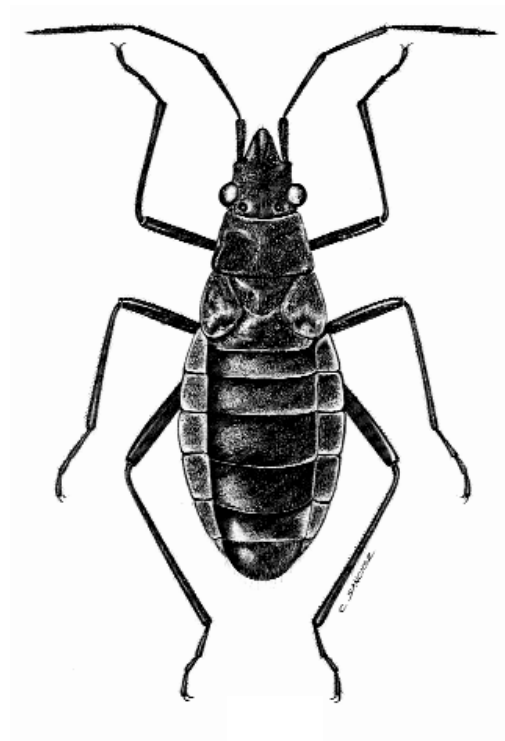


WĒKIU BUG BASELINE MONITORING

QUARTERLY REPORT
3rd QUARTER 2004



Pacific Analytics, L.L.C.

**Cover : Wēkiu Bug drawn by Mr. C. Sanchez of the University of the
Philippines College of Science and Humanities.**

WĒKIU BUG
BASELINE MONITORING

QUARTERLY REPORT
3rd QUARTER 2004

Prepared for

The Outrigger Telescopes Project
WM Keck Observatory
Kamuela, Hawai'i



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WĒKIU BUG BASELINE MONITORING

QUARTERLY REPORT 3rd QUARTER 2004

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Wēkiu Bug Baseline Monitoring EXECUTIVE SUMMARY

II. EXECUTIVE SUMMARY

The Mauna Kea Science Reserve (MKSJ) is located on the summit of Mauna Kea, the tallest mountain in Hawai'i. Within the reserve are the world's two largest optical telescopes, constituting the W.M. Keck Observatory (WMKO). The slopes of Pu'u Hau'oki directly adjacent to and below the WMKO are part of a unique natural environment that supports the Wēkiu bug, a rare insect. Wēkiu bug habitat generally occurs on the upper elevations of Mauna Kea. Populations of Wēkiu bugs also occur on other cinder cones above about 11,700' (3,570 m) elevation.

The National Aeronautics and Space Administration (NASA), together with the California Institute of Technology (CalTech)/Jet Propulsion Laboratory (JPL), the California Association for Research in Astronomy (CARA) and the University of Hawai'i (UH), have proposed to protect and enhance Wēkiu bug habitat on Pu'u Hau'oki to mitigate potential disturbance by on-site construction and installation of the Outrigger Telescopes Project. To that end these participants have prepared the Wēkiu Bug Mitigation Plan and Wēkiu Bug Monitoring Plan. They are

also the participants in this Wēkiu Bug Baseline Monitoring Plan.

Sampling of Wēkiu bug habitat was approved to establish baseline population estimates of the Wēkiu bug in the area surrounding the site of the proposed Outrigger Telescopes Project and at a control site on Pu'u Wēkiu. The intended purpose of this activity is to gather reliable scientific information about population trends in both areas that can be used to determine the effectiveness of habitat protection and restoration, and the impacts, if any, due to construction of the Outrigger Telescopes Project.

Sampling of Wēkiu bugs is being conducted to answer two main Questions of Interest. They are:

- 1) How, where and when are the Wēkiu bug populations changing? Locations of interest include current habitat on Pu'u Hau'oki crater and undisturbed Wēkiu bug habitat at Pu'u Wēkiu (for comparison).

- 2) Are weather phenomena, human activities, and/or other factors associated with Wēkiu bug and/or other resident arthropod population change?

Wēkiu Bug Baseline Monitoring
INTRODUCTION

impacts, if any, due to construction of the Outrigger Telescopes Project.

trap design described in previous quarterly reports.

The Hawai'i Department of Land and Natural Resources (DLNR) approved a recommendation for doubling the number of traps for Wēkiu bug monitoring. Five new traps were established on Pu'u Hau'oki and five on Pu'u Wēkiu for this monitoring session. All of the traps deployed for Wēkiu Bug Baseline Monitoring continue to be of the improved live-

This is the eleventh Quarterly Report of Baseline Monitoring. The results of the sampling effort conducted August 21, 2004 through September 11, 2004 are reported. Comparisons to previously collected data are presented, along with new analysis and interpretations of correlations of changes in Wēkiu bug populations with weather related phenomena.



**Establishing new live-traps disturbs only a small amount of habitat.
(Photo taken August 18, 2004 on Pu'u Hau'oki)**

V. METHODS

Live Traps

Nondestructive sampling is one of the best approaches to monitoring rare and sensitive invertebrate species. Data on relative abundance can be collected with specially designed live-traps that cause minimal disturbance to species and their habitats. Non-destructive live-traps for Wēkiu bugs were developed and tested during the 1997-98 MKSR arthropod assessment. These live-traps provide Wēkiu bugs with food, moisture, and protection from predators and changing weather conditions, and can sustain captured individuals for several days.

Ten live-traps were set on Pu'ū Hau'oki and Pu'ū Wēkiu at the same locations where traps were installed during the previous sampling session. Five new live-traps were established on each cinder cone for reasons explained in the Discussion (Chapter VII).

Protocol for Setting Live-Traps

The sampled habitat was accessed with a minimum of disturbance to the habitat and cinder slopes. Care was taken to avoid creation of new trails or evidence of foot traffic.

Traps were installed at each sampling station by carefully digging into the cinder, disturbing only the amount of cinder necessary to set up the trap (Step 1). A hardware cloth tube was inserted into the holes so that the top of the tube was slightly below the existing surface (Step 2). The hole around the tube was refilled with the cinder that was removed from the hole and a 4-inch apron of local ash and small-sized cinder was created around each trap (Step 3). The apron allows Wēkiu bugs to easily walk into the traps.

All traps were set by placing reservoir cups into the wire tubes and pouring about 15 ml of purified water into the reservoir (Step 4). About a teaspoon of shrimp paste was spread on the coffee filter wick in the trap cups and two to three pieces of re-hydrated shrimp were added to each cup (Step 5). Four to five pieces of native cinder, 1/2" to 1" in diameter were added and the trap cups were placed into the reservoir cups such that the coffee-filter wicks made contact with the water reservoirs (Step 6).

Chum, consisting of pureed pre-moistened shrimp, was distributed

Wēkiu Bug Baseline Monitoring
METHODS

Setting a Wēkiu Bug Live-Trap



Step 1
Dig Trap Hole



Step 2
Install Wire Tube



Step 3
Create Trap Apron



Step 4
Fill Reservoir



Step 5
Bait Trap



Step 6
Add Cinder Habitat



Step 7
Distribute Chum Bait



Step 8
Emplace Cap Rock

Wēkiu Bug Baseline Monitoring
 RESULTS

VI. RESULTS

SAMPLING INFORMATION

During the 3rd Quarter 2004 baseline monitoring session there were a total of twenty-one sampling nights, making seven 3-day sampling periods.

A total of thirty Wēkiu bugs were captured, 28 on Pu‘u Hau‘oki and 2 on Pu‘u Wēkiu. The trap capture rate (number of Wēkiu bugs per trap per 3-days) ranged from 0.0 to 0.7 Wēkiu bugs. The overall trap capture rate during the 3-week sampling session was 0.4 (± 0.1) Wēkiu bugs for Pu‘u Hau‘oki, and 0.03 (± 0.03) Wēkiu bugs for Pu‘u Wēkiu (Table 1). For comparison, average trap capture rates

from previous baseline monitoring sessions and the 1997/98 Arthropod Assessment are provided (Table 2 and Table 3). Figure 1 graphs the trap average capture rates for all Baseline Monitoring on Pu‘u Hau‘oki (beginning 1st Quarter 2002). Figure 2 shows the quarterly variation in average trap capture rates for Baseline Monitoring on Pu‘u Hau‘oki.

Overall mortality was 3% (1 of 30). Apparently the improved live-trap design is helping to reduce Wēkiu bug mortality in the live-traps.

TABLE 1.
3rd QUARTER 2004 SAMPLING PERIOD
AVERAGE TRAP CAPTURE RATES
 The average number of Wēkiu bugs per trap per 3-days
 for each sampling period during 3rd Quarter 2004 Baseline Monitoring.

Location	8/24/2004	8/27/2004	8/30/2004	9/2/2004	9/5/2004	9/8/2004	9/11/2004	AVERAGE \pm SE
Pu‘u Wēkiu	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.03 \pm 0.03
Pu‘u Hau‘oki	0.30	0.20	0.10	0.60	0.50	0.70	0.40	0.40 \pm 0.10

Wēkiu Bug Baseline Monitoring
RESULTS

TABLE 2.
QUARTERLY BASELINE MONITORING
AVERAGE TRAP CAPTURE RATES
 The average number of Wēkiu bugs per trap per 3-days
 for each of the Quarterly Baseline Monitoring Sampling Sessions.
 Yearly average trap capture rates for Baseline Monitoring are in **RED**.

Location	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year Avg.
Pu'u Wēkiu 2002	0.03	0.03	0.3	0.2	0.1
Pu'u Wēkiu 2003*	2.8	11.5	0.5	0.00	3.7
Pu'u Wēkiu 2004	0.00	2.0	0.03**		0.7
Pu'u Hau'oki 2002	1.0	10.3	4.0	4.0	4.8
Pu'u Hau'oki 2003	18.5	90.6	12.4	0.8	30.6
Pu'u Hau'oki 2004	2.1	8.8	0.4**		3.8

* Different trap locations on Pu'u Wēkiu in 2003

** Ten trap average

TABLE 3. SAMPLING PERIOD AVERAGE TRAP CAPTURE RATES
 The average number of Wēkiu bugs per trap per 3-days
 for each sampling period during the 1997/98 Arthropod Assessment.
 Average trap capture rates for the 1997/98 Arthropod Assessment are in **RED**.

Location	Aug. 1997	Jan. 1998	April 1998	July 1998	Avg. 1997/98
Pu'u Wēkiu	0.15	0.0	0.07	0.15	0.11
Pu'u Hau'oki	0.20	0.0	0.20	1.10	0.38

**Wēkiu Bug Baseline Monitoring
RESULTS**

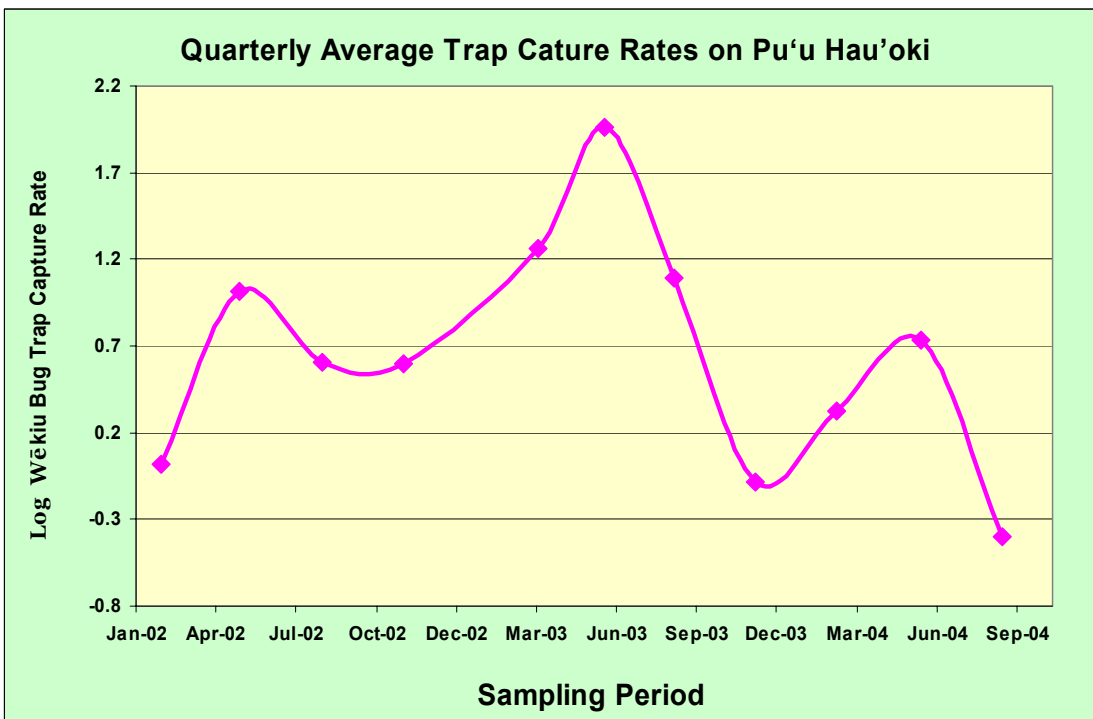


FIGURE 1. Plot of the Log Average Wēkiu Bug Trap Capture Rate per Sampling Period on Pu'u Hau'oki since Wēkiu Bug Baseline Monitoring began with the 1st Quarter 2002 sampling session.

Wēkiu Bug Baseline Monitoring
RESULTS

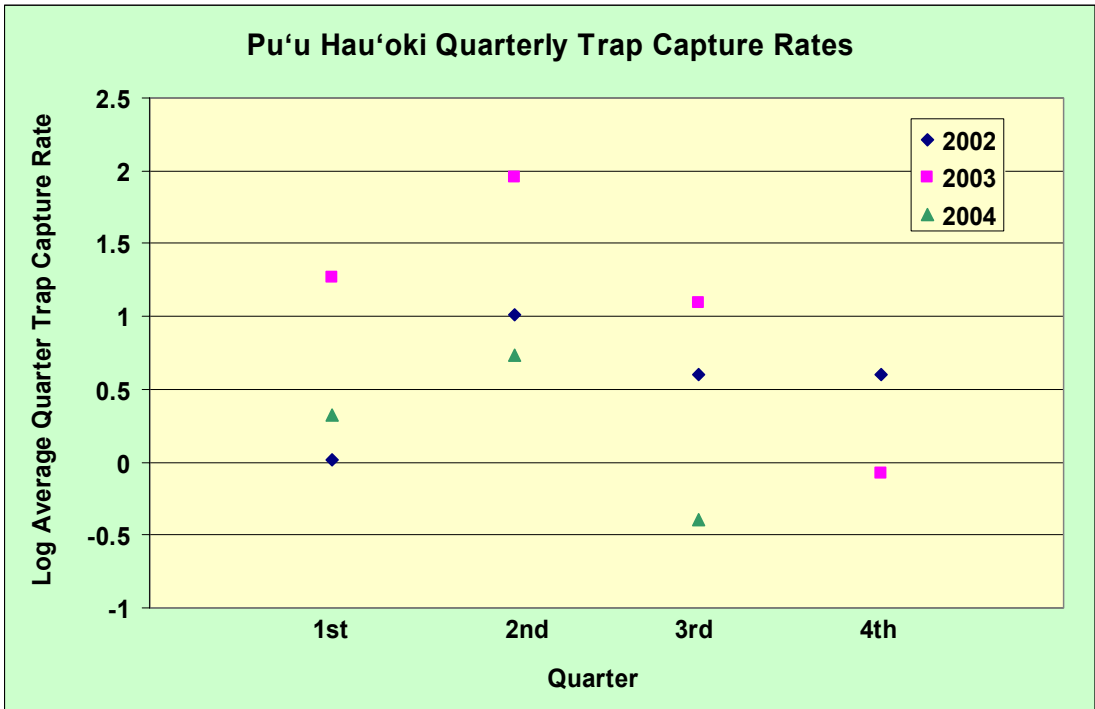


Figure 2. Pu'u Hau'oki Quarterly Average Trap Capture Rates.
 The log average quarterly trap capture rate of Wēkiu bugs on Pu'u Hau'oki
 for three years of Wēkiu Bug Baseline Monitoring.

**Wēkiu Bug Baseline Monitoring
RESULTS**

WEATHER INFORMATION

Figure 3 is a graph of Wēkiu bug trap capture rates and temperature for the 3rd Quarter 2004 monitoring session, and uses temperature data collected from the HOBO® data loggers. There was a general indication that as average temperature increased, the Wēkiu bug trap capture rate also increased.

Graphs of previous monitoring sessions are based on temperature data collected by the UKIRT Observatory. Weather information was not available for the 2nd Quarter

2004 monitoring session due to damage at the UKIRT weather station. A Graph of the log average Wēkiu bug trap capture rate plotted with average temperature for quarterly sampling sessions appears in Figure 4.

In previous Baseline Monitoring sessions, there was a general trend that indicated the number of Wēkiu bugs captured increased as average temperature increased. It appears from Figure 3 that Wēkiu bugs are not active below an average temperature of about -2°C.

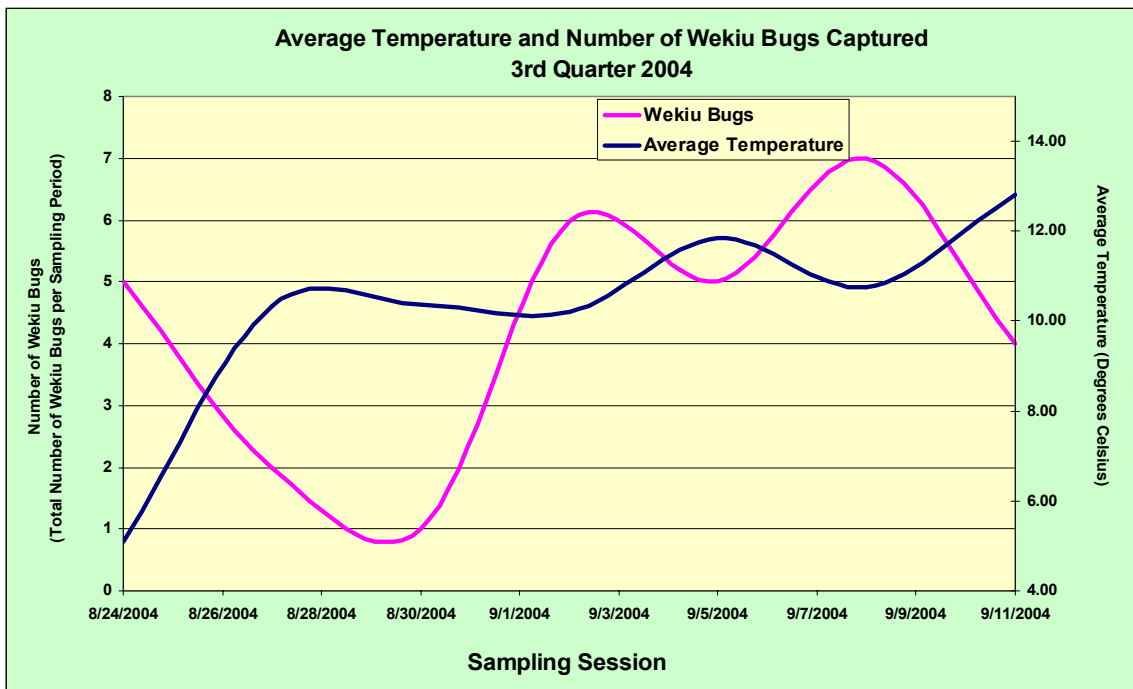


FIGURE 3. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured per Sampling Period at all sampling locations during the 3rd Quarter 2004 sampling session.

**Wēkiu Bug Baseline Monitoring
RESULTS**

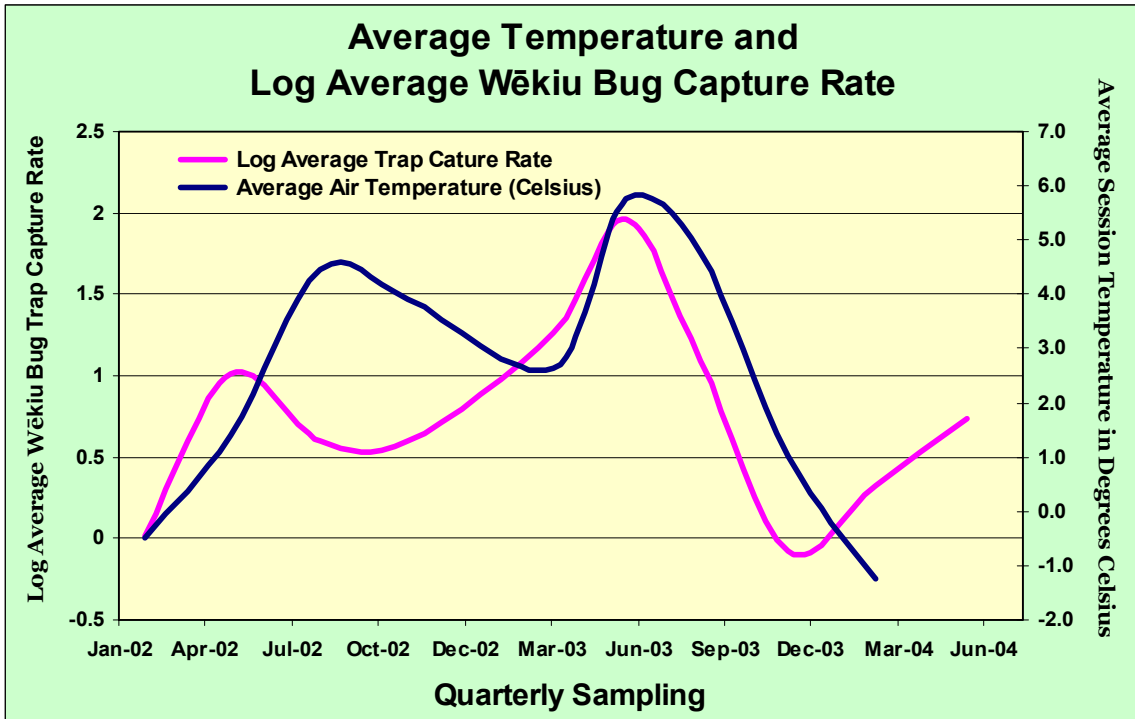


FIGURE 4. Plot of Baseline Monitoring Session Average Temperature (Celsius) and Natural Log Average Number of Wēkiu Bug Trap Capture Rate per Session on Pu’u Hau’oki.

Temperature measurements will be taken using the new data loggers and represent measurements of substrate. In past monitoring sessions, weather data was collected from near by observatories that measure air

temperature near those buildings. Because the two measurements appear to be quite different, new graphs will be added that compare temperature and trap capture data (see Figure 3). Figure 4 will no longer be updated.

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Hau'oki Inner Slope Photographic Archive

**AUGUST - SEPTEMBER 2004
TRAPS 1 - 5**



**Pu'u Hau'oki inner slope
August 21, 2004**



**Pu'u Hau'oki inner slope
August 24, 2004**



**Pu'u Hau'oki inner slope
August 27, 2004**



**Pu'u Hau'oki inner slope
August 30, 2004**

Wēkiu Bug Baseline Monitoring
RESULTS

TRAPS 1 - 5



Pu'u Hau'oki inner slope
September 2, 2004



Pu'u Hau'oki inner slope
September 5, 2004



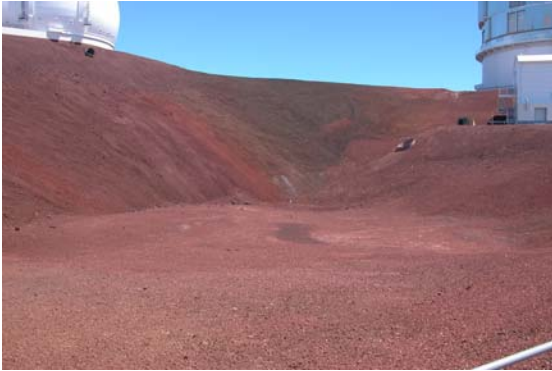
Pu'u Hau'oki inner slope
September 8, 2004



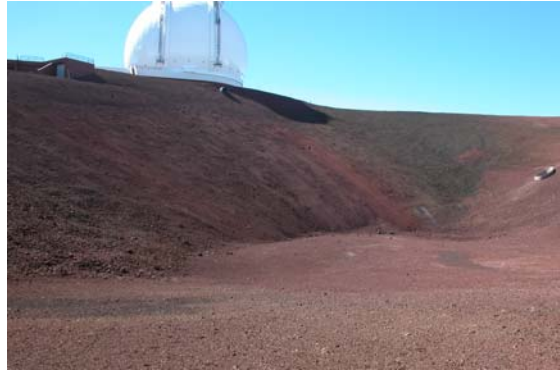
Pu'u Hau'oki inner slope
September 11, 2004

Wēkiu Bug Baseline Monitoring
RESULTS

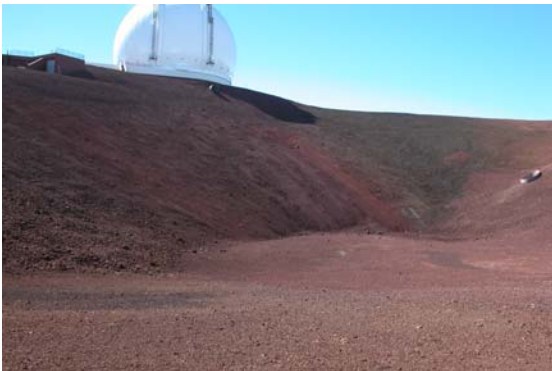
AUGUST - SEPTEMBER 2004
TRAPS 6 - 10



Pu'u Hau'oki inner slope
August 21, 2004



Pu'u Hau'oki inner slope
August 24, 2004



Pu'u Hau'oki inner slope
August 27, 2004



Pu'u Hau'oki inner slope
August 30, 2004

Wēkiu Bug Baseline Monitoring
RESULTS

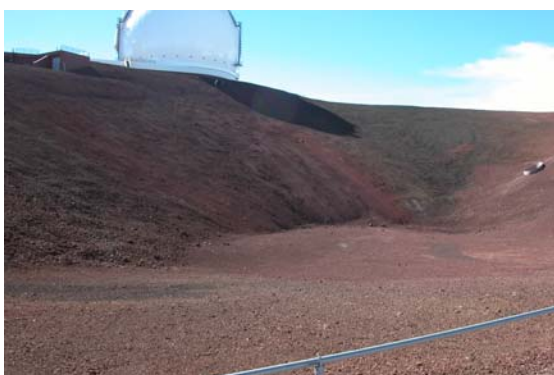
TRAPS 6 - 10



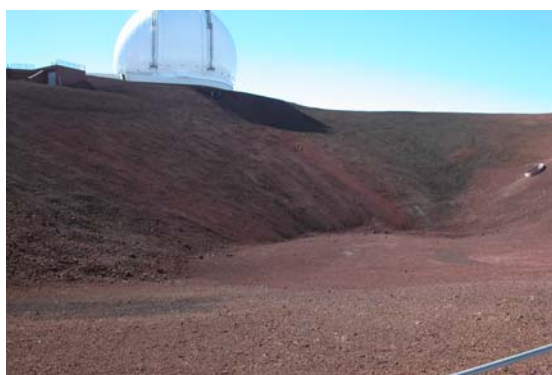
Pu'u Hau'oki inner slope
September 2, 2004



Pu'u Hau'oki inner slope
September 5, 2004



Pu'u Hau'oki inner slope
September 8, 2004



Pu'u Hau'oki inner slope
September 11, 2004

**Wēkiu Bug Baseline Monitoring
RESULTS**

TRAPS 1 - 5



**Pu'u Wēkiu inner slope
September 2, 2004**



**Pu'u Wēkiu inner slope
September 5, 2004**

Photo not Available

**Pu'u Wēkiu inner slope
September 8, 2004**



**Pu'u Wēkiu inner slope
September 11, 2004**

Wēkiu Bug Baseline Monitoring
RESULTS

AUGUST - SEPTEMBER 2004
TRAPS 6 - 10



Pu'u Wēkiu inner slope
August 21, 2004



Pu'u Wēkiu inner slope
August 24, 2004



Pu'u Wēkiu inner slope
August 27, 2004



Pu'u Wēkiu inner slope
August 30, 2004

XX

Wēkiu Bug Baseline Monitoring RESULTS

XX

TRAPS 6 - 10



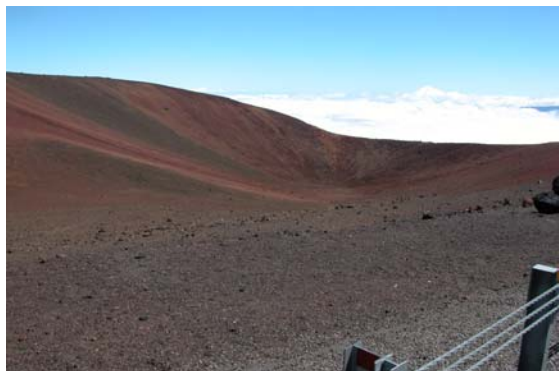
**Pu'u Wēkiu inner slope
September 2, 2004**



**Pu'u Wēkiu inner slope
September 5, 2004**

Photo not Available

**Pu'u Wēkiu inner slope
September 8, 2004**



**Pu'u Wēkiu inner slope
September 11, 2004**

**Wēkiu Bug Baseline Monitoring
RESULTS**

Pu‘u Wēkiu and Hau Kea Photographic Archive

AUGUST - SEPTEMBER 2004



**Pu‘u Wēkiu and Hau Kea
August 21, 2004**



**Pu‘u Wēkiu and Hau Kea
August 24, 2004**



**Pu‘u Wēkiu and Hau Kea
August 27, 2004**



**Pu‘u Wēkiu and Hau Kea
August 30, 2004**

Wēkiu Bug Baseline Monitoring
DISCUSSION

VII. DISCUSSION

Trapping Data

Permission to begin Baseline Wēkiu bug monitoring was received on January 21, 2002. On January 28, 2002 Pacific Analytics personnel installed 10 live-traps in designated areas, five on the inner slopes of Pu'u Hau'oki and five on the slopes of Pu'u Wēkiu. Sampling began in February 2002.



Adult Wēkiu bug on cinder near a live-trap.

Over the four quarters of monitoring during 2002, 696 Wēkiu bugs were captured in live-traps, and Wēkiu bug trap capture rates averaged 4.82 bugs per trap per 3-day trapping period on Pu'u Hau'oki, and 0.13 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

Over the four quarters of monitoring during 2003, 4,237 Wēkiu bugs were captured in live-traps. Wēkiu bug trap capture rates averaged 30.57 bugs per trap per 3-day trapping period on Pu'u Hau'oki, and 3.71 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

During the 1st Quarter 2004 sampling session a total of eighty-six Wēkiu bugs appeared in or near the traps. The 1st Quarter 2004 average trap capture rate was 2.1 bugs per trap per 3-day trapping period on Pu'u Hau'oki and 0.00 on Pu'u Wēkiu.

During the 2nd Quarter 2004 sampling session a total of three hundred eighty-three Wēkiu bugs appeared in or near the traps. The 2nd Quarter 2004 average trap capture rate was 8.8 bugs per trap per 3-day trapping period on Pu'u Hau'oki and 2.0 on Pu'u Wēkiu.

In August 2004 permission to install 10 additional live-traps was received. Pacific Analytics personnel installed 10 additional live-traps in designated areas, five on the inner slopes of Pu'u Hau'oki and five on the inner slopes of Pu'u Wēkiu.

The Department of Land and Natural Resources (DLNR) approved the

Wēkiu Bug Baseline Monitoring DISCUSSION

additional traps based on recommendations from a panel of Wēkiu bug experts that met in June 2004. The new traps are placed near the trapping locations used during the 1982 arthropod assessment and will provide a better comparison between historic and current data.

There are also statistical implications from the additional traps. Increasing the number of traps will reduce the standard errors associated with future samples enabling detection of finer differences between quarterly sampling sessions.

During the 3rd Quarter 2004 sampling session Wēkiu bugs appeared in two of ten of the traps on Pu‘u Wēkiu and eight of ten traps on Pu‘u Hau‘oki. A total of thirty Wēkiu bugs appeared in or near the traps during the seven trapping sessions. All live bugs were released back into their habitat.

Average 3rd Quarter 2004 trap capture rate on Pu‘u Hau‘oki was 0.4 (±0.1) bugs per trap per 3-day trapping period. Average 3rd Quarter 2004 trap capture rate on Pu‘u Wēkiu was 0.03 (±0.03) bugs per trap per 3-day trapping period.

The 3rd Quarter 2004 Wēkiu bug capture rate on Pu‘u Hau‘oki was one tenth the capture rate measured in the 3rd Quarter 2002 sampling session, and

thirty times smaller that the capture rate measured in the 3rd Quarter 2003 sampling session (Table 2).

The 3rd Quarter 2004 Wēkiu bug capture rate on Pu‘u Wēkiu was one tenth the capture rate measured in the 3rd Quarter 2002 sampling session, and sixteen times smaller that the capture rate measured in the 3rd Quarter 2003 sampling session (Table 2).

There were no construction activities or chemical spills that resulted in major habitat disturbance during 2003 and 2004 that could account for the drop in trap capture rate. The drop was apparently part of a normal cycle, or was caused by other factors that were not readily apparent.

About 20% of the Wēkiu bugs were captured in the 3rd Quarter 2004 sampling session were immature stages. During the 3rd Quarter 2002 and 2003 sampling sessions were 23% and 50% respectively. 2003 was apparently an exceptional year, with high trap capture rates and high reproductive rates. Further analysis of conditions leading up and during 2003 may provide clues about what factors may influence Wēkiu bug populations.

The average temperatures during the 3rd Quarter 2004 sampling session were measured using data loggers placed directly in the cinder. In

