IX. MONITORING

Analysis

This Mitigation Report provides recommendations for protection and enhancement of the Wēkiu bug habitat and population adjacent to the proposed Outrigger Telescope construction site. The recommendations are based on current scientific hypotheses about Wēkiu bug autecology. Hypothesis formation is an important stage in the scientific method, but it is not the complete process. Hypotheses must be investigated, and evidence must be gathered, (in an unbiased manner), in order to acquire new knowledge.

Environmental monitoring is the scientific investigation of the changes in environmental phenomena, attributes and characteristics that happen over time. An investigation concerned only with measuring environmental phenomena at a single point in time is called an inventory. Monitoring is a series of inventories taken over time, repeated measurements taken in such a way as to be comparable with each other. The general purpose of the comparisons is to detect, understand, and predict the changes.

Managers of the observatories on Mauna Kea need reliable, scientific information about the Wēkiu bug, about the impacts of management actions to the habitat, and about changes in the population over time. Environmental monitoring is the best way to obtain that information. Monitoring will provide the data needed to protect and enhance natural resources, to modify management actions, to aid in compliance with environmental statutes, and to enhance public education and appreciation of the natural resources at the summit of Mauna Kea.

Two types of monitoring are necessary: **compliance** monitoring and **effectiveness** monitoring. Compliance monitoring investigates the extent to which contractors, operators, managers, and visitors comply with Wēkiu bug protection guidelines and rules. Effectiveness monitoring investigates the changes in Wēkiu bug habitat and population that happen concurrently with construction and operation of the Outrigger Telescopes.

Monitoring Recommendations

Recommendation IX-1: A Wēkiu Bug Monitoring Plan should be developed, with both compliance and effectiveness monitoring components.

CARA, JPL, NASA, and UH have already recognized the need for a Wēkiu Bug Monitoring Plan, and development of that Monitoring Plan is underway. The Monitoring Plan will specify tasks, budgets, schedules, and methods for both compliance and effectiveness monitoring. The Monitoring Plan will describe analytical methods for assuring that the recommendations in this Mitigation Report are implemented and adhered to during construction, (compliance). The Monitoring Plan will also provide a systematic and efficient approach for measuring Wēkiu bug habitat and population changes before and during Outrigger Telescope construction, (effectiveness).

We have identified the following seven-step process for planning of environmental monitoring:

1) Prepare clear statements of the important Questions of Interest.
2) Design the sampling systems
3) Develop sampling protocols for data collection
4) Prepare the data management systems
5) Plan the analysis and interpretation systems
6) Develop a reporting system
7) Develop a monitoring sustainability plan

Important Questions of Interest (QI's) are those with answers that can be efficiently estimated and that yield the information necessary for management decision-making. The Monitoring Plan will identify the important issues and concerns, and reduce general problems to questions of specific, measurable attributes. Among those will be compliance checks to ensure that the recommendations in this Mitigation Report are followed. The QI's will also include measurement of Wēkiu bug population changes and changes in habitat characteristics, to be examined for relationships to natural phenomena (weather/climate) and human activities at the summit.

The second step in monitoring planning will be design of the sampling systems that will be used to investigate the QI's selected. The sampling systems will be statistically valid, robust, cost-efficient, and effective at answering the QI's. Sampling system design

techniques to be applied include cost allocation analysis, sampling structure determinations, sample size determinations, scale evaluations, randomization, replication, blocking, and covariate determinations. Schedules of sampling efforts will also be developed. Designed experiments, based on expected operational activities, could be incorporated into the sampling system to measure the effectiveness of mitigation actions. Control areas will be planned for operational management treatments where applicable.

Sampling methodologies will be designed for each QI. These could include quadrats, transects, plots, traps, telemetry, or other sampling methods. Evaluation will be made of the desirability of permanent sampling stations versus temporary stations.

Sample size determinations will be made for each QI. These will be based on estimated inferential strength measures such as variance, standard deviation, and population considerations including distributional assumptions. Because monitoring is the investigation of change over time, schedules for repeated samplings will be developed for each QI. The frequency of measurement will also be based on inferential strength measures desired and estimated rates of change.

Analysis will be made of cost versus utility for each sampling system. Evaluation will be made of the projected cost of sampling and the potential value of the information to be gained through sampling for each QI. When applicable, cost allocation algorithms will be applied to each sampling system to build in efficiency.

The designed sampling systems will include procedures for evaluating operational treatments and mitigation activities. Cause-and-effect hypotheses may be tested only through designed experiments with control of confounding factors. Sampling systems will utilize experimental design principles including: controls, factorization, blocking designs, and factorial arrangement of treatment levels. Efforts will be made to incorporate such designs into operational treatments with the most efficiency and least disruption to construction and management activities.

The third step will be to develop sampling protocols, (field manuals that guide data collection). Sampling protocols will be developed for each sampling system selected. The protocols will include specific methods to be used, descriptions of the tools necessary for data collection, and randomization schemes for determining trap placement and location. Nondestructive sampling techniques will be recommended.

The fourth step will be the preparation of a data management plan. The data management plan will evaluate and recommend data entry methodologies, including hand-held field computers. The plan will also evaluate and recommend error-checking procedures and algorithms to ensure the accuracy and precision of measurements and counts. Archiving and data backup methodologies will be developed, including archival of associated protocols and field notes. Database software will be specified, and appropriate data fields will be elucidated. Recommendations for curation of scientific specimens and field sample materials will also be made, if needed.

The fifth step in monitoring planning will be the development of an analysis and interpretation plan. Statistical analysis and scientific interpretation are necessary to produce logical inferences and new knowledge from monitoring data. Techniques of exploratory data analysis (EDA), graphics, statistical distribution tests, data transformations, and modeling will be specified. Monitoring models such as time trend analysis, survival analysis, growth and mortality models, diversity index models, and population change models will be evaluated and recommendations for selection made. Evaluations will include review of the selected sampling system designs and the statistical structure of the data to be collected.

The data analysis and interpretation plan will include discussion of the QI's and the environmental parameters to be estimated. Inferential strength measures appropriate to each QI will be evaluated. Methods of biological interpretation will be discussed.

The sixth step will be the development of a plan for reporting the results of monitoring. Monitoring reports will be carefully planned with consideration of the intended audience and the appropriate application of the findings. The report and presentation plan will include discussion of the types of reports, publishable units, and demonstrations that are applicable and appropriate. Discussion will include evaluations and recommendations for the types of charts, tables, and maps that will be included in monitoring reports and presentations. Monitoring report dates will be scheduled.

A seventh step would be development of a monitoring sustainability plan. Such a step would include establishing institutional commitment to secure annual budgetary planning for future monitoring efforts.

Monitoring happens in the context of time. Environmental changes, and cycles and trends in those changes, are often detected only after several years of data collection. By involving other stakeholders, such as other Mauna Kea observatories, the Hawai‘i

Department of Land and Natural Resources, the US Fish and Wildlife Service, native Hawaiian groups, environmental groups, and concerned citizens, the University of Hawai‘i will help to build community commitment and sustainability to monitoring.

Recommendation IX-2: The Wēkiu Bug Monitoring Plan should be implemented through a Monitoring Program.

A Monitoring Program would implement the tasks, budgets, schedules, and methods for both compliance and effectiveness monitoring specified in the Monitoring Plan. The Monitoring Program would assure that mitigation is implemented and adhered to during construction, (compliance), and that measurements and analysis are made of Wēkiu bug population changes and attributes before, during, and after Outrigger Telescope construction, (effectiveness).

Recommendation IX-3: Construction contracts should ensure that compliance violations are corrected.

The recommendations in this Mitigation Report should become guidelines and rules for contractors building the proposed Outrigger Telescopes, light tunnels, and retaining walls. A well-designed Monitoring Program will detect violations of those guidelines, should they occur. Violations or other errors should be corrected in a manner that protects and enhances Wēkiu bug populations and habitat.

X. LIST OF RECOMMENDATIONS

IV-1 Wēkiu bug habitat should be restored in areas damaged by on-site Outrigger Telescope construction, and in the crater floor of Puʻu Hau ʻOki. Restored areas should total at least three times the total area damaged by new construction. [page 12]

IV-2: Under no circumstances should cinder or other materials be side-cast into Wēkiu bug habitat. Temporary, and if possible, permanent barriers should be built along the slope breaks above the inner slopes of Puʻu Hau ʻOki crater. [page 13]

IV-3: Educational signs should be placed along the slope break above Wēkiu bug habitat, and at the service road adjacent to the crater floor. [page 14]

IV-4: The WMKO staff should continue current practices for dealing with on-site deep snow events. [page 14]

V-1: Water should be applied to excavation sites and cinder stockpiles. [page 17]

V-2: Dust-generating activities should be suspended during high winds. [page 17]

V-3: Soil-binding stabilizers should be used sparingly, and should never be applied to Wēkiu bug habitat. [page 18]

VI-1: The WMKO staff should continue to follow Federal guidelines specifying the use and disposal of substances used in the washing and recoating of observatory mirrors. [page 20]

VI-2. Contractors should minimize the amount of on-site paints, thinners, and solvents. Painting and construction equipment should not be cleaned on-site. Contractors should keep a log of hazardous materials brought on-site and report spills immediately to a designated WMKO representative. [page 22]

VII-1: Construction trash containers should be tightly covered to prevent construction wastes from being dispersed by wind. [page 25]

VII-2: Construction materials stored at the site should be covered with tarps, or anchored in place, and not be susceptible to movement by wind. [page 25]

VII-3: Outdoor trash receptacles should be secured to the ground and attached lids. [page 25]

VII-4: If construction materials and trash are blown into Wēkiu bug habitat, they should be collected with a minimum of disturbance to the habitat. [page 26]

VIII-1: Earthmoving equipment should be free of large deposits of soil, dirt and vegetation debris that may harbor alien arthropods. [page 31]

(a) Pressure-wash to remove alien arthropods

(b) Eradicate ant infestations at equipment storage sites and staging areas

(c) Inspect large trucks, tractors, and other heavy equipment before proceeding up the observatory road.

VIII-2: All construction materials, crates, shipping containers, packaging material, and observatory equipment should be free of alien arthropods when delivered to the summit. [page 32]

(a) Inspect shipping crates, containers, and packing materials before shipment to Hawai‘i

(b) Inspect construction materials before transport to the summit area

VIII-3: Outdoor trash receptacles should be secured to the ground, have attached lids and plastic liners, and be collected frequently to reduce food availability for alien predators. [page 33]

VIII-4: New alien arthropod introductions detected during monitoring should be eradicated. [page 34]

(a) Ant eradication

(b) Yellowjacket eradication

(c) Alien spider eradication

IX-1: A Wēkiu Bug Monitoring Plan should be developed, with both compliance and effectiveness monitoring components. [page 36]

IX-2: The Wēkiu Bug Monitoring Plan should be implemented through a Monitoring Program. [page 39]

IX-3: Construction contracts should ensure that compliance violations are corrected. [page 39]

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