

**ARTHROPOD FAUNA INVENTORY  
AND ASSESSMENT FOR THE  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII**

**December 2005**

Prepared for

**KC Environmental, Inc.  
Makawao, Hawai'i**



*Pacific Analytics, L.L.C.*

**Natural Resource Consultants**

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.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

ARTHROPOD FAUNA INVENTORY  
AND ASSESSMENT FOR THE  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

December 2005

I. TABLE OF CONTENTS

	Page
I. TABLE OF CONTENTS .....	1
II. EXECUTIVE SUMMARY .....	2
III. INTRODUCTION .....	3
IV. PROJECT DESCRIPTION .....	5
V. METHODS .....	6
VI. RESULTS AND DISCUSSION .....	10
VII. BIBLIOGRAPHY .....	15

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

## II. EXECUTIVE SUMMARY

Keonehunehune on 'Ulupalakua Ranch below Pu'u Makua is the proposed relocation site for radio and television broadcast facilities currently located adjacent to the Haleakalā High Altitude Observatories near the summit of Haleakalā. The pre-existing broadcast facilities at the proposed site reduce the need for the level of infrastructure improvements that would be necessary at alternative sites.

Various environmental and cultural issues are being addressed prior to relocation of the broadcast facilities to Keonehunehune. One of these is the potential impact of broadcast facility construction on arthropod resources that may be present on the proposed site.

To that end, an Environmental Assessment is being prepared. Pacific Analytics, LLC has been contracted to conduct an Arthropod Fauna Inventory and Assessment for the proposed broadcast facility located at 'Ulupalakua Ranch. The purpose of the Arthropod Fauna Inventory and Assessment is to describe any potential arthropod fauna impacts from the proposed construction

and operation of broadcast facilities and recommend measures that could be employed to mitigate impacts.

The proposed site has been previous disturbed by cattle grazing. Only pasture grasses, mostly kikuyu, can be found on the site, except for the occurrence of one native plant, *pukamole*. It is very unlikely that Hawaiian native arthropod species would use the site, except as a resting place if moving between patches of native vegetation.

A majority of the arthropod specimens that were collected were alien flies. Three species of true bugs (Order Heteroptera) were identified, along with an aphid and parasitic wasp. One juvenile Lycosid spider, and one small centipede were captured and both are likely Hawaiian native species. No ants were observed at the site. A total of fifteen arthropod species were collected representing six orders.

None of the species collected are listed as threatened or endangered, and none are considered rare or species of concern.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

### III. INTRODUCTION

The Haleakalā volcano on the island of Maui is one of the highest mountains in Hawai'i, reaching an elevation of 3,055-m (10,023-ft) at its summit on Pu'u `Ula`ula. Near the summit is a volcanic cone known as Kolekole with some of the best astronomy viewing in the world.

The mountain's summit is also an ideal location for television and radio broadcast facilities. The line-of-sight paths for signals reach the populated areas in the County of Maui, the Windward side of O'ahu, and the Kona Coast of Hawai'i. Unfortunately, the signals from broadcast facilities cause interference to the electronic instrumentation at the nearby observatories.

Because of the development of increasingly sensitive electro-optical systems it has become essential to relocate the broadcast facilities and reduce the interference with astro-nomical research.

One of the sites being considered for the relocated broadcast facilities is Keonehunuhune on `Ulupalakua Ranch below Pu'u Makua. While Keonehunuhune is lower in elevation than the present broadcast facilities adjacent to the observatories, technical advances in RF antenna propagation combined with other refinements for digital TV broadcast

during the last decade have improved that site's potential for coverage of the broadcaster markets on Maui and Hawai'i. The pre-existing broadcast facilities at that site also reduce the need for the level of infrastructure improvements that would be necessary at alternative sites.

Various environmental and cultural issues are being addressed prior to relocation of the broadcast facilities to Keonehunuhune. One of these is the potential impact of broadcast facility construction on arthropod resources that may be present on the proposed site.

To that end, an Environmental Assessment is being prepared. Pacific Analytics, LLC has been contracted to conduct an Arthropod Fauna Inventory and Assessment for the proposed broadcast facility located at 'Ulupalakua Ranch., to meet NEPA Environmental Assessment requirements for the proposed relocation of the broadcast facility currently located adjacent to the Haleakalā High Altitude Observatories to 'Ulupalakua Ranch. The purpose of the Arthropod Fauna Inventory and Assessment is to describe any potential arthropod

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

fauna impacts from the proposed construction and operation of broadcast facilities and recommend measures that could be employed to mitigate impacts.

The Arthropod Fauna Inventory and Assessment consisted of a site visit with a project planner familiar to the proposed location, and a one-day site reconnaissance, including visual habitat inspection and sweep net collecting of arthropods.

A search of the literature found little information about the arthropod fauna in the general area; however a large amount of information was available on the botanical resources of the nearby Kanaio Natural Area Reserve. The natural entomofauna of the area was constructed from the available information for use in this assessment.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

#### IV. PROJECT DESCRIPTION

The Project consists of six tasks. The tasks were:

- Task I) Conduct a site visit and one-day site reconnaissance with a project planner familiar to the proposed location.
- Task II) Visually inspect for Hawaiian native arthropod habitats.
- Task III) Collect arthropods at the site using a sweep net and other standard arthropod collecting methods.
- Task IV) Identify and curate collected specimens.
- Task V) Research the literature and reconstruct a description of the historic Hawaiian native entomofauna that occurred in the area.
- Task VI) Prepare a Final Report of Findings.

Compare the reconstructed entomofauna to the fauna that was identified during this assessment;

Discuss the current status of resident arthropods on the proposed site,

List any species of concern or special interest,

Describe any potential arthropod fauna impacts from the proposed construction and operation of the broadcast facilities

Make recommendations about measures that could be employed to mitigate impacts.

## V. METHODS

### Site Description

The proposed site for the relocated broadcast facilities is Keonehunehune on `Ulupalakua Ranch below Pu`u Makua. The proposed site is at 1,336-m (4,383-ft) above sea level on the southwest slope of Haleakalā on the island of Maui, Hawai`i.

The proposed site is approximately 0.11-ha (0.28-ac) of undeveloped land within the existing 1.2-ha (3-ac) `Ulupalakua Ranch Antenna Farm Site. The surrounding area has been grazed by cattle since the late 19th century, and by the early 20th century the native vegetation was almost entirely replaced by non-indigenous grasses and Eucalyptus trees (Rock 1974). In the late 1940s, kikuyu grass was introduced to enhance the use of the area as pasture (HEAR 2005). Only one Hawaiian native plant species, *pukamole* (*Lythrum maritimum* Kunth) was identified during the site reconnaissance.

Annual precipitation at the proposed site averages between 510-mm (20-in) and 760-mm (30-in) falling primarily as rain and mist from November through April (Juvik and Juvik 1998).



*Pukamole* flowers that can be found at the proposed project site. (Photo by Starr and Starr 2005).

The prevailing winds are south-southeast. Temperatures are moderate, reaching a mean maximum of 24°C (75°F) in July and August and falling to a mean minimum of 21°C (70°F) in February (Armstrong 1983).

The soils in the region of the proposed site are andisols, evolved from volcanic ash. Soils such as this accumulate large amounts of Phosphorous, and cover more land in the Hawai`i than any other type (Rock 1974, Juvik and Juvik 1998).

The leeward slope of Haleakalā was once covered by dryland forest. Dryland forests occurred on all the main islands at 300-m (985-ft) to 1,500-m (4,920-ft) elevation (Wagner et al.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

1990). Remnants of this forest type indicate its former extents across much of southern Haleakalā volcano.

Many of the dryland trees have extremely hard, durable, and heavy wood that was used by early Hawaiians as a source of unique natural materials for tool making, canoe building, kapa making, and weapons (Medeiros et al. 1998). Other species were used as medicines and dyes, and some had religious significance (HEAR 2005).

Dryland forests were among the most diverse of the native communities in Hawai'i, containing a rich variety of trees, shrubs, and ferns. Many of these species can still be found in an area on the 'Ulupalakua Ranch known as Auwahi, generally considered one of the most intact dryland forest areas in the state (Wagner et al. 1990).

A multi-agency cooperative effort is being made at an experimental dryland forest restoration project at a 10 acre enclosure in western Auwahi. Partners include 'Ulupalakua Ranch, Biological Resources Division, U.S. Geological Survey (BRD-USGS), U.S. Fish and Wildlife Service (USFWS), Native Hawaiian Plant Society (NHPS), and Living Indigenous Forest Ecosystems (LIFE). A partial list of plants

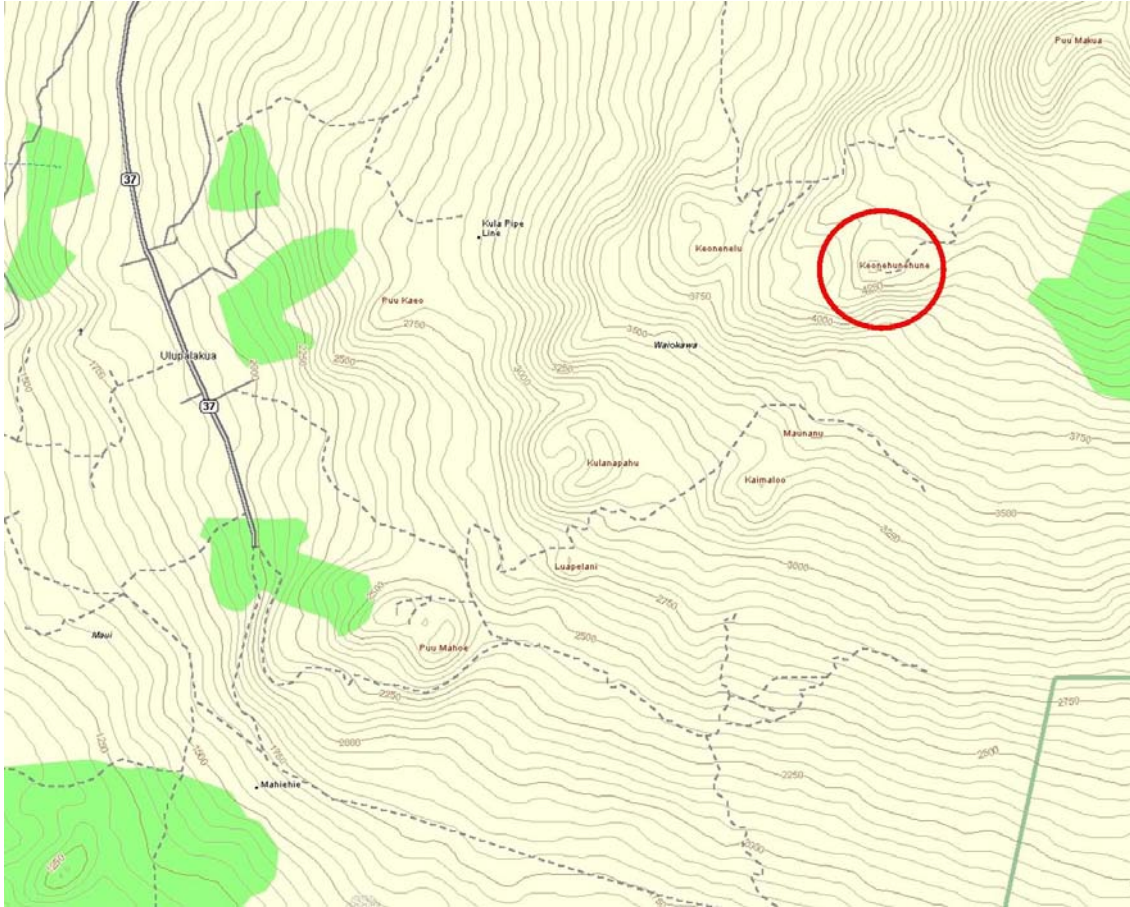
that occur within the restoration site was used as a basis of determining the entomofauna that historically occurred here.

It should be noted that the forests surrounding the proposed site have been damaged or displaced by burning, grazing, and invasion by non-native plant species. As a result, much of the original native shrubs and understory were replaced largely by a thick mat of introduced kikuyu grass (*Pennisetum clandestinum*) (Medeiros et al. 1998). Only one Hawaiian native plant species, *pukamole* (*Lythrum maritimum* Kunth) was identified at the proposed site. Due to the lack of Hawaiian native vegetation at the proposed site, arthropods that once occurred there likely no longer use the site. However, these species may still occur in the nearby, remnant patches of dryland forest and may occasionally be found at the proposed site.

**Sampling**

Arthropods were sampled at the site using a sweep net and by visually inspecting habitats where they would likely occur. Sampling was conducted on September 30, 2005

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII



Map showing the location (red circle) of the proposed site where arthropod sampling was conducted.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

**Identification**

References for general identification of the specimens included Fauna Hawaiiensis (Sharp (ed) 1899-1913) and the 17 volumes of Insects of Hawai'i (Zimmerman 1948a, 1948b, 1948c, 1948d, 1948e, 1957, 1958a, 1958b, 1978, Hardy 1960, 1964, 1965, 1981, Tentorio 1969, Hardy and Delfinado 1980, Christiansen and Bellinger 1992, Liebherr and Zimmerman 2000, and Daly and Magnacca 2003). Other publications that were useful for general identification included The Insects and Other Invertebrates of Hawaiian Sugar Cane Fields (Williams 1931), Common Insects of Hawai'i (Fullaway and Krauss 1945), Hawaiian Insects and Their Kin (Howarth and Mull 1992), and An Introduction to the Study of Insects Sixth Edition (Borror, Triplehorn, and Johnson 1989).

For specific groups specialized keys were necessary. Most of these had to be obtained through library searches. Keys

used to identify Heteroptera included those by Usinger (1936, 1942), Ashlock (1966), Beardsley (1966, 1977), and Gagné (1997). Keys used to identify Hymenoptera included Cushman (1944), Watanabe (1958), Townes (1958), Beardsley (1961, 1969, 1976), Yoshimoto and Ishii (1965), and Yoshimoto (1965a, 1965b).

Identifications of those specimens identified to genus or species level are unconfirmed and subject to change after comparison to specimens in museums.

In many cases changes in family and generic status and species synonymies caused species names to change from those in the keys. Species names used in this report are those listed in Hawaiian Terrestrial Arthropod Checklist Third Edition (Nishida 1997).

1  
2

## VI. RESULTS AND DISCUSSION

### General Observations

The proposed site has been previously disturbed by cattle grazing. Only pasture grasses, mostly kikuyu, can be found on the site, except for the occurrence of one native plant, *pukamole*. It is very unlikely that Hawaiian native arthropod species would use the site, except as a resting place if moving between patches of native vegetation.

A majority of the arthropod specimens that were collected were alien flies. Three species of true bugs (Order Heteroptera) were identified, along with an aphid and parasitic wasp. One juvenile Lycosid spider, and one small centipede were captured and both are likely Hawaiian native species. No ants were observed at the site. A total of fifteen arthropod species were collected representing six orders.

None of the species collected are listed as threatened or endangered, and none are considered rare or species of concern.

### Historic Entomofauna

The historic composition of the entomofauna at the proposed site was estimated from observations made in the

nearby Kanaio Natural Area Reserve (e.g., Medeiros *et al.* 1993), and from the annotated check-list of insects that occur on various components of Hawaiian forests (Swezey 1954).

The entomofauna of the dryland forest that once occurred here was probably as rich and diverse as the flora. There are numerous examples that illustrate the increase in the total number of insect species with increasing plant diversity (e.g., Murdoch *et al.* 1972, Southwood *et al.* 1979). At least seventy-seven plant species now occur on the 4-ha (10-ac) Auwahi forest restoration site on the 'Ulupalakua Ranch. Using known host records (Swezey 1954), it is estimated that at least 600 species of insects once occurred here.

The only known threatened or endangered invertebrate species that currently occurs near the proposed site is Blackburn's Sphinx Moth. Once considered extinct, populations have recently been discovered in several locations on O'ahu, Kaua'i, Maui, Moloka'i, Hawai'i, and Kaho'olawe. The true host plant of this moth was discovered by Betsy Harrison Gagne to be the 'aiea (*Nothocestrum latifolium*

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

A. Gray), a plant common in Kanaio reserve but uncommon to rare elsewhere in the Hawaiian Islands.

**Current Inventory**

Of the fifteen arthropod species collected during this study, at least four are indigenous Hawaiian species. All of the species collected have been previously reported from Maui.

**Class Arachnida**

**Order Araneae - Spiders**

Only one wolf spider, a juvenile, was captured during the site survey. Juvenile stages are difficult to identify to species. There are eleven endemic species of *Lycosa* in Hawai'i, seven that have been found on Maui.

**Class Chilopoda -Centipedes**

Centipedes are elongate, flattened arthropods with 15 or more pairs of legs, one pair per body segment. They occur in a variety of habitats, where they feed on spiders and insects.

There are 24 species of centipedes reported in Hawai'i, only one from Maui, the non-indigenous, *Mecistocephalus spissus* Wood (Nishida 1997). Only one specimen was collected in this study. Because of a lack of taxonomic keys, it was not identified.

**Class Insecta**

**Order Coleoptera - Beetles**

Beetles are the most diverse group of arthropods in Hawai'i. There are 1,983 species of beetles reported in Hawai'i (Nishida 1997), 544 on Maui (B.P. Bishop Museum 2002). No beetles were collected during this study but a few rove beetles were observed near dung. It is likely that other beetle species of dung beetles also occur at the site.

**Order Collembola - Springtails**

Collembola are small, insect-like arthropods. They are abundant and ubiquitous, exceeding all other insects in numbers of individuals (Christiansen and Bellinger 1992). Most species are detritivores and few are pests. One hundred and sixty-nine species of Collembola are found in Hawai'i, sixty on Maui (Nishida 1997). Because of their small size (0.25-6 mm), Collembola are seldom observed or reported. Collembola were observed in the matted grass, but none were collected for identification.

**Order Diptera - Flies**

Diptera is the second most diverse order of insects in Hawai'i, with 1,449

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

species representing fifty-seven families. Some of the families, such as Dolichopodidae and Drosophilidae, showed remarkable species radiations and unusual evolutionary developments (Howarth and Mull 1992).

At least six species of flies were observed at the proposed site. The most abundant were house flies (Family Muscidae), and hump-backed flies (Family Phoridae). Flies are probably attracted by dung, where they lay their eggs. Most of these species are not indigenous to Hawai'i.

**Order Heteroptera - True Bugs**

The order Heteroptera contains 408 species in Hawai'i, 304 of which are endemic. Most species feed on plants, inserting their straw-like mouth parts into the plant to extract the juices. Some species are predaceous.

Three specimens of Heteroptera were collected at the proposed site. One was an introduced species of seed bug (Family Lygaeidae), *Geocoris punctipes* (Say). This bug is widespread in southwestern United States and Mexico and was first found in the Hawaiian Islands by Swezey in 1935. One of its host plants is Bermuda grass (*Cynodon dactylon*).

The other two specimens of Heteroptera are from Hawaiian endemic genera. One was a predaceous damsel bug of the genus *Nabis*. Twenty-six species of *Nabis* are

known in Hawai'i, eleven on Maui. Many more are undescribed. The other specimen was of the genus *Sarona*. These small plant bugs feed on a variety of Hawaiian native plants, including *māmaki* (*Pipturus*, Urticaceae). (Asquith 1994).

**Order Hymenoptera  
Bees and Wasps**

Bees and wasps are common in Hawai'i. There are 1,270 species that occur in Hawai'i. Of these species, 652 are endemic to Hawai'i that consist largely of small parasitic wasps, mud-daubers, and yellow-faced bees. The yellow-faced bees (family Colletidae) are important pollinators of native plants (Howarth and Mull 1992). Many of the non-indigenous species were purposely released for biological control of agricultural pests.

One small parasitic species of the family Braconidae was collected at the site.

**Order Lepidoptera  
Moths and Butterflies**

There are 1,148 species of moths and butterflies found in Hawai'i, a majority (957) of which are endemic. Many of the endemic species are small moths with a wingspan of less than 1 cm (Howarth and Mull 1992). One of the largest Hawaiian endemic

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

insects is also a moth, Blackburn's Sphinx Moth, *Manduca blackburni* (Butler).

No specimens of Lepidoptera were collected at the site, but several small moths were observed flying nearby. Other than the alien grasses, there is virtually no vegetation on which for Lepidoptera larvae can develop. Lepidoptera at the site are likely only passing through on their way from one patch of vegetation to another or blown there by the wind.

**Summary of the Arthropod Fauna**

The arthropods species that were collected at Keonehunehune on 'Ulupalakua Ranch during this study were typical of a site dominated by alien grasses and disturbed by grazing. No Hawaiian native arthropod species were found that are locally unique to the site, and most of the species identified were not indigenous to Hawai'i. No species were found whose habitat is threatened by normal broadcast facility operations.

The diversity of the arthropod fauna at the proposed broadcast facilities site is very low compared to what would be expected in undisturbed Hawaiian dryland forests that once covered this area. This would be expected given the fact that almost 100% of the site is covered by alien pasture grasses and has been grazed by cattle for more than 100 years.

Development of the site will not impact the availability of habitat of Hawaiian native arthropod species. With some basic precautions, the construction and operation of the proposed broadcast facilities should have no impact on Hawaiian native arthropods.

One of the biggest concerns with any development is the introduction of ants. Ants have apparently had a serious negative impact on Hawaiian native arthropods on the Kanaio Natural Area Reserve (Medeiros *et al.* 1993), and elsewhere in Hawai'i (Cole *et al.* 1992). No ants were found during this study. With some practical precautions, the site should remain ant free.

Other alien arthropod species also have the potential to impact the native ecosystem. No obviously threatening alien species were found during this study and with similar precautions as those used for ants, none should be introduced by broadcast facility construction or operation. The lack of vegetation other than grasses at the proposed site should make it difficult for most alien species to establish populations.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

**Recommendations**

The biggest potential threat to Hawaiian native arthropods that could result from the construction and installation of the proposed broadcast facilities is the introduction of ants or other damaging alien arthropods, and the introduction of invasive plant species. While there would be no direct impact on the proposed site, these invasive species could migrate to nearby areas where Hawaiian native plant and animal species occur. Once there, they could have a devastating effect on the native flora and fauna.

It is recommended that vehicles and earth moving equipment be pressure washed and inspected for alien species before proceeding to the proposed construction site. Construction material and shipping

containers should also be inspected for alien arthropod species. And eradicated if found. Care should be taken to collect and properly dispose of any trash or other organic substances that would attract ants or other alien species.

Once constructed, the proposed broadcast facilities should be inspected periodically for ants and other alien arthropod species, and if any are found they should be eradicated immediately. The utilization of a bait-toxicant mix in control of social insects such as ants and wasps can, if correctly presented, be extremely effective (Medeiros *et al.* 1993).

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

VII. BIBLIOGRAPHY

- Armstrong, R.W. (Ed.). 1983. Atlas of Hawai'i. Second Edition. University of Hawai'i Press, Honolulu. 238 pages.
- Ashlock, P.D. 1966. New Hawaiian Orsillinae (Hemiptera-Heteroptera: Lygaeidae). Pac Ins 8(4): 805-825.
- Asquith, A. 1994. Revision of the Endemic Hawaiian Genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthrtylinae). Bishop Museum Occasional Papers No. 40:1-81.
- Beardsley, J.W. 1961. A review of the Hawaiian Braconidae (Hymenoptera). Proc Haw Ent Soc 17(3): 333-366.
- Beardsley, J.W. 1980. Haleakalā National Park Crater District Resources Basic Inventory: Insects. University of Hawai'i at Manoa, Department of Botany, Cooperative National Park Resources Studies Unit Technical Report 31. 49 pages.
- Borror, D.J., C.A. Triplehorn, and N.F. Johnson. An Introduction to the Study of Insects. Sixth Edition. Saunders College Press, San Francisco.
- Christiansen, K. and P. Bellinger. 1992. Insects of Hawai'i Collembola. Volume 15. University of Hawai'i Press, Honolulu. 445 pp.
- Cole, F.R., A.C. Medeiros, L.L. Loope & W.W. Zuehlke. 1992. Effects of the argentine ant on arthropod fauna of Hawaiian high-elevation shrubland. Ecology 73(4): 1313-1322.
- Daly, H.V. and K.N. Magnacca 2003 Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera:Apoidea) Volume 17. University of Hawai'i Press, Honolulu. 234 pp.
- Fullaway, D.T. & N.L.H. Krauss. 1945. Common Insects of Hawai'i. Tongg Publishing Co., Honolulu. 228 pp.
- Gagne, W.C. 1997. Insular Evolution, Speciation, and Revision of the Hawaiian Genus *Nesiomiris* (Hemiptera:Miridae). Bishop Museum Bulletin in Entomology 7. Bishop Museum Press, Honolulu.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

Hardy, D.E. 1960. Diptera: Nematocera-Brachycera. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 10. Diptera: Nematocera--Brachycera. University of Hawai'i Press, Honolulu. ix + 368 pp.

Hardy, D.E. 1964. Lonchopteridae. Pp. 257-262 In: E.C. Zimmerman. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 11. Diptera: Brachycera, Family Dolichopodidae. Cyclorrhapha, series Aschiza. Families Lonchopteridae, Phoridae, Pipunculidae, and Syrphidae. University of Hawai'i Press, Honolulu. vii + 458 pp.

Hardy, D.E. 1964. Pipunculidae. Pp. 302-379 In: E.C. Zimmerman. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 11. Diptera: Brachycera, Family Dolichopodidae. Cyclorrhapha, series Aschiza. Families Lonchopteridae, Phoridae, Pipunculidae, and Syrphidae. University of Hawai'i Press, Honolulu. vii + 458 pp.

Hardy, D.E. 1964. Syrphidae. Pp. 380-419 In: E.C. Zimmerman. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 11. Diptera: Brachycera, Family Dolichopodidae. Cyclorrhapha, series Aschiza. Families Lonchopteridae, Phoridae, Pipunculidae, and Syrphidae. University of Hawai'i Press, Honolulu. vii + 458 pp.

Hardy, D.E. 1965. Diptera: Cyclorrhapha II, series Schizophora, section Acalypterae I, family Drosophilidae. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 12. University of Hawai'i Press, Honolulu. vii + 814 pp.

Hardy, D.E. 1966. Descriptions and notes on Hawaiian Drosophilidae (Diptera). Pp. 195-244 In: M.R. Wheeler (ed.). Studies in genetics. III. Morgan centennial issue. The University of Texas, Austin. vi + 563 pp.

Hardy, D.E. 1981. Diptera: Cyclorrhapha IV, series Schizophora, section Calyptratae. Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 14. University of Hawai'i Press, Honolulu. vi + 491 pp.

ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

Hardy, D.E. & M.D. Delfinado. 1980. Diptera: Cyclorrhapha III, series Schizophora, section Acalypterae, exclusive of family Drosophilidae. Pp. 1-451 In: Insects of Hawai'i. A manual of the insects of the Hawaiian Islands, including an enumeration of the species and notes on their origin, distribution, hosts, parasites, etc. Volume 13. University of Hawai'i Press, Honolulu. vi + 451 pp.

HEAR 2005. Hawaiian Ecosystems at Risk project website. History of Auwahi. <http://www.hear.org/naturalareas/auwahi/history.htm>. Accessed December 26, 2005.

Howarth, F.G. and W.P. Mull. 1992. Hawaiian Insects and their Kin. University of Hawai'i Press, Honolulu.

Howarth, F.G. and G.W. Ramsey. 1989. The conservation of island insects and their habitats. Chapter 4 in *The Conservation of Insects and Their Habitats*, N.M. Collins and J.A. Thomas, editors. Academic Press.

Juvik, S.P. and J.O. Juvik (Eds.). 1998. Atlas of Hawai'i. Third Edition. University of Hawai'i Press, Honolulu. 333 pages.

Liebherr, J.K. and E.C. Zimmerman 2000. Hawaiian Carabidae (coleopteran), Part 1: Introduction and Tribe Platynini. Volume 16. University of Hawai'i Press, Honolulu. 494 pp.

Medeiros, A. C., L.L. Loope, and C. G. Chimera. 1993. Kanaio Natural Area Reserve Biological Inventory And Management Recommendations. Prepared for the State of Hawai'i Natural Area Reserves System.

Medeiros, A. C., C. F. Davenport and C. G. Chimera. 1998. Auwahi: ethnobotany of a Hawaiian dryland forest. Technical Report 117 Cooperative National Park Resources Studies Unit, University Of Hawai'i At Manoa.

Murdoch, W.W., F.C. Evans, and C.H. Peterson. 1972. Diversity and pattern in plants and insects. *Ecology* 53:819-829.

Nishida, G. M. 1997. Hawaiian Terrestrial Arthropod Checklist Third Edition. Hawai'i Biological Survey. Bishop Museum Technical Report No. 12. Bishop Museum, Honolulu.

Perkins, R.C.L. 1899-1913. Fauna Hawaiiensis. Cambridge-at-the-University-Press.



ARTHROPOD FAUNA INVENTORY AND ASSESSMENT  
PROPOSED BROADCAST FACILITIES SITE  
'ULUPALAKUA RANCH, MAUI, HAWAII

Zimmerman, E.C. 1948-1980. Insects of Hawai'i. University of Hawai'i Press, Honolulu.