DOE/OR/22088--3

U.S. FISH AND WILDLIFE SERVICE
Pacific Islands Office, Ecological Services

HAWAI'I GEOTHERMAL PROJECT ANNOTATED BIBLIOGRAPHY: BIOLOGICAL RESOURCES OF THE GEOTHERMAL SUBZONES, THE TRANSMISSION CORRIDORS AND THE PUNA DISTRICT, ISLAND OF HAWAI'I.

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October 1993

HAWAI'I GEOTHERMAL PROJECT ANNOTATED BIBLIOGRAPHY.

Introduction

Task 1 of the Hawai'i Geothermal Project Interagency Agreement between the Fish and Wildlife Service and the Department of Energy - Oak Ridge National Laboratory (DOE) includes an annotated bibliography of published and unpublished documents that cover biological issues related to the lowland rain forest in Puna, adjacent areas, transmission corridors, and in the proposed Hawai'i Geothermal Project (HGP). The 51 documents reviewed in this report cover the main body of biological information for these projects. The full table of contents and bibliography for each document is included along with two copies (as requested in the Interagency Agreement) of the biological sections of each document. The documents are reviewed in five main categories:

I. Geothermal Subzones (29 documents)
II. Transmission Cable Routes (8 documents)
III. Commercial Satellite Launching Facility (Spaceport; 1 document)
IV. Manganese Nodule Processing Facility (2 documents)
V. Water Resource Development (1 document)
VI. Ecosystem Stability and Introduced Species (11 documents)

Category I directly addresses the Hawai'i Geothermal Project subzones on the island of Hawai'i. Data on the old Kahauale'a geothermal subzone is included in this review. This area was later rezoned as the Kahauale'a Natural Area Reserve. The Wao Kele o Puna Natural Area Reserve, just down slope of Kahauale'a, was rezoned as the new upper (Kīlauea) geothermal subzone. Category II includes HGP documents and other related documents dealing with electric transmission routes. Reviews of the documents in Categories III and IV were requested by DOE in the HGP-EIS Implementation Plan. Category V covers a draft EIS for pumping water across the island of Hawai'i. Geothermal power is considered as part of this proposal. The water resource would also be useful to the manganese nodule processing facility. Category VI covers some of the documents that may be useful in assessing the impact of geothermal development on biological resources.

The biological information presented in these documents does not adequately cover the full range of organisms and habitats that need to be evaluated in order to make a full assessment of the biological resources in the geothermal subzones and the affects of geothermal development on these resources. Most of the geothermal or power line documents rely on a few earlier documents that covered one or two groups of organisms (usually plants and forest birds). These few major documents are indicated under the "Relevance to the HGP-EIS" heading as presenting new biological data. Most conspicuously missing from all but a few of the surveys and assessments of impacts are reports on the invertebrate fauna, including cave organisms. This fauna constitutes most of the animal life in Hawai'i and greatly influences the dynamics of local habitats and ecosystems. In Hawai'i, a complete biological assessment or survey must cover the major groups of terrestrial organisms (plants, birds, bats and invertebrates) and their habitats.

I. GEOTHERMAL SUBZONES

Title 1: *Survey of lava tubes in the former Puna Forest Reserve and on adjacent State of Hawai'i lands.*

Author(s), date: H. McEldowney and F.D. Stone. Prepared for the State of Hawai'i, Department of Land and Natural Resources, Historic Preservation Division. October 1991.

Relevance to the HGP-EIS: Original biological information on lava tube species; useful.

Summary: Survey of 3 lava tube systems that may extend 1.2 miles into the upper geothermal zone. Maps indicate segments of the tubes with roots systems that support native cave invertebrate species. Seven cave invertebrate species were seen on a short survey and 17 other potential species are listed. The native cave species are mainly found in root-rich areas away from entrances. Authors recommend that the tubes be protected with a 3000 foot buffer zone for forest integrity. The cave fauna may be sensitive to hydrogen sulfide and other heavy gases that may settle into the cave system.

Title 2: *Botanical survey of proposed new well site 2. BLNR designated geothermal resource subzone. Middle East Rift Zone of Kīlauea, Puna District, Island of Hawai'i.*

Author(s), date: C.H. Lamoureux. Prepared for True Geothermal Energy Company and Mid-Pacific Geothermal, Inc. August 1990.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: A one day botanical survey of the proposed well site found 40 endemic, 12 indigenous, and 21 alien plants. No candidate or endangered species were seen. Vegetation mapping refers to Char and Lamoureux 1985 (see below) and describes the area as "'ōhi'a-a(2)" or wet 'ōhi'a forest with native species and exotic shrubs. Describes the subcanopy assemblage of plants. Alien malabar melastome and strawberry guava are common in the area. Recommends a weed control program similar to that proposed in Lamoureux *et al.* 1987 (see below).

Title 3: *Ornithological survey of the proposed geothermal well site 2. DLNR designated geothermal resource subzone. Middle East Rift Zone, Puna District, Island of Hawai'i.*

Author(s), date: J. Jeffrey. Prepared for True Geothermal Energy Company and Mid-Pacific Geothermal, Inc. August 1990.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: A two day bird survey of the proposed well site found 5 native (65% of 262 sightings) and 4 alien bird species. Native apapane were the most common; an average of 4.8 birds per station and 33% of all sightings. Japanese white-eyes were the next most commonly seen bird (3.7 per station; 26% of all sightings). Hawaiian thrush (omao) were the third most common bird (3.1 per station; 21% of all sightings). Two Hawaiian hawks were seen, and a Hawaiian hawk nest with a nestling was found within 400 feet of the proposed well site. Recommend no clearing of the pad until the hawk nestling fledges. The hawk was the only endangered species seen.

Title 4: *Botanical survey of proposed well site 2 (new) and its access road. BLNR designated geothermal resource subzone. Middle East Rift Zone of Kīlauea, Puna District, Island of Hawai'i.*

Author(s), date: C.H. Lamoureux, W.P. Char, G. Murakami for True/Mid-Pacific Geothermal Venture. June 1990.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: This report is nearly identical to the January 1990 document. The exact location of the new well site is not evident, although a map of stake locations is included. The well site is in an area dominated by uluhe. One unknown mint was encountered, almost certainly an introduced weed. All large trees in the area were checked for nests of the Hawaiian hawk, but none were found. Again only a plant checklist is given.

Title 5: *Botanical survey of proposed well sites 2 and 3 and of the proposed roads leading to these sites from well site 1. BLNR designated geothermal resource subzone. Middle East Rift Zone of Kīlauea, Puna District, Island of Hawai'i.*

Author(s), date: C.H. Lamoureux, W.A. Whistler, C.T. Imada for True/Mid-Pacific Geothermal Venture. January 1990.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: Data collected over two days of walk-through surveys. The strip surveys extended 100 feet to each side of the road centerline, and areas twice as large as the actual well site were examined. No plants listed or proposed for listing were found. Much of the text is lifted verbatim from the Nov. 1987 paper. Pig damage was extensive and many introduced weeds were common. Plants indicative of Hawaiian habitation were also found. The authors suggest means of minimizing weed extension and invasion

during and after construction activities. Although a plant checklist is included, there is no map of the well sites.

Title 6: *Environmental review. 500 MW geothermal development within the three geothermal resource subzones of the Kīlauea East Rift Zone, Puna District, Island of Hawai'i.*

Author(s), date: MCM Planning, with a subcontract to Char and Associates for floral and faunal studies. Prepared for the State of Hawai'i, Department of Business and Economic Development. March 1989.

Relevance to the HGP-EIS: No new biological data or interpretations; minimally useful.

Summary: The document covers all 3 geothermal subzones and relies on biological data from earlier studies, including Char and Lamoureux 1985 and Jacobi 1985. Discusses Probable impacts on biota include direct loss of habitat and native communities to development, invasion of non-native species, long-term affects, and ecological processes. Has maps and descriptions of vegetation types in each subzone and an appendix of plant species. Birds that may be found in the geothermal area are briefly discussed along with bats and feral mammals. A table of expected groups of invertebrate species is included.

Title 7: *Biological survey of the proposed access road and well site 1. BLNR designated geothermal resource subzone, Middle East Rift Zone of Kīlauea, Puna District, Island of Hawai'i.*

Author(s), date: C.H. Lamoureux, W.P. Char, P. Higashino, and M.S. Kjargarrd. Prepared for True/Mid Pacific Geothermal Venture. November 1987.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: One-day survey of plants and birds along a proposed access road. There were 51 endemic, 17 indigenous and 35 alien plants (3 Polynesian introductions) observed along the route. Two candidate endangered species, *Bobea timonioides* and *Tetraplasandra hawaiensis*, were seen. Refers to vegetation maps of Char and Lamoureux 1985 (see below) and provides a brief description of the vegetation in the area. Describes the area as "'ōhi'a-a(2)" or wet 'ōhi'a forest with native species and exotic shrubs. The avifaunal study is presented as Appendix I and contains an annotated species list of birds seen, species status, comments on the habitat of the observation. Five native and five alien species were seen. Native species were seen more frequently in the less disturbed upper portion of the study area. Author indicates that native honeycreeper species were more correlated with the vigor and density of *Metrosideros* that with native understory plants. Elepaio and Hawaiian thrush densities were probably more sensitive to understory plant vigor since they rely on insects or fruits. No data is

given for these observations. No Hawaiian hawks were observed but high densities of hawk have been seen in nearby locations. The area is a viable avian habitat. Brief descriptions of endangered or candidate birds and plants are given. Recommendations include realigning the road and well site away from areas with endangered species, keep shade trees along road edges to reduce shade-intolerant weeds and do not make windrows, which are prime habitat for weeds.

Title 8: *Puna Geothermal Venture Project. Draft environmental impact statement.*

Author(s), date: Fluor Technology, Inc. for the Thermal Power Company. August 1987.

Relevance to the HGP-EIS: No original biological information; minimally useful.

Summary: Summarizes a biological survey by Char and Stemmerman 1984, within 1 mile of the PGV power plant. The survey reported 240 species of plants, 98 being native or endemic species. Rare species included Cyrtandra spp., Tetraplasandra hawaiiensis, and Bobea spp.; none were within the site of power plant. The study area was mostly second growth, with 1/3 covered by a 1955 lava flow. The open canopy 'ōhi'a forest was the single largest vegetation type. The only endemic bird species was the endangered Hawaiian hawk. A map of sightings in 1984-1986 include nesting and foraging of 5-7 hawks within and around the project site.

Title 9: *Geothermal resource subzone designations in Hawai'i.*

Author(s), date: State of Hawai'i, Department of Business and Economic Development. June 1986.

Relevance to the HGP-EIS: No new biological information, minimally useful.

Summary: Uses biological information from Jacobi 1985 and Char and Lamoureux 1985. Reviews potential geothermal zones on all islands. Geologic hazards and risk minimization described and mapped.

Title 10: *Final supplemental environmental impact statement to the revised environmental impact statement for the Kahauale'a Geothermal Project.*

Author(s), date: R.M. Towill Corp. for True/Mid-Pacific Geothermal Venture. February 1986.

Relevance to the HGP-EIS: Contains some new information; moderately useful.

Summary: This document amended the original EIS following a land swap between the State of Hawai'i and Campbell Estate that realigned the upper geothermal subzone. Relies, in part, on data from Char and Lamoureux 1985 and Jacobi 1985, as well as some new surveys within the geothermal subzone. No survey methodology given. Briefly discusses biological succession on lava flows. The new surveys found 4 rare or endangered species within the geothermal resources subzone (= upper geothermal subzone). Authors conclude that the small size of the project footprint combined with avoidance of sensitive areas and areas of "great evolutionary importance" make it is unlikely that geothermal development will interfere with successional or evolutionary processes. No criteria are given for identifying sensitive or evolutionarily important areas. No data on effectiveness of recommended weed control, although weeds are identified as hazards to biological succession. No data supporting the statement that the endangered Hawaiian bat does not inhabit the upper geothermal subzone. No data supporting the statement that noise, night light, transmission cables and waste emissions from the plant will not affect birds.

Title 11: *Environmental assessment for rezoning conservation land from protective (P) subzone to limited (L) subzone. Puna, Hawai'i.*

Author(s), date: The Estate of James Campbell. December 1985.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Specifically deals with down zoning land exchanged between the State of Hawai'i and Campbell Estate (Kahauale'a land exchanged for the Puna Forest Reserve and the Wao Kele O Puna Natural Area Reserve). Zoning changes include down zoning lower elevation land from Preservation to Limited and concurrently upzoning Kahauale'a lands. All biological information is from Jacobi 1985 and Char and Lamoureux 1985. States that no significant impacts to the area are anticipated due to the proposed rezoning. Does not address geothermal development.

Title 12: *Proposed Kīlauea middle east rift geothermal resource subzone (Puna Forest Reserve), Island of Hawai'i. Circular C-114.*

Author(s), date: State of Hawai'i, Department of Land and Natural Resources, Division of Water and Land Development. August 1985.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Preparatory documentation for land swap and rezoning. No biological surveys were done. Information from Jacobi 1985, Char and Lamoureux 1985, and from

the Hawaiian hawk (1984) and Hawaiian goose (1983) recovery plans. Brief discussion of effects of geothermal emissions on plants.

Title 13: *Botanical survey of the potential geothermal areas in state-owned land in the Middle East Rift Zone of Kīlauea, Puna district, island of Hawai'i.*

Author(s), date: W.P. Char and C.H. Lamoureux for True/Mid Pacific Geothermal Venture. July 1985.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: This is a survey of what is now the Campbell Estate geothermal area. Much of the information presented is drawn from Char and Lamoureux 1985 and Jacobi 1985. Eleven person-days in the field were used to gather the data, and were focused on high-quality 'ōhi'a forests. Describes major vegetation types, notes occurrences of candidate endangered species of plants. Proposes mitigation measures for construction activities and advises that some areas (high-quality forest) be avoided. The map cited in the text is missing. Species found are listed and abundance information is given.

Title 14: *Puna geothermal area biotic assessment. Puna District, County of Hawai'i. Final report.*

Author(s), date: W.P. Char and C.H. Lamoureux. Department of Botany, University of Hawai'i, for the State of Hawai'i, Department of Business and Economic Development. April 1985.

Relevance to the HGP-EIS: Major source of data for many other documents; very useful.

Summary: This major plant and bird survey covers all of the geothermal subzones, and emphasizes ecosystem types. The area was surveyed in Nov-Dec '84. The report has extensive descriptions of ecosystem types, locations and habitats of endangered and candidate plant species and a plant species list. The bird survey by Berger is very limited, with only 2 days in the field. Appendices of color photos of 8 candidate plants and ecosystem types are included. Also includes the Jacobi vegetation map of the Puna district.

Title 15: *Environmental impact analysis of potential geothermal resource areas. Circular C-106.*

Author(s), date: Flora and fauna section by Lee Hannah of the University of Hawai'i Environmental Center for the State of Hawai'i, Department of Land and Natural Resources, Division of Water and Land Development. October 1984.

Relevance to the HGP-EIS: No new biological information; moderately useful.

Summary: Native habitat and forest quality were used to assess the value of the resource and the impact of geothermal development. Native habitat importance was defined by the presence of endangered species, which correlates well with the value of an area to native fauna. Three categories of habitats (closed canopy, open canopy and cleared land) were used to assess the forest quality and potential disturbance by geothermal development. Uses the Jacobi vegetation maps. Lists endangered birds that may be in the geothermal resource area. Briefly discusses snails and insects, including cave species, that co-occur with native vegetation, and would be lost by disruption of the forest.

Title 16: *A report on geothermal resource subzones for designation by the Board of Land and Natural Resources.*

Author(s), date: Flora and fauna section by Lee Hannah of the University of Hawai'i Environmental Center for the State of Hawai'i, Department of Land and Natural Resources, Division of Water and Land Development. August 1984.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Same information as in the above document.

Title 17: *Terrestrial biological survey, Puna Geothermal Venture studies, Puna Hawai'i.*

Author(s), date: W.P. Char, M. Stemmermann for Bechtel Group/Thermal Power Co. April 1984.

Relevance to the HGP-EIS: Original biological information; useful.

Summary: Includes a brief literature review of previous surveys of the area, and presents plant and bird survey data for a 1 mile circle around the PGV site. A total of 15 person-days were used to gather the botanical data. Rare, endemic species found include 3 *Cyrtandra* spp., *Tetraplasandra hawaiiensis*, and *Bobea* sp., none of which were found on the actual PGV site. There are stands of closed 'ōhi'a forest 20-30 m tall on some of the pu'u and in Leilani Estates. Three other native forest types are described. All vegetation descriptions are detailed, and a species checklist is provided. The bird survey, conducted in January over 2.5 days, revealed 11 species, only two of which were native. The Hawaiian hawk nests in the area and was sighted repeatedly on Pu'u Honuaula, the

current PGV site. Two evening hours were spent searching for bats, but none were sighted.

Title 18: *Revised environmental impact statement for the Kahauale'a Geothermal Project.*

Author(s), date: R. M. Towill Corp. for True/Mid-Pacific Geothermal Venture. June 1982.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Uses the same biological information presented in the February 1982 environmental assessment. Report includes maps of the baseline survey and sample sites, site-specific plant lists and anecdotal accounts of flora seen in surveys. The endangered Hawaiian fern *Adenophorus periens* was dense along proposed access road. Sightings from 2 days of bird surveys are presented in tables along with a brief discussion of endangered animal species in the area and potential impacts. Concludes that the project will not harm these species, despite a lack of information on their basic biology. Appendix B is a vegetation map of Kahauale'a. The sources listed are U.S. Forest Service/State Division of Forestry and Wildlife. The map designations are forestry-oriented and of minimal value except to designate dominant tree species, which is 'ōhi'a for the entire area. Appendix I is an Environmental baseline study. It is mainly concerned with air and soil chemistry and trace metals found in plant tissues, and has no additional data regarding plant or animal distributions.

Title 19: *Environmental impact statement for the Kahauale'a Geothermal Project. District of Puna, Island of Hawai'i, State of Hawai'i.*

Author(s), date: R. M. Towill Corp. for True/Mid-Pacific Geothermal Venture. April 1982.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Uses the same biological information presented in the February 1982 environmental assessment. See the revised version and the final supplement.

Title 20: *Environmental assessment for the Kahauale'a Geothermal Project. Puna District, Island of Hawai'i, Hawai'i.*

Author(s), date: R. M. Towill Corp. for True/Mid-Pacific Geothermal Venture. February 1982.

Relevance to the HGP-EIS: No new biological data presented; minimally useful.

Summary: This area was exchanged for land that contains the present upper geothermal subzone (Titles 5 and 7). The document summarizes biological surveys conducted either by Ecotrophics, Inc. (plants and birds, see below) or by the Fish and Wildlife Service (reported by Scott et al. 1986, see below). No data or information on methods and extent of the surveys are presented. The summary briefly identifies major communities and the endangered fern (*Adenophorus periens*). States that recent biological surveys indicate that this fern is common and well distributed in the area, but presents no supporting data. The Fish and Wildlife Service also reported endangered O'u (*Psittirostra psittacea*) in the upper section of this area. A brief Ecotrophics (see below) survey in September 1981 did not report seeing O'u but did report the endangered Hawaiian hoary bat, and significant damage due to feral pigs.

Title 21: *Progress Report: Environmental survey of the Campbell Estate geothermal prospect at Kahauale'a.*

Author(s), date: Ecotrophics. Prepared for Mid-Pacific Geothermal, Inc. September 1981 to April 1982.

Relevance to the HGP-EIS: New biological information; very useful.

Summary: A progress report dated September 1981 plus a Supplemental Report: Surveys of 9 and 23 January, 1982 in the Campbell Estate/Mid-Pacific Geothermal Prospect dated February 1982, and another Supplemental Report: Survey of April 9-10, 1982 in the Kahauale'a geothermal project prospect area. Includes primary data regarding forest status, distribution and abundance of rare plants, air and plant chemistry, and bird abundance in what is now the Kahauale'a Natural Area Reserve. The main survey was along the proposed access road leading south from Captain's Drive. Quadrats were established to estimate abundances of 3 rare species observed: *Adenophorus periens, Cyrtandra* sp. nov., *Cyanea* sp. nov., all along the first 2 km of trail. All species appear to require a dense overstory of 'ōhi'a and hapu'u fern, and would be affected by opening of the canopy. An additional survey for *Adenophorus periens* traversed 12 km and found plants throughout the area bordering the Hawai'i Volcanoes National Park. The bird surveys were based on approximately 10 hours of observations at two sites. The Hawaiian hawk was the only endangered species observed. A total of 70 person-days of field work covered some 500 acres.

Title 22: *The Hawaiian ecosystem and its environmental determinants with particular emphasis on promising areas for geothermal development.*

Author(s), date: S.M. Seigel, Department of Botany, University of Hawai'i, for the U.S. Department of Energy; printed as the Hawai'i Energy Resource Overviews, Volume 3: Geothermal, The Environment, 1 & 2 geobiology. June 1980.

Relevance to the HGP-EIS: No new biological information; useful overview.

Summary: Interesting overview of the uniqueness of Hawaiian ecosystems. Includes information on dispersal to Hawai'i, principal terrestrial ecosystems and vegetation patterns, vertebrate fauna, terrestrial snails, insects and marine invertebrates. Introduced pest species are also included.

Title 23: *The impact of geothermal development on the State of Hawai'i. Executive summary.*

Author(s), date: B.Z. Seigel, Pacific Biomedical Research Center, University of Hawai'i, for the U.S. Department of Energy; printed as the Hawai'i Energy Resource Overviews, Volume 7: Geothermal, Summary. June 1980.

Relevance to the HGP-EIS: No new biological information; moderately useful.

Summary: Summarizes areas of special concern, with recommendations by experts. Indicates that no studies have been done on effects of gaseous products on native organisms, but cites Ka'u desert as an example of suppression of vegetation by acid/toxic emissions. Suggests that emissions, noise, etc. need long-term studies.

Title 24: *Environmental assessment, Hydrothermal Geothermal Subprogram. Hawai'i Geothermal Research Station, Hawai'i County, Hawai'i.*

Author(s), date: United States Department of Energy. June 1979.

Relevance to the HGP-EIS: Weak biological assessment; minimally useful.

Summary: Gives a superficial overview of plants and animals in the area of the research station. Indicates that endangered plants are not likely to be found in the area. Indicates that negative effects on native or endangered species will not result because none occur on the project site.

Title 25: *Revised environmental impact statement for the Hawai'i Geothermal Research Station utilizing the HGP-A well at Puna, Island of Hawai'i.*

Author(s), date: Robert M. Kamins for the State of Hawai'i, Department of Planning and Economic Development. March 1978.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Biological section is the same as in the original EIS, below.

Title 26: *Environmental impact statement for Geothermal Research and Development Facility utilizing the HGP-A well at Puna, Hawai'i.*

Author(s), date: Robert M. Kamins for the State of Hawai'i, Department of Planning and Economic Development. January 1978.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Superficially summarizes plant and bird surveys done by Siegel, et al. 1976 for Ecotrophics, Inc (see above). Anticipates no effects on biota due to local geothermal development.

Title 27: *An assessment of geothermal development in Puna, Hawai'i.*

Author(s), date: R.M. Kamins and K.J. Tinning, Hawai'i Geothermal Project, University of Hawai'i; for the U.S. Energy Research and Development Administration, the State of Hawai'i, and the County of Hawai'i. January 1977.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Companion document to Environmental Baseline Study (see below), which has the original field studies.

Title 28: *Environmental assessment of the Hawai'i Geothermal Project well flow test program.*

Author(s), date: United States Energy Research and Development Administration. November 1976.

Relevance to the HGP-EIS: No original information; minimally useful.

Summary: Cursory coverage of flora and fauna. No new data or interpretations. Predicts negligible effects due to habitat destruction, noise, and waste effluent.

Title 29: *Environmental baseline study for Geothermal development in Puna, Hawai'i.*

Author(s), date: Kamins, R.M., M.J. Chun, A.J. Berger, W.B. Bonk, B.A. Siegel, S.M. Siegel, T. Speitel, L.S. Lau, R.W. Buddemaier, P. Kroopnick, and T. Hufen; Hawai'i Geothermal Project, University of Hawai'i. Supported by the United States Energy Research and Development Administration. September 1976.

Relevance to the HGP-EIS: original, quantitative data; moderately useful.

Summary: Describes the vegetation on the 4 acre HGP-A well site. Includes a table of plant species and densities in two quadrats and two transects. Data on mercury content in plants is presented for the well site along with control samples from Hawai'i Volcanoes National Park. Faunal studies were brief and limited to birds and mammals within a 1 mile radius of the well site. No native birds or mammals were seen in the two-day survey.

II. TRANSMISSION CABLE ROUTES. Note that and annotated bibliography has previous been prepared as part of the Hawai'i Deep Water Cable Program. A copy of this bibliography is given in Appendix II.

Title 1: *Hawai'i Deep Water Cable Program. Executive summary.*

Author(s), date: Hawaiian Electric Company for the U.S. Department of Energy. September 1990.

Relevance to the HGP-EIS: Overview of HGP program. No biological data; minimally useful.

Summary: Concise overview of the Hawai'i Deep Water Cable Program and its importance to the Hawai'i Geothermal Project. Includes the same bibliography published as HDWCP Phase II-D, Task 5.

Title 2: *Appendix B. Hawai'i Geothermal/Transmission Project regional study. Draft.*

Author(s), date: CH2M Hill and ERCE for the State of Hawai'i, Department of Business and Economic Development. June 1990. Also dated as DRAFT 12/90.

Relevance to the HGP-EIS: No new biological data; moderately useful.

Summary: Provides an environmental database for the transmission corridor on the Island of Hawai'i.No proposed transmission corridor is specifically covered. Land use section identifies "Unimproved Lands" in 3 sections (Hilo, Hamakua, and Kohala) along the S.E. side of the island. These lands include areas of biological interest. Data on rare plants and animals are taken from the database of The Nature Conservancy of Hawai'i. Describes vegetation types, the status and occurrence of 8 plant species, rare invertebrates (weevils, snails, prawns), fish, turtles, birds, bats. Good descriptions of ecosystem types and threats to each (from forests & wetlands to anchialine pools). States that transmission lines may not conflict with protection of species and ecosystems. Does not consider the impacts on seabirds moving into nesting or roosting sites.

Title 3: *Environmental impact statement for Pohoiki geothermal transmission line.*

Author(s), date: DHM Planners, Inc. with the Bishop Museum and Dames and Moore, for the Hawaiian Electric Light Company, Inc. May 1989.

Relevance to the HGP-EIS: No new information; minimally useful.

Summary: Same biological information as in the Pohoiki geothermal transmission line routing study (see below).

Title 4: *Pohoiki geothermal transmission line routing study.*

Author(s), date: DHM Planners, Inc. with the Bishop Museum and Dames and Moore, for the Hawaiian Electric Light Company, Inc. November 1987.

Relevance to the HGP-EIS: Surveys include original biological data; very useful.

Summary: Vegetation maps, aerial photographs and ground surveys used to select potential transmission corridors. Botanical, entomological and ornithological surveys are included as appendices. Includes comments on cave systems in the archaeological appendix. The botanical report consists of a brief narrative and list of plants for each of the 6 areas surveyed and a summary recommending that botanical concerns be omitted from final route selection. The bird survey lists species (mostly non-native) and locations. The endangered Hawaiian hawk and Hawaiian stilt were the only native birds seen. Recommends routing along the main highway. Arthropods were collected during day and night sampling. A listing of species includes 12 new Hawaiian species. Areas of special interest include, the Pahoa cave system, the kipuka south of Pahoa, the Seaview Road site and the Kazumura cave system. Recommend routing to avoid these critical sites.

Title 5: *Hawai'i Deep Water Cable Program. Phase II-C, Task 1. Environmental assessment.*

Author(s), date: Krasnick, G. and J. Mansur of Parsons Hawai'i for the State of Hawai'i, Department of Planning and Economic Development. August 1987.

Relevance to the HGP-EIS: Overview of biological problems, no new biological information; moderately useful.

Summary: Biological information is taken from earlier studies. Provides a List of exclusion areas for Hawai'i, Maui and O'ahu. States that the transmission corridor may pass through other natural areas, but also say that areas that could be adversely affected would be avoided. Provides a cursory description of vegetation in west Puna, Keaau, the saddle area, coastal Kohala, southern Maui and Waimanalo. Provides a list of threatened and endangered species that may be present in the vicinity of the terrestrial portions of the corridor. Discusses probable impacts including the effects of electromagnetic fields and mitigation. Also considers the impact of the cable on marine organisms.

Title 6: *Hawai'i Deep Water Cable Program. Phase II-B, Task 5. Overland transmission corridor study. Hawai'i, Maui, O'ahu.*

Author(s), date: DHM Planners Inc. for Parsons Hawai'i, the Hawaiian Electric Company, Inc. and the State of Hawai'i, Department of Planning and Economic Development. July 1985.

Relevance to the HGP-EIS: No new biological information; minimally useful.

Summary: Four exclusion areas and 15 constraint factors are mapped and overlaid. The exclusion areas include Natural Area Reserves protective subzones for unique biological, geological and archaeological features, National Parks and National Historic sites. Low, medium and high constraints are identified for vegetation and wildlife. Vegetation constraints only consider plant canopy height. Wildlife constraints are based on endangered or threatened species and their habitats. Invertebrates and the Hawaiian hoary bat are not considered in setting constraint levels. Maps of three islands showing composite biological constraints, exclusion areas and potential corridors.

Title 7: *Transmission line routing study. Kamana to Keamuku. 138 KV line.*

Author(s), date: EDAW, Inc. for Hawai'i Electric Light Company, Inc. February 1983.

Relevance to the HGP-EIS: Weak biological assessment. No new data or data not presented; minimally useful.

Summary: Rainfall, vegetation cover, critical habitats and endangered species are used to identify areas of high, medium and low constraints on development. Barren lava, cinder lands, urbanized lands and areas without endangered species and critical habitat are considered to have a low degree of constraint. No corridor was completely free of medium-high constraint. Vegetation was based on 1978 orthophoto and field surveys. No survey methodology or data is presented. No new data on animals. The statements on Palilia were based on an interview with L. Kramer, USFWS; the statements on kipuka and cave habitats (i.e., arthropods) were based on old archival sources at the Bishop Museum.

III. COMMERCIAL SATELLITE LAUNCHING FACILITY (SPACEPORT)

Title 1: *Conceptual plan. Commercial satellite launching facility, Palima Point, Ka'ū, Hawai'i. Draft environmental impact statement. Volumes 1-10.*

Author(s), date: MCM Planning, Inc. for the State of Hawai'i, Department of Business, Economic Development and Tourism. August 1993.

Relevance to the HGP-EIS: New biological information; excellent biotic assessment but minimally useful for HGP-EIS.

Summary: Volume I summarized the nine other volumes. Three major biological impacts are considered. Transportation accidents will negatively affect areas as far as 1 km from the highway. Normal launches should have no adverse biological effects but conflagrations after launch could produce adverse effects. Similarly, on-site toxic spills would produce negative biological effects and could potentially contaminate ground water and the near-shore marine environment. Effects on Hawai'i Volcanoes National Park are covered in Volume II and the biological surveys and risk assessment volumes. **Botanical survey (Appendix IIIA)**: 21 field days within the launch area and the "optimal band" surrounding the launch area. No biologically sensitive communities were found. Vegetation is dominated by alien species with some natives, including pili grass, pioneer 'ōhi'a on young lava flows and shoreline plants. **Bird and mammal survey (Appendix IIID)**: Helicopter survey plus 23 daylight hours of ground surveys and 3 nights with bat detectors. Endangered Hawaiian hawks seen on site and Hawaiian hoary bats seen near the site. Other native birds may occasionally use the site or may fly over the site in route to roosting or nesting areas. Numerous introduced birds and mammals (pigs, mongoose and goats) were common. Potential impacts are discussed. **Marine, anchialine pond, and sea turtle surveys (Appendix IIIE):** detailed study of near shore and anchialine environments include fish, marine invertebrates, algae, anchialine pond fauna (including an unidentified and possibly new species of goby) and water chemistry. Sea turtles censused from shore and nesting areas were identified. Threats from increased access and launch activities are discussed. Also, disruption of commercial and recreational fishing during launches in the 50 mile marine closure area are discussed (see Appendix IXB). **Ecological risk assessment (Appendix VIIIB):** evaluates the potential effects of air pollutants and accidental spills of fuel during transport and launching. Used eco-toxicological literature on non-Hawaiian species to assess risks to Hawaiian species listed as federally endangered, threatened or candidate-for-listing and found within a 15 km radius of the launch facility. Lack of data on some of the chemicals and lack of relevant ecological data make sublethal, chronic and acute effects on populations, communities and ecosystems extremely difficult to model. Concludes that normal launch conditions should have no adverse effects on native organisms and ecosystems, but spills or conflagrations after launch could produce adverse effects.

IV. MANGANESE NODULE PROCESSING FACILITY

Title 1: *Proposed marine mineral lease sale: exclusive economic zone adjacent to Hawai'i and Johnston Islands. Final environmental impact statement. Volumes 1 and 2.*

Author(s), date: U.S. Department of the Interior, Minerals Management Service and the State of Hawai'i, Department of Business and Economic Development. December 1989

Relevance to the HGP-EIS: Good EIS; no new biological information. Minimally useful for the HPG-EIS.

Summary: The geographic areas covered in this EIS are seamounts in the oceans around the main Hawaiian Islands, the Northwest Hawaiian Islands and Johnston Island, plus three land-bases sites for a processing plant located on O'ahu (Ewa District) or Hawai'i (Puna or Kohala Districts). No site-specific impact analyses have been done and no detailed biological studies have been conducted. Commercially valuable biological resources or endangered species that may be impacted by mining and processing are reviewed. Good coverage of marine vertebrate and invertebrate groups associated with seamounts, and marine and terrestrial birds, mammals and sea turtles mainly associated with the Northwest Hawaiian Islands. Poor coverage of terrestrial species in the vicinity of the proposed processing plants. Endangered terrestrial plants and vertebrates are briefly discussed. Flora and fauna of the Northwest Hawaiian Islands are mentioned but not discussed. Good discussion of possible direct, indirect and cumulative impacts that may result from development. Includes biological opinions from appropriate federal agencies.

Title 2; *The feasibility and potential impact of manganese nodule processing in the Puna and Kohala Districts of Hawai'i.*

Author(s), date: R.W. Jenkins, M.K. Jugel, K.M. Keith and M.A. Meylan for the State of Hawai'i, Department of Planning and Economic Development and the U.S. Department of Commerce, National Oceanic and Atmospheric Administration. November 1981.

Relevance to the HGP-EIS: No significant biological information; minimally useful.

Summary: Discusses scenarios for two different locations, Puna and Kawaihae. No field studies were done to assess the biological impact to the area. Only cursory coverage is given for vegetation and fauna, including the marine environment. Birds and mammals are discussed but no terrestrial invertebrates are considered. A preliminary impact assessment did not consider affects on biological resources.

V. WATER RESOURCE DEVELOPMENT

Title 1: *Revised draft environmental impact statement. Water resource development and across-island transmission, island of Hawai'i.*

Author(s), date: Okahara and Associates, Inc. and Y.K. Hahn and Associates for the State of Hawai'i, Department of Land and Natural Resources. November 1992.

Relevance to the HGP-EIS: New biological data; very useful for HGP transmission corridor assessment.

Summary: The proposal is to transport by pipe 20 million gallons per day of water from Hilo (windward, South Hilo) to Waimea (leeward, South Kohala) via Pohakuloa (saddle between Mauna Loa and Mauna Kea). The transport system will require 30 megawatts of electrical energy, and identifies geothermal energy plants as well suited to provide the base energy load. Water usage includes agriculture and development projects. Environmental studies do not include the geothermal subzones but does cover the area from Kaumana to Waimea, which corresponds to a geothermal cable transmission route. The 7 day botanical survey (Appendix D) includes floristics and vegetation, alien plant patterns, rare plants. Makes recommendations for minimizing fragmentation and disturbance to the native ecosystem along the transport route. Lava tubes in the area are identified and a list of invertebrate and arthropod species inhabiting the tubes and cracks in the area along the proposed pipeline are listed (Appendix E). A 6 day bird survey identified native, alien and endangered species and unique communities along the route. Seven endemic and 18 alien species were seen, including the endangered Hawaiian hawk. Impacts and mitigation are discussed.

VI. ECOSYSTEM STABILITY AND INTRODUCED SPECIES

Title 1: *Replacement of* Metrosideros polymorpha, *'ōhi'a, in Hawaiian dry forest succession.*

Author(s), date: L. Stemmermann and T. Ihsle. Biotropica, Vol. 25: 36-45. 1993.

Relevance to the HGP-EIS: Good study; moderately useful.

Summary: 'ōhi'a dominates pioneer dry forest communities in Hawai'i, while other tree taxa dominate later seral stages. Tree density is greater in the later seral communities, and the dominant species there exhibit significantly lower mid-day plant water potentials than 'ōhi'a from nearby pioneer communities. this pattern suggest that the greater water stress experienced by the later seral trees may be due to competition for limited water, and this may restrict 'ōhi'a from these areas. The replacement of 'ōhi'a in later seral stages of Hawaiian dry forests contrasts with its maintenance as the dominant canopy component in both early and late seral rain forest communities.

Title 2: *The effect of alien predatory ants (Hymenoptera: Formicidae) on Hawaiian endemic spiders (Araneae: Tetragnathidae).*

Author(s), date: R.G. Gillespie and N. Reimer. Pacific Science Vol. 47: 21-33. 1993.

Relevance to the HGP-EIS: Good study; moderately useful.

Summary: Examines the distribution of alien ants in mesic and wet forests in Hawai'i and the extent to which they overlap the range of native *Tetragnatha* spiders. Three ant species were implicated in the exclusion or reduced abundance of native spiders. Laboratory studies showed that the spiders were vulnerable to attack by these ants. Discusses why non-Hawaiian *Tetragnatha* and alien spiders in Hawai'i are not affected by the ants.

Title 3: *Alien plant invasions in native ecosystems of Hawai'i: Management and Research.*

Author(s), date: C.P. Stone, C.W. Smith and J.T. Tunison, eds. 1992

Relevance to the HGP-EIS: Good review; very useful.

Summary: Papers presented at a National Park Service symposium. Forty-four papers in ten subtopics, as follows. Perspectives: overview of problems with introduced plants. Especially, Vitousek's paper on effects of alien plants on native ecosystems (also published in *Biological invasions of North America and Hawai'i*, eds. H.A. Mooney and

J. Drake, 1986). Status and distribution of some important alien plants in Hawai'i: chapters on origin and distribution (Wester for all islands; Jacobi and Warshauer for 6 species on the island of Hawai'i; plus others). Specific species include *Clidemia hirta*, *Melastoma candidum*, *Passiflora mollissima*, *Pasidium cattleianum* and *Myrica faya*. Physical and chemical control: Includes discussions of herbicides (Santos, *et al.*) uprooting (Tunison) and fire (Smith and Tunison) as possible control agents. The paper on fire includes a discussion of the effects of fire on native plant species and historic and current causes of fire. Biological control: Papers discuss the use of insects and fungus to control several noxious weed species in Hawai'i. Agency, organization, and landowner approaches: papers discuss various approaches used by public and private agencies to control alien plants. Introduced plants in the absence of ungulates: Papers indicate that eliminating feral ungulates can contribute to recovery of some native plant species. However, native recovery after ungulate removal depends on a number of variables and cannot be assumed (Stone *et al.*) Choosing which plants to introduce: Paper discuss importation rules and the needs of horticulture and agriculture. Choosing which plants to control: Papers discuss modeling invading plant species, methods of prioritizing plant species for control programs, and cost evaluation of control programs. Ecosystem approaches, education, and community involvement: Overview of environmental education in Hawai'i. Conclusion: Brief summary of major conclusions of all the papers.

Title 4: *Seedling and clonal recruitment of the invasive tree* Psidium cattleianum*: Implications for management of native Hawaiian forests.*

Author(s), date: L.F. Huenneke and P.M. Vitousek. Biological Conservation Vol. 53:199-211. 1990.

Relevance to the HGP-EIS: Good study of an invasive species in Hawai'i; very useful.

Summary: Study of the reproductive biology of strawberry guava and its dependence on non-native animals for dispersal. Seeds will germinate under a wide range of conditions including undisturbed sites. Seedlings and clonal suckers are common, and suckers contribute a greater leaf area than seedlings. Germination and establishment do not depend on animal dispersal or on disturbances. Control of strawberry guava cannot rely entirely on control of non-native animals.

Title 5: *A botanical baseline study of forests along the East Rift Zone of Hawai'i Volcanoes National Park adjacent to Kahauale'a.*

Author(s), date: Cuddihy, L.W., S.J. Anderson, and C.P. Stone - Hawai'i Volcanoes National Park; C.W. Smith - Department of Botany, University of Hawai'i. December 1986.

Relevance to the HGP-EIS: Good study of upper elevation forest in the Puna area; useful.

Summary: A study of forested areas in the National Park that would be downwind of the proposed Kahauale'a drill sites. The study site nearest to the geothermal subzone was about 6 km from the up slope boundary of the upper geothermal subzone. Details (with diagrams) of vegetation survey methods are given, including understory, epiphyte and canopy sampling devices. Detailed abundance data and cluster analyses are presented. Measured growth rates of *Ilex* and *Metrosideros*, found growth in some trees, shrinkage in others. Concluded that 7 months was too short for collection of adequate data. An analysis of plants and soil was done for S, Cl, B, Pb, As.

Title 6: *Forest bird communities of the Hawaiian Islands: their dynamics, ecology and conservation.*

Author(s), date: Scott, J.M., S. Mountainspring, F.L. Ramsey and C.B. Kepler. Studies in Avian Biology No. 9. Cooper Ornithological Society. 1986.

Relevance to the HGP-EIS: Excellent scientific bird survey; very useful.

Summary: Covers all of the main Hawaiian Islands. Fully describes the study area, survey methodology and data analyses. Provides individual accounts for native and introduces bird species. Discusses community ecology and conservation issues. Many of these topics are central to the assessing the biological impact of geothermal development. Information on the Puna area has been summarized by Jacobi 1985 (see below).

Title 7: *Summary of the biological information collected during the U.S. Fish and Wildlife Service's Hawai'i Forest Bird Survey in the Puna study area on the Island of Hawai'i.*

Author(s), date: J.D. Jacobi. Unpublished report, U.S. Fish and Wildlife Service, Mauna Loa Field Station, Hawai'i. November 1985.

Relevance to the HGP-EIS: Good summary; very useful.

Summary: Summarizes data for the Puna area published in the Scott et al. 1986 forest bird study (see above). This area includes part of the upper geothermal subzone. Covers sampling methodology, vegetation mapping, vegetation types and rare and endangered plants and birds.

Title 8: *Hawai'i's terrestrial ecosystems: preservation and management.*

Author(s), date: C.P. Stone and J.M. Scott, eds. 1985.

Relevance to the HGP-EIS: Good review; very useful.

Summary: Papers from a symposium on Hawaiian terrestrial ecosystems. 19 papers in 5 subtopics: Status, research, and management needs of the native Hawaiian biota: Papers discuss current status and conservation needs of Hawaiian plants (Jacobi and Scott; Wagner *et al.*), birds (Scott *et al.*) and invertebrates (Gagne and Christensen). Status, research, and management needs for alien biota: Papers discuss the impacts of alien arthropods and mollusks (Howarth), plants (Smith), vertebrates (Stone) and avifaunal diseases (van Ripper and van Riper) on native organisms. Ecosystem monitoring, restoration, and management in Hawai'i: Papers discuss ecological and management aspects of exclosures on vegetation (Loope and Scowcroft), 'ōhi'a dieback (Mueller-Dombois); population size (Schonewald-Cox) and preserve design (Franklin). Roles of responsible groups: One paper on participation of public and private agencies (Kepler). Conclusion: Summary of the symposium.

Title 9: *The biological resource value of native forest in Hawai'i with special reference to the tropical lowland rain forest at Kalapana.*

Author(s), date: D. Mueller-Dombois. Prepared for Bio Power Corporation, January 1985. Also published in Elepaio Vol 45: 95-101. 1985.

Relevance to the HGP-EIS: No new biological information; moderately useful.

Summary: Discusses the important of forests as seed sources for successional events that follow lava flows, soil types from basaltic lava versus ash and their role in native versus alien species composition, the presence of all primary rain forest successional stages on a small scale, side-by-side mosaic, and problems in vegetation mapping that tends to obscure unique aspects of differ areas of forest that fall under one mapping classification. Also includes references to other ecosystem and successional papers.

Title 10: *Ecological studies of Hawaiian* Metrosideros *in a successional context.*

Author(s), date: L. Stemmermann. Pacific Science Vol 37: 361-373. 1983.

Relevance to the HGP-EIS: New biological information; moderately useful.

Summary: Documents the distributional differences in varieties *Metrosideros polymorpha* ('ōhi'a) growing on adjacent young and old lava flows. Pubescent varieties found on

young volcanic substrates and tend to absence from older rain forest soils. A common garden experiment confirms the genetic basis of the varieties. Pioneer 'ōhi'a are able to maintain turgor at lower relative water content than are older forest, glabrous varieties of 'ōhi'a.

Title 11: *Successional trends in the coastal and lowland forest on Mauna Loa and Kīlauea volcanoes, Hawai'i.*

Author(s), date: I.A.E. Atkinson. Pacific Science Vol 24: 387-400. 1976.

Relevance to the HGP-EIS: New biological information; moderately useful.

Summary: Three trends in forest succession on coastal and lowland lava flows begin on bare rock with high rain fall. In coastal forests *Metrosideros polymorpha* is replaced by *Pandanus tectorius*. Inland, succession give rise to *Metrosideros polymorpha* forest and *Metrosideros polymorpha/Diospyros ferrea* forests within 400 years. The same successional events occur on pahoehoe and aa flows. Seasonal rainfall and wind blow salts were considered to be important in differentiating between coastal and inland successional events. Recommends protection of coastal forests for future study.