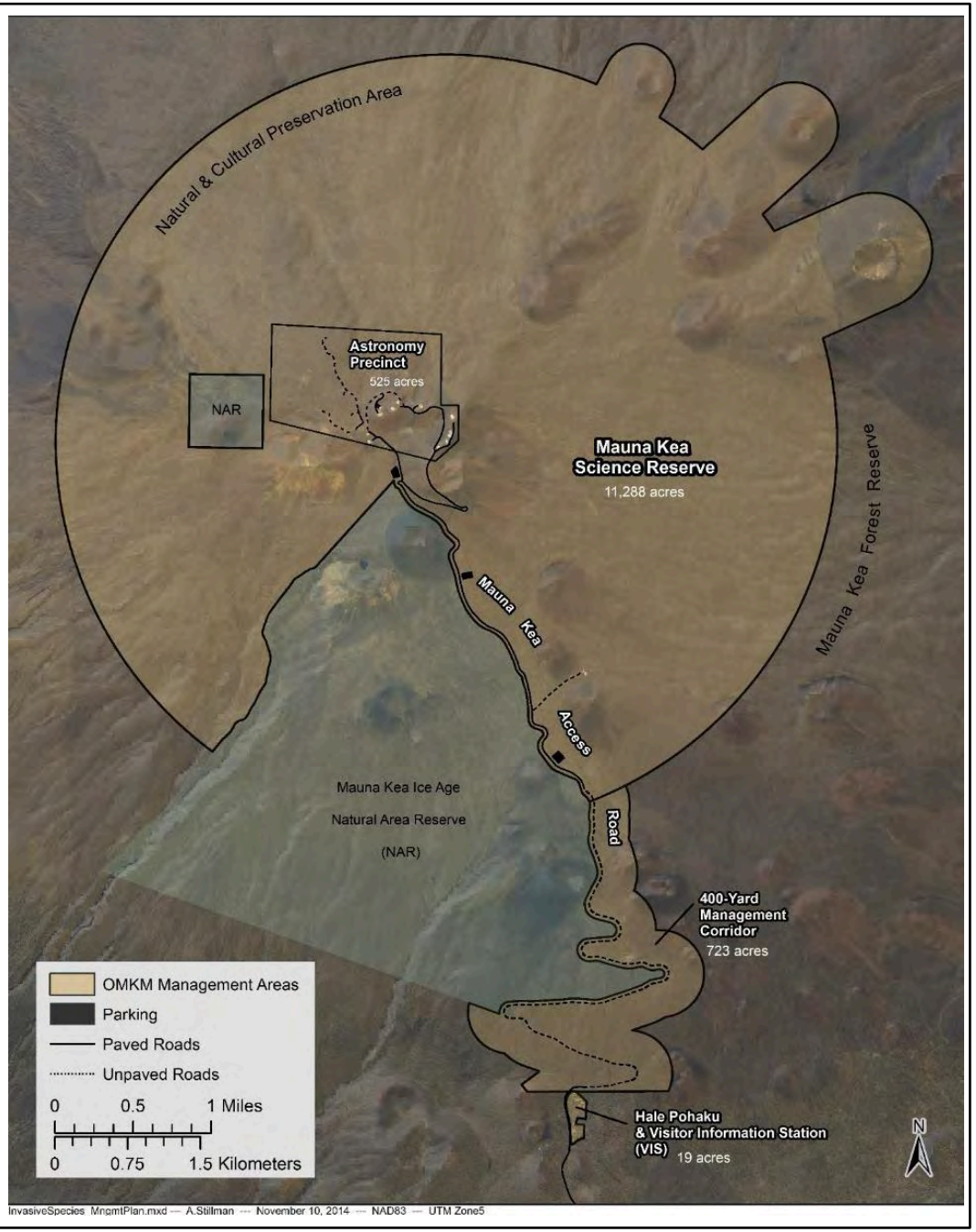
2025 INVASIVE AND NATIVE SPECIES MONITORING REPORT

Prepared by Justin Yeh, Taylor Warner, and Anuhea Robins

- Purpose is to prevent, detect and control invasive species on our managed lands (11,288 acres)
- 2025 Highlights
  - 96 vehicle/ equipment inspections conducted
  - 1,616 individuals captured in facility surveys
  - 6,406 arthropods identified in annual monitoring
  - 1,131 native wēkiu bugs observed

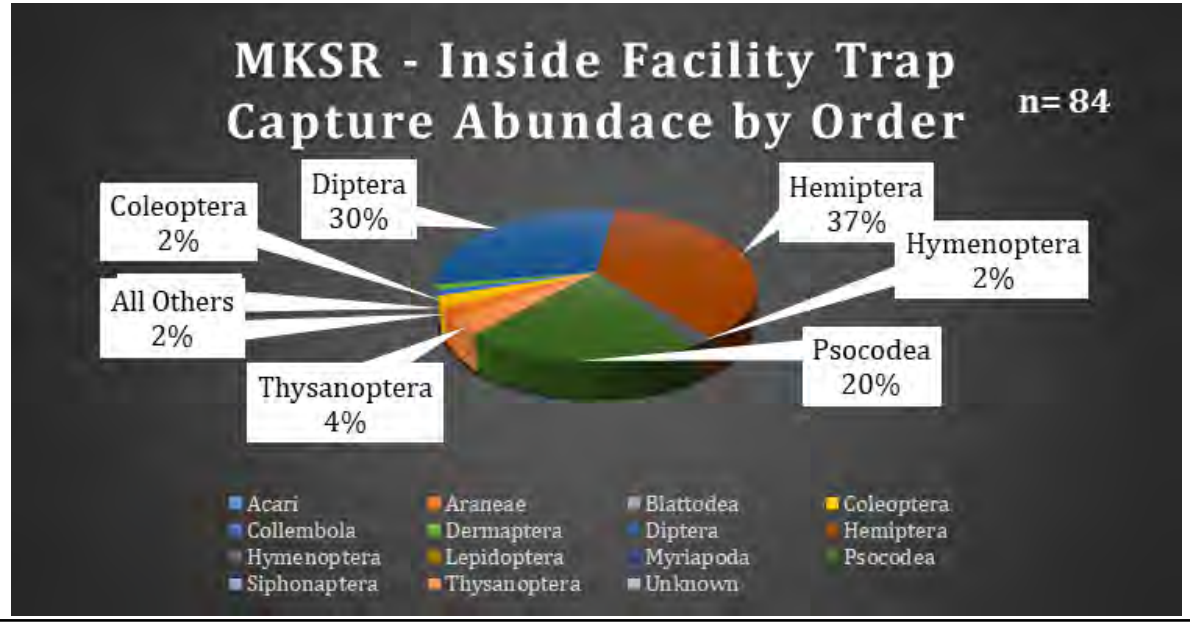


Prevention- Delivery and Equipment Inspections

- Purpose: To reduce the risk of introducing new invasive species via vehicles and equipment.
- 96 total inspections
- 2 remediations (pressure washing)
- Inspected baseyard facilities for regular deliveries and observatories.

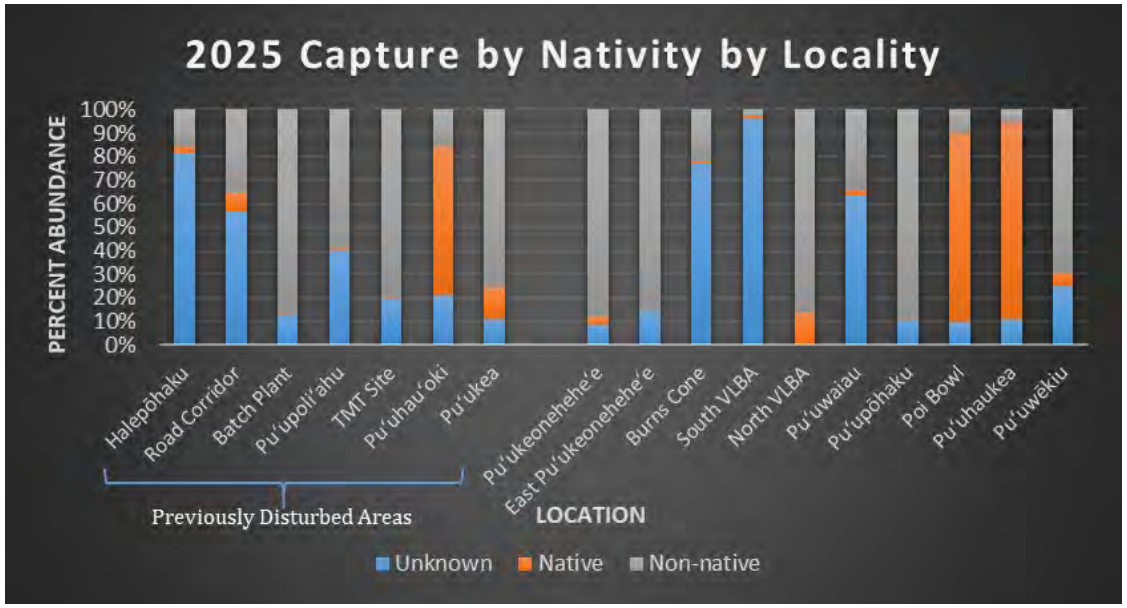
Early Detection Monitoring- Facility Surveys

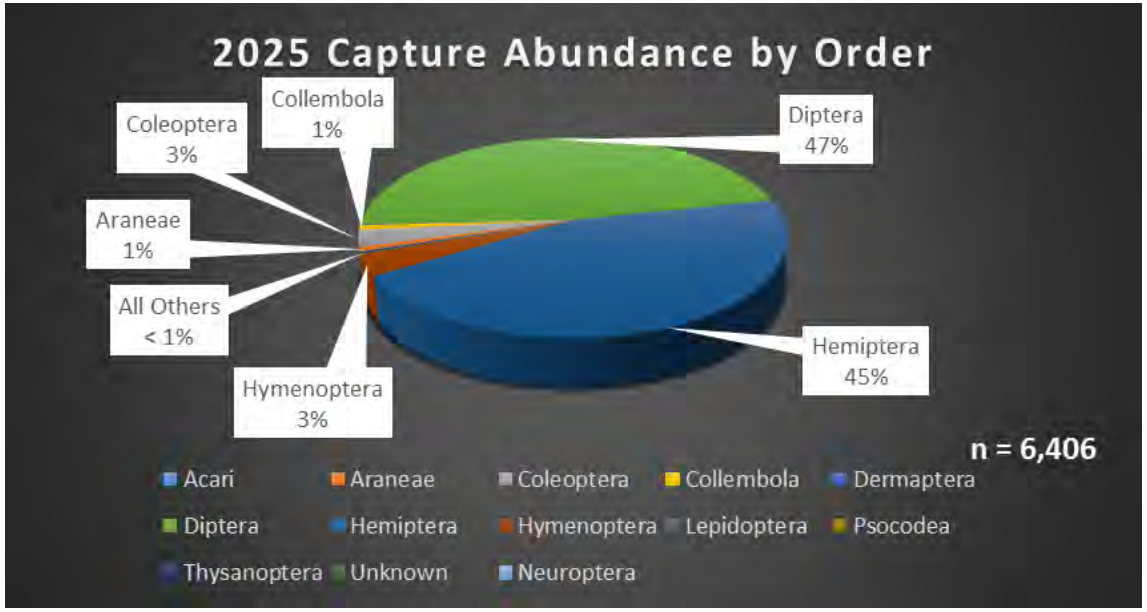
- 60 monitoring locations across telescope facilities and mid-level buildings
  - Hawaiian wolf spider (*H. hawaiiensis*) and wēkiu and *N. terrestris*
  - 7 non-native species, including the german cocakroach, western yellowjacket, and the ant found in previous years *C. kagutsuchi*
- Halepohaku showed the highest species richness and abundance (1,157 individuals)



Annual Alien Invertebrate Monitoring

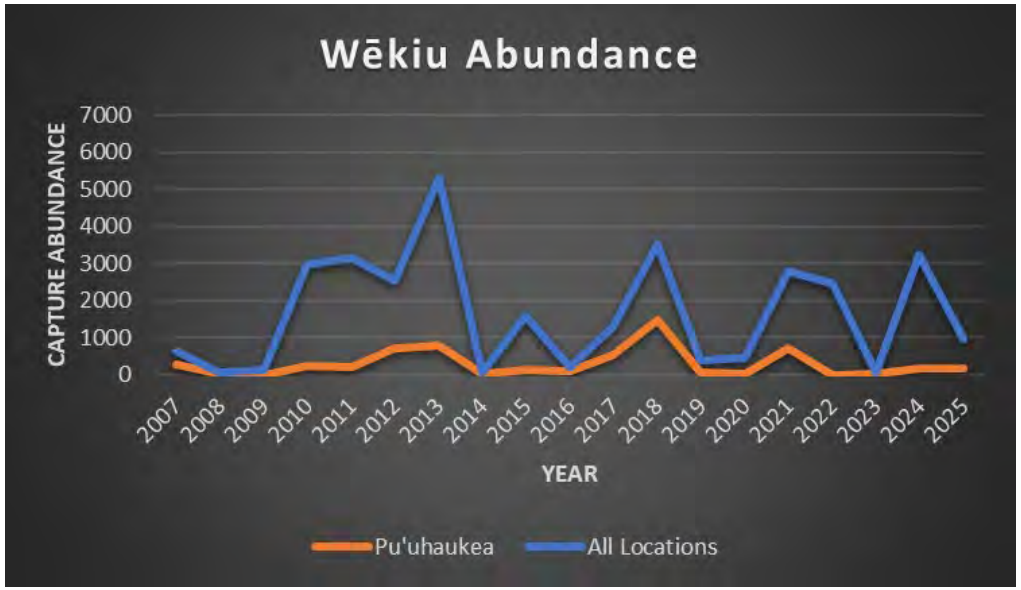
- 111 sites surveyed- 222 traps set
- Community Composition
  - 18.61% Native
  - 54.48% Non-Native (0.98% are considered threats)
  - 26.91% Unidentified
- Flies and seed bugs were the most common captures





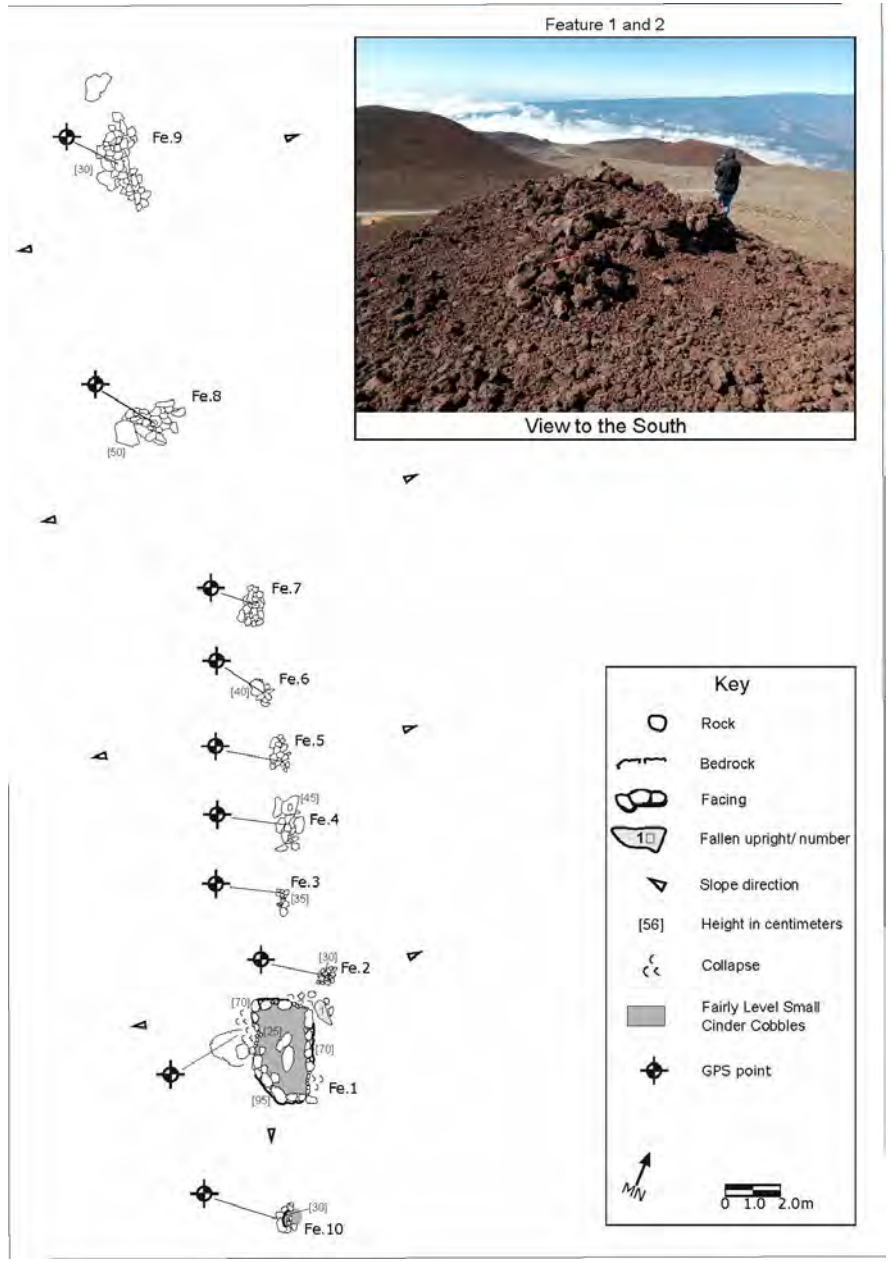
Native Species Monitoring- Wēkiu Bug

- 1,131 bugs captured/observed in 2025
- All life stages were observed, indicating a reproducing population
- Populations naturally fluctuate annually due to biotic and abiotic (climatic) factors



Historical Property Monitoring

- 56 historic properties
- Updated plan view maps to reflect additional features for three sites
- Two sites were not relocated due to GPS issues
- No biological threats found



Incidental Monitoring and Vegetation

- Argentine ants: Found on seeds collected along the Access Road in March (8,000 ft)
  - A very large established population was recorded in the area, we conducted a 100m
  - 22 of 157 baited vials observed Argentine ant.
- Fountain Grass: Found adjacent to Halepohaku and removed immediately
- Common Invasive Weeds: The rangers removed 1233 fireweed, along with 21 mullein and 20 hairy cat's ear from the summit road during their trash walks.

Rapid Response

- Ant Control: Barrier treatments using Talstar Professional were used for control of the established C. kagutsuchi
- Vespid Management: Yellowjacket populations in the greenhouse were successfully reduced through trapping and targeted insecticide applications
- Honey Bee Control: 6 hive traps were deployed at HP; two established hives were removed by a local beekeeper in June.

Conclusion and Future Outlook

- Monitoring remains critical for early detection of high-risk threats like Argentine ant and fountain grass.
- Community effort: Success relies on volunteers for weed pulls and reports from our staff (rangers and observatory personnel)
- Collaboration: Ongoing partnerships with DLNR, DHHL, and neighboring landowners are essential for resource protection.

2025
Invasive & Native Species Monitoring Report

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

University of Hawai'i at Hilo
CENTER FOR MAUNAKEA STEWARDSHIP

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Executive Summary

The Center for Maunakea Stewardship (CMS), formerly the Office of Maunakea Management (OMKM), manages lands on Maunakea, Hawai'i, owned by the State of Hawai'i and leased to the University of Hawai'i (UH). The management area encompasses a total of 11,288 acres and includes the Mauna Kea Science Reserve (MKSR), the Astronomy Precinct, mid-level facilities at Halepōhaku (HP), and the Summit Access Road Corridor (see Appendix A). The 2009 Comprehensive Management Plan (CMP) (Ho'akea, 2009) is the guiding management document for these areas and provides a policy framework for UH to address measures to protect the cultural, natural, and recreational resources on UH managed lands. The Natural Resources Management Plan (NRMP) (SRGI, 2009), a sub-plan of the CMP, addresses the threat 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) (Vanderwoude et al., 2015) to prevent, detect, monitor, respond to, and control new and established invasive species within the UH management area. This report documents invasive species management actions (including native species monitoring) during 2025.

Sections in this report include *Prevention*, *Early Detection Monitoring*, *Native & Established Species Monitoring*, *Rapid Response,* and *Control*. During the period discussed here, a total of 96 inspections of equipment and vehicles being used on the mountain were conducted and these are summarized in the *Prevention* section.

The *Early Detection Monitoring* section discusses four distinct monitoring efforts all aimed at detecting the introduction or expansion of invasive species. Facility Surveys, in which around 60 quarterly-placed insect traps (7 of which are placed monthly) in and around facilities in the MKSR and at Halepōhaku, captured 1,616 individuals from at least 70 distinct taxa. Annual Alien Invertebrate Monitoring surveys, in which more than 200 insect traps of four different kinds were placed at 111 distinct sites around the summit and at the 9,200 ft. level, captured/observed 6,406 arthropod individuals of 12 different taxonomic orders. A total of 1,131 wēkiu bugs (*Nysius wekiuicola*) were captured or observed during the 2025 Annual Alien Invertebrate Monitoring survey. These variances are illustrated in the tables and graphs in the Annual Alien Invertebrate Monitoring survey section. Data from Rotating Panel Surveys, carried out concurrently with Archaeological Monitoring, and the Incidental Early Detection Monitoring are also included in this section.

Native and Established Species Monitoring focuses primarily on the native wēkiu bug (*Nysius wekiuicola*). Specific instances of invasive threats that required immediate action are discussed case by case in the section *Rapid Response*. Over the 12-month period discussed here, rapid response procedures were initiated to address one distinct threat. Finally, the *Control* section describes efforts to bring or keep numbers of certain invasive plant and animal species that are already too well-established to eradicate to acceptable levels. In 2025, plant and 4 animal species were the focus of sustained control efforts.

Introduction

The Maunakea Invasive Species Management Plan (ISMP) was approved by the Maunakea Management Board in 2015 (Vanderwoude et al., 2015). 2016, then is the first year in which all work was conducted in accordance with protocols finalized in that document, though many of these protocols were already followed in previous years. Wēkiu bug (*Nysius wekiuicola*) and alien invertebrate monitoring efforts are a continuation of work done previously by the Bernice Pauahi Bishop Museum.

Sections in this report emphasize plant, vertebrate, and invertebrate threats. These threats are explained in detail in Standard Operating Procedure (SOP) D: Maunakea Plant Threats, Identification, Collection, & Processing Guide (Kirkpatrick et al., 2016); SOP B: Maunakea Vertebrate Threats, Identification, Collection, and Processing Guide (Yogi & Kirkpatrick, 2016); and SOP C: Maunakea Invertebrate Threats, Identification, Collection, & Processing Guide (Kirkpatrick & Klasner, 2015) documents developed as part of the ISMP.

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 (primarily vehicles and equipment). Prevention procedures for plants and arthropods are based on a comprehensive effort to identify and analyze the risk associated with potential invasion pathways. Preventative management actions include inspection requirements and strict sanitation procedures for contractors and staff throughout UH managed lands. Sanitation guidelines are found in the Maunakea ISMP (Vanderwoude et al., 2015).

Delivery And Equipment Inspections

The main purpose of inspections is to reduce the risk of frequent "users" (observatory staff, Maunakea Shared Services, and CMS itself) introducing new invasive species on Maunakea. This section summarizes all inspections conducted in 2025. Any rapid response activities that resulted from these inspections to ensure that any new invasive species were addressed swiftly and appropriately wherever found are described later in this report (see Native & Established Species Monitoring).

Study Area

Most inspections conducted in 2025 occurred in Hilo at delivery base yards and facility warehouses. Less frequently, inspections occurred in Kona and Waimea. Examples of inspected items include aggregate materials, lumber, heavy equipment, empty dumpsters, lowboy trailers and semi-trucks, chiller units, and wooden crates containing electronic equipment.

Methods

Inspections are conducted to ensure that materials, supplies, and/or vehicle(s) coming to the mountain are clean and free of animal, plant, and earthen materials. Inspections are done by simple observation and, in some cases, baiting. Specific inspection methods vary depending on the item. For example, pallets and crates require a close look at corners and crevices while inspections of larger vehicles and equipment focus on dirt-collecting areas such as wheel wells, tires, mudflaps, etc. Bait is used when a delivery item is stored outdoors for more than a week. In these cases, index cards (or vials) baited with peanut butter, jelly, and spam are left out for at least 20 minutes and observed for invertebrate activity (primarily ants). After an inspection is completed, concerns are reported to the inspection requestor. Most concerns can be handled by the facility staff and require a subsequent self-inspection, but some situations require a re-inspection after remediations are completed.

Results and Discussion

A total of 96 inspections were conducted in 2025 by Department of Land and Natural Resources (DLNR) approved biological inspectors. Below, Table 1 displays the number of inspections, remediations, instances of non-compliance, and rush inspections (those with less than 24 hours' notice) for each facility during this period. For all inspections that required remediation, corrective actions (e.g. pressure wash, vacuum, etc.) were taken and items passed subsequent inspection.

Table 1. 2025 Invasive Species Inspections. Abbreviations for facilities include: CFHT- Canada France Hawai'i Telescope, Gemini- Gemini North Telescope, IRTF- NASA Infrared Telescope Facility, JCMT- James Clerk Maxwell Telescope, Keck- W. M. Keck Observatory, MKSS- Maunakea Shared Services, CMS- Center for Maunakea Stewardship, SMA- The Submillimeter Array, Subaru- Subaru Telescope, UH88- The University of Hawai'i 88-inch (2.24-meter) telescope, VLBA- The Very Long Baseline Array.

Facility	Number of Inspections	Remediations	Non-compliance	Rush Inspections
CFHT	7	0	0	1
Gemini	6	1	0	1
IRTF	7	0	0	0
JCMT	2	0	0	0
Keck	32	0	0	0
MKSS	9	1	0	0
CMS	1	0	0	1
Other	1	0	0	0
SMA	12	0	0	4
Subaru	13	0	0	1
UH88	3	0	0	0
VLBA	3	0	0	1
TOTAL	**96**	**2**	**0**	**9**

Early Detection Monitoring

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, whether they are new to the island or encroaching from established populations at lower elevations. In the case of species new to the island, early detection also decreases the likelihood of dispersal outside of UH managed lands. Early detection methods are dependent in large part on consistent monitoring activities. During the period outlined here, early detection efforts focused on three large taxonomic groups—invertebrates, plants, and vertebrates—and took four primary forms—Facility Surveys, Rotating Panel Surveys, Annual Alien Invertebrate Monitoring, and Incidental Early Detection Monitoring.

Facility Surveys

Introduction

Since 2012, all facilities on UH managed lands have been monitored for invasive arthropod species using baited traps. In the Mauna Kea Science Reserve (MKSR), traps are placed in all in-use telescope facilities (each facility has 2 or more traps), the summit lunch room, the Batch Plant parking area, and the Thirty Meter Telescope (TMT) construction site when there is construction activity. At Halepōhaku (HP), traps are placed in the common building, kitchen, dorms, the maintenance building, parking lots, Ranger offices (moved to the common building in 2018) and trailer, the Visitor Information Station (VIS), the VIS storage warehouse and presentation room, and the VIS management office.

Until 2018, this amounted to 63 trap locations. In 2018, one of the longhouses near the VIS, underneath which one trap had previously been placed, was removed. In 2019, the decision was made to stop placing traps at the Caltech Submillimeter (CSO) and Hōkū Keʻa (UH 24") Observatory facilities, as they were no longer in use. However, invasive species monitoring for CSO and Hōkū Keʻa have been conducted quarterly since 2023 as part of the decommissioning process outlined in SOP 15: Decommissioning Monitoring and Early Detection of Invasive Species Threats (Yeh et al., 2023; results will be provided in a separate annual report). In addition, a new trap was added in February this year at the newly installed Ranger trailer at the visitor station. Although not considered a permanent facility, a trap was added in the Ranger trailer at the request of the Rangers. Consequently, as of this year, traps were placed at 60 locations and were monitored on a monthly and/or quarterly basis.

Methods

The main purpose of facility trap surveys is to detect new invertebrate species in or around facilities, the biggest concern being ants. Facility monitoring employs indoor and outdoor baited sticky traps along with perimeter searches. CMS uses HoyHoy cockroach 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, parking lots, control rooms, and other areas with significant human traffic. All outside traps are covered with a plastic container for weather

protection. Perimeter searches were also conducted on a quarterly basis around all HP facilities and parking lots when staff resources allowed. Surveying entailed hand searches, invasive weed pulls, and baiting with peanut butter, jelly, and spam vials (when needed).

Facility Surveys occurred on a monthly and quarterly basis. Monthly monitoring had traps deployed at seven trap sites located in the HP common and kitchen areas, the VIS warehouse, and the Ranger trailer with a monthly replacement cycle. Quarterly monitoring had traps deployed at all sixty trap sites (including sites hosting monthly traps) every quarter (every 3 months) and were retrieved within a week. Once retrieved, traps were processed in a lab and all observed and collected invertebrates were identified to the lowest possible taxonomic unit necessary (typically to family) to determine if the species was a threat. Monthly and Quarterly monitoring data were analyzed and reported separately in this report.

Results

In 2025, 323 facility traps were deployed with a total of 1,616 arthropod individuals from 16 taxonomic orders captured/observed during this monitoring period. A detailed list of all arthropod taxa captured in facility traps during this period can be found in Appendix B. Detailed results for Monthly and Quarterly traps are analyzed and presented below.

Summary of Monthly Facility Surveys

Monthly facility surveys deployed 83 traps and captured a total of 52 individuals of at least 23 distinct invertebrate taxa (see Table 2 for the full list). However, it is important to note that fourteen traps went missing and were not retrieved. These missing traps were mainly located in the HP Commons building and in the HP kitchen, and were likely accidentally trashed, misplaced, or destroyed.

Table 2. List of all captured taxa in 2025 monthly facility traps. Species of concern are **bolded**.

Order	Family/Scientific Name	Common Name	Nativity	# Observed
Acari	Unknown	Mite	Unknown	2
Araneae	Unknown	Spider	Unknown	3
Blattodea	***Blatella germanica***	**German cockroach**	**Non-native**	**3**
Coleoptera	***Laemostenus complanatus***	**Cosmopolitan ground beetle**	**Non-native**	**1**
Coleoptera	*Naupactus cervinus*	Fuller rose beetle	Non-native	1
Coleoptera	Unknown	Beetle	Unknown	1
Diptera	*Calliphora latifrons*	Blue bottle fly	Non-native	2
Diptera	Calliphoridae sp.	Blow fly	Unknown	1
Diptera	Drosophilidae spp.	Vinegar fly	Unknown	8
Diptera	Mycetophilidae sp.	Fungus gnat	Unknown	1
Diptera	Phoridae spp.	Scuttle fly	Unknown	5
Diptera	Psychodidae sp.	Moth fly	Unknown	2
Diptera	*Bradysia nitidicollis*	Dark-winged fungus gnat	Non-native	2
Diptera	Sciaridae spp.	Dark-winged fungus gnat	Unknown	5
Diptera	*Minilimosina fungicola*	Lesser dung fly	Non-native	1
Entomobryomorpha	Entomobryidae spp.	Slender springtail	Unknown	2
Hemiptera	Aphididae spp.	Aphid	Non-native	4
Hemiptera	*Neacoryphus bicrucis*	White-crossed seed bug	Non-native	2
Hemiptera	*Nysius palor*	Seed bug	Non-native	2
Hemiptera	*Orthotylus sophoricola*	Plant bug	Native	1
Hemiptera	Unknown	True bug	Unknown	1

Psocodea	Unknown	Barklice	Unknown	1
Unknown	Unknown	Unknown	Unknown	1

Summary of Quarterly Facility Surveys

Quarterly facility surveys deployed 240 traps and captured a total of 1,564 individuals of at least 70 distinct invertebrate taxa. However, it is important to note that eleven traps went missing and were not retrieved. These missing traps were mainly located inside facilities (i.e., HP, Gemini, SMA, Subaru, and UKIRT), and were likely accidentally trashed, misplaced, or destroyed.

Table 3. Summary of the arthropod captures from the 2025 Quarterly facility traps.

Facility type and location	Arthropod Individuals Captured	Unique Taxonomic Orders Identified
Inside Facilities – MKSR	84	9
Outside Facilities – MKSR	323	6
Inside Facilities – HP	77	9
Outside Facilities – HP	1,080	12
Totals	1,564	15

Quarterly Facility Surveys - Inside Facilities

There are 49 trap sites that are located inside facilities. Quarterly Facility traps located indoors captured a total of 161 arthropods (10.56% native, 54.66% non-native [3.73% threats], and 34.78% undetermined) of at least 12 distinct orders, 84 in the Maunakea Science Reserve (MKSR) and 77 at HP. The majority of individuals captured inside MKSR facilities were true bugs (Hemiptera), flies (Diptera), and barklice (Psocodea). HP indoor traps captured mostly true bugs, flies, and wasps. Figures 1, 2, and 3 provide details on the arthropod capture abundance by order and location.

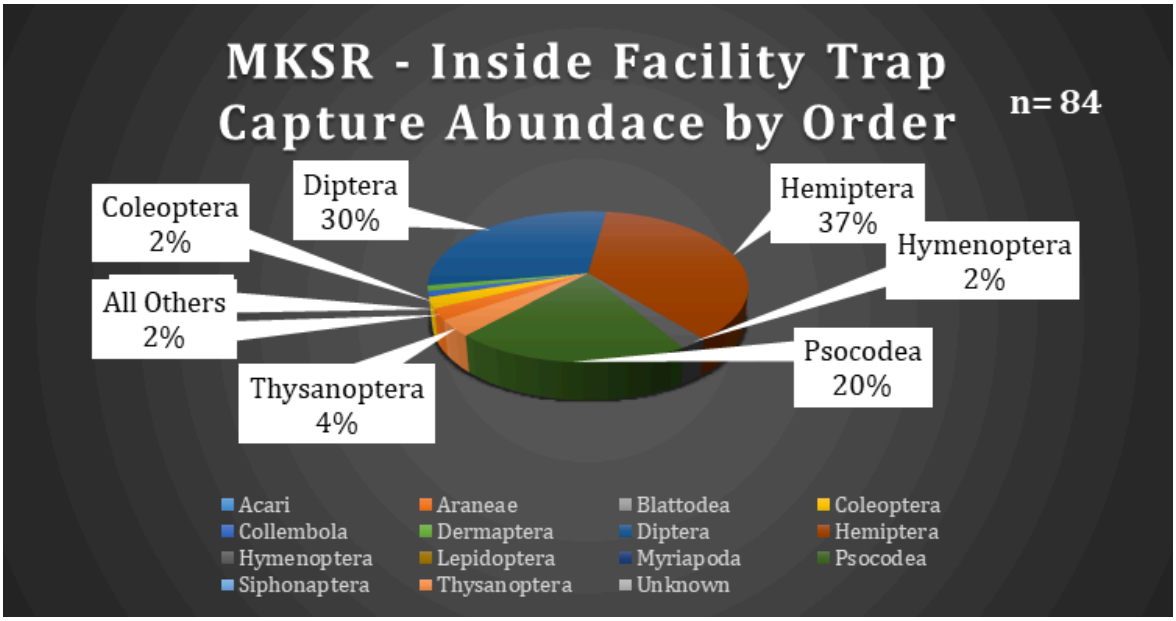

Figure 1. Total capture abundance by order for all indoor facility traps located within the MKSR, where "n" is the total number of invertebrates captured.

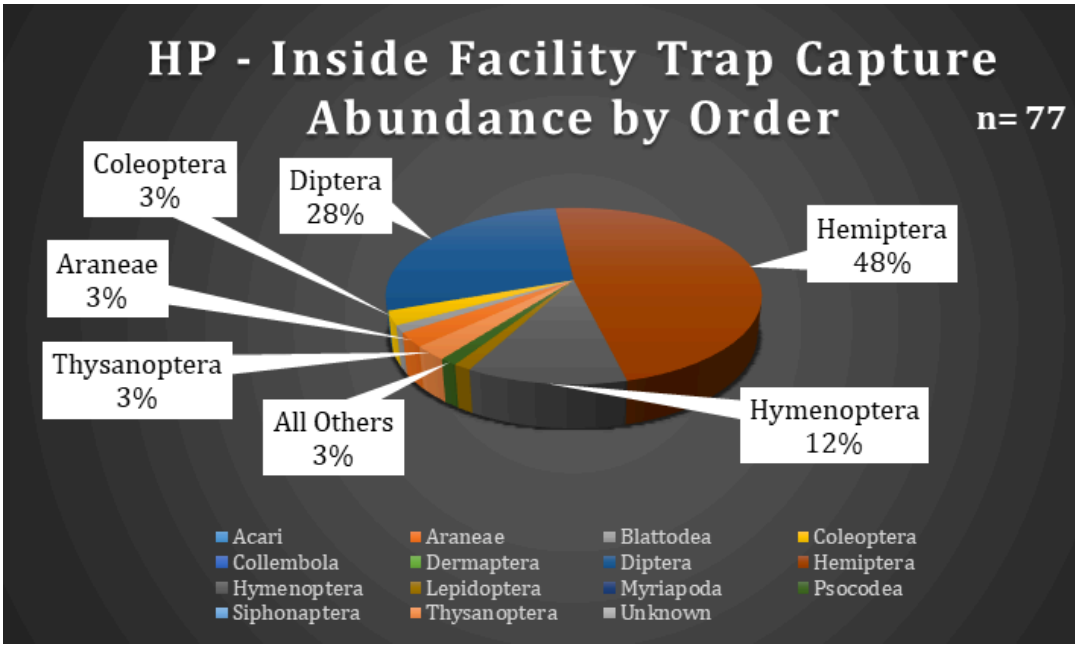

Figure 2. Total capture abundance by order for all indoor facility traps located at HP, where "n" is the total number of invertebrates captured.

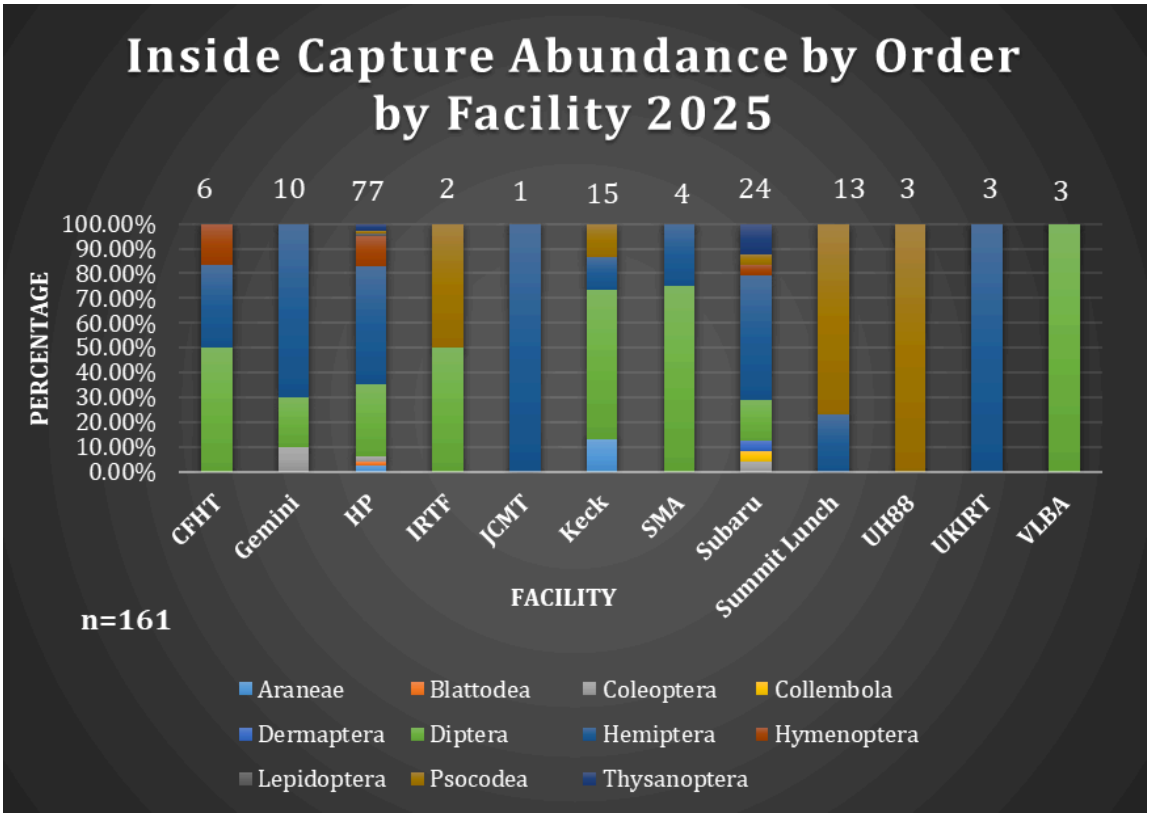

Figure 3. Total indoor trap capture abundance by order for all facilities, where "n" is the total number of invertebrates captured.

Quarterly Facility Surveys - Outside Facilities

There are a total of 11 trap sites located outside of facilities. Quarterly Facility traps located outside captured a total of 1,403 arthropods (0.86% native, 36.85% non-native [7.34% threats], and 62.30% undetermined) of at least 12 distinct orders, 323 in the Maunakea Science Reserve (MKSR) and 1,080 at HP. The majority of individuals captured outside MKSR facilities were true bugs and flies. HP outdoor traps captured mostly springtails (Collembola) and wasps/ants. Figures 4, 5, and 6 provide details on the arthropod capture abundance by order and location.

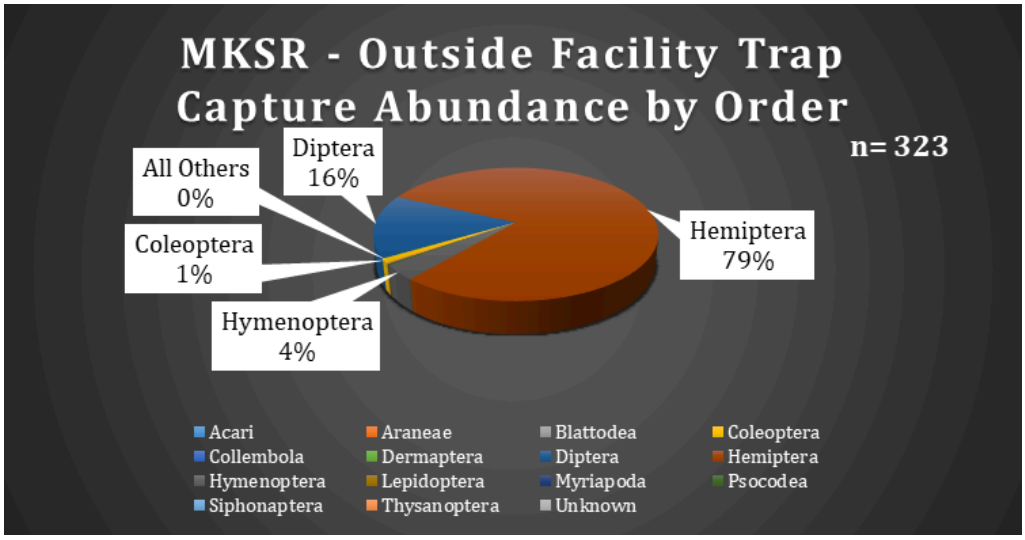

Figure 4. Total capture abundance by order for all outdoor facility traps located within the MKSR, where "n" is the total number of invertebrates captured.

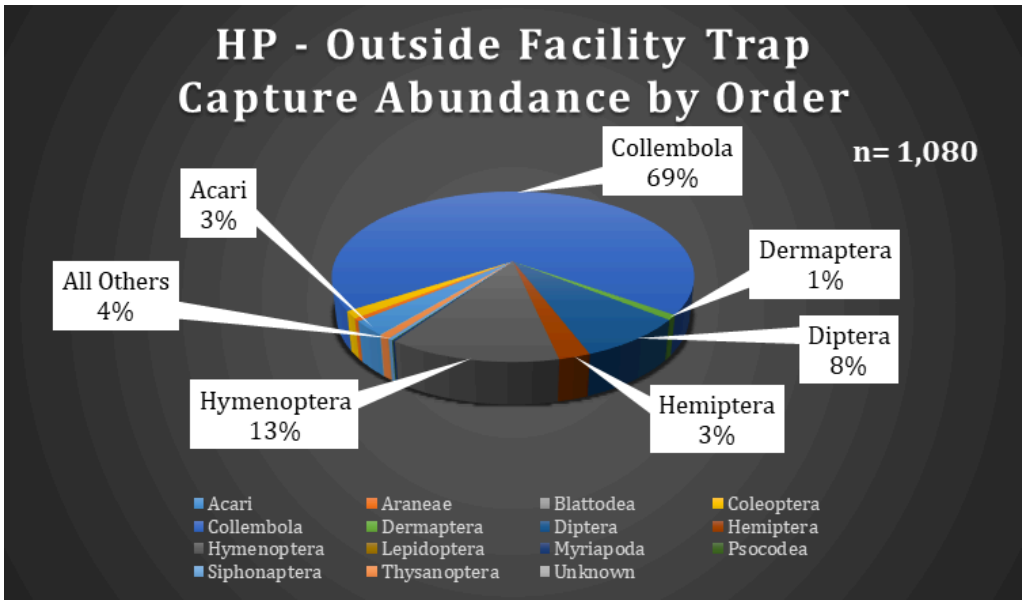

Figure 5. Total capture abundance by order for all outdoor facility traps located at HP, where "n" is the total number of invertebrates captured.

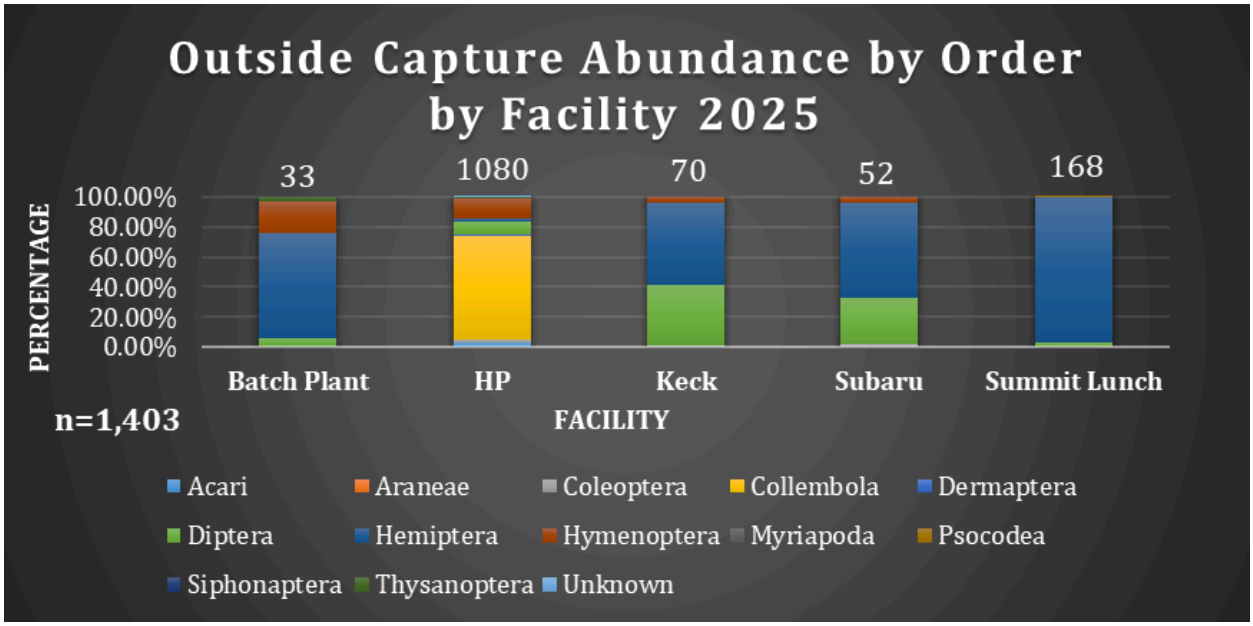

Figure 6. Total outdoor trap capture abundance by order for all facilities, where "n" is the total number of invertebrates captured.

Conclusion

Several species of interest were captured during Facility Surveys this year. Three native species were captured: the Hawaiian wolf spider (*H. hawaiiensis*) and two seed bugs (*N. wekiuicola* and *N. terrestris*). These three species are frequently found during arthropod monitoring. Interestingly, *N. wekiuicola* were detected in multiple indoor locations, including the third-floor breakroom of the Subaru Telescope, as well as the third-floor operations room and the ground-level loading bay of the Canada–France–Hawaii Telescope. Seven captured non-native species were confirmed to be threats: two spiders (*T. tenuis* and *M. arcifera*), two beetles (*L. complanatus* and *N. rufipes*), German cockroach (*B. germanica*), ant (*C. kagutsuchi*), and two wasps (*H. exiguae* and *V. pensylvanica*). The two species of most concern are *C. kagutsuchi* and the western yellowjacket (*V. pensylvanica*), both of which are actively managed at HP by CMS staff.

HP displayed the highest arthropod species richness (14 distinct orders) and abundance (1,157 individuals) compared with the other facilities. At HP, inside captures were dominated by Hemiptera, Diptera, and Hymenoptera, whereas outside captures were primarily Collembola, Hymenoptera, and Diptera. At the summit facilities, Diptera, Hemiptera, and Psocodea were the dominant orders observed inside, while outside captures were mainly Hemiptera, Diptera, and Collembola.

Rotating Panel Surveys

Study Area

Rotating Panel Early Detection Plant and Invertebrate surveys were conducted alongside State-mandated historic property monitoring every year during this period. Rotating panel survey locations varied based on annual, 3-year, or 5-year rotations, depending on the site. During 2025, only 49 of 56 annual historic sites within the Mauna Kea Science Reserve (MKSR) were surveyed (map shown in Appendix C). The remaining seven sites (IDs 16203, 16204, 16248, 21452, 25767, 25805, and 25809) could not be located during this monitoring period.

Methods

The main purpose of invertebrate and plant early detection surveys is to detect, document, and monitor invasive species threats at sites across a variety of habitats within UH management jurisdiction. All observed and 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 in opposing cardinal directions and left out for 10-15 minutes. While waiting for the vials, a 10-minute hand search (overturning rocks and visual inspection) was conducted up to 10 m out from each site. All known observed invertebrates were recorded and unknown specimens were collected and identified in the lab.

Vegetation
Vegetation was observed within a 10 m radius of the historic properties. Native vegetation was documented; non-native vegetation was pulled, documented, and disposed of. The roots of pulled plants were carefully observed for ants and other potential invertebrate threats. All vegetation including lichens[1] were recorded.

Results & Discussion

Rotating panel surveys were conducted during July and August. During 2025, surveys were conducted as follows (see Table 4):

Table 4. The number of surveys conducted, baited vials placed, and specimens observed in 2025.

No. of Surveys Conducted	Baited Vials Placed	No. of Specimens Observed
49	199	139

A comprehensive list of invertebrate observations at historic properties in the MKSR during the 2025 surveys can be found in Appendix D.

[1]

Vegetation

Table 5 displays the number of individuals of each plant species observed during the 2025 survey. In most cases, invasive species are pulled and carried out for disposal.

Table 5. Plant species observed during the 2025 Rotating Panel surveys, nativity, and number of specimens observed.

Scientific Name	Common Name	Nativity	# Observed
Agrostis sandwicensis	Hawai'i bentgrass	Native	12
Anthoxanthum odoratum	Sweet vernal grass	Non-native	3
Asplenium adiantum-nigrum	ʻIwaʻiwa fern	Native	8
Asplenium trichomanes	ʻOwāli'i fern	Native	1
Bidens menziesii subsp. *filiformis*	Koʻokoʻolau	Native	2
Bromus catharticus	Rescuegrass	Non-native	1
Bromus diandrus	Great brome grass	Non-native	216
Cenchrus clandestinus	Kikuyu grass	Non-native	10
Chenopodium oahuense	ʻĀweoweo	Native	19
Erodium cicutarium	Alfilaria, pin clover	Non-native	604
Heterotheca grandiflora	Telegraph weed	Non-native	9
Holcus lanatus	Yorkshire fog	Non-native	1
Nassella cernua	Nodding/foothill needle grass	Non-native	584
Poa pratensis	Kentucky bluegrass	Non-native	78
Poaceae sp.	Grass	Unknown	58
Pteridium aquilinum	Hawaiian bracken fern	Native	2
Rumex acetosella	Sheep sorrel	Non-native	138
Rumex giganteus	Pāwale	Native	1
Senecio madagascariensis	Fireweed	Non-native	225
Sophora chrysophylla	Māmane	Native	22
Stenogyne rugosa	Māʻohiʻohi	Native	35
Taraxacum officinale	Common dandelion	Non-native	2
Trifolium arvense	Rabbit foot-clover	Non-native	200
Trisetum glomeratum	Pili uka grass	Native	80
Verbascum thapsus	Common mullein	Non-native	26
Verbascum virgatum	Wand mullein	Non-native	234
Vulpia bromoides	Brome fescue	Non-native	32
Unknown	Grass	Unknown	122
Unknown	Lichen*	Unknown	34
Unknown	Moss*	Unknown	7

*It is not possible to count individual lichen and mosses; figures indicate the number of sites at which each was observed. Lichen colors recorded in the field were pale green, bright green, yellow, orange, white, gray and/or black. Moss colors recorded in the field were black or green.

Conclusion

No new vegetation threats were observed during Rotating Panel surveys in 2025. A few spiders (Order: Araneae) and wasps (Order: Hymenoptera) were collected for further identification and were confirmed to not be threats.

Annual Alien Invertebrate Monitoring

Introduction

From 2007 to 2012, the Bishop Museum was contracted by OMKM to conduct biological surveys to monitor native and established non-native invertebrates and detect invertebrate threats. Beginning in 2013, OMKM conducted the surveys internally using locations and methods consistent with those used by the Bishop Museum. This section includes results for all species captured during the CMS 2025 survey effort. Detailed wēkiu bug (*Nysius wekiuicola*) data and analysis can be found in the *Native & Established Species Monitoring* section further on in the report.

Study Area

Alien invertebrate surveys are conducted concurrently with wēkiu bug monitoring surveys to reduce impacts to the environment. Alien invertebrate study areas include the Halepōhaku (HP) staff headquarters at 2,850 m (9,300 ft) elevation, the Mauna Kea Ice Age Natural Area Reserve (NAR), the road corridor, the Mauna Kea Science Reserve (MKSR), and puʻu (cinder cones) within the Astronomy Precinct that extend to the summit at 4,205 m (13,796 ft). Survey location maps are in Appendix E, and Appendix F contains a table of GPS coordinates, elevation, and trap types for each survey location. Coordinate and elevation data was retrieved from GPS units in the field using the WGS 84 datum. It should be noted that most location names are not official, but rather are a means of labeling sites to easily identify specific areas of the vast summit region on Maunakea. Unless otherwise stated, puʻu names were derived from U.S. Geological Survey (USGS) geology maps and the Geographic Names Information System (GNIS).

Methods

The objectives of survey fieldwork are to document native and alien species found within UH managed lands and neighboring lands (especially the NAR) and identify species that could be threatening to cultural sites, natural resources, and/or human health and safety. All arthropod specimens were identified by comparing to previous catches. Collected specimens were identified to the lowest possible taxonomic unit necessary to determine if the species was a threat.

To accomplish our objectives, we sampled over a broad range of habitats at the summit including undisturbed wēkiu bug habitat and nearby disturbed habitat types that are associated with past or present human activity. Each trapping area had 1-14 sites, with each site containing at least one of four trap types (detailed below). Trap areas were defined using Natural Resources Conservation Service (NRCS) soil survey data (http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). Exceptions were made to address potential management impacts at certain sites, for example, within the road corridor or Thirty Meter Telescope (TMT) site.

2025 traps mirrored traps used since 2013 and included yellow pan traps; baited pitfall traps; kill pitfall traps; and peanut butter, jelly, and spam sticks (PBJS sticks) (Figure 7). All traps were retrieved within 3-4 days. All specimens that were collected in traps were kept for further analysis

with the exception of live native arthropods (such as wēkiu bugs), which were captured, recorded, and released.

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 food-grade propylene glycol and water. Propylene glycol prevents freezing during nighttime temperatures, slows evaporation, is safe for the environment, and acts as a preservative for captured specimens.

Kill Pitfall Traps
Kill pitfall traps were used to capture crawling arthropods. In an attempt to reduce wēkiu bug mortality, kill pitfall traps were not placed in potential or known wēkiu bug habitats. To install this trap, a small hole was dug and a plastic cup positioned in the hole such that its top was level with the surface substrate. Then, a quarter of the cup was filled with a 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 putrid bait. These traps keep arthropods alive by providing them with food and water until they are retrieved. Baited pitfall traps were placed in all habitats. Two nested plastic cups with a wick between them were placed in a hole in the substrate and the rim of the top cup made level with the substrate's surface. Once the cups were set, about 1 cm of water was added to the bottom cup and the other, upper cup was inserted back into the bottom cup. This allows water from the bottom cup to move up through the wick into the top cup, providing water for captured arthropods. A few rocks were placed in the cup for shelter (no more than ½ full) and the rim and cap rock were baited with tuna. The baited cap rock was placed over the trap to prevent rain or snow from filling it.

Peanut Butter, Jelly, & Spam (PBJS) Sticks
PBJS sticks were used to survey primarily ants. The use of different baits allows for attraction variation across different ant species. Chopsticks were baited with peanut butter, jelly, and spam and laid on the ground, secured with a rock where needed. These were caged in large-gauge wire netting where birds and other animals were likely to steal the bait (mostly at elevations below 11,000 ft.).

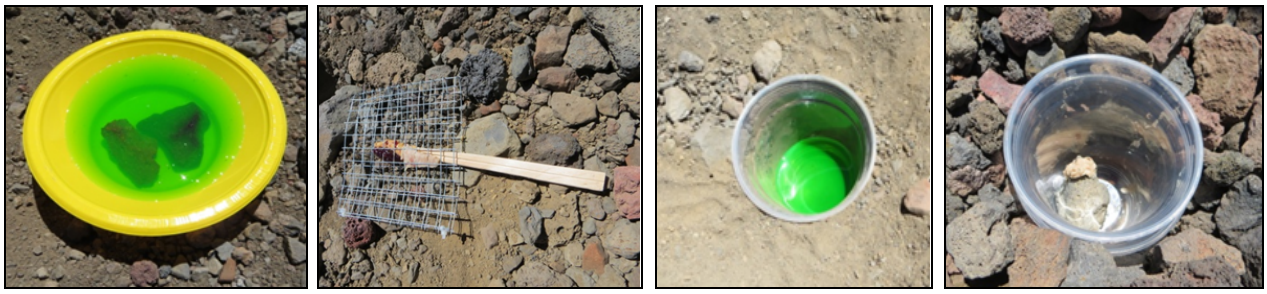

Figure 7. Images of the four trap types, from left to right: yellow pan, PBJS sticks, kill pitfall (without cap rock), and the baited pitfall (without cap rock) traps.

Hand Search

Hand searching is practiced on the ground level and includes turning over rocks and/or brushing a hand over the substrate in search for invertebrate threats and native species. Hand searches were conducted for roughly 10 minutes throughout a 5-meter radius of each site.

Vegetation Survey

The presence of native and non-native (including invasive) plants was recorded within a 10-meter radius of each trapping site. Non-native (including invasive) plants observed in the NAR and MKSR were removed and documented. The roots of non-native pulled plants were carefully observed for ants and other invasive arthropods. All vegetation near trapping sites within the MKSR and NAR was recorded.

Results & Discussion

CMS Alien Invertebrate surveys are generally conducted from late spring to mid-summer of each year. During 2025, surveys were conducted as follows (see Table 6):

Table 6. The number of sites surveyed, traps sets, invertebrates observed, taxa and number of wēkiu bugs observed for 2024 and 2025.

Year	No. of sites surveyed	No. of traps set	No. of Invertebrate Individuals observed*	No. of Invertebrate taxa observed	No. of Wēkiu observed
2024	111	222	8,980	108	7,008
2025	111	222	6,406	145**	1,131

*Does not include those observed during hand searches.
**61 of which are morphospecies, and 51 with identification to the species level.

A comprehensive list of all invertebrate taxa captured or observed during Annual Alien Invertebrate surveys from 2025 can be found in Appendix I. There were no new identified record captures to the Management Area this survey year. However, we were unable to identify 61 morphospecies (or proxy taxa based on morphological similarities) to the species level. These morphospecies can potentially be new record captures and will be sent out for complete identification.

Taxa Observed

The charts below provide an overview of the diversity of taxa observed in the various alien monitoring traps.

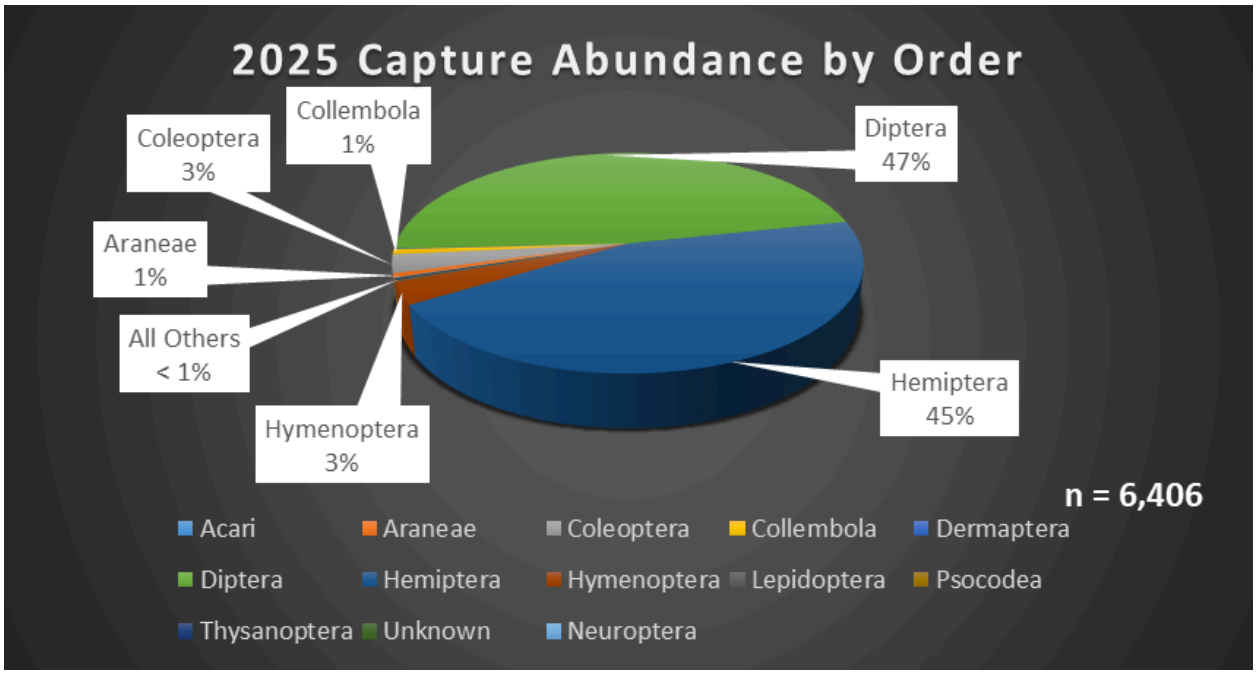

Figure 8. Pie chart showing the capture percentage by order for all trap types combined (this does not include hand search[2] data) from 2025. The 'n' value in the bottom right displays the total number of arthropods captured.

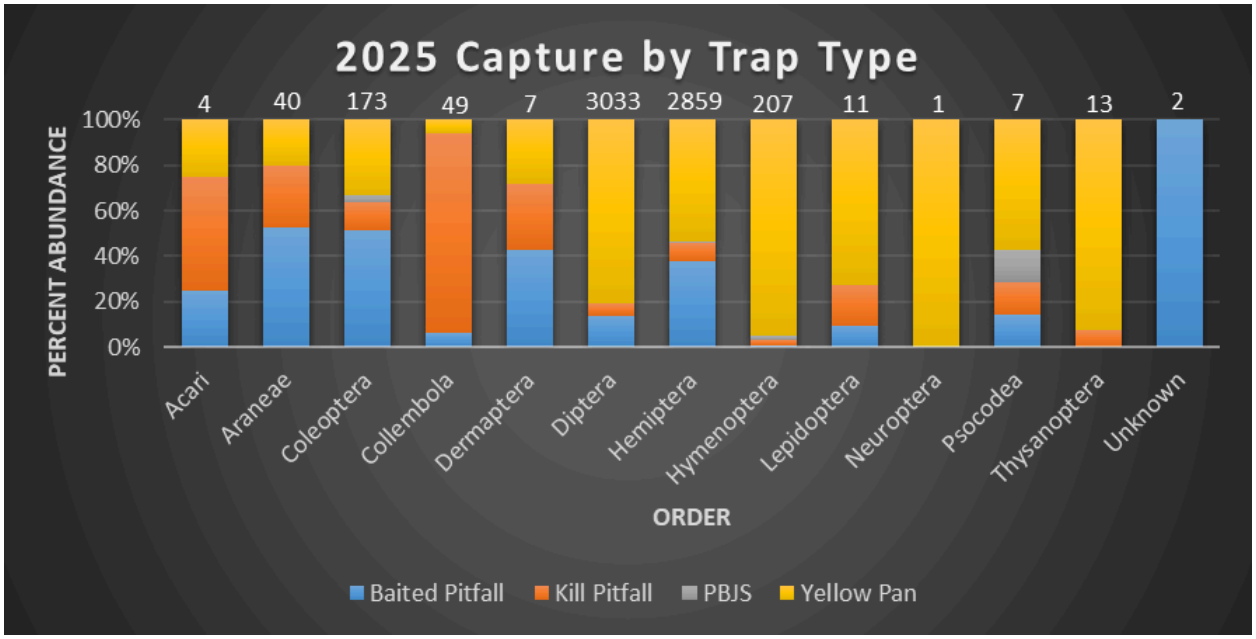

Figure 9. The bar graph shows the percentage of individuals in each order captured by each trap type (not including hand search data). The numbers on the top of each bar represent 'n', the number of individuals captured within that order.

[2] Hand search abundance data is not quantified but rather estimated.

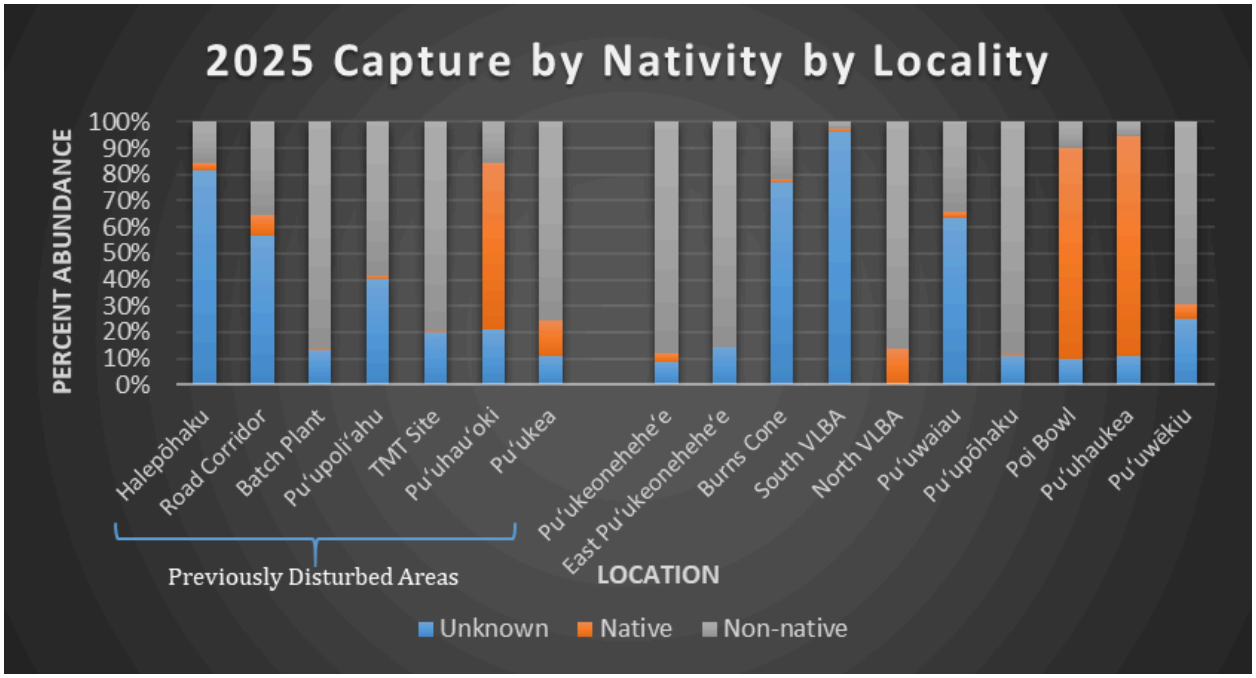

Figure 10. The graph shows captured invertebrate abundance by nativity by locality (not including those observed in hand searches). Nativity[3] can be non-native, native, or unknown if nativity cannot be determined. Locations are grouped as previously disturbed habitats and un-disturbed habitats and go from low elevation at left to high elevations at right. It should be remembered that not all types of traps are placed at all localities, and that certain types of traps (i.e. yellow pan traps) are more attractive to many of the non-native species found on Maunakea.

Conclusion

The majority of arthropods captured during this period were flies (Order: Diptera) and seed bugs (Order: Hemiptera). See Annual Wēkiu Bug Monitoring section in the Native & Established Species Monitoring section for details on the wēkiu bug monitoring results. A total of 6,406 arthropod individuals were captured in this year's monitoring traps (not including those observed during hand searches). Of all arthropods captured and observed, approximately 18.61% were native, 54.48% were known to be non-native (0.98% threats), and about 26.91% were of undetermined nativity. With a few exceptions, non-native Araneae (spiders), Coleoptera (beetles), Muscid flies (Diptera: Muscidae), and Hymenoptera (ants, bees, and wasps) are considered threats, as they commonly predate on, parasitize, or dominate the resources of native species. Vegetation observed at trapping sites were predominantly native grasses and lichen, though invasive fireweed (*S. madagascariensis*) and grasses were also frequently observed and pulled.

[3] Nativity was determined using various resources such as the Insects of Hawai'i series (The University of Hawai'i Press, Honolulu), the Hawaiian Terrestrial Arthropod Checklist (Nishida 2002), and the revised checklist (Matsunaga et al. 2019).

Incidental Early Detection Monitoring

Introduction

Non-native vertebrates, invertebrates, and vegetation can pose major threats to native ecosystems. Therefore, timely detection and monitoring of new non-native species is key. Detection of native species is also of interest, especially if they are rarely observed by Maunakea users. Beginning in 2013, OMKM started documenting incidental observations and collections of species reported by Maunakea users, including Rangers, VIS staff, observatory staff, and others. CMS continues to collaborate with neighboring landowners and state agencies on possible biological threat issues on Maunakea, and vice versa. Incidental monitoring serves as both an early detection method and a monitoring strategy. This section includes all incidental reports of species observed within UH managed lands and adjacent lands. Species include those that 1) are not established within the management area, 2) are unique or rarely observed within the management area, or 3) are common in the habitat, but not typically encountered by Maunakea users (i.e. *Hogna* spiders). Any non-native species not previously documented on UH managed lands is considered a threat until further investigation. Early detection of threat species and their locations provides CMS with a better understanding of trends within threat populations and can help CMS build its knowledge of ranges of rare and unusual species.

Study Area

The study site includes all University of Hawai‘i managed lands and neighboring lands (including Natural Area Reserves (NARS), Forest Reserves (DLNR), and Department of Hawaiian Home Lands properties (DHHL) where CMS-related projects may occur.

Methods

Incidental reports are made through simple visual observation while conducting other activities within the Management Area. Incidental observation is a vital method for early detection, as simple awareness and active observation between field activities can allow for a much broader survey of the Management Area. These observations can be made by any Maunakea user, including CMS employees, researchers, on-mountain staff (Maunakea Rangers, Observatory staff, etc.), and neighboring landowners and managers (Maunakea Watershed Alliance, Natural Area Reserves, etc.). When an unusual or threat species is observed, the specimen (whole or part) is collected or photographed, if possible, for further identification and verification. Once verified, the incident is recorded and a report generated, if necessary. Vertebrate reports vary by vertebrate type (see below) and may entail follow-up procedures to remove the animal. Additionally, all evidence of scat is reported to CMS. If observed plant species are identified as non-native, all individuals are pulled. Detected non-native invertebrates require extensive study and planning if eradication or control tactics are necessary.

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. Maunakea users report sightings and observations of ungulate activity to CMS, and these are documented for further analysis and reported to NARS and DLNR.

Cats
Feral cats (*Felis catus*) are sparse at ~9,200 ft. and above but are occasionally observed. When cats are observed, they are reported and MKSS staff put out live traps that are checked daily for activity. Captured cats are documented and taken to the DLNR in Hilo.

Dogs
Feral dogs (*Canis familiaris*) are rarely observed, with no reports in recent years. Occasionally, hunting or pet dogs get lost or are abandoned. Feral dog sightings are reported to DOFAW, DHHL, and BIISC; abandoned and lost dogs are captured when possible, documented, and taken to the Hawai‘i Island Humane Society.

Rodents
Rodents found on Maunakea include mice and rats. There are three known established rodent species on UH managed lands: the black rat (*Rattus rattus*), and two mice (*Mus musculus* & *Mus domesticus*). Rats are not very common and are rarely 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, MKSS staff place baited snap traps or electronic traps around the inside of their facility. Traps are checked daily; carcasses are disposed of in the rubbish can and documented. All other incidental rodent observations and captures by Maunakea users are also documented.

Mongoose
Mongoose (*Herpestes auropuntatus*) are not common at higher elevations on Maunakea and are rarely observed on UH managed lands. When mongooses are observed, they are reported to DOFAW, DHHL, and BIISC.

Rabbits
Rabbits (*Lepus curpaeums*) are rarely reported, and the few reports received have been sightings on DHHL lands. When rabbits are observed, they are reported to DOFAW, DHHL, and BIISC.

Birds
See SOP B: Maunakea Vertebrate Threats Identification, Collection, and Processing Guide (Yogi & Kirkpatrick, 2016) for a list of bird species on UH managed lands. The occasional dead bird is not typically documented, though all dead native or banded birds are collected in a ziploc bag and reported to DOFAW. Large mortality events of non-native birds are reported to DOFAW.

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

Results and Discussion

Vertebrate Observations

During 2025, CMS received reports of every vertebrate type mentioned above except mongoose and rabbits. The most common sightings were of introduced game birds. Chukars (*Alectoris chukar*), California quail (*Callipepla californica*), and erkel‘s francolins (*Pternistis erckelii*) were observed frequently around Halepōhaku, often with chicks in summer months (June – August). Chukars were also seen along the road to the summit and around the Astronomy Precinct fairly often. In July a small group of pigeons were observed near the 2 mile marker of the access road. In April feral sheep (*Ovis aries*/*Ovis musimon*) were observed on top of Pu'uhaukea, possibly due to aerial eradication efforts. Feral pigs were also spotted a few times along the access road. In May, a coqui frog (*Eleutherodactylus coqui*) was captured at the VIS, representing a notable detection. Several sightings of ‘apapane (*Himatione sanguinea*) near and around Halepōhaku were reported in the fall of 2025, particularly in December, when high abundances were associated with māmane flowering at this elevation. ‘Apapane track nectar availability, often appearing in high numbers during peak bloom events. In December a lost hunting dog was captured at the VIS and returned to its owner. It should be noted that not every vertebrate incident is reported and therefore these results can only help in forming limited assumptions on the trends of vertebrates on Maunakea.

Invertebrate Observations

Though many invertebrates are observed on Maunakea throughout the year, only those seen less frequently or in unusual circumstances (i.e. large numbers, new elevations, etc.) are generally recorded in incidental reports and discussed here. Sightings reported from 2025 are listed in Table 7 below, in the order in which they were reported.

Table 7. Incidental invertebrate sightings in 2025.

Order	Family	*Scientific name*	Common name	Loc.	Threat
Hymenoptera	Apidae	*Apis mellifera*	European honey bee	VIS	Yes
Hymenoptera	Formicidae	*Cardiocondyla kagutsuchi*	Ant	HP	Yes
Hymenoptera	Vespidae	*Vespula pensylvanica*	Yellow jacket	HP	Yes
Hymenoptera	Formicidae	*Linepithema humile*	Argentine ant	DHHL	Yes

1. *Apis mellifera*

Several reports of honey bee (*Apis mellifera*) activity near the Visitor Information Station (VIS), and some cases of attacks, prompted hive trapping at Halepōhaku. For more details on honey bee management, please see section Honey Bee Control.

2. *Cardiocondyla kagutsuchi*

Ants (*Cardiocondyla kagutsuchi*) were occasionally captured in traps or observed at Halepohaku throughout the year. These cases are highlighted in the Facility Surveys, Annual Alien Invertebrate Monitoring, and Ant Control sections.

During a rapid response procedure for Argentine ants (*Linepithema humile*), *C. kagutsuchi* were observed along the Maunakea Access Road below HP. More information on this case can be found in the Rapid Response section.

3. *Vespula pensylvanica*

Vespula pensylvanica is a widely established species in the Hawaiian Islands. While there were multiple reports of yellow jackets throughout the year, there was only one case where control was necessary. More information on this case can be found in the Vespid Control section.

4. *Linepithema humile*

In early March, CMS NR staff observed ants on seeds collected along the Maunakea Access Road in the Department of Hawaiian Homelands (DHHL) management area. Specimens were sent to the Hawai‘i Ant Lab for identification and they were confirmed to be Argentine ants. CMS notified DLNR and DHHL, and initiated rapid response procedures. Please see the Rapid Response section for more information.

Vegetation Observations

In 2025, CMS had reported sightings of all invasive weeds commonly found in UH managed lands on Maunakea, including black-jack (*Bidens pilosa*), telegraph weed (*Heterotheca grandiflora*), hairy cat's ear (*Hypochaeris radicata*), evening primrose (*Oenothera stricta*), sheep's sorrel (*Rumex acetosella*), fireweed (*Senecio madagascariensis*), dandelion (*Taraxicum officinale*), and mullein (*Verbascum thapsus*). Of these, fireweed was by far the most frequently reported (1,233 individuals), likely because it is abundant, easily identified at various stages of maturity, and the subject of an organized focus for the Maunakea Rangers, who look for, pull, and report occurrences of the plant as part of their daily checks of the mountain. Mullein and hairy cat's ear were also commonly reported (22 and 21 individuals, respectively), though it should be noted that hairy cat's ear is easily confused with dandelion, and in some cases may have been misreported.

Fountain grass (*Cenchrus setaceum*) and gorse (*Ulex europaeus*) are of the greatest concern due to their highly invasive natures. These species dominate other areas of Maunakea, and steps were taken immediately by CMS staff to remove all individuals found. Gorse and fountain grass was found above the Puʻu Huluhulu junction along the Maunakea Access Road. Although this is not UH managed land, efforts were made by CMS staff to remove the individuals to avoid seeds being transported higher up by traffic on the road, a common vector for invasive species.

Eucalyptus (*Eucalyptus* spp.) and apple trees (*Malus* spp.) are known to exist in a few places on UH managed lands and along the Maunakea Access Road between the VIS and the Saddle Road. Neither is native, and efforts are made to cut back individuals on UH managed land to avoid flowering and spread. Individuals are revisited from time to time and re-trimmed, as trees tend to regrow, even from stumps. Other non-native plants on this list were reported only once or twice during the period and, whenever possible, steps were taken to remove those that might be likely to spread.

Native & Established Species Monitoring

Monitoring of native and established species is important for understanding population and ecosystem changes over time. Native and established species monitoring goals include status documentation of established native and non-native species and tracking of invasive threats

(species of threat to cultural and natural resources and/or to human health and safety) to help determine management effectiveness of both rapid response and control actions. This section includes monitoring results for wēkiu bugs, threat invertebrate and vegetation control, and rapid response cases.

Annual Wēkiu Bug Monitoring

Introduction

As part of the ongoing long-term study started by Hawaiʻi Biological Survey of the Bishop Museum, the CMS continues monitoring wēkiu bug (*Nysius wekiuicola*) populations, a species endemic to the Maunakea summit area of Hawai'i Island. The objectives for the 2025 field season were to continue to document wēkiu bug populations found within UH managed lands and neighboring lands (Natural Area Reserve [NAR]).

Study Area

Wēkiu bug surveys were done concurrently with Annual Alien Invertebrate Monitoring to reduce impacts to the environment. See the Early Detection Monitoring section above for alien species monitoring methods and results. Wēkiu bug monitoring occurs in the Alpine Stone Desert, which includes the Mauna Kea Science Reserve (MKSR) and the NAR. Monitoring begins at about 3,700 m and extends to the summit at 4,205 m, encompassing core wēkiu bug habitat. See Appendix E for survey locations, GPS coordinates, trap dates, and trap types associated with captured species. WGS 84 data was used for recording GPS locations and altitude.

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 and, 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 more easily identify specific areas of the vast summit region of Maunakea.

Methods

Trapping was conducted in wēkiu bug habitats with a focus on areas of potential alien invertebrate invasion. Sampling sites ranged from undisturbed habitat to human disturbed habitat types. Each trapping area had between 1 and 14 sites, and each site contained at least one wēkiu bug trap. Trapping areas (see Appendix E and Appendix F) were defined using Natural Resources Conservation Service (NRCS) soil survey data.

Baited pitfall traps were used to capture wēkiu bugs (see *Baited Pitfall Trap* methods in the Annual Alien Invertebrate Monitoring section above) and were retrieved within 3-4 days to prevent wēkiu bug mortality. All captured wēkiu bugs were recorded and released, while all other captured specimens (bycatch) were recorded and/or collected for further analysis. All invertebrate

specimens collected were identified to the lowest possible taxonomic unit necessary to determine if the species was a threat.

Results

A total of 977 wēkiu bugs were captured in 85 baited pitfall traps during nine 3-4 day trapping periods in 2025, however in all trap types we collected 1,130. Locations with the highest wēkiu bug abundances include Puʻuhauoki, Puʻuhaukea, and Poi Bowl. See Appendix G and Appendix H for wēkiu bug captures and rates per individual trap site. All captured arthropod specimens from baited pitfall traps are shown in the Early Detection Monitoring section above and the list of all arthropods captured during annual surveys are in Appendix I. Below, Table 8 displays wēkiu bug captures of all trap types (not including hand searches) by location. Column "Total Traps" refers to the number of trapping sites at each location. "Trap Days" refers to the combined number of days traps at a site were set out.

Table 8. Number of wēkiu bugs captured in 2025 by location and trapping information.

Location	Total Traps	Trap Days	Wēkiu Captures
Batch Plant	7	28	0
Poi Bowl	7	28	130
Puʻuhauʻoki	8	32	712
Puʻuhaukea	14	56	170
Puʻukea	2	8	90
Puʻupōhaku	6	24	1
Puʻupoliʻahu	7	28	0
Puʻuwēkiu	10	40	22
Puʻuwaiʻau	2	8	0
TMT Site	9	36	2
N VLBA	7	28	2
S VLBA	6	24	1
Totals	**85**	**340**	**1,130**

Below are two summary tables (Table 9 & 10) and graphs (Figure 11 & 12) displaying trends in wēkiu bug capture rates (bugs/trap per trap day) for Puʻuhaukea (within the Mauna Kea Ice Age Natural Area Reserve) from Bishop Museum related studies since 2001 and for the entire summit region since 2007 (when trap sites became consistent). Trapping data from 2001-2006 used a combination of glycol and shrimp baits unlike trapping efforts from 2007-2012, which only used shrimp paste. From 2013 to present, wēkiu bug traps have been baited with canned tuna.

Table 9. Puʻuhaukea wēkiu bug capture history from 2001 to 2025.

Year & Month of Trapping event	Total Wēkiu bugs[4]	Number of traps	Total Trap Days	Bugs/ trap day
2001 (June) (Polhemus 2001)	473	10	40	11.8
2002 (September)	9	16	48	0.2

[4] The total number of wēkiu bugs displayed in this table slightly differs from the summary tables in the *2013 Invasive Species & Native Arthropod Report* (Kirkpatrick & Klasner, 2013), and previous Bishop Reports (Preston et al., 2023). Bug numbers were corrected based on datasheet counts and Bishop Reports.

2004 (July)	0	10	90	0
2005 (May/June)	8/11	18/16	162/144	0.05/0.08
2006 (April/May)	0/44	10/10	90/80	0/0.6
2007 (June)	274	13	66	4.2
2008 (July)	43	10	60	0.7
2009 (July)	1	10	60	0.02
2010 (June)	244	10	60	4.1
2011 (June)	207	10	60	3.5
2012 (June/July)	720	10	60	12.0
2013 (June)	788	14	42	18.8
2014 (June)	9	14	56	0.16
2015 (June/July)	128	14	42	3.05
2016 (July)	105	14	42	2.5
2017 (June)	534	14	42	12.7
2018 (June)	1,464	14	42	34.9
2019 (June)	57	14	42	1.4
2020 (June)	44	14	42	1
2021 (June)	719	14	56	12.8
2022 (not sampled)	0	0	0	0
2023 (October)	21	14	56	0.4
2024 (July)	183	14	56	3.3
2025 (June)	170	14	56	3.04

Table 10. Wēkiu bug capture history at all trap locations from 2007 to 2025 in baited pitfall traps only.

Year of Trapping event	# Wēkiu Captured[6]	Number of traps	Total Trap Days	Bugs / trap day
2007	645	42	240	2.7
2008	70	30	130	0.5
2009	120	50	280	0.4
2010	2,982	50	300	9.9
2011	3,146	50	300	10.5
2012	2,536	50	300	8.5
2013	5,290	88	290	18.2
2014	52	88	292	0.2
2015	1,586	101	303	5.23
2016	190	78	234	0.8
2017	1,306	72	216	6.0
2018	3,500	85	255	13.7
2019	401	85	255	1.6
2020	459	85	255	1.8
2021	2,789	81	324	8.6
2022	2,464	58	232	10.2
2023	76	86	344	0.2
2024	3,212	85	340	9.4
2025	977	85	340	2.9

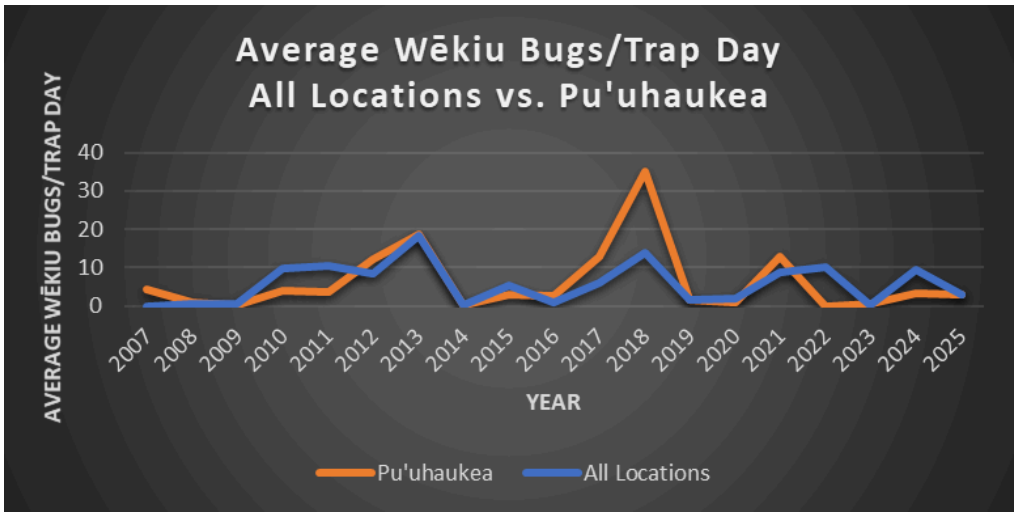

Figure 11. Trends in wēkiu bug capture rates (bugs/trap per trap day) for Pu‘uhaukea and all locations.

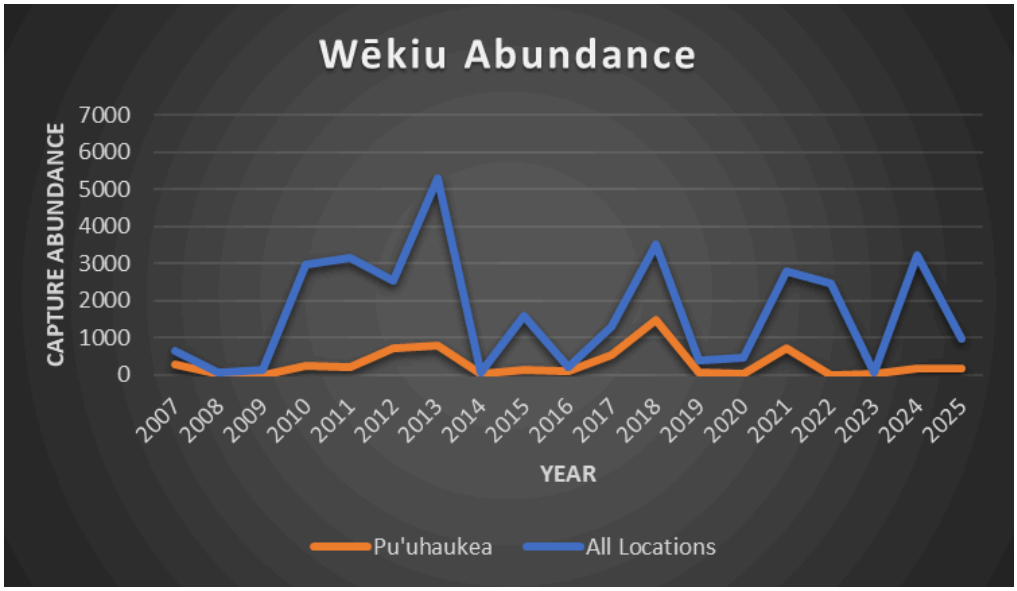

Figure 12. Trends in overall and Pu‘uhaukea wēkiu abundance by year.

Discussion

As can be seen in the charts above, wēkiu bug abundance varies widely from year to year. We hypothesize that wēkiu bug populations naturally fluctuate through time and are influenced by numerous biotic and abiotic (especially climatic) factors in their habitat. It is encouraging that all life stages are observed year after year, usually in relative proportion, indicating that the population continues to reproduce.

Rapid Response

Rapid response plans outline basic procedures to facilitate an efficient response to a new invasive species. While it would be impossible to anticipate every contingency, we can be prepared for new invasive species threats, and refer to established rapid response procedures. Rapid response procedures come into effect when a specimen is first identified as a threat and found on UH managed areas. The goal of a rapid response plan is to be able to quickly formulate the most effective control options (if any). This can be done by being properly prepared, identifying and understanding the invasive species, delimiting the invasions extent, generating a management plan by utilizing expert advice/literature, and organizing a reporting structure. When rapid response procedures are accomplished in a timely manner, control and eradication efforts are more effective, thereby reducing threats to cultural and natural resources. This section discusses the single case of rapid response for the year 2025.

Case 1: *Linepithema humile* (Formicidae)

In early March, CMS NR staff Leiana Kekoa-Lum observed ants on pilo (*Coprosma montana*) seeds collected along the Maunakea Access Road in the Department of Hawaiian Homelands (DHHL) management area. Specimens were sent to the Hawai‘i Ant Lab for identification and they were confirmed to be Argentine ants (*Linepithema humile*). CMS notified DLNR and DHHL, and initiated rapid response procedures. The CMS truck that was used to collect the seeds in that area was immediately sprayed with insecticide, visually inspected, and sent back down to Hilo. The area that the truck was parked at (upper HP parking lot and around the CMS greenhouse) was sprayed with insecticides (Talstar) and visually inspected to ensure the eradication of any hitchhiking ants.

With permission from DHHL, the CMS Resource Management team conducted Argentine ant delimiting surveys in the area where ants were detected. Rapid response protocols for this species followed the plan created by P. Heidenfeldt, J. Kirkpatrick, and A. Reedy in 2022. 156 vials baited with peanut butter, jelly, and SPAM (PBJS) were set out about every 10 m within a 100 m radius of where the ants were first detected. For the first survey day on April 7th, the focus was a 50 m radius with 57 baited vials and the remaining 99 were set out on April 9th. Vials were left out for 3-4 hours, then inspected for ants on-site before collection. Hand searches were conducted in the meantime. GPS points were created for all vials and hand search sites with ants (see Figure 13). Two additional Spam, PBJ baited sticky traps were set out near the initial detection site and left out for four days.

Figure 13. A map of the traps set out for the Argentine ant delimiting survey on DHHL land.

It was determined that Argentine ants are likely established throughout the 100 m radius survey site as about 22 of 156 baited vial locations observed Argentine ants, as well as multiple hand search sites. Some *Cardiocondyla kagutsuchi* individuals were also observed.

Figure 14. Argentine ants under a rock found during the Argentine ant delimiting survey on 4/7/2025.

Also of high concern, on April 8th, during one of the survey days, staff found hundreds of Argentine ants on the ground at the pull-off zone from the Mauna Kea Access Road that was used to access the survey site. The zone looked like a well-used parking zone as a hunter vehicle was parked there at the time. Due to this finding, an additional roadside delimiting survey was conducted. Sixteen sticky traps baited with PBJS were deployed along the Mauna Kea Access Road (from the initial detection site to HP, see Figure 15). The traps were retrieved on April 16th (5 days after they were set out) and processed.

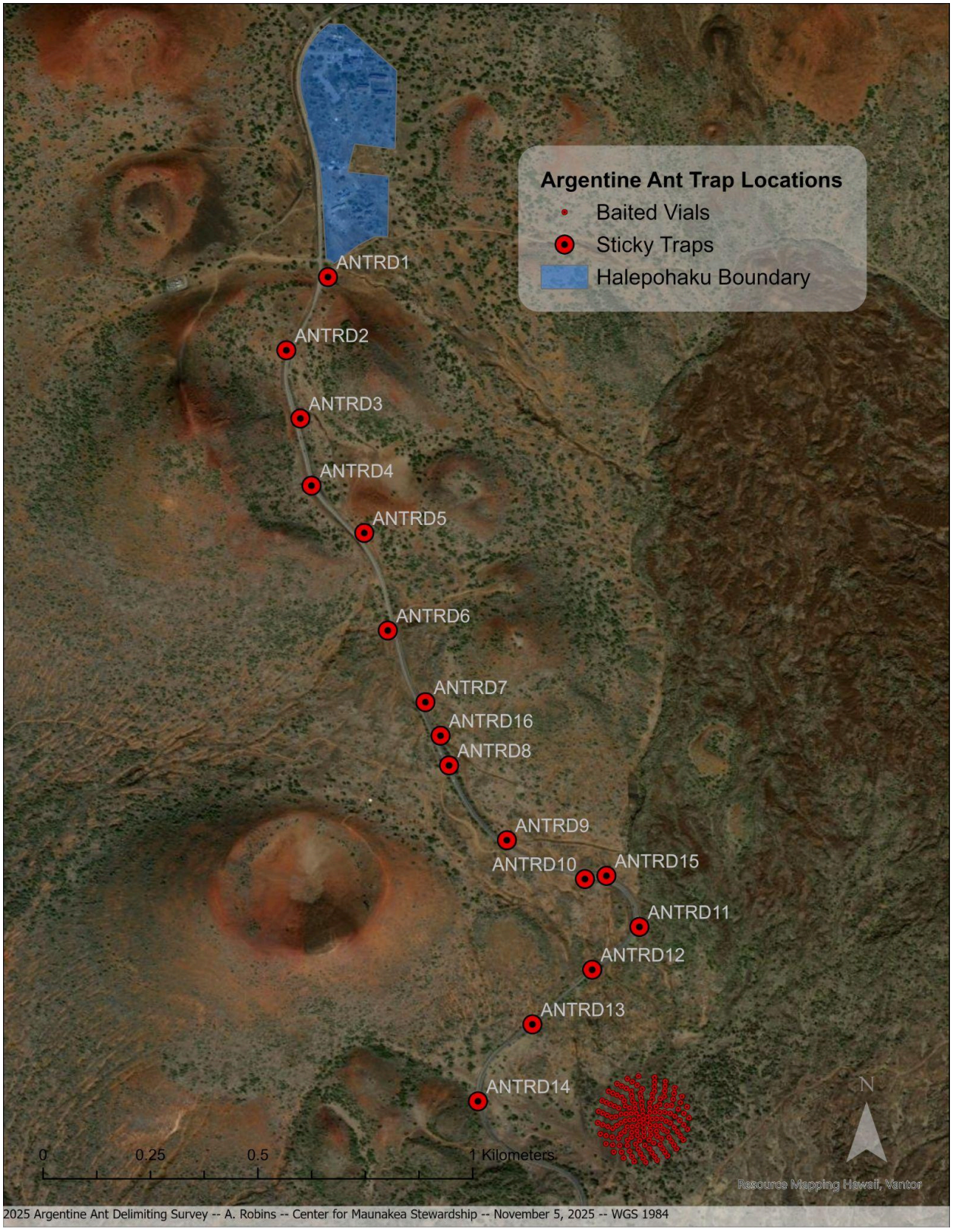

Figure 15. A map of the traps deployed along the Mauna Kea Access Road for the Argentine ant delimiting survey.

All sticky traps captured some kind of arthropod, and 7 of the 16 traps captured at least one ant. The ant species was identified to be *Cardiocondyla kagutsuchi*. A total of 46 *C. kagutsuchi* individuals were captured (at traps ANTRD07, 08, 09, 11, 12, 13, and 15). *Laemostenus complanatus* (Order: Coleoptera), a common invasive ground beetle, were also found in most of the traps. Only ants and threat beetles were recorded.

These results were relayed to DLNR and DHHL, and will help inform invasive species management strategies on Maunakea in the future.

Vespid Control

Introduction

Vespid (*Vespula pensylvanica*) control reduces threats to Maunakea's ecosystem, maintains public safety, and allows for a greater understanding of vespid population behavior. Vespid wasps undergo seasonal population increases in the summer and fall months. As this species poses a threat to both humans and native arthropods, steps were taken to try to control the population, which seem to be established in the HP area. Multiple observations of vespids at HP were reported throughout the year; however, it did not become a serious problem until the late summer. A large population of vespids were observed in the CMS greenhouse and prevented visitors from entering the area. This incident prompted vespid trapping to control the infestation.

Study Area

Monitoring efforts were focused around the CMS greenhouse.

Methods

In August, a wasp trap (W-H-Y®) was deployed above the CMS greenhouse water tank. The trap was deployed for about a month and then retrieved for processing.

Results and Discussion

Ten *Vespula pensylvanica* and four other arthropods (two *Apis mellifera*, one Calliphoridae sp., and one moth) were captured. Vespid populations in the greenhouse significantly decreased after this single trapping event. It is also important to note that a significant reduction in wasps and bees were observed in the greenhouse after the application of *MARATHON 1% Granular* insecticide in the potted plants to treat aphids. While vespid populations continue to decline during the winter season, they are expected to return next year. Vespid control will continue on a needed basis.

Honey Bee (*Apis mellifera*) Control

Introduction

European honey bees (*Apis mellifera*) are established on Maunakea. Monitoring honey bee 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. As they pose some danger to humans and compete with native *Hylaeus* bees for resources, efforts are made to control the population, though eradication is not considered a practical goal. Honey bees are not native to Hawai'i, but their ecological function as pollinators is essential to many plants that have lost their native pollinators. Honey bees on Maunakea are not directly controlled, but their population levels are regulated for public safety reasons. In 2025, there were several incidents where honey bees were disruptive to staff and visitors at Halepōhaku.

Study Area

The study site includes the VIS and Halepōhaku Utilities Building, Halepōhaku Dorm B and Dorm C.

Methods, Results, and Discussion

On February 12th, Visitor Information Station (VIS) staff reported honey bee (*Apis mellifera*) activity near the VIS trash cans and requested that we set out traps. Around that time, a CMS ranger was stung by a bee at HP. There were other cases of bee stings at HP throughout the year. Utilities staff also reported honey bee activity near their workshop space. CMS Resource Management staff set out six hive traps throughout HP with pheromones and traps provided by the United States Department of Agriculture. Traps were set in māmane trees at the following locations: the Utilities building drain, in between Dorm B and D, HP lower parking lot next to the stone cabins, right outside VIS Cabin 1, above the upper VIS parking lot (in the Bonner/Ranger Garden), and by the recycle bins at the VIS picnic area.

The traps were checked periodically and by February 25th, all traps but one had some bee activity. By March 6th, only the traps by the VIS recycle bins and the lower HP parking lot had bee activity, although it was very minimal (only 1-2 bees). On May 28th, hives were observed in two of the hive traps, located in the lower HP parking lot and in between the HP dorms. On June 4th, we partnered with a local beekeeper to remove the two established hives. The traps were replaced and stray bees were shortly observed at both sites.

In the late summer, a large increase in bee and yellow jacket activity was reported in the CMS greenhouse. There were so many that some visitors were too scared to enter. Hive traps were removed in November to prepare for the winter season. Hive traps will continue to be deployed after the winter season.

Vegetation Control

Introduction

Vegetation was removed around Halepōhaku and MKSR facilities through manual labor. Removing weeds reduces habitat for invasive arthropods (such as *Cardiocondyla kagutsuchi*), reduces the spread of invasive species on UH managed lands, and can help to detect new arthropods threats. We are investigating other control options such as herbicide application for long-term management and control.

Study Area

Vegetation control focused on human pathways and traffic areas. Sites included parking areas around Halepōhaku and the Visitor Information Station (VIS), areas along the Maunakea Access Road, and around the perimeter of facilities in the MKSR and Astronomy Precinct.

Methods

Vegetation control was achieved monthly through physical removal by volunteers, CMS staff, and Maunakea Rangers. Hand removal served two purposes; the removal of invasive vegetation (reduces seed spread & habitat for arthropod threats) and the detection of invasive arthropods associated with the roots of removed vegetation. The most effective way to observe ants is by simply pulling weeds because ants use invasive vegetation for habitat.

Volunteers were given vegetation removal instructions that included invasive plant identification, proper removal and disposal methods, and identification and reporting of ant detections if observed. CMS staff supervised volunteer activities. Hand tools such as hand trowels, picks, and weeders were used to remove vegetation and their roots. Removed vegetation was observed for ants, the excess dirt was shaken off, and vegetation was placed in trash bags and taken to the South Hilo Sanitary Landfill. When volunteers reported ants, the location was flagged, and documented for future survey locations and arthropod control (if applicable).

Additionally, Maunakea Rangers observe and remove invasive weeds in the MKSR and Astronomy precinct throughout each year. When invasive weeds are observed, the species, the number of individuals, and their locations are recorded and the weeds are removed. The rangers record invasive weed observations and removals in a ranger report that is sent daily to CMS staff. Staff then review, and document invasive species observations.

Results and Discussion

Invasive Weed Species Pulled by Volunteers

In 2025, the volunteer program engaged 615 volunteers, worked a total of 923 hours, and removed about 11,780 pounds of invasive weeds. CMS held twenty service-learning events with community organizations and volunteers. Most of the areas weeded were in the ʻĀhinahina Enclosure, in the HP restoration zones, and along the roadside between Halepohaku and the Visitor Information Station.

Table 11. List of the targeted invasive weeds (by family, genus, species, and common name) that were pulled on volunteer events in 2025.

Family	Genus & Species	Common Name
Asteraceae	*Heterotheca grandiflora*	Telegraph weed
Asteraceae	*Hypochaeris radicata*	Hairy cat's ear
Asteraceae	*Senecio madagascariensis*	Fireweed
Asteraceae	*Taraxacum officinale*	Common dandelion
Geraniaceae	*Erodium cicutarium*	Pin clover, Alfilaria
Onagraceae	*Oenothera stricta*	Chilean evening primrose
Poaceae	*Anthoxanthum odaoratum*	Sweet vernal grass
Poaceae	*Bromus catharticus*	Rescue grass
Poaceae	*Bromus diandrus*	Ripgut brome grass
Poaceae	*Holcus lanatus*	Yorkshire fog
Poaceae	*Nassella cernua*	Nodding needle grass
Poaceae	*Poa annua*	Annual bluegrass
Poaceae	*Poa pratensis*	Kentucky bluegrass
Poaceae	*Rytidosperma semiannulare*	Wallaby grass
Poaceae	*Vulpia bromoides*	Brome fescue
Polygonaceae	*Rumex acetosella*	Sheep sorrel
Scrophulariaceae	*Verbascum thapsus*	Common mullein
Scrophulariaceae	*Verbascum virgatum*	Wand mullein
Poaceae	*Cenchrus clandestinus*	Kikuyu grass

Conclusion

Volunteers and Maunakea Rangers serve as effective vegetation control and early detection agents on UH managed lands. These efforts are essential for long-term control of invasive species on Maunakea. After initial control efforts began the work became less intensive with a focus on lower elevations of the access road. Vegetation control along with occasional spot treatment for ants around Halepōhaku and VIS facilities have been effective. Invasive weed pulls reduce the risk of seed dispersal by Maunakea users and eliminate ant habitat for at least a few months until more weeds sprout up again. Continued vegetation control can allow for possible restoration of native plant species, a management goal for Halepōhaku.

Ant (Formicidae) Control

Introduction

Ant species are considered threats because they 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). The only established population of ants at HP are *Cardiocondyla kagutsuchi.* They were first detected at HP in 2013 and have been the subject of control since. In 2025, ants were observed at HP on multiple occasions prompting ant control procedures.

C. kagutsuchi were captured on multiple occasions during Facility Surveys at HP (i.e., at the bottom HP parking lot, at the VIS, at the Utilities building, and near/in the HP kitchen). Also, a single ant was captured in a kill pitfall trap near the upper VIS parking lot during Annual Alien Invertebrate Monitoring in August. Besides these surveys, ants were observed periodically in the restoration zones during routine weeding.

Study Area

Control efforts focused in the upper, lower, and gravel HP parking lots; the HP Commons building, the HP firehose corner near the kitchen, and the VIS parking lots.

Methods

Ants were typically observed in the roots of non-native vegetation (mainly fireweed and grasses) near HP and VIS parking lots. Ants tend to farm aphids and mealybugs that are found on the roots of invasive weeds. When ants were observed, we used *Talstar® Professional* insecticide, a liquid formulation with Bifenthrin as the active ingredient, as a barrier treatment control method. Insecticide dilution and application followed all label requirements. All applications were recorded in a detailed pesticide log and all applicators were pesticide certified by HDOA. Please see Appendix I for pesticide log and use records.

Results & Discussion

Monitoring and control for *Cardiocondyla kagutsuchi* (a common ant) continues.

Acknowledgements

We thank our Natural Resource Program predecessors (F. Klasner, J. Kirkpatrick, A. Reedy, D. Yogi, and J. Eiben) for building the framework for the work conducted in this report. 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 their research, making the monitoring surveys much easier for us. We thank J. Matsunaga for collecting the permits necessary for this work. Mahalo to biological inspectors D. Yogi, J. Parker, K. Young, and CMS staff for conducting vehicle inspections. Mahalo to the Pacific Consulting Services, Inc. (PCSI) for monitoring cultural sites on Maunakea and accompanying CMS staff on Rotating Panel surveys. We also thank C. Vanderwoude and S. Kaye for their efforts towards writing and executing the Maunakea Invasive Species Management Plan. A big, big mahalo to the many groups and community members that participated in CMS volunteer events and helped to clear invasive species at HP. Lastly, mahalo to the Maunakea Rangers for keeping us safe and joining in our efforts to protect the natural resources of Maunakea. Mahalo nui!

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APPENDICES

Appendix A: UH Management Areas on Maunakea

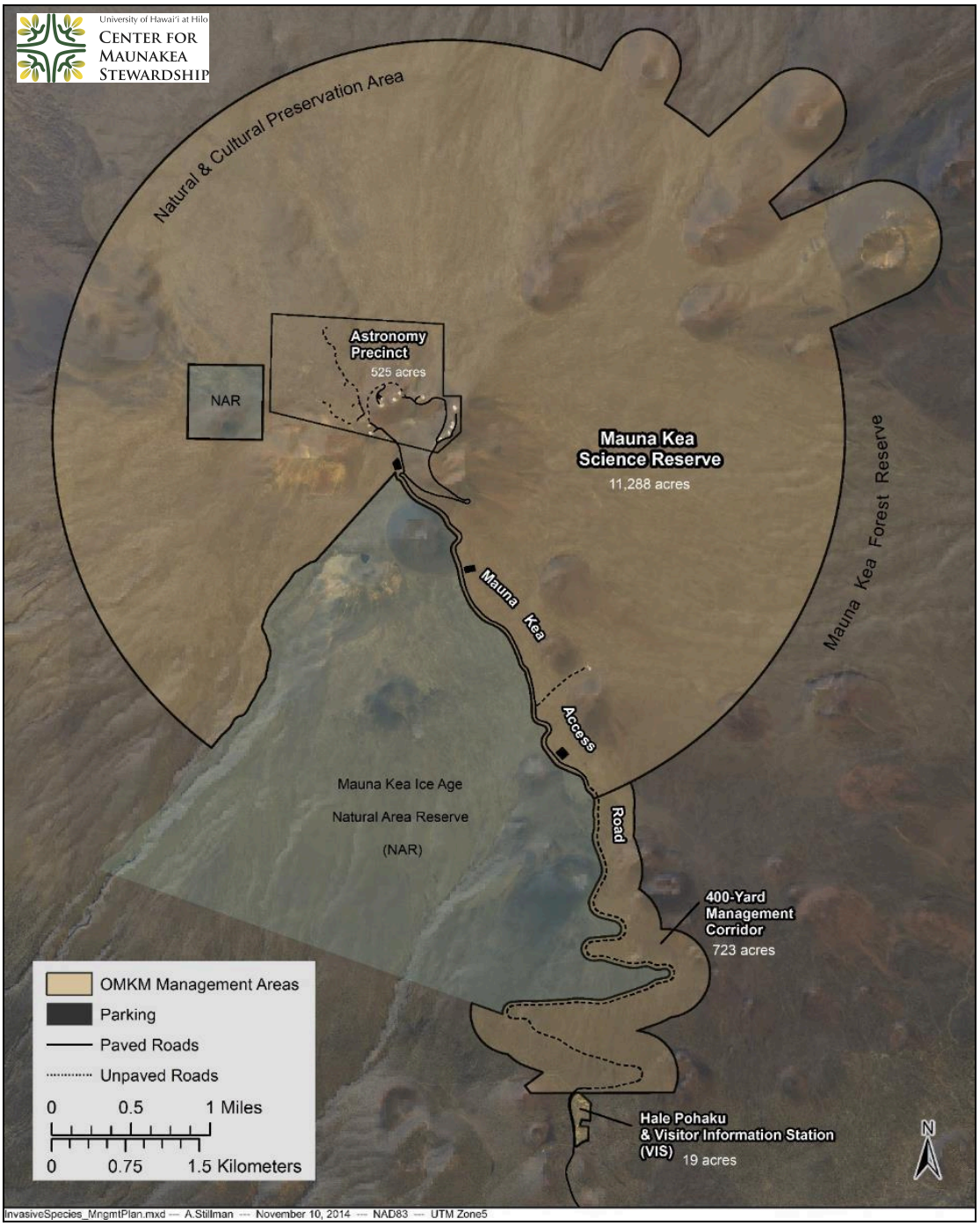

Figure A1. Map of the UH management areas on Maunakea, HI.

Appendix B: Facility Survey Arthropod Capture List

All arthropods captured during the 2025 Facility Survey are listed alphabetically by taxa. Confirmed potential threat species are **bolded**. For a few entries, the assigned morphospecies name is listed instead of the common name. Nativity[5] is either non-native, native, or unknown. Notable non-arthropod captures are included at the end of the table.

Table A1. List of all captured/observed species during the 2025 Facility Surveys.

Order	Scientific Name	Common/Morphospecies Name	Nativity
Acari	Anystidae sp.	Whirligig mite	Unknown
Acari	Bdellidae sp.	Snout mite	Unknown
Acari	Unknown	Acari_Big dark brown mite	Unknown
Acari	Unknown	Acari_Tiny round red mite	Unknown
Acari	Unknown	Mite	Unknown
Araneae	*Hogna hawaiiensis*	Hawaiian wolf spider	Native
Araneae	***Meriola arcifera***	**Ant-mimic spider**	**Non-native**
Araneae	Salticidae spp.	Jumping spider	Non-native
Araneae	***Tenuiphantes tenuis***	**Sheetweb spider**	**Non-native**
Araneae	Unknown	Spider	Unknown
Blattodea	***Blattella germanica***	**German cockroach**	**Non-native**
Coleoptera	Coccinellidae spp.	Lady beetle	Non-native
Coleoptera	Cryptophagidae sp.	Silken fungus beetle	Unknown
Coleoptera	Curculionidae sp.	Weevil	Unknown
Coleoptera	*Hippodamia convergens*	Convergent lady beetle	Non-native
Coleoptera	***Laemostenus complanatus***	**Cosmopolitan ground beetle**	**Non-native**
Coleoptera	Latridiidae sp.	Minute brown scavenger beetle	Unknown
Coleoptera	*Naupactus cervinus*	Fuller rose beetle	Non-native
Coleoptera	***Necrobia rufipes***	**Red-legged ham beetle**	**Non-native**
Coleoptera	Unknown	Beetle	Unknown
Collembola	Unknown	Collembola_Purple short	Unknown
Collembola	Unknown	Springtail	Unknown
Dermaptera	*Forficula auricularia*	European earwig	Non-native
Diptera	Agromyzidae spp.	Leafminer fly	Non-native
Diptera	*Bradysia nitidicollis*	Dark-winged fungus gnat	Non-native
Diptera	*Calliphora latifrons*	Blue bottle fly	Non-native
Diptera	Calliphoridae spp.	Blow fly	Unknown
Diptera	*Delia platura*	Seedcorn maggot fly	Non-native
Diptera	Drosophilidae spp.	Vinegar fly	Unknown
Diptera	*Haematobia irritans*	Horn fly	Non-native
Diptera	*Hydrellia tritici*	Black pasture fly	Non-native
Diptera	*Lucilia cuprina*	Australian sheep blow fly	Non-native
Diptera	*Minilimosina fungicola*	Lesser dung fly	Non-native
Diptera	Muscidae spp.	Muscid fly	Unknown
Diptera	Mycetophilidae sp.	Fungus gnat	Unknown
Diptera	Phoridae spp.	Scuttle fly	Unknown
Diptera	*Phormia regina*	Black blow fly	Non-native
Diptera	Psychodidae sp.	Moth fly	Unknown
Diptera	*Ravinia anxia*	Flesh fly	Non-native

[5] Nativity was determined using various resources such as the Insects of Hawai‘i series (The University of Hawai‘i Press, Honolulu), the Hawaiian Terrestrial Arthropod Checklist (Nishida 2002), and the revised checklist (Matsunaga et al. 2019).

Diptera	Sciaridae spp.	Dark-winged fungus gnat	Unknown
Diptera	Sepsidae spp.	Black scavenger fly	Non-native
Diptera	*Sepsis* sp.	Black scavenger fly	Non-native
Diptera	Syrphidae sp.	Hover fly	Non-native
Diptera	Unknown	Fly	Unknown
Entomobryomorpha	Entomobryidae spp.	Slender springtail	Unknown
Hemiptera	*Acizzia uncatoides*	Acacia psyllid	Non-native
Hemiptera	Aphididae spp.	Aphid	Non-native
Hemiptera	*Coridromius variegatus*	Plant bug	Non-native
Hemiptera	Lygaeidae sp.	Seed bug	Unknown
Hemiptera	*Neacoryphus bicrucis*	White-crossed seed bug	Non-native
Hemiptera	*Nysius palor*	Seed bug	Non-native
Hemiptera	*Nysius terrestris*	Seed bug	Native
Hemiptera	*Nysius wekiuicola*	Wēkiu bug	Native
Hemiptera	*Orthotylus sophoricola*	Plant bug	Native
Hemiptera	Unknown	True bug	Unknown
Hymenoptera	Braconidae spp.	Braconid wasp	Unknown
Hymenoptera	***Cardiocondyla kagutsuchi***	**Ant**	**Non-native**
Hymenoptera	***Hyposoter exiguae***	**Ichneumonid wasp**	**Non-native**
Hymenoptera	Ichneumonidae spp.	Ichneumonid wasp	Unknown
Hymenoptera	*Mesopolobus incultus*	Pteromalid wasp	Non-native
Hymenoptera	*Monoctonus paulensis*	Braconid wasp	Non-native
Hymenoptera	Unknown	Wasp	Unknown
Hymenoptera	***Vespula pensylvanica***	**Western yellowjacket**	**Non-native**
Lepidoptera	Unknown	Moth	Unknown
Myriapoda	Lithobiidae sp.	Stone centipede	Unknown
Poduromorpha	Hypogastruridae sp.	Springtail	Unknown
Psocodea	*Lepinotus patruelis*	Booklice	Non-native
Psocodea	Liposcelididae sp.	Booklice	Unknown
Psocodea	Unknown	Barklice	Unknown
Psocodea	Unknown	Psocodea_Clear wings	Unknown
Psocodea	Unknown	Psocodea_Dark bulbous eyes	Unknown
Siphonaptera	Unknown	Flea	Non-native
Thysanoptera	Thripidae sp.	Thrip	Unknown
Thysanoptera	Unknown	Thrip	Unknown
Thysanoptera	Unknown	Thysanoptera_Dark abdomen	Unknown
Thysanoptera	Unknown	Thysanoptera_Yellow band	Unknown
Non-arthropod taxa			
Muridae	***Mus musculus***	**Mouse**	**Non-native**

References

Matsunaga, J. N., Howarth, F. G., & Kumashiro, B. R. (2019). New state records and additions to the alien terrestrial arthropod fauna in the Hawaiian Islands. *Proceedings of the Hawaiian Entomological Society*, 51, 1-71.

Nishida, G. M. (2002). Hawaiian terrestrial arthropod checklist 4th ed. *Honolulu, Hawai'i: Hawai'i Biological Survey (Bishop Museum) Technical Report, 22.*

Appendix C: Map of the Rotating Panel Surveys Sites

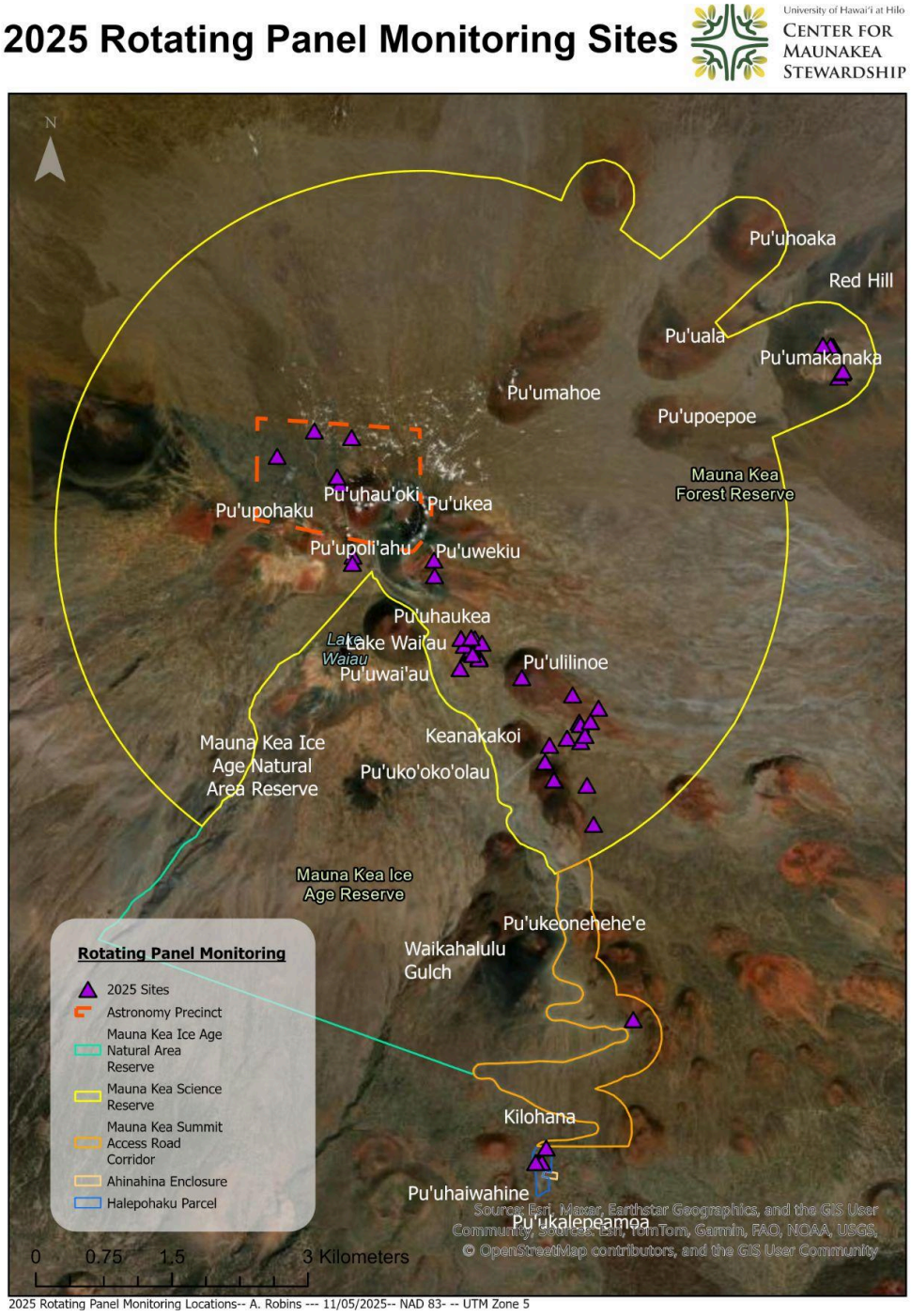

Figure A2. 2025 Rotating Panel monitoring locations.

Appendix D: Rotating Panel Surveys Arthropod Capture List

All arthropods captured during the 2025 Rotating Panel survey are listed alphabetically by taxa.

Table A2. Rotating panel surveys arthropod capture list.

Order	Family	Scientific Name	Common Name	Nativity
Acari	Unknown	Unknown	Mite	Unknown
Araneae	Linyphiidae	Unknown	Sheetweb spider	Unknown
Araneae	Lycosidae	Hogna hawaiiensis	Hawaiian wolf spider	Native
Araneae	Unknown	Unknown	Spider	Unknown
Coleoptera	Coccinellidae	Coccinella septempunctata	Seven-spot lady beetle	Non-native
Coleoptera	Coccinellidae	Hippodamia convergens	Convergent lady beetle	Non-native
Collembola	Entomobryidae	Unknown	Slender springtail	Unknown
Collembola	Unknown	Unknown	Springtail	Unknown
Diptera	Calliphoridae	Unknown	Blow fly	Unknown
Diptera	Syrphidae	Eristalis tenax	Drone fly	Non-native
Diptera	Unknown	Unknown	Fly	Unknown
Hemiptera	Lygaeidae	Neacoryphus bicrucis	White-crossed seed bug	Non-native
Hemiptera	Lygaeidae	Nysius palor	Seed bug	Non-native
Hemiptera	Lygaeidae	Nysius terrestris	Seed bug	Native
Hemiptera	Psyllidae	Unknown	Jumping plant lice	Unknown
Hymenoptera	Apidae	Apis mellifera	European honey bee	Non-native
Hymenoptera	Crabronidae	Unknown	Square-headed wasp	Unknown
Lepidoptera	Lycaenidae	Lampides boeticus	Pea blue butterfly	Non-native
Lepidoptera	Lycaenidae	Udara blackburni	Koa butterfly	Native
Lepidoptera	Noctuidae	Mythimna unipuncta	Armyworm moth	Non-native
Lepidoptera	Pieridae	Pieris rapae	White cabbage butterfly	Non-native
Lepidoptera	Unknown	Unknown	Moth	Unknown

References

Matsunaga, J. N., Howarth, F. G., & Kumashiro, B. R. (2019). New state records and additions to the alien terrestrial arthropod fauna in the Hawaiian Islands. *Proceedings of the Hawaiian Entomological Society*, 51, 1-71.

Nishida, G. M. (2002). Hawaiian terrestrial arthropod checklist 4th ed. *Honolulu, Hawaii: Hawaii Biological Survey (Bishop Museum) Technical Report, 22.*

Appendix E: 2025 Annual Survey Location Maps

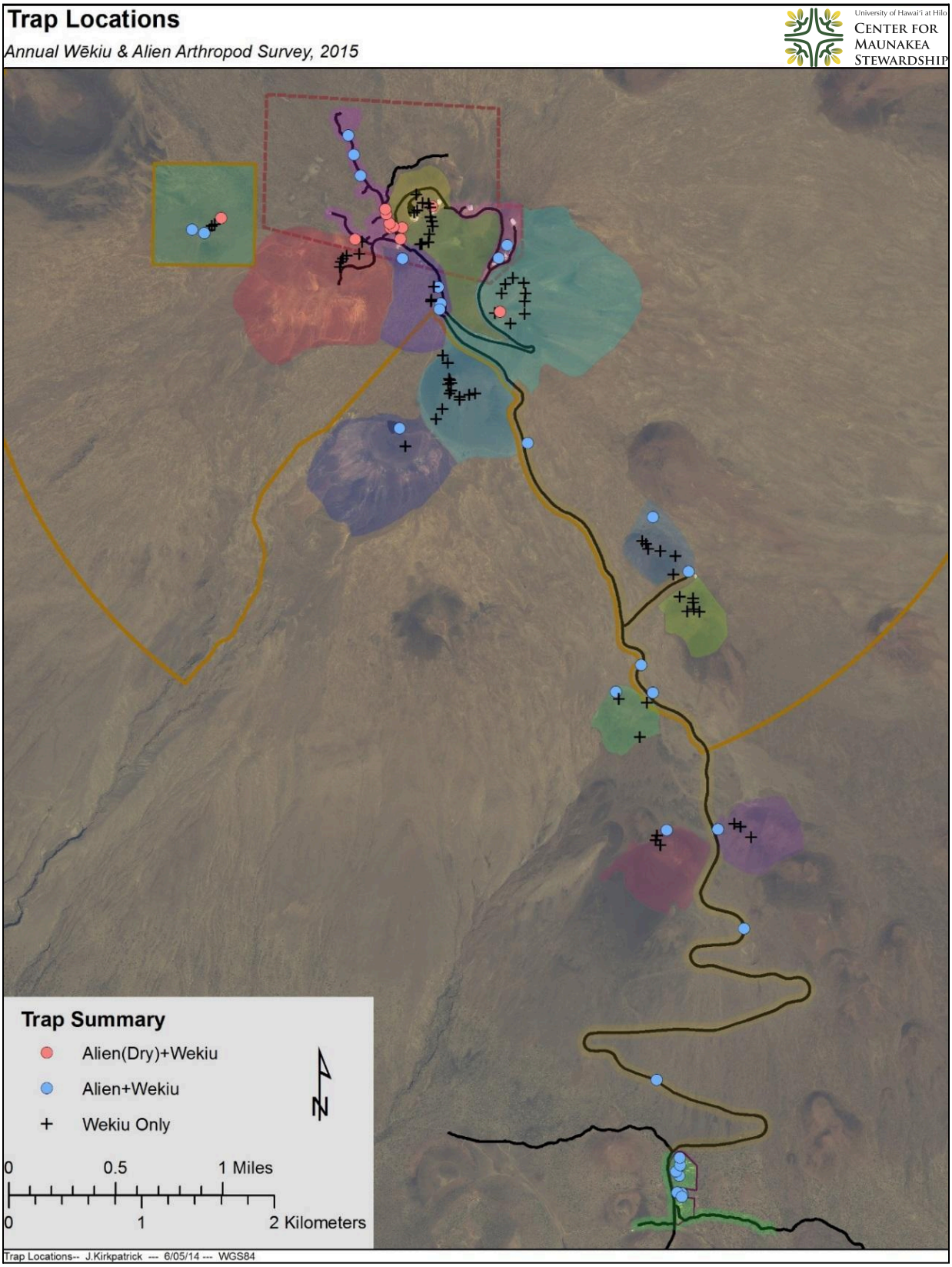

Figure A3. Annual Alien Invertebrate Monitoring survey locations.

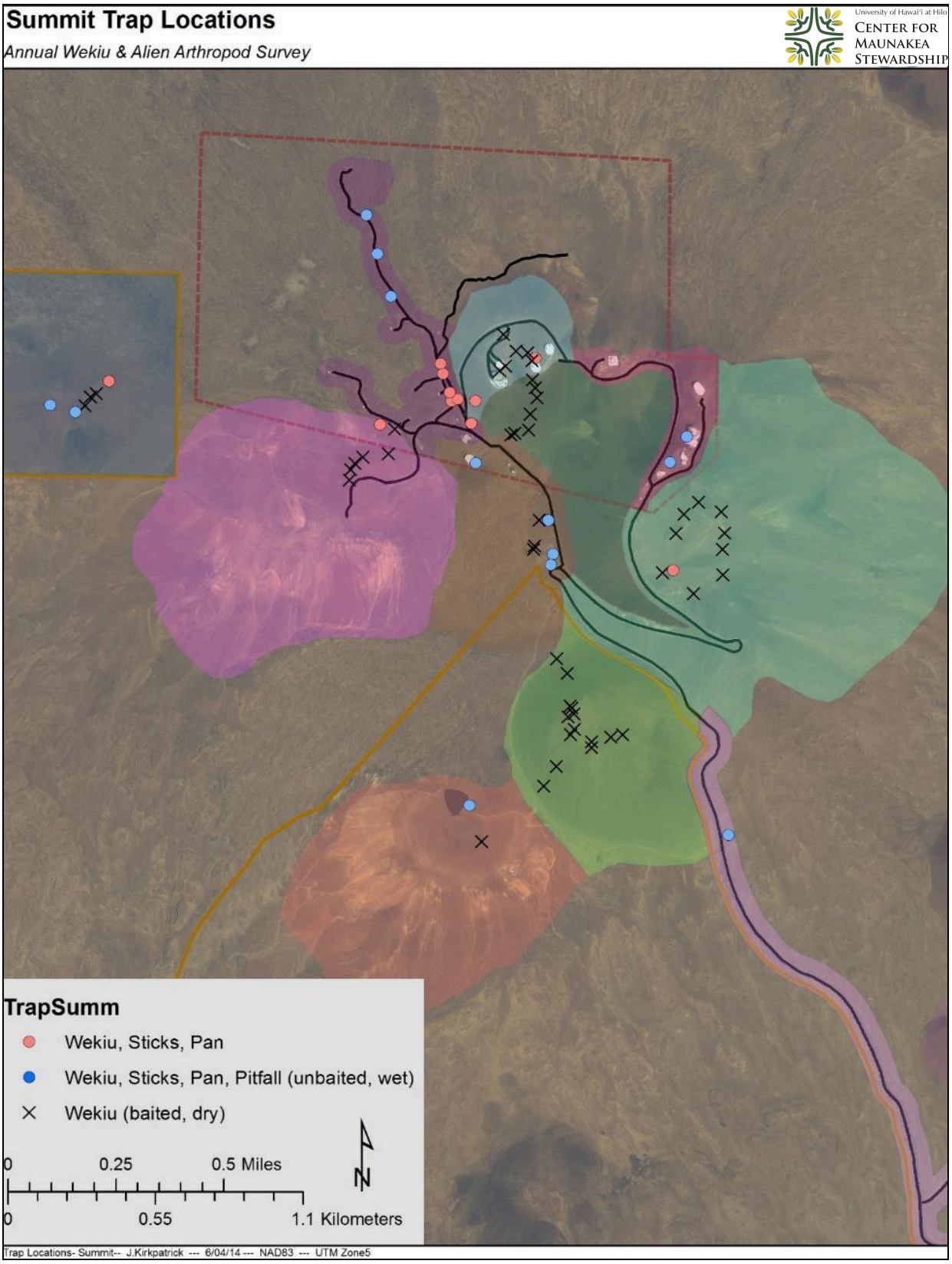

Figure A4. Annual Alien Invertebrate Monitoring survey locations at the Summit area.

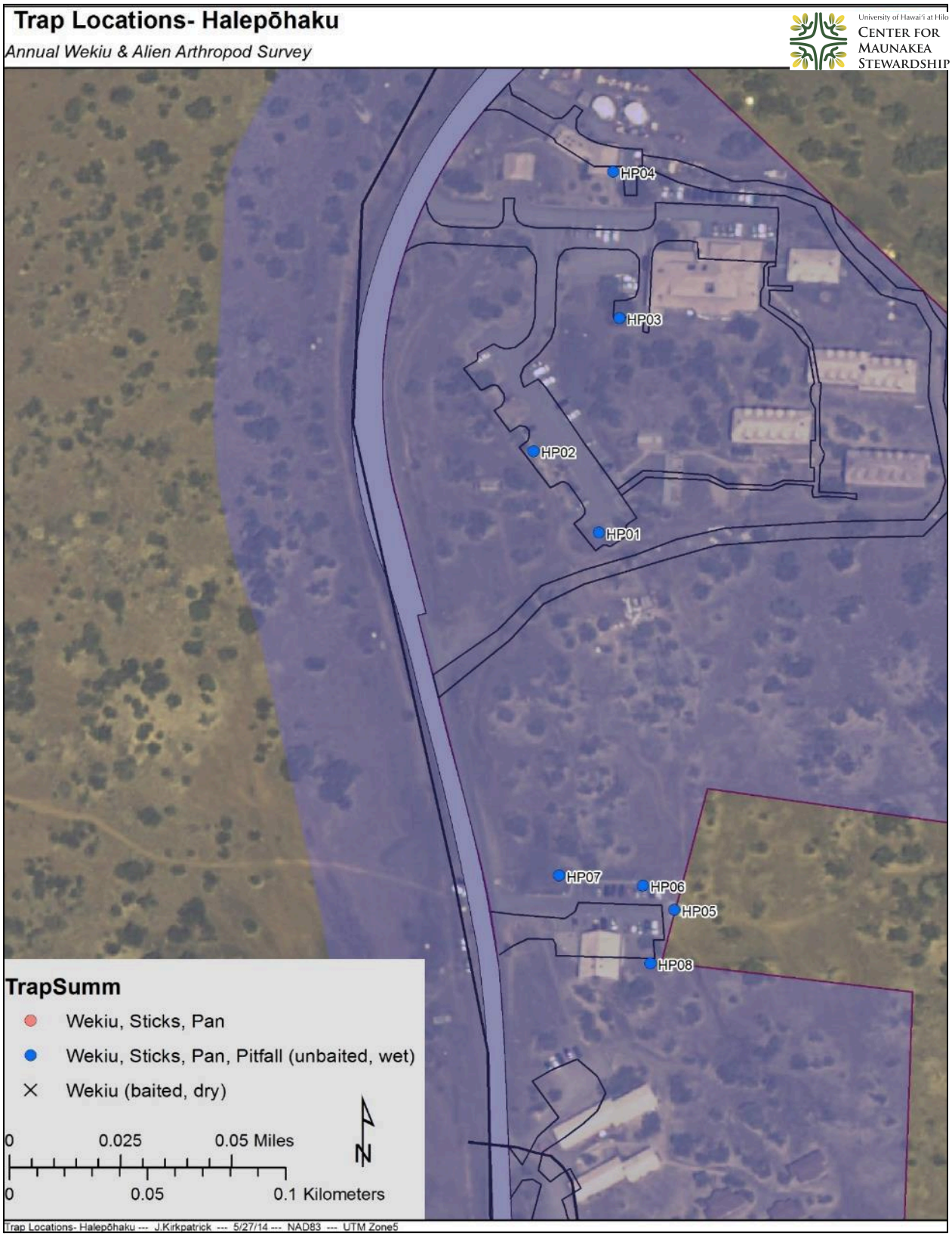

Figure A5. Annual Alien Invertebrate Monitoring survey locations at Halepōhaku.

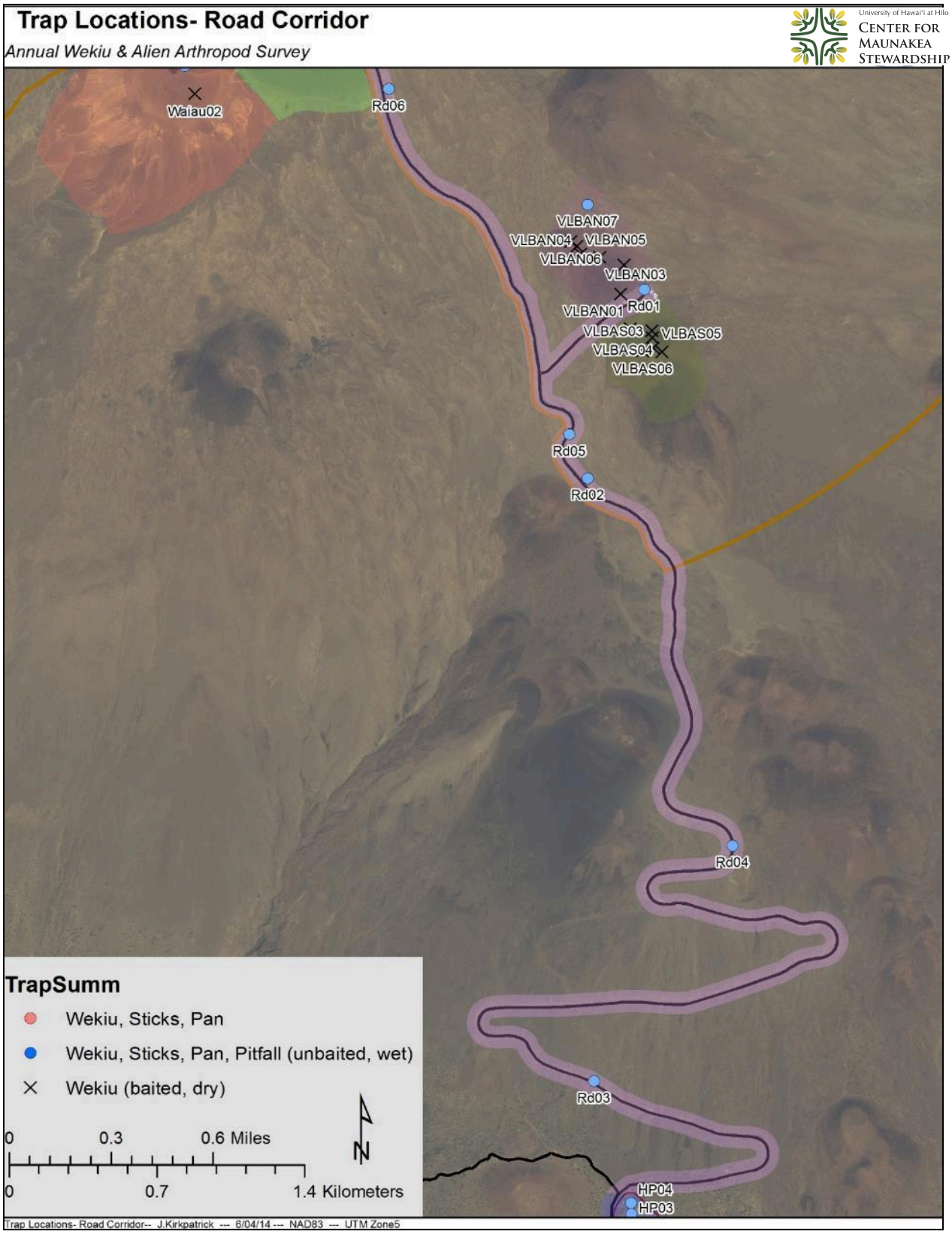

Figure A6. Annual Alien Invertebrate Monitoring survey locations on the Road Corridor.

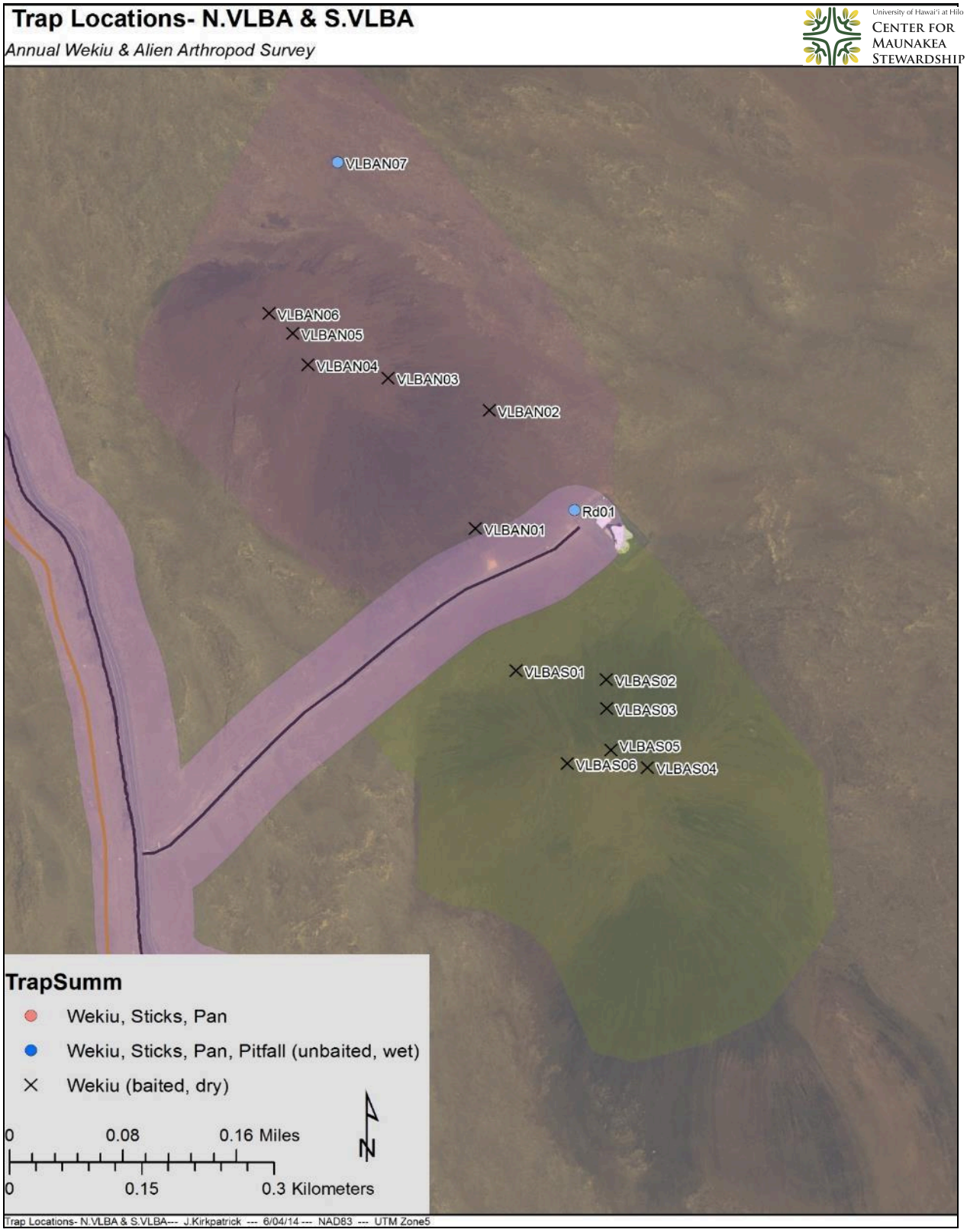

Figure A7. Annual Alien Invertebrate Monitoring survey locations on North and South VLBA.

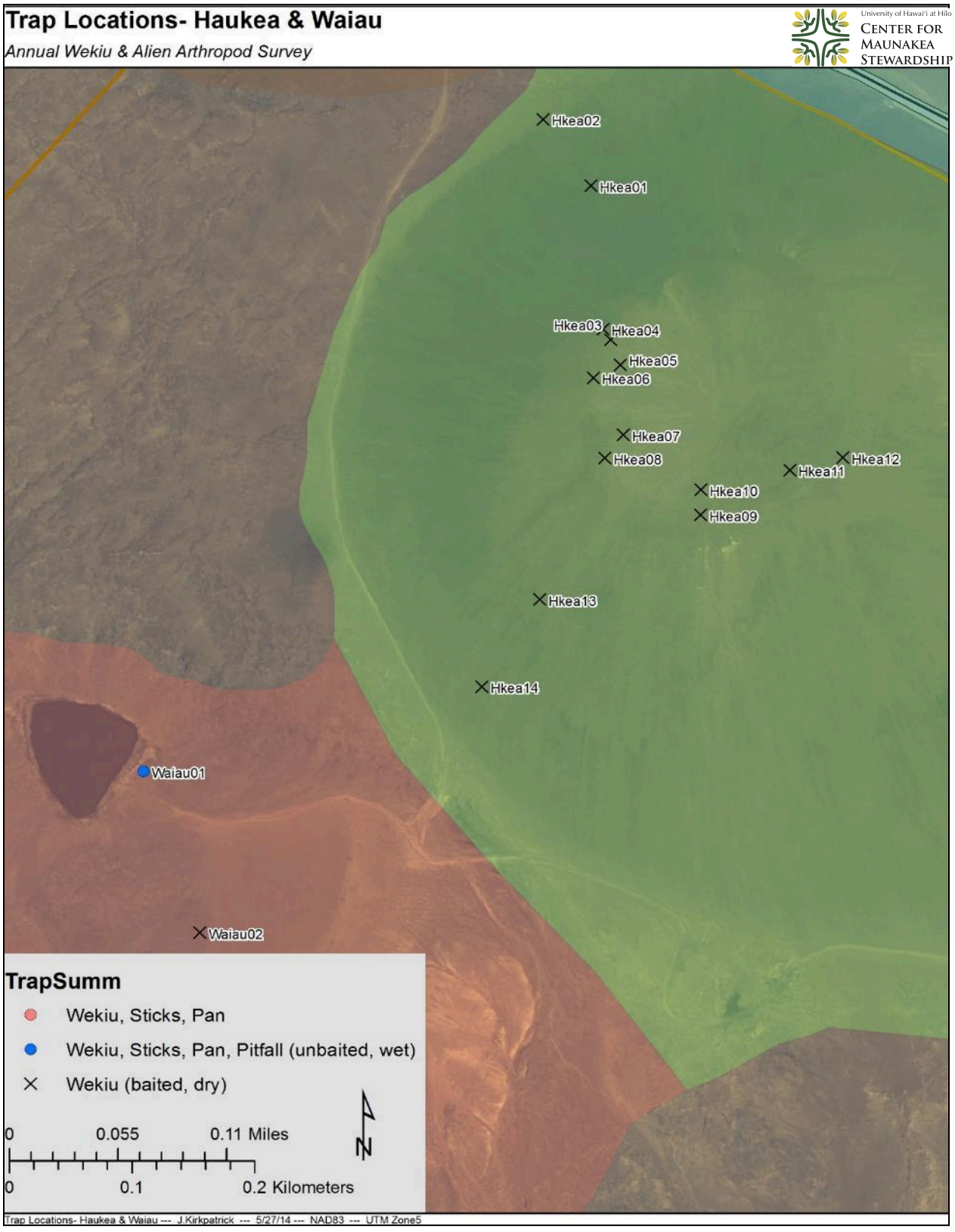

Figure A8. Annual Alien Invertebrate Monitoring survey locations on Pu‘uhaukea and Pu‘uwaiau.

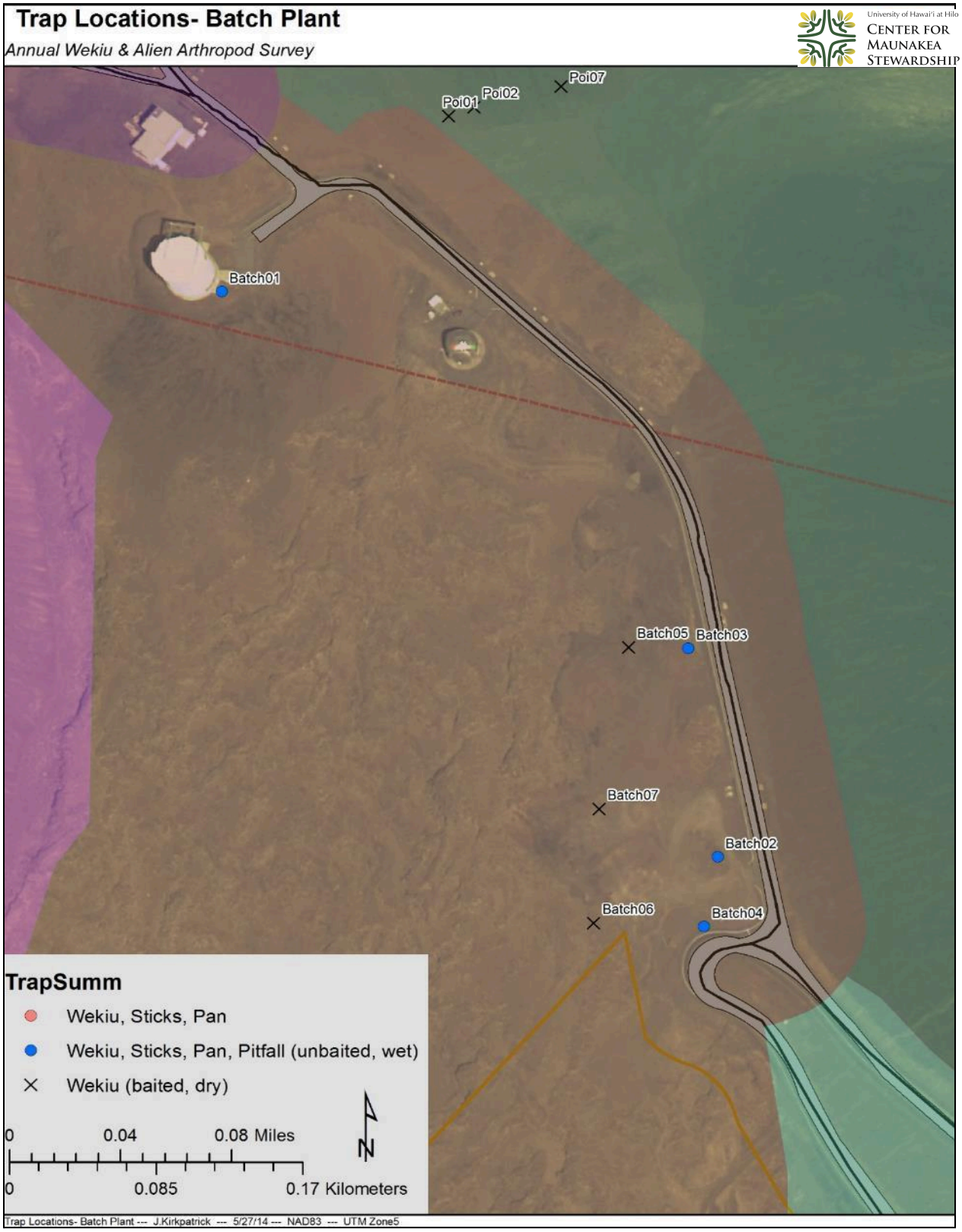

Figure A9. Annual Alien Invertebrate Monitoring survey locations at Batch Plant.

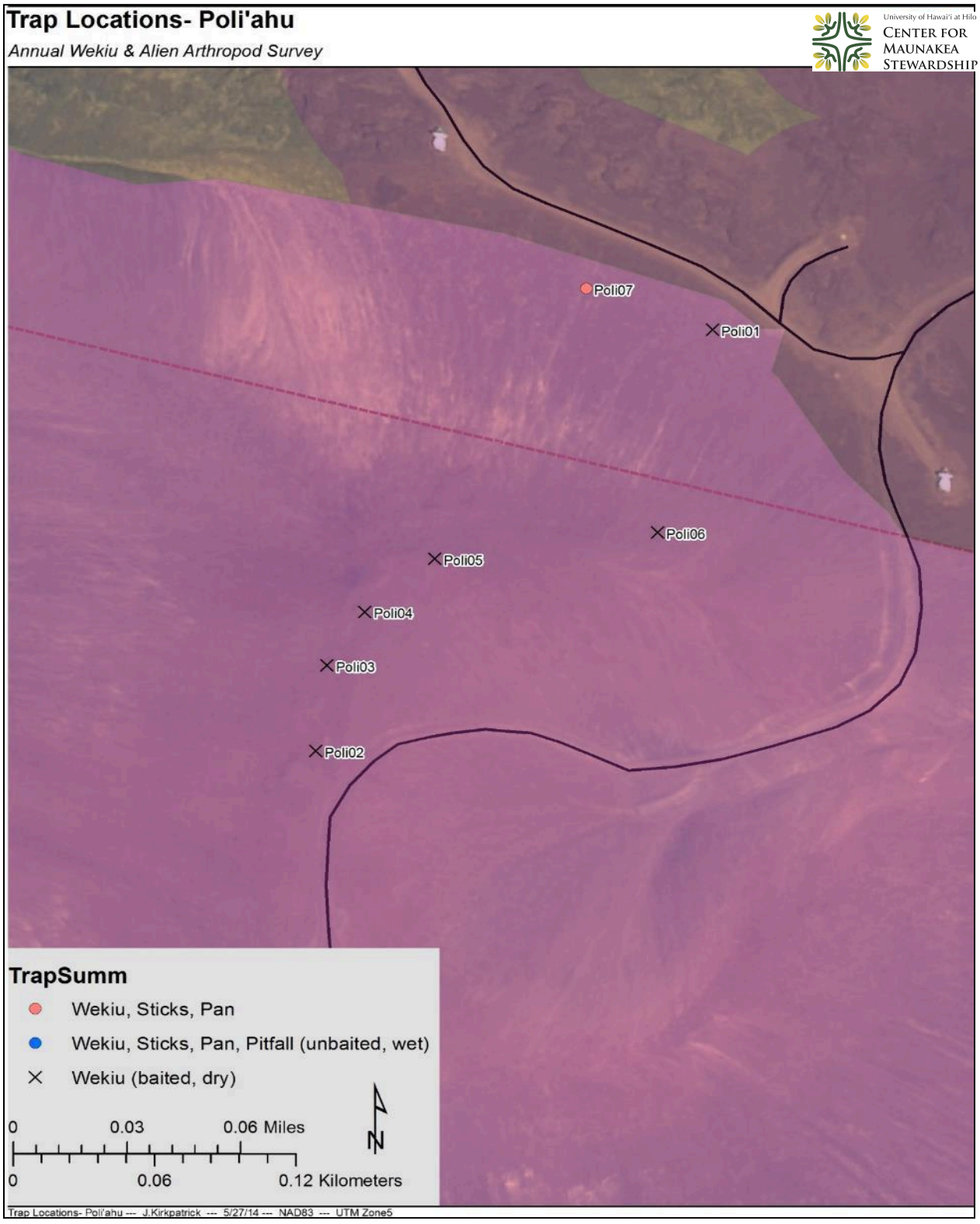

Figure A10. Annual Alien Invertebrate Monitoring survey locations at Pu‘upoliahu.

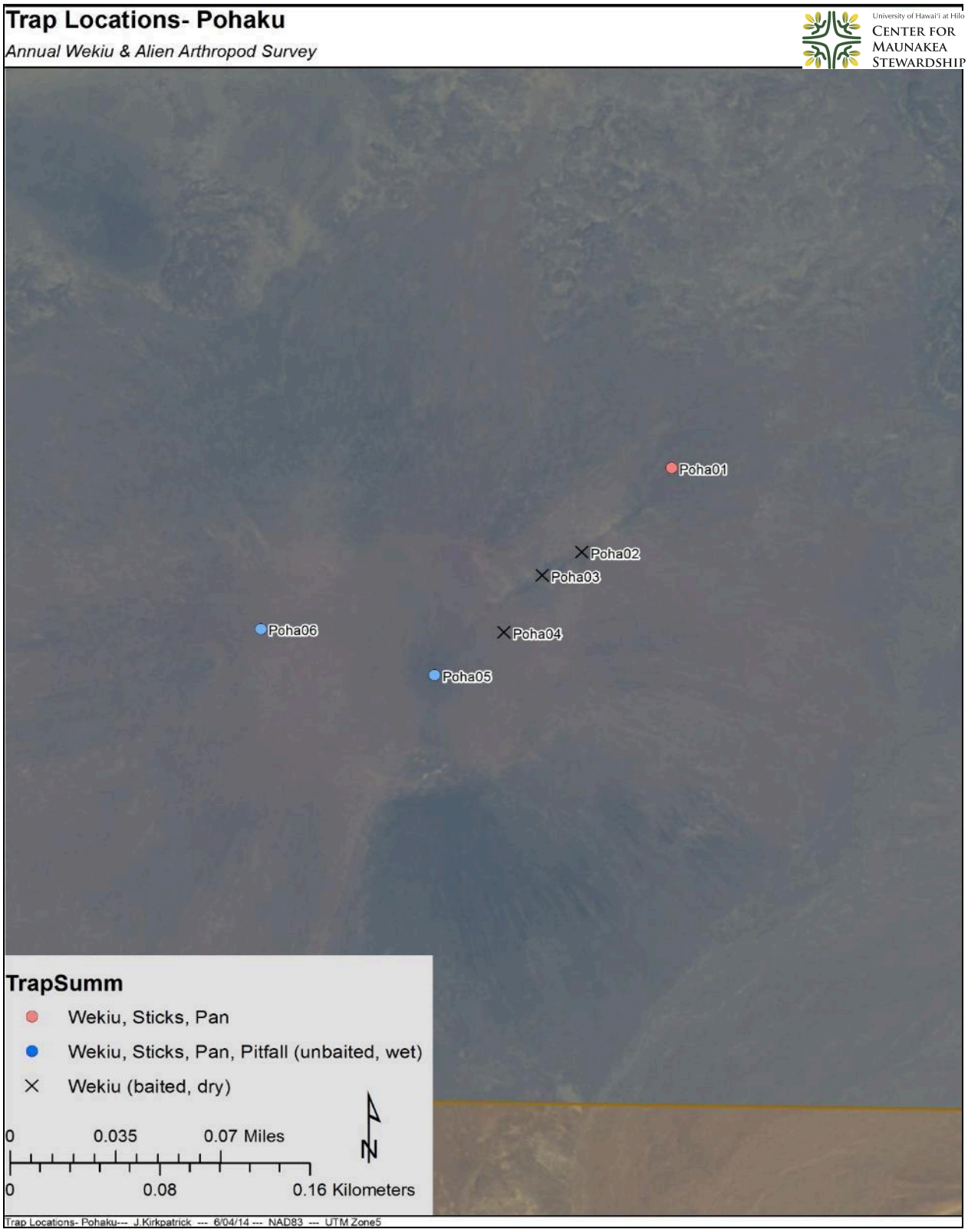

Figure A11. Annual Alien Invertebrate Monitoring survey locations at Puʻupōhaku.

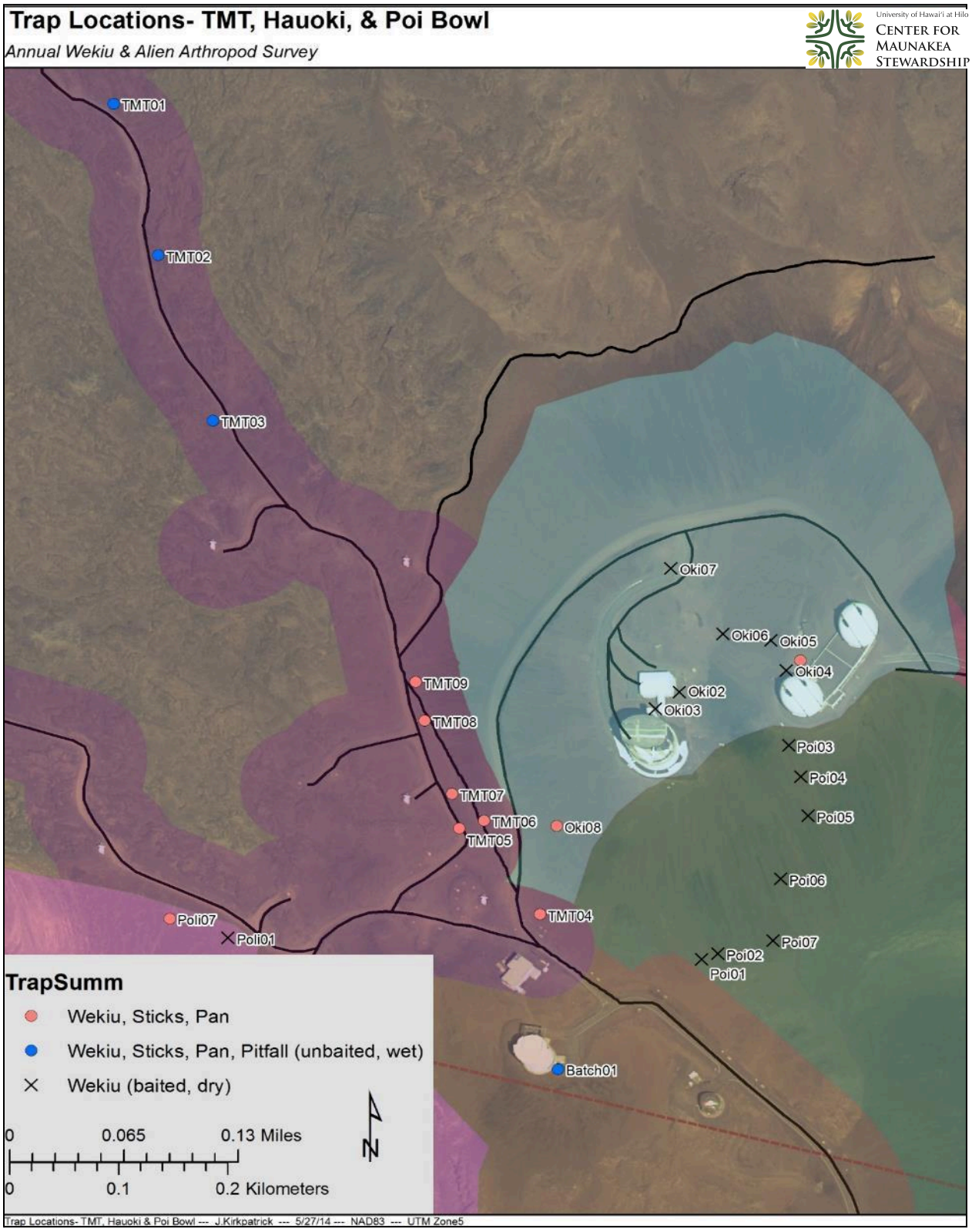

Figure A12. Annual Alien Invertebrate Monitoring survey locations at TMT, Pu‘uhau‘oki, and Poi Bowl.

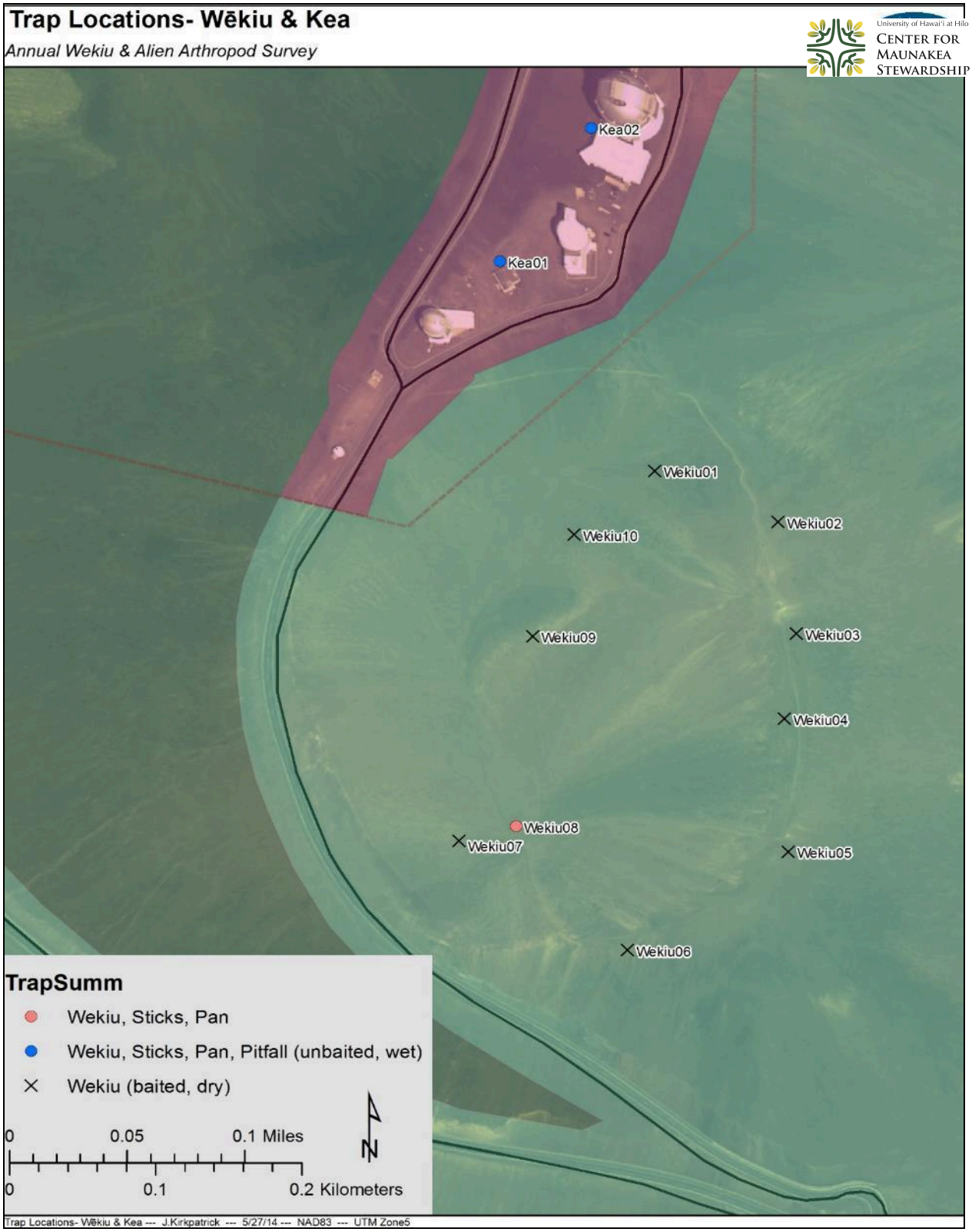

Figure A13. Annual Alien Invertebrate Monitoring survey locations at Pu'uwēkiu and Pu'ukea.

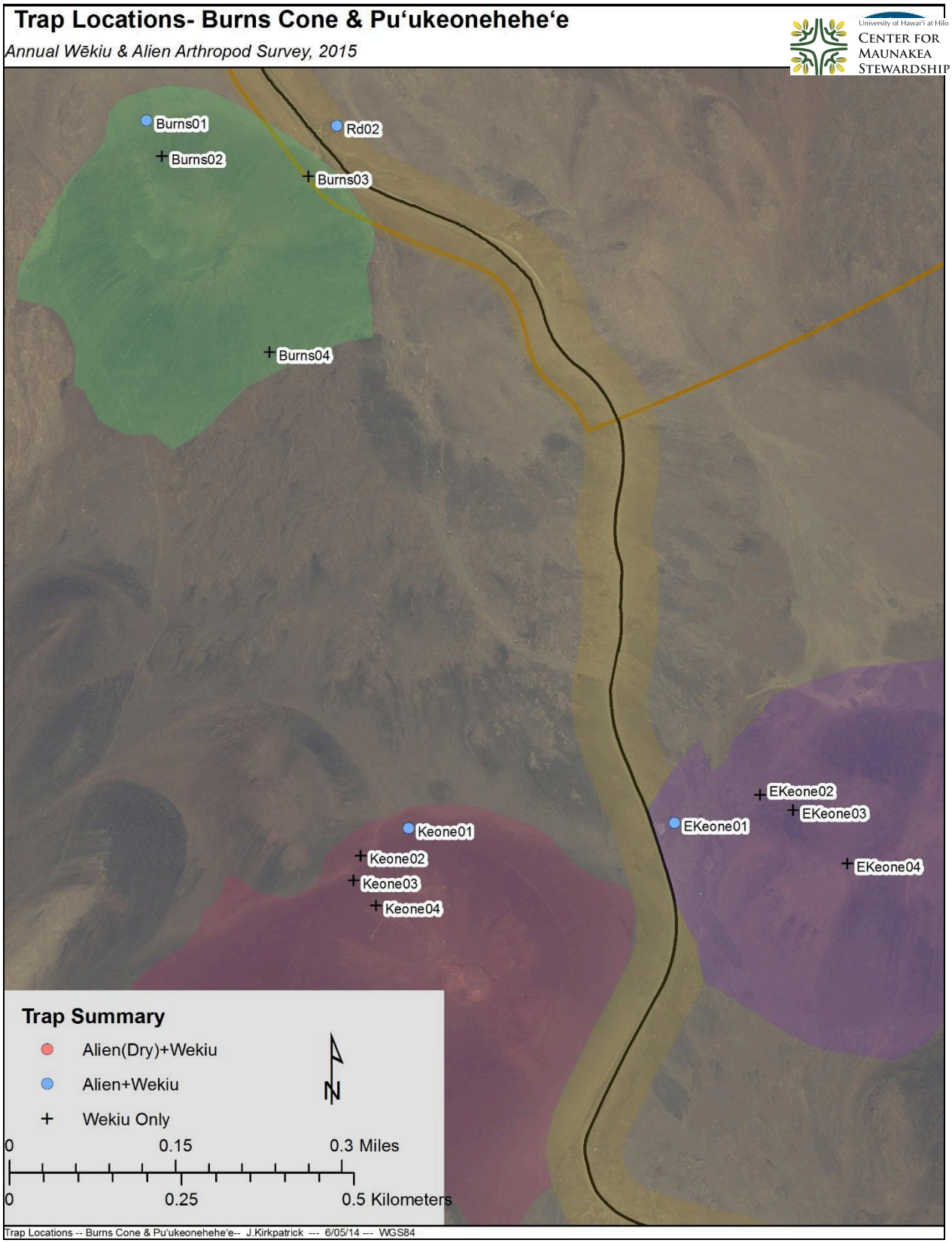

Figure A14. Annual Alien Invertebrate Monitoring survey locations at Burns Cone and Pu'ukeonehehe'e.

Appendix F: 2025 Annual Alien Invertebrate & Wēkiu Bug Trap Coordinates

Table A3. Annual Alien Invertebrate Monitoring trap locations surveyed in 2025 (including altitude in meters, geographic coordinates, and trap type). Alien trap types include all four trap types: PBJS sticks, yellow pan, kill pitfall, and baited pitfall. Alien(Dry) trap types include all 3 traps except kill pitfall. Wēkiu trap types include only baited pitfalls.

Location	Site ID	Altitude (m)	Latitude	Longitude	Trap Type
Batch Plant	Batch01	4106	19.822789950	-155.476869920	Alien
Batch Plant	Batch02	4056	19.819759980	-155.474079920	Alien
Batch Plant	Batch03	4082	19.820889940	-155.474259960	Alien
Batch Plant	Batch04	4064	19.819379940	-155.474150000	Alien
Batch Plant	Batch05	4080	19.820890000	-155.474590000	Wēkiu
Batch Plant	Batch06	4067	19.819900000	-155.474760000	Wēkiu
Batch Plant	Batch07	4063	19.820010000	-155.474740000	Wēkiu
Burns Cone	Burns01	TBD	19.793485000	-155.461087000	Alien
Burns Cone	Burns02	TBD	19.793012000	-155.460865000	Wēkiu
Burns Cone	Burns03	TBD	19.792773000	-155.458835000	Wēkiu
Burns Cone	Burns04	TBD	19.790424000	-155.459337000	Wēkiu
East Puʻukeonehe'ehe'e	EKeone01	TBD	19.784230000	-155.453634000	Alien
East Puʻukeonehe'ehe'e	EKeone02	TBD	19.784621000	-155.452456000	Wēkiu
East Puʻukeonehe'ehe'e	EKeone03	TBD	19.784424000	-155.451997000	Wēkiu
East Puʻukeonehe'ehe'e	EKeone04	TBD	19.783725000	-155.451233000	Wēkiu
Halepōhaku	HP01	2851	19.760589940	-155.456039970	Alien
Halepōhaku	HP02	2853	19.760859920	-155.456269970	Alien
Halepōhaku	HP03	2865	19.761309950	-155.455979960	Alien
Halepōhaku	HP04	2868	19.761799960	-155.456009960	Alien
Halepōhaku	HP05	2832	19.759329980	-155.455759930	Alien
Halepōhaku	HP06	2833	19.759409940	-155.455869990	Alien
Halepōhaku	HP07	2833	19.759439950	-155.456160000	Alien
Halepōhaku	HP08	2831	19.759149930	-155.455839980	Alien
Puʻuhaukea	Hkea01	TBD	19.815719444	-155.473500000	Wēkiu
Puʻuhaukea	Hkea02	TBD	19.816219444	-155.473880556	Wēkiu
Puʻuhaukea	Hkea03	4124	19.814549960	-155.473329990	Wēkiu
Puʻuhaukea	Hkea04	4120	19.814629920	-155.473389920	Wēkiu
Puʻuhaukea	Hkea05	4116	19.814359940	-155.473249950	Wēkiu
Puʻuhaukea	Hkea06	4125	19.814259940	-155.473460000	Wēkiu
Puʻuhaukea	Hkea07	4118	19.813829950	-155.473219940	Wēkiu
Puʻuhaukea	Hkea08	4128	19.813649990	-155.473359920	Wēkiu
Puʻuhaukea	Hkea09	4124	19.813229970	-155.472609990	Wēkiu
Puʻuhaukea	Hkea10	4115	19.813419990	-155.472609990	Wēkiu
Puʻuhaukea	Hkea11	4116	19.813579920	-155.471919990	Wēkiu
Puʻuhaukea	Hkea12	4126	19.813680000	-155.471509950	Wēkiu
Puʻuhaukea	Hkea13	4070	19.812570000	-155.473850000	Wēkiu
Puʻuhaukea	Hkea14	4042	19.811900000	-155.474290000	Wēkiu
Puʻuhauoki	Oki01	4174	19.826369950	-155.474809990	Alien(Dry)
Puʻuhauoki	Oki02	4151	19.826079930	-155.475859990	Wēkiu
Puʻuhauoki	Oki03	4164	19.825929980	-155.476069950	Wēkiu
Puʻuhauoki	Oki04	4171	19.826279930	-155.474929930	Wēkiu
Puʻuhauoki	Oki05	4162	19.826539930	-155.475069990	Wēkiu
Puʻuhauoki	Oki06	TBD	19.826589970	-155.475489930	Wēkiu
Puʻuhauoki	Oki07	TBD	19.827152780	-155.475952778	Wēkiu
Puʻuhauoki	Oki08	TBD	19.824900000	-155.476916667	Alien(Dry)
Puʻukea	Kea01	4223	19.822919960	-155.469959960	Alien
Puʻukea	Kea02	4213	19.823790000	-155.469379940	Alien
Puʻupōhaku	Poha01	4001	19.825379960	-155.489939990	Alien(Dry)
Puʻupōhaku	Poha02	4026	19.824949970	-155.490389930	Wēkiu

Puʻupōhaku	Poha03	4035	19.824829940	-155.490589920	Wēkiu
Puʻupōhaku	Poha04	4036	19.824539930	-155.490779940	Wēkiu
Puʻupōhaku	Poha05	4033	19.824319980	-155.491129970	Alien
Puʻupōhaku	Poha06	4044	19.824539930	-155.492019960	Wēkiu
Poi Bowl	Poi01	TBD	19.823760000	-155.475630000	Wēkiu
Poi Bowl	Poi02	TBD	19.823810000	-155.475490000	Wēkiu
Poi Bowl	Poi03	4168	19.825629990	-155.474899920	Wēkiu
Poi Bowl	Poi04	4153	19.825359930	-155.474789950	Wēkiu
Poi Bowl	Poi05	4144	19.825019960	-155.474719960	Wēkiu
Poi Bowl	Poi06	4123	19.824469940	-155.474949960	Wēkiu
Poi Bowl	Poi07	4105	19.823929970	-155.475009980	Wēkiu
Puʻupoliʻahu	Poli01	TBD	19.823890000	-155.479770000	Wēkiu
Puʻupoliʻahu	Poli02	4150	19.822149990	-155.481349970	Wēkiu
Puʻupoliʻahu	Poli03	4152	19.822499940	-155.481309980	Wēkiu
Puʻupoliʻahu	Poli04	4162	19.822719960	-155.481159950	Wēkiu
Puʻupoliʻahu	Poli05	4160	19.822939990	-155.480879990	Wēkiu
Puʻupoliʻahu	Poli06	4139	19.823059930	-155.479979940	Wēkiu
Puʻupoliʻahu	Poli07	TBD	19.824050000	-155.480283333	Alien(Dry)
Puʻukeonehe‘ehe‘e	Keone01	TBD	19.784108000	-155.457314000	Alien
Puʻukeonehe‘ehe‘e	Keone02	TBD	19.783737000	-155.457974000	Wēkiu
Puʻukeonehe‘ehe‘e	Keone03	TBD	19.783407000	-155.458068000	Wēkiu
Puʻukeonehe‘ehe‘e	Keone04	TBD	19.783075000	-155.457750000	Wēkiu
Road Corridor	Rd01	3753	19.801739980	-155.456009960	Alien
Road Corridor	Rd02	3667	19.793449940	-155.458449940	Alien
Road Corridor	Rd03	3032	19.767099920	-155.457749960	Alien
Road Corridor	Rd04	3390	19.777479980	-155.451659920	Alien
Road Corridor	Rd05	3658	19.795349950	-155.459299940	Alien
Road Corridor	Rd06	3932	19.810339980	-155.467699950	Alien
TMT/SMA	TMT01	4044	19.831119970	-155.480879990	Alien
TMT/SMA	TMT02	4058	19.829809960	-155.480469950	Alien
TMT/SMA	TMT03	4068	19.828379930	-155.479969970	Alien
TMT/SMA	TMT04	TBD	19.824133333	-155.477050000	Alien(Dry)
TMT/SMA	TMT05	TBD	19.824866667	-155.477766667	Alien(Dry)
TMT/SMA	TMT06	4106	19.824940000	-155.477550000	Alien(Dry)
TMT/SMA	TMT07	TBD	19.825166667	-155.477833333	Alien(Dry)
TMT/SMA	TMT08	TBD	19.825800000	-155.478083333	Alien(Dry)
TMT/SMA	TMT09	TBD	19.826133333	-155.478166667	Alien(Dry)
VLBA, N. Puʻu	VLBAN01	TBD	19.801530000	-155.457080000	Wēkiu
VLBA, N. Puʻu	VLBAN02	3776	19.802789980	-155.456949990	Wēkiu
VLBA, N. Puʻu	VLBAN03	3819	19.803119970	-155.458049950	Wēkiu
VLBA, N. Puʻu	VLBAN04	3860	19.803249980	-155.458919990	Wēkiu
VLBA, N. Puʻu	VLBAN05	3858	19.803579970	-155.459089980	Wēkiu
VLBA, N. Puʻu	VLBAN06	3864	19.803789940	-155.459349980	Wēkiu
VLBA, N. Puʻu	VLBAN07	3824	19.805409990	-155.458629980	Alien
VLBA, S. Puʻu	VLBAS01	TBD	19.800020000	-155.456620000	Wēkiu
VLBA, S. Puʻu	VLBAS02	3770	19.799939960	-155.455639990	Wēkiu
VLBA, S. Puʻu	VLBAS03	3786	19.799630000	-155.455629930	Wēkiu
VLBA, S. Puʻu	VLBAS04	3811	19.799009990	-155.455179990	Wēkiu
VLBA, S. Puʻu	VLBAS05	3809	19.799189950	-155.455579970	Wēkiu
VLBA, S. Puʻu	VLBAS06	3806	19.799040000	-155.456049940	Wēkiu
Puʻuwaiʻau	Waiau01	3990	19.811219990	-155.476909990	Alien
Puʻuwaiʻau	Waiau02	TBD	19.809999000	-155.476454000	Wēkiu
Puʻuwēkiu	Wekiu01	4196	19.821579940	-155.468930000	Wēkiu
Puʻuwēkiu	Wekiu02	4214	19.821259920	-155.468119970	Wēkiu
Puʻuwēkiu	Wekiu03	4225	19.820540000	-155.467989970	Wēkiu
Puʻuwēkiu	Wekiu04	4215	19.819989980	-155.468059960	Wēkiu
Puʻuwēkiu	Wekiu05	4207	19.819129990	-155.468019970	Wēkiu

Appendix G: 2025 Wēkiu Bug Capture Data

The number of wēkiu bug individuals captured at each site over the 2025 Annual Wēkiu Bug Monitoring and Annual Alien Invertebrate Monitoring survey period (including altitude in meters, geographic coordinates, and trap type) are listed below. Most trap locations were derived from Bishop Museum Monitoring Surveys.

Table A4. Annual Wēkiu Bug Monitoring trap locations surveyed from 2025 with the number of wēkiu bugs captured at each trap location (not including hand searches).

Location	Site ID	Altitude (meters)	Latitude	Longitude	# of Wēkiu	Trap Type
Batch Plant	Batch01	4106	19.822789950	-155.476869920	0	Alien
Batch Plant	Batch02	4056	19.819759980	-155.474079920	0	Alien
Batch Plant	Batch03	4082	19.820889940	-155.474259960	0	Alien
Batch Plant	Batch04	4064	19.819379940	-155.474150000	0	Alien
Batch Plant	Batch05	4080	19.820890000	-155.474590000	0	Wēkiu
Batch Plant	Batch06	4067	19.819900000	-155.474760000	0	Wēkiu
Batch Plant	Batch07	4063	19.820010000	-155.474740000	0	Wēkiu
Burns Cone	Burns01	TBD	19.793485000	-155.461087000	0	Alien
Burns Cone	Burns02	TBD	19.793012000	-155.460865000	0	Wēkiu
Burns Cone	Burns03	TBD	19.792773000	-155.458835000	0	Wēkiu
Burns Cone	Burns04	TBD	19.790424000	-155.459337000	0	Wēkiu
E. Puʻukeonehehe'e	EKeone01	TBD	19.784230000	-155.453634000	0	Alien
E. Puʻukeonehehe'e	EKeone02	TBD	19.784621000	-155.452456000	0	Wēkiu
E. Puʻukeonehehe'e	EKeone03	TBD	19.784424000	-155.451997000	0	Wēkiu
E. Puʻukeonehehe'e	EKeone04	TBD	19.783725000	-155.451233000	0	Wēkiu
Halepōhaku	HP01	2851	19.760589940	-155.456039970	0	Alien
Halepōhaku	HP02	2853	19.760859920	-155.456269970	0	Alien
Halepōhaku	HP03	2865	19.761309950	-155.455979960	0	Alien
Halepōhaku	HP04	2868	19.761799960	-155.456009960	0	Alien
Halepōhaku	HP05	2832	19.759329980	-155.455759930	0	Alien
Halepōhaku	HP06	2833	19.759409940	-155.455869990	0	Alien
Halepōhaku	HP07	2833	19.759439950	-155.456160000	0	Alien
Halepōhaku	HP08	2831	19.759149930	-155.455839980	0	Alien
Puʻuhaukea	Hkea01	TBD	19.815719444	-155.473500000	105	Wēkiu
Puʻuhaukea	Hkea02	TBD	19.816219444	-155.473880556	0	Wēkiu
Puʻuhaukea	Hkea03	4124	19.814549960	-155.473329990	2	Wēkiu
Puʻuhaukea	Hkea04	4120	19.814629920	-155.473389920	6	Wēkiu
Puʻuhaukea	Hkea05	4116	19.814359940	-155.473249950	0	Wēkiu
Puʻuhaukea	Hkea06	4125	19.814259940	-155.473460000	0	Wēkiu
Puʻuhaukea	Hkea07	4118	19.813829950	-155.473219940	0	Wēkiu
Puʻuhaukea	Hkea08	4128	19.813649990	-155.473359920	0	Wēkiu
Puʻuhaukea	Hkea09	4124	19.813229970	-155.472609990	0	Wēkiu
Puʻuhaukea	Hkea10	4115	19.813419990	-155.472609990	56	Wēkiu
Puʻuhaukea	Hkea11	4116	19.813579920	-155.471919990	0	Wēkiu
Puʻuhaukea	Hkea12	4126	19.813680000	-155.471509950	1	Wēkiu
Puʻuhaukea	Hkea13	4070	19.812570000	-155.473850000	0	Wēkiu
Puʻuhaukea	Hkea14	4042	19.811900000	-155.474290000	0	Wēkiu
Puʻuhauoki	Oki01	4174	19.826369950	-155.474809990	22	Alien(Dry)
Puʻuhauoki	Oki02	4151	19.826079930	-155.475859990	2	Wēkiu
Puʻuhauoki	Oki03	4164	19.825929980	-155.476069950	31	Wēkiu
Puʻuhauoki	Oki04	4171	19.826279930	-155.474929930	183	Wēkiu
Puʻuhauoki	Oki05	4162	19.826539930	-155.475069990	233	Wēkiu
Puʻuhauoki	Oki06	TBD	19.826589970	-155.475489930	179	Wēkiu
Puʻuhauoki	Oki07	TBD	19.827152780	-155.475952778	16	Wēkiu

Puʻuhauoki	Oki08	TBD	19.824900000	-155.476916667	46	Alien(Dry)
Puʻukea	Kea01	4223	19.822919960	-155.469959960	10	Alien
Puʻukea	Kea02	4213	19.823790000	-155.469379940	80	Alien
Puʻupōhaku	Poha01	4001	19.825379960	-155.489939990	1	Alien(Dry)
Puʻupōhaku	Poha02	4026	19.824949970	-155.490389930	0	Wēkiu
Puʻupōhaku	Poha03	4035	19.824829940	-155.490589920	0	Wēkiu
Puʻupōhaku	Poha04	4036	19.824539930	-155.490779940	0	Wēkiu
Puʻupōhaku	Poha05	4033	19.824319980	-155.491129970	0	Alien
Puʻupōhaku	Poha06	4044	19.824539930	-155.492019960	0	Wēkiu
Poi Bowl	Poi01	TBD	19.823760000	-155.475630000	24	Wēkiu
Poi Bowl	Poi02	TBD	19.823810000	-155.475490000	4	Wēkiu
Poi Bowl	Poi03	4168	19.825629990	-155.474899920	21	Wēkiu
Poi Bowl	Poi04	4153	19.825359930	-155.474789950	1	Wēkiu
Poi Bowl	Poi05	4144	19.825019960	-155.474719960	44	Wēkiu
Poi Bowl	Poi06	4123	19.824469940	-155.474949960	28	Wēkiu
Poi Bowl	Poi07	4105	19.823929970	-155.475009980	8	Wēkiu
Puʻupoliʻahu	Poli01	TBD	19.823890000	-155.479770000	0	Wēkiu
Puʻupoliʻahu	Poli02	4150	19.822149990	-155.481349970	0	Wēkiu
Puʻupoliʻahu	Poli03	4152	19.822499940	-155.481309980	0	Wēkiu
Puʻupoliʻahu	Poli04	4162	19.822719960	-155.481159950	0	Wēkiu
Puʻupoliʻahu	Poli05	4160	19.822939990	-155.480879990	0	Wēkiu
Puʻupoliʻahu	Poli06	4139	19.823059930	-155.479979940	0	Wēkiu
Puʻupoliʻahu	Poli07	TBD	19.824050000	-155.480283333	0	Alien(Dry)
E. Puʻukeonehehe'e	Keone01	TBD	19.784108000	-155.457314000	0	Alien
E. Puʻukeonehehe'e	Keone02	TBD	19.783737000	-155.457974000	0	Wēkiu
E. Puʻukeonehehe'e	Keone03	TBD	19.783407000	-155.458068000	0	Wēkiu
E. Puʻukeonehehe'e	Keone04	TBD	19.783075000	-155.457750000	0	Wēkiu
Road Corridor	Rd01	3753	19.801739980	-155.456009960	0	Alien
Road Corridor	Rd02	3667	19.793449940	-155.458449940	0	Alien
Road Corridor	Rd03	3032	19.767099920	-155.457749960	0	Alien
Road Corridor	Rd04	3390	19.777479980	-155.451659920	0	Alien
Road Corridor	Rd05	3658	19.795349950	-155.459299940	0	Alien
Road Corridor	Rd06	3932	19.810339980	-155.467699950	0	Alien
TMT/SMA	TMT01	4044	19.831119970	-155.480879990	0	Alien
TMT/SMA	TMT02	4058	19.829809960	-155.480469950	0	Alien
TMT/SMA	TMT03	4068	19.828379930	-155.479969970	0	Alien
TMT/SMA	TMT04	TBD	19.824133333	-155.477050000	0	Alien(Dry)
TMT/SMA	TMT05	TBD	19.824866667	-155.477766667	0	Alien(Dry)
TMT/SMA	TMT06	4106	19.824940000	-155.477550000	0	Alien(Dry)
TMT/SMA	TMT07	TBD	19.825166667	-155.477833333	0	Alien(Dry)
TMT/SMA	TMT08	TBD	19.825800000	-155.478083333	1	Alien(Dry)
TMT/SMA	TMT09	TBD	19.826133333	-155.478166667	1	Alien(Dry)
VLBA, N. Puʻu	VLBAN01	TBD	19.801530000	-155.457080000	0	Wēkiu
VLBA, N. Puʻu	VLBAN02	3776	19.802789980	-155.456949990	0	Wēkiu
VLBA, N. Puʻu	VLBAN03	3819	19.803119970	-155.458049950	2	Wēkiu
VLBA, N. Puʻu	VLBAN04	3860	19.803249980	-155.458919990	0	Wēkiu
VLBA, N. Puʻu	VLBAN05	3858	19.803579970	-155.459089980	0	Wēkiu
VLBA, N. Puʻu	VLBAN06	3864	19.803789940	-155.459349980	0	Wēkiu
VLBA, N. Puʻu	VLBAN07	3824	19.805409990	-155.458629980	0	Alien
VLBA, S. Puʻu	VLBAS01	TBD	19.800020000	-155.456620000	0	Wēkiu
VLBA, S. Puʻu	VLBAS02	3770	19.799939960	-155.455639990	0	Wēkiu
VLBA, S. Puʻu	VLBAS03	3786	19.799630000	-155.455629930	1	Wēkiu
VLBA, S. Puʻu	VLBAS04	3811	19.799009990	-155.455179990	0	Wēkiu
VLBA, S. Puʻu	VLBAS05	3809	19.799189950	-155.455579970	0	Wēkiu
VLBA, S. Puʻu	VLBAS06	3806	19.799040000	-155.456049940	0	Wēkiu
Puʻuwaiʻau	Waiau01	3990	19.811219990	-155.476909990	0	Alien
Puʻuwaiʻau	Waiau02	TBD	19.809999000	-155.476454000	0	Wēkiu

Puʻuwēkiu	Wekiu01	4196	19.821579940	-155.468930000	3	Wēkiu
Puʻuwēkiu	Wekiu02	4214	19.821259920	-155.468119970	9	Wēkiu
Puʻuwēkiu	Wekiu03	4225	19.820540000	-155.467989970	0	Wēkiu
Puʻuwēkiu	Wekiu04	4215	19.819989980	-155.468059960	2	Wēkiu
Puʻuwēkiu	Wekiu05	4207	19.819129990	-155.468019970	0	Wēkiu
Puʻuwēkiu	Wekiu06	4186	19.818479980	-155.469059920	0	Wēkiu
Puʻuwēkiu	Wekiu07	4159	19.819169980	-155.470169930	2	Wēkiu
Puʻuwēkiu	Wekiu08	4148	19.819269970	-155.469799950	6	Alien(Dry)
Puʻuwēkiu	Wekiu09	4178	19.820499930	-155.469709930	0	Wēkiu
Puʻuwēkiu	Wekiu10	4183	19.821159920	-155.469449930	0	Wēkiu

Appendix H: Wēkiu Bug Abundance and Capture Rate Maps

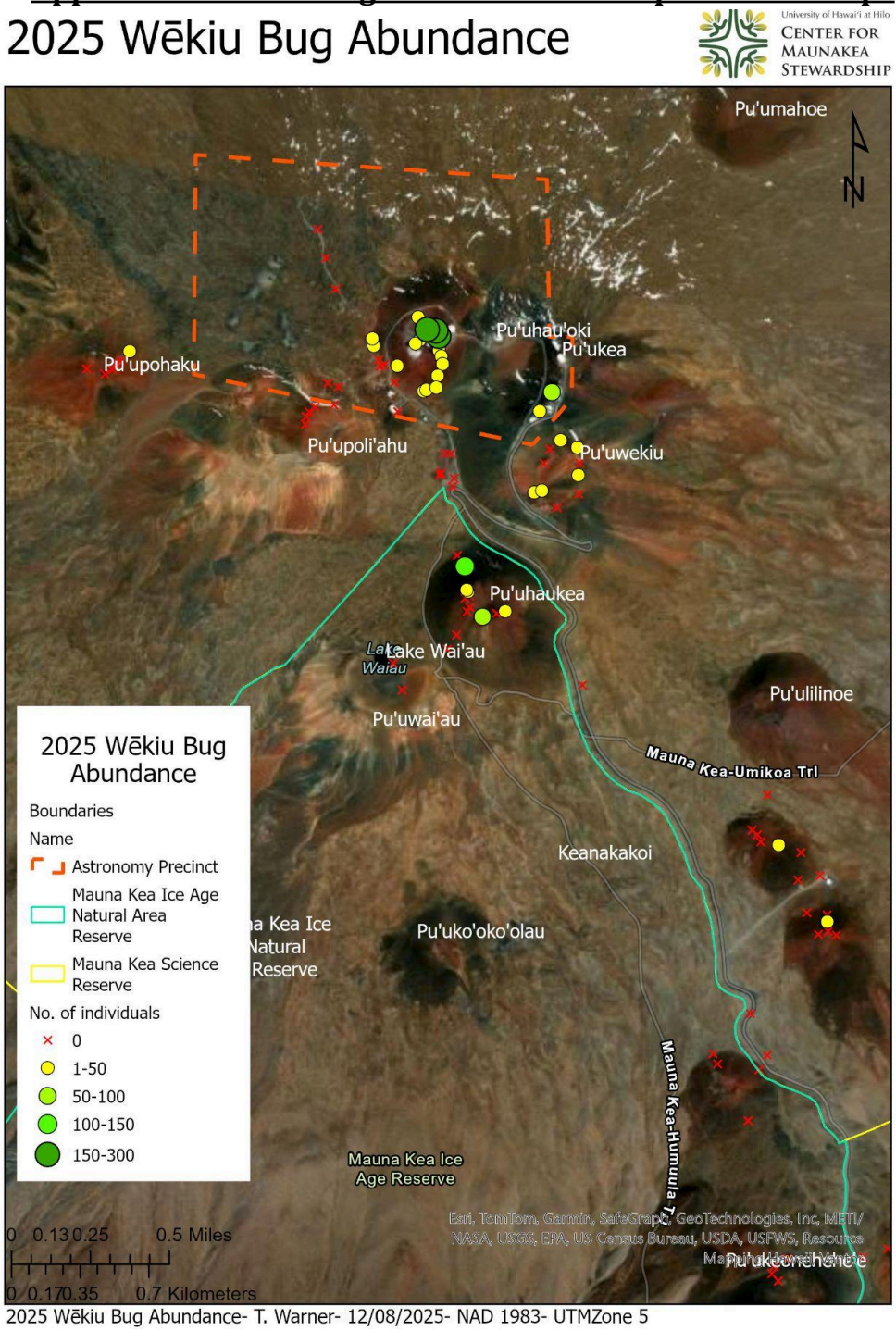

Figure A15. Map of the number of wēkiu bugs captured at each location during the Annual Wēkiu and Alien Invertebrate Monitoring surveys in 2025.

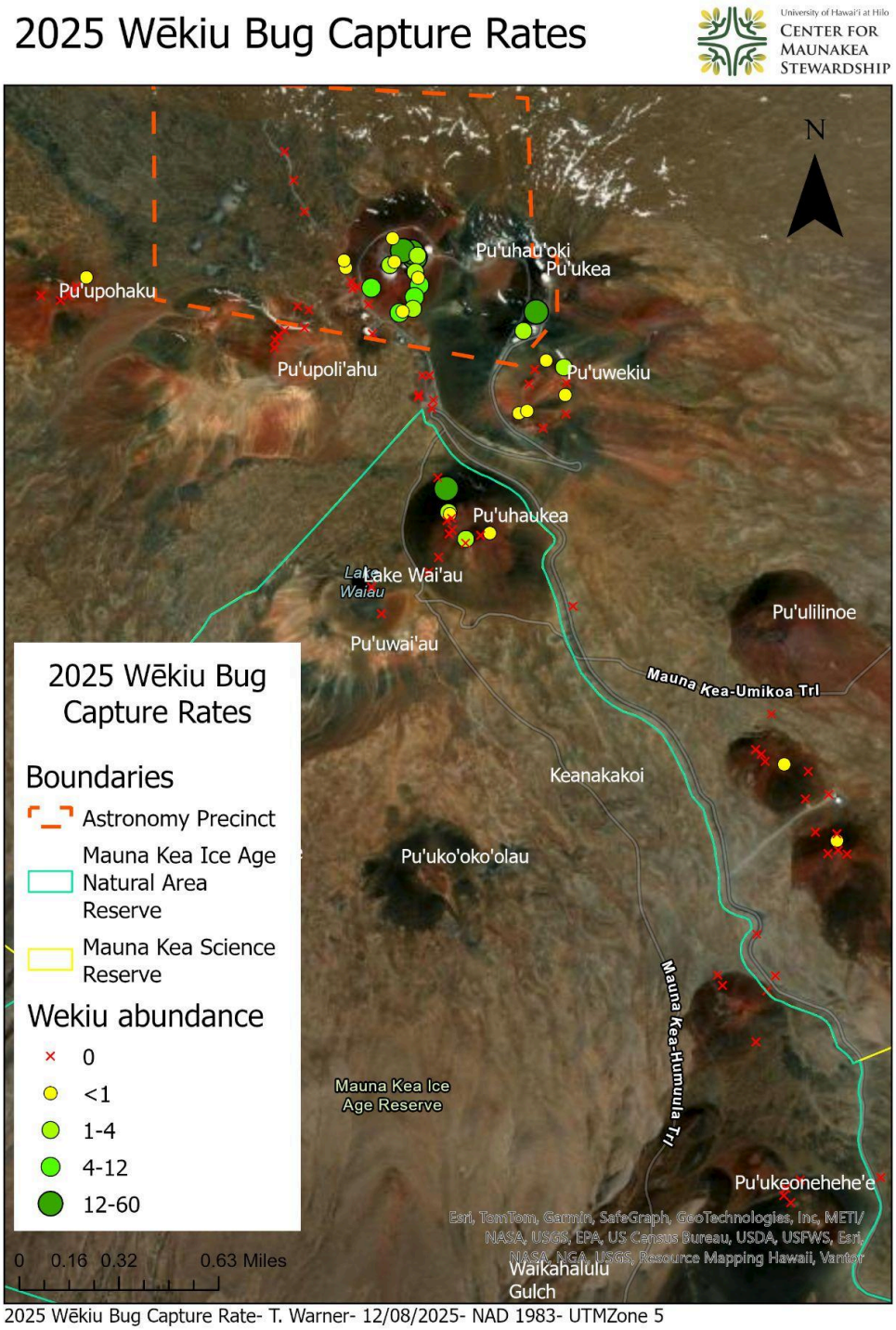

Figure A16. Map of the wēkiu bug capture rates (captures per trap per trap day) at each location during the Annual Wēkiu and Alien Invertebrate Monitoring surveys in 2025.

Appendix I: 2025 Annual Survey Arthropod Capture List

Table A5. All arthropods captured during the 2025 Annual Alien Invertebrate Monitoring surveys listed alphabetically by taxa. Potential arthropod threats are identified in **bold** font. Nativity[6] is either non-native, native, or unknown.

Order	Family	Scientific Name	Morphospecies	Nativity
Acari	Eupodidae	Unknown	NA	Unknown
Acari	Unknown	Unknown	Acari_Hairy legs	Unknown
Acari	Unknown	Unknown	Acari_Red nose	Unknown
Acari	Unknown	Unknown	NA	Unknown
Araneae	**Agelenidae**	***Hololena curta***	**NA**	**Non-native**
Araneae	**Linyphiidae**	***Tenuiphantes tenuis***	**NA**	**Non-native**
Araneae	Linyphiidae	Unknown	Linyphiidae_Male unknown	Unknown
Araneae	Linyphiidae	Unknown	Linyphiidae_Opal eyes	Unknown
Araneae	Lycosidae	*Hogna hawaiiensis*	NA	Native
Araneae	Salticidae	Unknown	NA	Unknown
Araneae	Salticidae	Unknown	Salticidae_4 tails	Unknown
Araneae	Salticidae	Unknown	Salticidae_Black gray	Unknown
Araneae	Salticidae	Unknown	Salticidae_Dark, light brown	Unknown
Araneae	Salticidae	Unknown	Salticidae_Jackolantern	Unknown
Araneae	Salticidae	Unknown	Salticidae_Tiny blondie	Unknown
Araneae	Salticidae	Unknown	Salticidae_White beard	Unknown
Araneae	Unknown	Unknown	NA	Unknown
Coleoptera	**Cleridae**	***Necrobia rufipes***	**NA**	**Non-native**
Coleoptera	Coccinellidae	*Coccinella septempunctata*	NA	Non-native
Coleoptera	Coccinellidae	*Harmonia conformis*	NA	Non-native
Coleoptera	Coccinellidae	*Hippodamia convergens*	NA	Non-native
Coleoptera	Coccinellidae	*Hyperaspis inflexa*	NA	Non-native
Coleoptera	Coccinellidae	Unknown	Coccinellidae_Brown head	Non-native
Coleoptera	Coccinellidae	Unknown	NA	Non-native
Coleoptera	Curculionidae	Unknown	Curculionidae_Dark brown	Unknown
Coleoptera	Latridiidae	Unknown	Latridiidae_Not serrated	Non-native
Coleoptera	Latridiidae	Unknown	Latridiidae_Serrated	Non-native
Coleoptera	Latridiidae	Unknown	NA	Non-native
Coleoptera	Unknown	Unknown	NA	Unknown
Collembola	Entomobryidae	Unknown	NA	Unknown
Collembola	Unknown	Unknown	Collembola_Purple short	Unknown
Dermaptera	Forficulidae	*Forficula auricularia*	NA	Non-native
Diptera	Agromyzidae	*Liriomyza* sp.	NA	Non-native
Diptera	Agromyzidae	Unknown	NA	Non-native
Diptera	Anthomyiidae	*Delia platura*	NA	Non-native
Diptera	Calliphoridae	*Calliphora latifrons*	NA	Non-native
Diptera	Calliphoridae	*Calliphora vomitoria*	NA	Non-native
Diptera	Calliphoridae	*Lucilia cuprina*	NA	Non-native
Diptera	Calliphoridae	*Phormia regina*	NA	Non-native
Diptera	Calliphoridae	Unknown	NA	Unknown
Diptera	Drosophilidae	Unknown	NA	Unknown
Diptera	Ephydridae	*Hydrellia tritici*	NA	Non-native
Diptera	**Muscidae**	***Coenosia humilis***	**NA**	**Non-native**
Diptera	Muscidae	*Haematobia irritans*	NA	Non-native

[6] Nativity was determined using various resources such as the Insects of Hawai‘i series (The University of Hawaii Press, Honolulu), the Hawaiian Terrestrial Arthropod Checklist (Nishida 2002), and the revised checklist (Matsunaga et al. 2019).

Diptera	Muscidae	Unknown	NA	Unknown
Diptera	Phoridae	Unknown	NA	Unknown
Diptera	Polleniidae	*Pollenia rudis*	NA	Non-native
Diptera	Polleniidae	Unknown	NA	Unknown
Diptera	Sarcophagidae	*Ravinia anxia*	NA	Non-native
Diptera	Sarcophagidae	Unknown	NA	Non-native
Diptera	Sciaridae	*Bradysia nitidicollis*	NA	Non-native
Diptera	Sciaridae	Unknown	NA	Unknown
Diptera	Sepsidae	*Sepsis thoracica*	NA	Non-native
Diptera	Sepsidae	Unknown	NA	Non-native
Diptera	Sepsidae	Unknown	Sepsidae_Dark legs	Non-native
Diptera	Sepsidae	Unknown	Sepsidae_Dark legs lg	Non-native
Diptera	Sepsidae	Unknown	Sepsidae_Yellow tibia	Non-native
Diptera	Sphaeroceridae	*Minilimosina fungicola*	NA	Non-native
Diptera	Sphaeroceridae	Unknown	NA	Unknown
Diptera	Syrphidae	*Allograpta* sp.	NA	Non-native
Diptera	Syrphidae	*Eristalis tenax*	NA	Non-native
Diptera	Syrphidae	*Simosyrphus grandicornis*	NA	Non-native
Diptera	Syrphidae	*Toxomerus marginatus*	NA	Non-native
Diptera	Syrphidae	Unknown	NA	Non-native
Diptera	Tephritidae	Unknown	Tephritidae_Faint marks	Unknown
Diptera	Unknown	Unknown	Diptera_Black 4 dots	Unknown
Diptera	Unknown	Unknown	Diptera_Chubby black	Unknown
Diptera	Unknown	Unknown	Diptera_Hooked dm-cu	Unknown
Diptera	Unknown	Unknown	Diptera_Isopod abs	Unknown
Diptera	Unknown	Unknown	Diptera_Pointy butt	Unknown
Diptera	Unknown	Unknown	Diptera_Shiny fly	Unknown
Diptera	Unknown	Unknown	NA	Unknown
Hemiptera	Aphididae	Unknown	NA	Non-native
Hemiptera	Cicadellidae	Unknown	Cicadellidae_Bright green	Unknown
Hemiptera	Cicadellidae	Unknown	Cicadellidae_Pale face	Unknown
Hemiptera	Cicadellidae	Unknown	Cicadellidae_Unknown nymph	Unknown
Hemiptera	Cicadellidae	Unknown	NA	Unknown
Hemiptera	Geocoridae	*Geocoris pallens*	NA	Non-native
Hemiptera	Lygaeidae	*Hyalopeplus pellucidus*	NA	Non-native
Hemiptera	Lygaeidae	*Neacoryphus bicrucis*	NA	Non-native
Hemiptera	Lygaeidae	*Nysius palor*	NA	Non-native
Hemiptera	Lygaeidae	*Nysius terrestris*	NA	Native
Hemiptera	Lygaeidae	*Nysius* sp.	NA	Non-native
Hemiptera	Lygaeidae	*Nysius wekiuicola*	NA	Native
Hemiptera	Lygaeidae	Unknown	Lygaeidae_Unk nymph 1	Unknown
Hemiptera	Miridae	*Coridromius variegatus*	NA	Non-native
Hemiptera	Miridae	*Orthotylus sophoricola*	NA	Native
Hemiptera	Psyllidae	*Acizzia uncatoides*	NA	Non-native
Hemiptera	Psyllidae	*Heteropsylla cubana*	NA	Non-native
Hemiptera	Psyllidae	Unknown	NA	Unknown
Hemiptera	Psyllidae	Unknown	Psyllidae_Sharp butt	Unknown
Hemiptera	Unknown	Unknown	Hemiptera_Unknown nymph	Unknown
Hemiptera	Unknown	Unknown	NA	Unknown
Hymenoptera	**Apidae**	***Apis mellifera***	**NA**	**Non-native**
Hymenoptera	Bethylidae	Unknown	Bethylidae sp. 2	Native
Hymenoptera	Braconidae	*Aphidius platensis*	NA	Non-native
Hymenoptera	**Braconidae**	***Diadegma blackburni***	**NA**	**Non-native**

Hymenoptera	**Braconidae**	***Dolichogenidea* sp.**	**Braconidae_Dolichogenidea sp.**	**Non-native**
Hymenoptera	Braconidae	*Meteorus laphygmae*	NA	Non-native
Hymenoptera	Braconidae	Unknown	Braconidae_Orange eyeliner	Unknown
Hymenoptera	Braconidae	Unknown	NA	Unknown
Hymenoptera	Chalcididae	Unknown	NA	Unknown
Hymenoptera	Colletidae	*Hylaeus* sp.	NA	Native
Hymenoptera	Crabronidae	Unknown	Crabronidae sp. 2	Unknown
Hymenoptera	Encrytidae	*Metaphycus* sp.	Metaphycus_Tiny yellow	Non-native
Hymenoptera	Figitidae	*Alloxsta ramulifera*	NA	Non-native
Hymenoptera	**Formicidae**	***Cardiocondyla kagutsuchi***	**NA**	**Non-native**
Hymenoptera	**Ichneumonidae**	***Ichneumon laetus***	**NA**	**Non-native**
Hymenoptera	Ichneumonidae	Unknown	Ichneumonidae_Orange legs	Unknown
Hymenoptera	Ichneumonidae	Unknown	Ichneumonidae_Swollen hind tibia	Unknown
Hymenoptera	Ichneumonidae	Unknown	Ichneumonidae_Swollen legs	Unknown
Hymenoptera	Ichneumonidae	Unknown	Ichneumonidae_Tiger butt	Unknown
Hymenoptera	Ichneumonidae	Unknown	NA	Unknown
Hymenoptera	Mymaridae	Unknown	Mymaridae_Short club	Unknown
Hymenoptera	Mymaridae	Unknown	Mymaridae_Skinny wings	Unknown
Hymenoptera	Pteromalidae	*Mesopolobus incultus*	NA	Non-native
Hymenoptera	Scelionidae	Unknown	Scelionidae_Round butt	Unknown
Hymenoptera	Unknown	Unknown	Chalcididae_Yellow legs	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Anoplius toluca?	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Bee striped legs	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Blue gaster	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Clear legs	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Shiny blue pterostigma	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Shiny long butt	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Shiny tiny wasp	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Small brown butt	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Tiny green yellow	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Trichopria lookalike	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Wide black butt	Unknown
Hymenoptera	Unknown	Unknown	Hymenoptera_Yellow jaws	Unknown
Hymenoptera	Unknown	Unknown	NA	Unknown
Hymenoptera	**Vespidae**	***Vespula pensylvanica***	**NA**	**Non-native**
Lepidoptera	Lycaenidae	*Lampides boeticus*	NA	Non-native
Lepidoptera	Lycaenidae	*Udara blackburni*	NA	Non-native
Lepidoptera	Noctuidae	*Agrotis* sp.	NA	Non-native
Lepidoptera	Noctuidae	Unknown	NA	Unknown
Lepidoptera	Noctuidae	Unknown	Noctuidae_Unk 1	Unknown
Lepidoptera	Oecophoridae	*Agronopterix ulicetella*	NA	Non-native
Lepidoptera	Pieridae	*Pieris rapae*	NA	Non-native
Neuroptera	Hemerobiidae	*Hemerobius pacificus*	NA	Non-native
Psocodea	Ectopsocidae	Unknown	Ectopsocidae_White head	Unknown
Psocodea	Unknown	Unknown	NA	Unknown
Psocodea	Unknown	Unknown	Psocodea_Clear wings	Unknown
Thysanoptera	Thripidae	Unknown	NA	Unknown
Thysanoptera	Unknown	Unknown	Thysanoptera_Dark abdomen	Unknown

References

Matsunaga, J. N., Howarth, F. G., & Kumashiro, B. R. (2019). New state records and additions to the alien terrestrial arthropod fauna in the Hawaiian Islands. *Proceedings of the Hawaiian Entomological Society*, 51, 1-71.

Nishida, G. M. (2002). Hawaiian terrestrial arthropod checklist 4th ed. *Honolulu, Hawai'i: Hawai'i Biological Survey (Bishop Museum) Technical Report, 22.*

Appendix J: Pesticide log

Table A6. The 2025 pesticide log for UH managed lands, including EPA regulation number, formulation type, the active ingredients in the pesticide, the targeted pest, the application date/time, the dilution rate, the total volume of pesticide applied (ounces), the targeted application rate, and the total area cover (in square feet).

#	EPA Reg No.	Formulation	Active Ingredient	Targeted Pest	Application Date	Dilution Rate	Total Volume of Pesticide Applied	Targeted Application Rate	Total Area Covered
1	84009-12	Liquid	Gylphosate 41%	Kikuyu, fireweed, mullein, etc.	1/8/25	2oz/gal	16 oz	4.5 qts/ acre	1527.7sqft
2	84009-12	Liquid	Glyphosate 41%	Kikuyu, fireweed, mullein, etc.	6/13/2025	2 oz/gal	14 oz	1-2qt / acre	4550 sq ft
3	84009-12	Liquid	Glyphosate41%	Kikuyu, fireweed, mullein, etc.	6/24/2025	3 oz/gal	6 oz	1-2qt / acre	3944.42 sq ft
4	279-3206	Liquid	Bifenthrin 7.9%	*Cardiocondyla kagutsuchi*	7/17/2025	1oz/gal	2.5 oz	1oz / 1,000 sq ft	2500 sq ft
5	84009-12	Liquid	Glyphosate 41%	Kikuyu, fireweed, mullein, etc.	7/18/2025	2 oz/gal	10 oz	1-2qt / acre	9,850 sq ft
6	59807-15	Granular	Imidacloprid 1%	Beetles	09/03/2025	N/A	18 oz	0.25 tsp/ 3 in pot	432 sq ft

Table A7. Information for each entry in the pesticide log (Table A6) on the site treated, the name of the certified applicator, the restricted entry interval, and whether double notification was required.

#	Site Treated	Name of Certified Applicator	Restricted Entry Interval (REI)	Double Notification Required?
1	Parking lot below Storage Warehouse	L. Kekoa-Lum	4 hours	No
2	HP parking lots and Zone I	J. Yeh	4 hours	No
3	Zone I and G	J. Yeh	4 hours	No
4	HP parking lots	J. Yeh	After spray has dried	No
5	Bonner, Access Road roadside	J. Yeh	After spray has dried	No
6	CMS greenhouse (in pots)	J. Yeh	None	No