.O. (1978). "Caste and ecology in the social insects." Princeton University Press: Princeton, New Jersey.

Passera, L. (1994). Characteristics of tramp species. In: Williams, D.F. ed. "Exotic ants: biology, impact, and control of introduced species." Westview Press: Boulder, CO.

Smith, M.R. (1965). "House-infesting ants of the eastern United States." U.S. Dept. Agriculture Technical Bulletin: Washington D.C., No.1326, 105.

Smith, E.H. & Whitman, R.C. (1992). "Field Guide to Structural Pests." National Pest Management Association: Dunn Loring, VA.

Ulloa-Chacon, P. & Jaramillo, G.I. (2003). Effects of Boric Acid, Fipronil, Hydramethylnon, and Diflubenzuron Baits on Colonies of Ghost Ants. *Journal of Economic Entomology*, 96(3), 856-862.

Wetterer, J.K. (2009). Worldwide spread of the ghost ant *Tapinoma melanocephalum*. Myrmecological News, 12, 23-33.

APPENDIX J: INVASIVE ARTHROPOD INSPECTION REPORT FOR CONCRETE BARRIERS AT HALEPŌHAKU

Prepared by J. Zarders

Introduction

An inspection for invasive arthropods was conducted on November 19, 2015 for Dept. of Transportation concrete barriers staged at Halepōhaku (HP) (Figure 1). The barriers arrived at HP on November 17, 2015 and were placed at the gravel staging area below the VIS and Ranger offices. The barriers were delivered by the Department of Transportation at the request of the State of Hawaii Attorney General's office, without following Office of Maunakea Management Invasive Species Management Plan cleaning and inspection protocols. BIISC staff noticed the barriers the day after their arrival and placed a sticky trap (baited with peanut butter, sugar water and spam) approximately 5 feet away from concrete barriers in the adjacent landscape. The following day (Nov. 19), members of University of Hawaii at Hilo (UHH) Entomology lab and BIISC conducted a visual inspection accompanied by a baited survey of the materials. The barriers and surrounding area (~20' buffer) were treated with Talstar® Pro on 12/8/15.

Figure 1: Concrete barrier staging site circled in red.

Methods

Initially, a single sticky trap was placed near the barriers on November 18th and was observed on the morning of November 19th. The sticky trap was placed nearby the barriers (Site ID: HP33) as a part of the BIISC routine weekly invasive species monitoring efforts and remained in the same location for one week. It was then retrieved on November 25th. On Nov. 19 the barriers were surveyed using 10 baited vials filled with peanut, butter, sugar water, & spam. Vials were placed out of the rain in holes and underneath the concrete barriers. Hand searches were conducted for 45 minutes and resulted in the collection of several live and dead specimens.

Observations

- Weather at HP was cloudy with constant rain (not ideal for detecting species) on 11/19.
- Concrete barriers appeared clean, but upon further inspection revealed compacted soil and plant material in discrete locations on the barriers.
- Plant material appeared to mainly comprise of ʻōhiʻa leaves (of concern for inadvertent transport of rapid ʻōhiʻa death by DOT throughout Hawaii island).
- Baited vials were collected after 45 minutes.

Results

1. NO ants collected in survey.
2. A single LIVE cockroach immature found alive on top of a concrete barrier.
3. Several DEAD wasp larvae were extracted from earthen nests made in the grooves of the lettering on the concrete barriers (Figure 2)
4. Several spider egg sacs were found in leaf litter and cracks of the concrete barriers.
5. A single minute LIVE spider was extracted from a hole filed with soil and plant material (Figure 3).
6. Two LIVE isopods were extracted from the same hole that the spider was collected from (Figure 3).
7. Two Calliphoridae flies were observed in the sticky trap when observed the morning of 11/19.
8. Two mites, two spiders, and a single springtail was observed in the BIISC sticky trap during its retrieval on 11/25.

*The spider individual is being reared at the UHH Entomology lab and all other specimens were collected and are being stored at the UH Hilo - Komohana freezer.

Recommendations

1. OMKM will work with DOT, State Attorney General, and DLNR staff to increase awareness of OMKM and Maunakea Invasive Species Management Plan requirements.
2. DLNR and BIISC staff will be notified of ʻōhiʻa plant product movement with road barriers such that they can work with DOT to minimize risk as appropriate.
3. OMKM quarterly monitoring will continue. Should the TMT project resume, monitoring frequency will be weekly.

Figure 2: Wasp larvae extracted from earthen nest.

Figure 3: Spider egg sac extracted from hole.