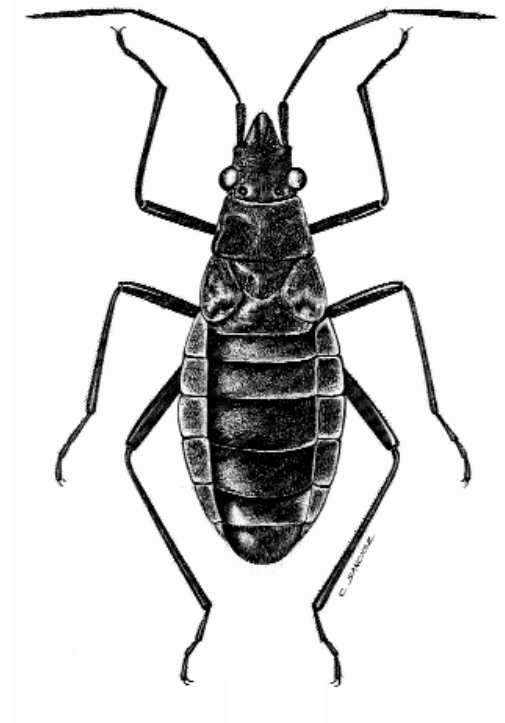


WĒKIU BUG
BASELINE MONITORING

QUARTERLY REPORT
1st QUARTER 2006



Pacific Analytics, L.L.C.

WĒKIU BUG
BASELINE MONITORING

QUARTERLY REPORT
1st QUARTER 2006

Prepared for

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



Pacific Analytics, L.L.C.

P.O. Box 219
Albany, Oregon 97321
www.statpros.com

Prepared by:

Pacific Analytics, L.L.C.
Post Office Box 219
Albany, Oregon 97321
Tel. (541) 926-0117
mail@statpros.com
www.statpros.com

Gregory Brenner
Senior Associate / Project Manager

The pictures contained in this report are for the exclusive use by Pacific Analytics, L.L.C and its clients. All photographs are copyrighted by Pacific Analytics, L.L.C. and may not be reproduced or used without the express written permission of 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 1st QUARTER 2006

I. TABLE OF CONTENTS

	Page
I. TABLE OF CONTENTS	1
II. EXECUTIVE SUMMARY	2
III. INTRODUCTION	4
IV. QUESTIONS OF INTEREST	6
V. METHODS	8
VI. RESULTS	12
VII. DISCUSSION	31

XX

Wēkiu Bug Baseline Monitoring
EXECUTIVE SUMMARY

XX

II. EXECUTIVE SUMMARY

The Mauna Kea Science Reserve (MKSr) 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

III. INTRODUCTION

The Mauna Kea Science Reserve 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 11,700' (3,570 m) elevation.

Current plans call for adding four to six Outrigger Telescopes on the WMKO site. The Outrigger Telescopes would be placed strategically around the existing Keck Telescopes.

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 populations of Wēkiu bugs were last measured at these sites in 1998 during an arthropod assessment which became part of the Environmental Impact Statement prepared for the Mauna Kea Science Reserve Master Plan approved in 2000 by the UH Board of Regents. This new monitoring activity will provide current information.

The intended purpose of the current 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

IV. QUESTIONS OF INTEREST

Important Questions of Interest are those with answers that can be efficiently estimated and that yield the information necessary for management decision-making. The following Questions of Interest were developed in the Baseline Monitoring Plan and are the focus of this report.

Question 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).

Justification:

Baseline monitoring of Wēkiu bugs will yield reliable scientific information about the current status of Wēkiu bugs, and trends in their population. The information will be useful to compare to status and trends during construction of the proposed Outrigger Telescopes.

Monitoring goals:

- 1) To provide historical records of change in Wēkiu bug population attributes, and characteristics,
- 2) To detect trends, periodicities, cycles, and/or other patterns in those changes, and
- 3) To associate auxiliary phenomena, attributes, and characteristics with trends and patterns of change in Wēkiu bug population attributes, and characteristics.

**Wēkiu Bug Baseline Monitoring
QUESTIONS OF INTEREST**

Question 2

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

Justification:

Snow, rain, day/night temperatures, and other weather phenomena may be associated with Wēkiu Bug population change. Monitoring these indirect factors will aid in understanding trends in Wēkiu Bug population change.

Monitoring goals:

To associate environmental phenomena and attributes, and characteristics of human activities with trends and patterns of change in Wēkiu Bug populations.



Traps were often found buried by snow after storms. Photo taken March 25, 2006.

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.

During the 1st Quarter 2006 sampling session twelve live-traps were open for the entire sampling session, eight traps on Pu'u Hau'oki and four traps on Pu'u Wēkiu. Traps were set at the same monitoring stations installed during previous sampling sessions. Snow cover and frozen cinder prevented opening other monitoring stations.

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.

Monitoring stations were established in previous sampling sessions 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.

Traps were set at each available monitoring station 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).

Wēkiu Bug Baseline Monitoring
METHODS

Chum, consisting of pre-moistened shrimp, was distributed around the traps and a teaspoon of shrimp paste was spread on the bottom of the cap rocks (Step 7). Irrigation flags to mark the locations were wrapped around cap rocks, ten to fifteen inches in diameter. The cap rocks were then placed over each trap such that the entire trap was shaded from sunlight (Step 8).

Traps were checked for Wēkiu bugs every three days during the sampling session, or as weather permitted. During each live-trap check, an area about 20 cm in diameter around the live-trap was checked for the presence of Wēkiu bugs. The cap rock was also inspected for the presence of Wēkiu bugs. The trap cups were then removed and carefully inspected for Wēkiu bugs. Live Wēkiu bugs, if present, were counted and released to cinder habitat one to two meters away

from the live-trap. Dead arthropods were collected in vials filled with alcohol.

Live-traps were reset by topping off the water reservoir, and by placing new bait and chum in and around the live-traps. When the 3-week sampling session was complete, both cups were removed, and cap rocks placed over the wire tubes. Small identification tags containing contact information were attached to the flag wires. The same monitoring stations will be used for future sampling.

Traps were opened for the 1st Quarter 2006 baseline monitoring session on March 11, 2006 and were closed on March 31, 2006. Summit weather conditions caused frequent summit access road closures which interfered with scheduled sampling during this quarter of monitoring.

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

During the 1st Quarter 2006 baseline monitoring session there were a total of twenty sampling nights, making two 3-day sampling periods, two 4-day sampling periods, and one 6-day sampling period.

No Wēkiu bugs were captured on Pu‘u Hau‘oki and Pu‘u Wēkiu (Table 1). Approximately four hours were spent searching for Wēkiu bugs in open areas and near the margins of snow fields, but no Wēkiu bugs were observed.

For perspective, average trap capture rates from previous baseline monitoring sessions and the 1982 and 1997/98 Arthropod Assessments are provided (Table 2 and Table 3).

Average trap capture rates reported for the 1982 and 1997/98 arthropod assessments are those measured in comparable locations on Pu‘u Hau‘oki crater and Pu‘u Wēkiu as those measured for Wēkiu Bug Baseline Monitoring. The 1982 measurements were recorded during July and August.

Figure 1 graphs the log₁₀ average trap capture rates for all Baseline Monitoring on Pu‘u Hau‘oki (beginning 1st Quarter 2002). Figure 2 shows the quarterly variation in log₁₀ average trap capture rates for Baseline Monitoring on Pu‘u Hau‘oki.

TABLE 1.
1ST QUARTER 2006 SAMPLING PERIOD
AVERAGE TRAP CAPTURE RATES
 The average number of Wēkiu bugs per trap per 3-days
 for each sampling period during the 1st Quarter 2006 Baseline Monitoring.

Location	03/14/2006	03/18/2006	03/21/2006	03/25/2006	03/28/2006	03/31/2006	AVERAGE ± SE
Pu‘u Wēkiu	0.00	0.00	0.00	0.00	NA	0.00	0.00
Pu‘u Hau‘oki	0.00	0.00	0.00	0.00	NA	0.00	0.00

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	0.0	3.7
Pu'u Wēkiu 2004	0.00	2.0	0.03	0.06	0.5
Pu'u Wēkiu 2005	1.14	0.64	1.26	0.12	0.79
Pu'u Wēkiu 2006	0.00				0.00
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	0.21	2.9
Pu'u Hau'oki 2005	15.92	5.09	5.99	0.62	6.91
Pu'u Hau'oki 2006	0.00				0.00

* - different trap locations on Pu'u Wēkiu in 2002

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 1982 and 1997/98 Arthropod Assessments.
Average trap capture rates for the 1997/98 Arthropod Assessment are in **RED**.

Location	Aug. 1997	Jan. 1998	Apr-98	Jul-98	1997/98 Avg.	Jul-82
Pu'u Wēkiu	0.15	0	0.07	0.15	0.11	225
Pu'u Hau'oki	0.2	0	0.2	1.1	0.38	105.6

**Wēkiu Bug Baseline Monitoring
RESULTS**

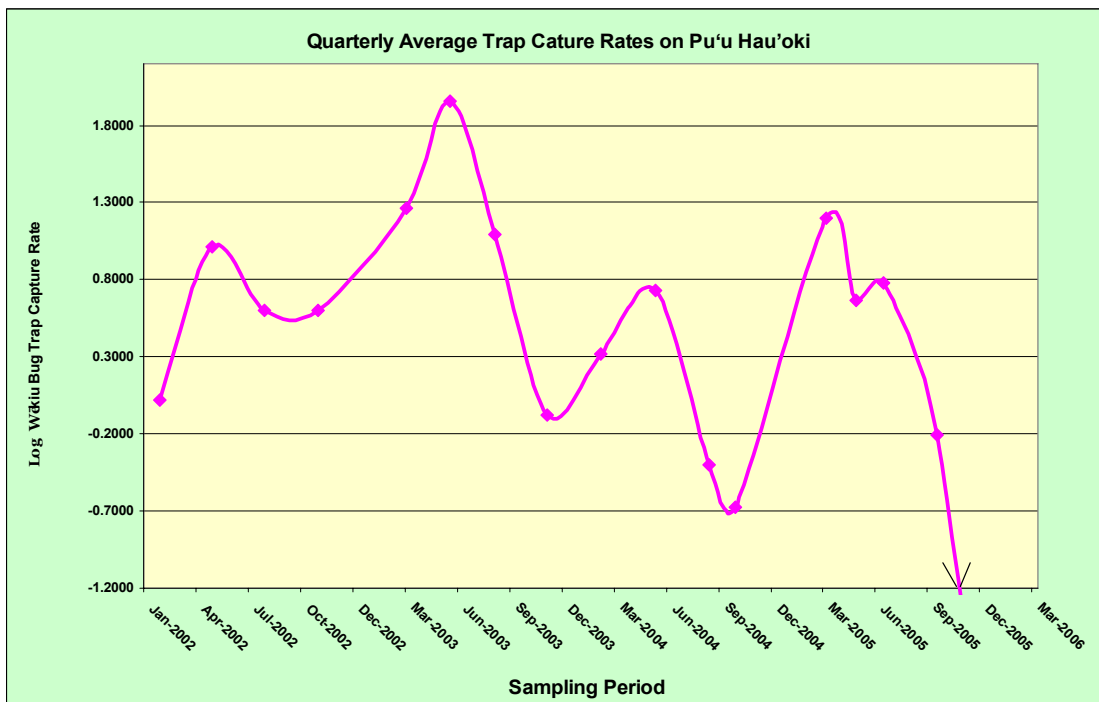


FIGURE 1. Graph of the log₁₀ Average Wēkiu Bug Trap Capture Rate per Sampling Period on Pu'u Hau'oki since Wēkiu Bug Baseline Monitoring began in February 2002.

Wēkiu Bug Baseline Monitoring
 RESULTS

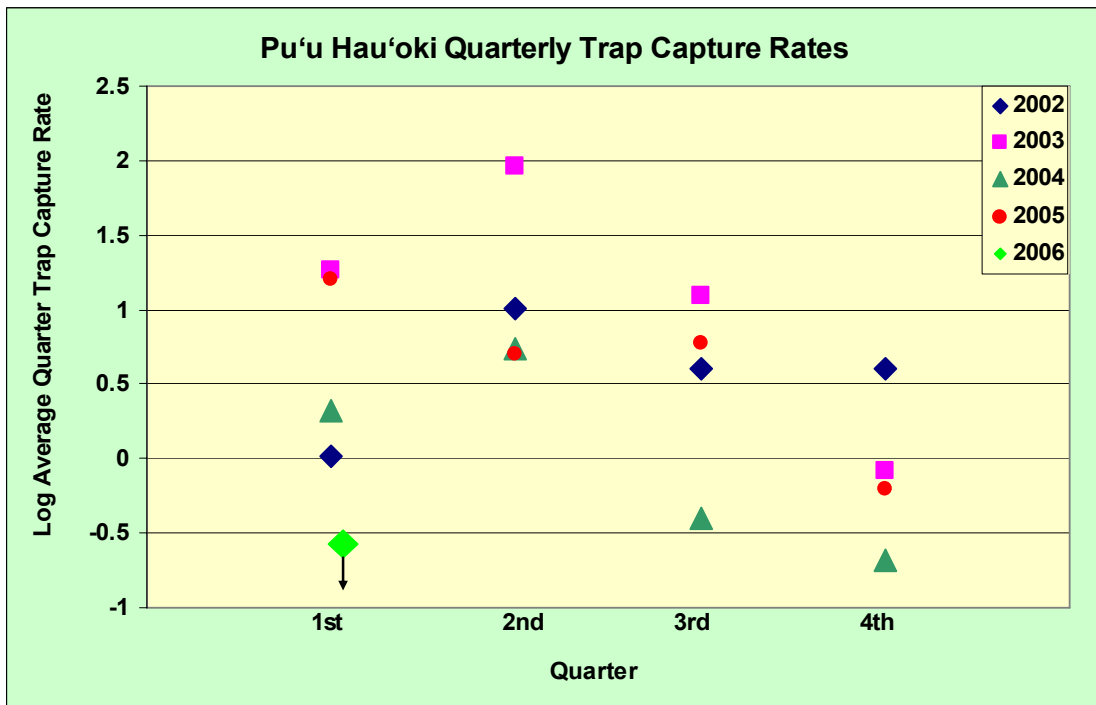


FIGURE 2. Pu'u Hau'oki Quarterly Average Trap Capture Rates.
 The \log_{10} average quarterly trap capture rate of Wēkiu bugs on Pu'u Hau'oki
 for four years of Wēkiu Bug Baseline Monitoring.

**Wēkiu Bug Baseline Monitoring
RESULTS**

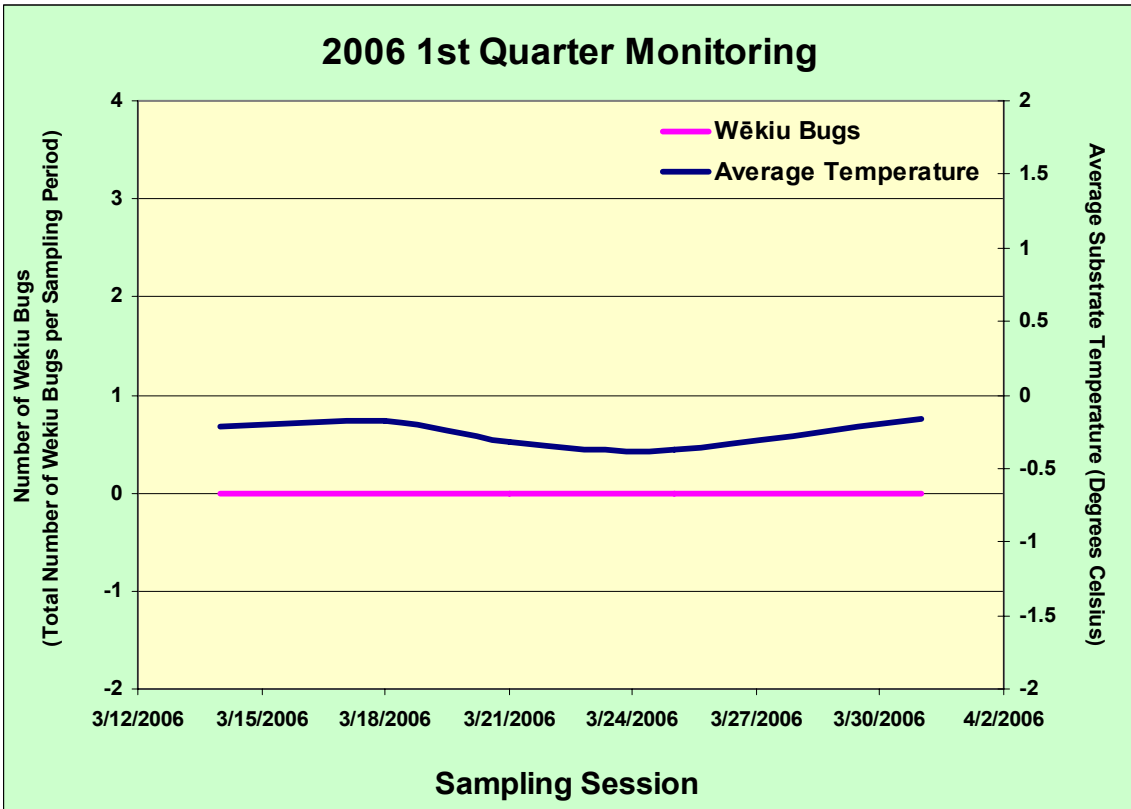


FIGURE 3. Plot of Average Temperature (Celsius) and Total Number of Wēkiu Bugs Captured per Sampling Period at all sampling locations during the 1st Quarter 2006 sampling session.

**Wēkiu Bug Baseline Monitoring
RESULTS**

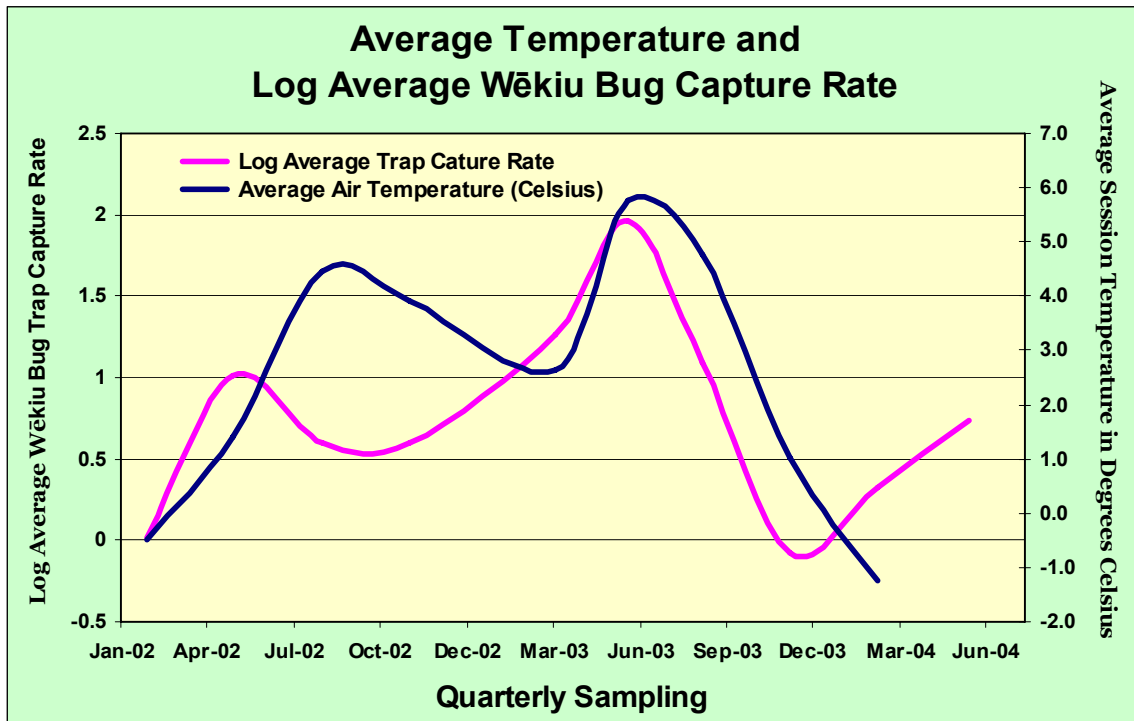


FIGURE 4. Plot of Baseline Monitoring Session Average Temperature (Celsius) and Natural Log Average Number of Wēkiu Bug Trap Capture Rate per Session on Pu’u Hau’oki.

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Hau'oki Inner Slope Photographic Archive

MARCH 2006
TRAPS 1 - 5



Pu'u Hau'oki inner slope
March 11, 2006



Pu'u Hau'oki inner slope
March 14, 2006



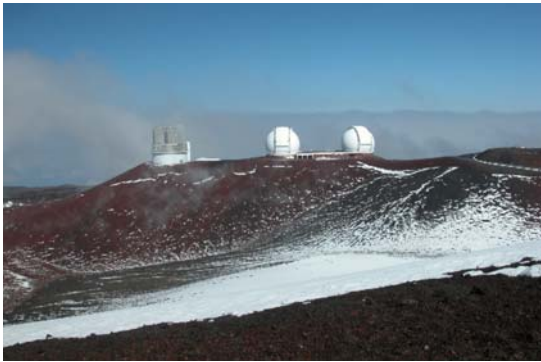
Pu'u Hau'oki inner slope
March 18, 2006



Pu'u Hau'oki inner slope
March 21, 2006

Pu'u Hau'oki Outer Slope Photographic Archive

MARCH 2006



Pu'u Hau'oki outer slope
March 11, 2006



Pu'u Hau'oki outer slope
March 14, 2006



Pu'u Hau'oki outer slope
March 18, 2006



Pu'u Hau'oki outer slope
March 21, 2006

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Wēkiu Photographic Archive

**MARCH 2006
TRAPS 1 - 5**



**Pu'u Wēkiu inner slope
March 11, 2006**



**Pu'u Wēkiu inner slope
March 14, 2006**



**Pu'u Wēkiu inner slope
March 18, 2006**



**Pu'u Wēkiu inner slope
March 21, 2006**

Wēkiu Bug Baseline Monitoring
RESULTS

**MARCH 2006
TRAPS 6 - 10**



**Pu'u Wēkiu inner slope
March 11, 2006**



**Pu'u Wēkiu inner slope
March 14, 2006**



**Pu'u Wēkiu inner slope
March 18, 2006**



**Pu'u Wēkiu inner slope
March 21, 2006**

Wēkiu Bug Baseline Monitoring
RESULTS

Pu'u Wēkiu and Pu'u Hau Kea Photographic Archive

MARCH 2006



**Pu'u Wēkiu and Pu'u Hau Kea
March 11, 2006**



**Pu'u Wēkiu and Pu'u Hau Kea
March 14, 2006**



**Pu'u Wēkiu and Pu'u Hau Kea
March 18, 2006**



**Pu'u Wēkiu and Pu'u Hau Kea
March 21, 2006**

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-trap monitoring stations 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.

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.

Over the four quarters of monitoring during 2004, 518 Wēkiu bugs were captured in live-traps. Wēkiu bug trap capture rates averaged 2.9 bugs per trap per 3-day trapping period on Pu'u

Hau'oki, and 0.5 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

Over the four quarters of monitoring during 2005, 1,383 Wēkiu bugs were captured in live-traps. Wēkiu bug trap capture rates averaged 6.9 bugs per trap per 3-day trapping period on Pu'u Hau'oki, and 0.8 bugs per trap per 3-day trapping period on Pu'u Wēkiu.

No Wēkiu bugs were captured or observed during the 1st Quarter 2006 sampling period. This was the first Quarterly sampling period during which no Wēkiu bugs were observed on Pu'u Hau'oki. Trap capture rates have typically been low during the colder months of previous sampling periods, and the severe mountain storms and snow cover experienced during March probably influenced Wēkiu bug activity.

There have been two other Quarterly sampling periods during which no Wēkiu bugs were captured on Pu'u Wēkiu, 4th Quarter 2003 and 1st Quarter 2004. A significant amount of snow fell during those Quarters as well, and average temperatures were low.

