June 2003 FEIS
Koa Timber Commercial
Forestry operations

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Final

Environmental Impact Statement
for

KOA TIMBER COMMERCIAL FORESTRY OPERATIONS

June 2003

HH 279A

Office of Environmental Quality Control
235 S. Beretania #702
Honolulu HI 96813
586-4185

DATE DUE

July 22, 2003

FINAL
ENVIRONMENTAL IMPACT STATEMENT

for the

KOA TIMBER COMMERCIAL FORESTRY OPERATIONS

South Hilo, Hawai`i
TMKs: 3-2-7-01:01 and 3-2-8-01:02

This environmental impact statement and all ancillary documents were prepared under my direction or supervision and the information submitted, to the best of my knowledge, fully addresses document content requirements set forth in Section 11-200-17, Hawai`i Administrative Rules.

Kyle Dong
President

Date

Prepared By: Koa Timber, Inc.

PREFACE

This Final Environmental Impact Statement (FEIS) has been prepared in compliance with the requirements of Chapter 343, Hawai'i Revised Statutes (HRS) and Title 11, Chapter 200 Hawai'i Administrative Rules (HAR). It addresses the anticipated environmental impacts associated with a Conservation District Use Application (CDUA) for a proposed commercial koa timber forestry operation in the State Conservation District. The accepting authority for the FEIS is the State Department of Land and Natural Resources (DLNR).

An Environmental Impact Statement Preparation Notice (EISPN) for this project was published in November 2001. Comments received on the EISPN, and responses to those comments, are included in this document.

A previous proposal had included an additional parcel of land to the north, Tax Map Key 2-9-005: 002. This parcel has been dropped from the project and is no longer part of the project site.

Please note that changes made to the text of the Draft EIS are distinguished by the <u>underline</u> identifying the new text, and the ~~strikethrough~~ identifying deleted text.

SUMMARY

APPLICANT:	Koa Timber, Inc. 91-188 Kalaeloa Boulevard Kapolei, Hawai'i 96707
ACCEPTING AUTHORITY:	Department of Land & Natural Resources Division of Land Management State of Hawai'i P.O. Box 621 Honolulu, Hawai'i 96809
PROJECT LOCATION:	Makahanaloa, Onomea, Alakahi, Pu'u Moi, Aleamai, Pāpa'ikou, and Pauka'a, South Hilo District, Island and County of Hawai'i
TAX MAP KEY:	3rd / 2-7-01:01 and 2-8-01:02
AREA:	13,129 acres
EXISTING USE:	Undeveloped Forest
STATE LAND USE DISTRICT:	Conservation and Agricultural
ZONING	Open, A-20a
PROPOSED ACTION:	<u>Commercial koa timber forestry operation, including</u>: • Harvesting – Using helicopters to transport trees harvested in the Conservation District to a staging area in the Agricultural District for truck transport to Hilo Harbor. No roads will be constructed in the Conservation District. • Koa regeneration – Activities to stimulate growth of koa trees and generation of seedlings. • Pest management – Hand application of herbicide to control invasive plants, such as strawberry guava. Hunting and trapping of feral pigs. • Inventory and survey – Monitoring of koa resources, native ecosystems, and threatened and endangered species, maintaining records using GPS (global positioning) and GIS (geographic information system) technology.
POTENTIAL IMPACTS	<u>Beneficial Impacts</u>: • Control of invasive pests – i.e., strawberry guava and feral pigs – will improve conditions for koa and native plant regeneration.

- Surveys, GIS database, and ongoing monitoring will yield valuable information about koa growth in a native rainforest, effects of helicopter harvesting and koa regeneration activities.
- 28 jobs, plus additional jobs from economic effects.
- Estimated tax revenues to State: $263,000 per year.
- Continuous supply of koa for local craftspersons.
- Contribution to Hawaiian hoary bat research.

Potential Adverse Impacts/Proposed Mitigation:

- Pre-harvest surveys and planning to avoid impacts on threatened and endangered plant and animal species.
- No-harvest buffer to avoid helicopter noise and/or encroachment on Hakalau Forest NWR.
- Streamside Management Zones and no-harvest buffers to avoid sedimentation impacts on stream water quality, aquatic organisms.
- Strict cleaning practices will be implemented to avoid introduction of alien species into higher-elevation rainforest during forestry activities.

ALTERNATIVES CONSIDERED

No Action: No commercial timber operations within the Conservation District. This would preclude beneficial and potential adverse impacts.
Conventional Harvesting: This is considered infeasible due to potential for significant environmental impacts.

COMPATIBILITY WITH PLANS

State Plan:

- Promotes forestry as one element of diversifying the agricultural base and the economy.
- Calls for prudent management of natural resources, including beneficial uses.
- Encourages protection of rare or endangered species and habitats.

State Agricultural District: Forestry is an allowed use.
State Conservation District: Commercial forestry is an identified use in the Resource Subzone.
County of Hawai'i General Plan:

- Balance economic development with effects on physical and social environment.
- Promote prudent use of island's natural resources.

PERMITS REQUIRED

Conservation District Use Application

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1. SETTING AND PROJECT DESCRIPTION

1.1 Project Purpose and Need

The purpose of the Project is to develop a sustainable forestry for koa in an existing rainforest area. Using adaptive management, the Project will harvest timber in sustainable increments and take actions to enhance the growth and regeneration of koa and the rainforest ecosystem in ways that are consistent with native Hawaiian culture. The Project will produce economic and social benefits by providing income to the company, employment for residents, tax revenues for the State and County governments, and a supply of koa lumber for use on the Big Island and elsewhere.

1.2 Location and Ownership

The project site consists of two parcels (TMK 3rd/2-7-01:01 and 2-8-01:02) located ten miles north of the City of Hilo above the towns of Pāpa'ikou and Pepe'ekeo, between the 1,400- and 3,600-foot elevations (herein referred to as the "Site"). Totaling approximately 13,129 acres, the Site encompasses portions of the ahupua'as of Makahanaloa, Onomea, Alakahi, Pu'u Moi, Aleamai, Pāpa'ikou, and Pauka'a, in the South Hilo District, Island of Hawai'i (see Figures 1 and 2).

Located on the wet, windward side of the island, the Site varies in elevation from 1,400 to 3,600 feet. It consists mostly of open forest, with very little closed canopy. The terrain is characterized by dense, mature rainforest vegetation. Dominant canopy trees are koa and 'ōhi'a. The upper portion of the site (generally above 3,000 feet) is dominated by dense uluhe fern, with patches of wet open sedge lands. Very few koa trees survive in these areas. Dense strawberry guava is found at lower elevations and along the southern (Hilo) boundary.

Koa Forest, Inc. is the fee simple owner of the Site. The property is bordered by the Hilo Forest Reserve (State-owned) to the north and south, former sugarcane lands owned by Mauna Kea Agribusiness to the east, and Hakalau Forest National Wildlife Refuge to the west (see Figure 3).

1.3 Project Description

The primary goal of Koa Timber is to harvest koa timber in a way that sustains and enhances the koa forest and native ecosystems. This will be accomplished by selectively logging a limited amount of koa timber each year, controlling alien plant species, and creating conditions that will enhance regeneration of koa trees and other plants native to the area. Logging activities will be planned and carried out in a manner that protects endangered plants and animals.

Based on implementation of the Forest Management Plan and recommendations concerning preservation of native ecosystems, the project is expected to yield substantial benefits:

- Jobs for local Hawai'i residents within the forest products industry.
- Responsible stewardship of a unique resource that is at risk. Regeneration is vital to this native forest. Degraded portions of the native forest will continue to decline over time. Other portions of the native forest that currently are in good condition are likely to experience hastened deterioration without active management.
- Establishment of a sustainable forest. The annual budget will include funding to aid forest sustainability programs. ~~An Advisory Committee of~~ Third Party consultants which will include foresters ~~and~~, biologists and consultants such as Dr. Randy Senock, Dr. Ron Terry and Wade Lee will provide guidance on the direction and implementation of silvicultural activities.
- A sustainable, high-quality supply of koa to maintain jobs for Hawai'i's craftspeople. An estimated 5,000 board feet per month of milled lumber will be allocated to Big Island craftspeople. With a reliable supply of koa, artists and businesses can expand the market for this uniquely Hawaiian wood.

Koa Timber commissioned Atterbury Consultants, Inc. (ACI), to prepare two reports: the Sustained Harvest Estimate and the Forest Management Plan (FMP). This section summarizes the reports, which are included in the document as Appendixes A and B.

1.3.1 Sustained Harvest Estimate

The forest has generated naturally and consists of all-aged stands. With its large elevational gradient, the Site encompasses several different forest types (see Section 2.4 below for a description and map of forest/vegetation types). The volume of merchantable koa varies by forest type. The forest is constantly changing with the spread of invasive species, both flora and fauna. It is likely that feral pigs are spreading strawberry guava and other non-native species. These exotic species compete for light, water, and growing space with native koa and ʻōhiʻa.

The only harvesting to date has been in the portion of the Site that lies within the State Agricultural District. Field examination of this tractor- and helicopter-logging site has shown little damage and a heavy crop of koa seedlings. Natural seeding fills in open areas very quickly and, with the proper conditions, can grow rapidly the first few years.

Koa is a rather short lived species. Current literature gives the species maximum merchantable age at about 100 years. Beyond this age, mortality and defect will render most koa trees unusable. Koa forests experience heavy mortality, especially at young ages. Less than one percent of koa seedlings will live to 100 years.

Virtually all trees of merchantable size have two or more tops. Apparently, the wind breaks out the tops when the trees get through the main canopy. This results in trees with a good peeler (thin strips for veneer) or saw-log to the first fork in the trunk. The distance to the fork and the number of stems above the fork create a large statistical variation in the volume of timber in some diameter classes.

Information reviewed in preparing the Sustained Harvest Estimate included an earlier "Koa Forest Inventory" prepared in 2001 by Jaakko Poyry Consulting. This report was based on three weeks of extensive helicopter photography and fieldwork. Because the raw data and GIS (geographic information system) maps from this project are not available, however, the report has been used only as a source of general information and for comparison of timber volumes. Other information sources included a timber volume estimate prepared by Northern Tier Forestry (also used for comparison); growth data from a few 40-year growth

plots (not on this forest) and from some regeneration permanent plots; and other literature on koa.

There is a considerable amount of literature describing the variety of pests and their impact on koa forests; however, there is very little concerning growth data, yield tables, or growth models. This dearth of inventory information presents the greatest problem in determining a sustainable harvest base.

The sustained harvest estimate is based on (1) a stand table constructed from timber survey data that provides an estimated inventory of trees by diameter class and the amount of board-feet of timber; (2) information from studies of koa growth rates, and (3) agriculture survey after harvesting.

The construction of a stand table for the Site was based on limited data collected by Toby Atterbury of Atterbury Consultants, Inc., and Jim Todd of Woodward-Stuckart. Observations consisted of 32 plots, encompassing 163 trees. In order to develop a more accurate forest inventory, additional data needs to be collected from cruise plots throughout the property. Monitoring reports over time will yield data regarding growth rates in this forest. These data will be used to further refine the sustained harvest plan.

The Site includes streams and areas that have little or no koa. ʻŌhiʻa is dominant in the upper elevations, and there are groves of eucalyptus in the lower-elevation lands. Deducting an estimated 3,100+ acres for stream buffers, non-koa areas and a buffer along the common boundary with the Hakalau National Forest Wildlife Refuge (western boundary), the net timber area is estimated to be 10,000 acres. These acreages will be refined using GIS mapping, when a detailed inventory has been completed.

Several growth plots have been measured over the last 40 years and provide a good, but limited, record for koa. These data come from even-aged stands, which typically show a higher growth rate (more than double) than what can be achieved in a natural, all-aged forest. Natural forests have openings and a much less uniform stocking. Additional growth data is needed by forest cover type, elevation, all-aged stands, and other criteria to complete the picture. Based on the available data, ATI estimates the annual growth rate at 100 board feet per acre.

In Table 1, "Total Board Feet" (column 7) is calculated by multiplying the Average BF per Acre" by the net timber area (10,000 acres). This yields an estimate of 26,560,000 board feet of koa timber available for harvest. Estimating conservatively, one year's growth will add an average of 100 board feet per acre. With 10,000 acres, the growth estimate for the entire harvest area is 1.0 million board feet per year.

Table 1. Stand Table Summary, Koa Timber, Inc.

DBH	Trees per Acre	Cumulative Trees per Acre	Average BF per Tree	Average BF per Acre	Cumulative BF per Acre	Total Board Feet	Cumulative Board Feet
8	0.597	0.597	20	12	12	120,000	120,000
9	0.606	1.203	30	18	30	180,000	300,000
10	0.807	2.010	35	28	58	280,000	580,000
11	0.932	2.942	43	40	98	400,000	980,000
12	1.686	4.628	50	84	182	840,000	1,820,000
13	1.935	6.563	66	128	310	1,280,000	3,100,000
14	3.165	9.728	69	219	529	2,190,000	5,290,000
15	1.456	11.184	93	135	664	1,350,000	6,640,000
16	2.676	13.860	92	247	911	2,470,000	9,110,000
17	1.804	15.664	107	193	1,104	1,930,000	11,040,000
18	1.518	17.182	124	188	1,292	1,880,000	12,920,000
19	1.379	18.561	173	239	1,531	2,390,000	15,310,000
20	0.998	19.559	216	216	1,747	2,160,000	17,470,000
21	0.774	20.333	142	110	1,857	1,100,000	18,570,000
22	0.851	21.184	254	216	2,073	2,160,000	20,730,000
23	0.645	21.829	257	166	2,239	1,660,000	22,390,000
24	0.578	22.407	277	160	2,399	1,600,000	23,990,000
25	0.258	22.665	140	36	2,435	360,000	24,350,000
26	0.258	22.923	461	119	2,554	1,190,000	25,540,000
27	-	23.224	500	-	2,554	-	25,540,000
28	-	23.224	500	-	2,554	-	25,540,000
29	-	23.224	500	-	2,554	-	25,540,000
30	0.301	23.224	339	102	2,656	1,020,000	26,560,000
Totals	23.224			2,656		26,560,000	

Standard abbreviations: DBH = diameter at breast height (in inches); BF = board feet.
Source: Atterbury Consultants, Inc.

Based on Table 1, ACI computed a harvest schedule. ACI assumed a partial cut prescription for an all-aged stand, only harvesting trees ~~18~~ 13 inches DBH and larger over a ~~10~~ 7-year harvest cycle. That is, every acre will be visited once every ~~10~~ 7 years. During each entry, the number of available trees on a specific acre may vary from zero to ten.

ACI estimated that there will be 7.56 trees harvested per acre over a ~~10~~ 7-year cutting cycle, amounting to 1,552 board feet per acre. These estimates are computed by adding the trees per acre column and board feet per acre column for diameter classes ~~18~~ 13 - and above. If we assume that only 10,000 total timbered acres are available, there will be 1,000 acres available each year of the cutting cycle. The estimated annual volume is:

1,000 acres * 1,552 BF/acre = 1,522,000 board feet

Please note that this annual harvest volume figure is only an "estimate." The amount will vary by year, and may actually be plus or minus 25 percent depending on the accuracy of currently available data.

1.3.2 Forest Management Plan

In summary, the primary objectives of Koa Timber's Forest Management Plan are as follows:

- Log mature and dead and dying koa trees with minimum impact to adjacent trees through the use of heli-logging.
- Create a sustainable harvest while improving the native forest.
- Foster regeneration of koa trees.
- Control alien plant species.
- Protect endangered plants and animals.

The Forestry Management Plan (Appendix B) describes the following aspects of the Project operations: timber harvest, harvest methods, transport, land set-asides, forest inventory, forest regeneration, management of invasive species, surveying and monitoring for

threatened and endangered species, land management practices, and organization. These topics are summarized below.

Timber Harvest: Harvesting will be scheduled on a ~~10~~7-year cycle, so that each acre will be visited once every ~~10~~ 7 years. Based on an estimated koa timber area of 10,000 acres, this means that approximately 1,000 acres will be visited each year. The FMP prescribes a partial cut of the all-aged stand, only harvesting trees ~~18~~ 13 inches DBH (diameter at breast height) and larger. Based on current surveys, the number of appropriately-sized trees on a given acre will vary from zero to six or seven. While the "Sustained Harvest Estimate" projects a sustained harvest of 1.5 million board feet per year, the initial proposal is to harvest a lesser amount, 1.0 million BF annually. This is equivalent to the estimated timber growth of 1.0 million BF per year (100 BF/acre/year * 10,000 net acres = 1.0 million BF).

In the first year of operation, Koa Timber will complete a detailed forest inventory of the Site, which will be incorporated with other information in a GIS-based database (see below). Completion of this inventory and annual monitoring of growth and regeneration will provide the data with which Koa Timber can refine and adjust the sustainable harvest.

Harvest Methods: Harvesting will not take place during the months ~~January~~ June through ~~March.~~ August. Prior to that time, harvest units will be mapped and trees will be selected and marked for harvest. Selection will include mature trees of ~~18~~ 13 inches DBH or larger, including some trees that are dead or dying. Some dead or dying trees will be retained as habitat for various native fauna. Selection will also seek to optimize spacing around residual trees in order to maximize growth and regeneration of juvenile koa. Foot trails to selected trees, to allow access for felling and yarding crews, will be built and covered with ferns for soil protection.

Trees will be felled using chainsaws. Logs will be bucked to maximize utilization standards. Downed woody debris will be retrieved if marketable. Slash from harvesting operations will be lopped to lie within 36 inches of the ground. If the debris could interfere with planting or natural regeneration, then it will be left in piles. Small crown branches and leaves shall be scattered to hasten natural decomposition. This will also provide organic matter for the soil and habitat for insects.

In order to minimize damage to felled trees as well as to surrounding trees and vegetation, Koa Timber will use helicopters to land crews and to remove the felled trees to a staging area. No roads will be constructed within the Conservation District, thus preserving forest habitat, avoiding soil erosion, and reducing the potential for introducing alien species. The felled trees will be lifted in place and not skidded to a clearing.

Transport: Based at Hilo Airport, helicopters will travel north parallel to the coast, turning west and following Kapue Stream mauka to the Site (see Figure 4). Helicopters will deliver the cut trees to a cleared staging area, located on Agricultural District land in the northeastern corner of TMK 2-7-001: 001. During log extraction, helicopter flights will originate and end within the Site. Initially, while harvesting timber on the Agricultural lands, the company used a staging area located in the southeastern corner of the site. Moving the staging area north is intended to avoid noise impacts on residences located near the southeastern corner of the property.

As in its current timber operations, Koa Timber will stack and hold cut trees at the staging area and truck about 10-12 trailer-loads per week to its sawmill in Pepe'ekeo. At the sawmill, which is located in a warehouse near the old Pepe'ekeo sugar mill, the logs are trimmed and cut. The cut logs are then trucked to Hilo Harbor, also at the rate of 10-12 truckloads per week, for shipment to Oahu via regularly-scheduled Young Brothers barge. The transport of logs to the sawmill and Hilo continues at this relatively low rate until all of the harvested timber is processed – well beyond the three-month harvest period.

Land Set-Asides: Approximately 3,100 acres of the total 13,129 acres will be set aside from harvest activities. This will include mauka lands designated as Critical Habitat by the U.S. Fish & Wildlife Service. A mauka buffer area of at least 300 feet will be reserved from harvest, in order to minimize inadvertent encroachment and noise on the adjacent Hakalau Forest National Wildlife Refuge.

Forest Inventory: Sustainability of the forest will be assured by closely monitoring the ecosystem. Geographical Information Systems (GIS) will be used to make accurate and updateable maps of the property. These electronic maps should include various layers of information, such as Public Land Survey System (PLSS), ownership lines, zoning lines, roads, streams, topographic lines and/or elevation points, streams and stream buffers, timber

type zones, harvest history, records concerning endangered species, invasive species locations, invasive species control activities, harvesting plans, forest inventory plot locations, images (geo-referenced and orthographically-corrected), and other needed data. A forest inventory of the property will be constructed and maintained in digital format. All data and information needed for harvest planning and tracking and monitoring of biological resources will be included in these files and linked to the GIS.

Images (satellite and air photo) that are geo-referenced and orthographically processed will be acquired and included as a layer in the GIS. These will be used to stratify the image into timber types. The GIS will be used to calculate stream buffers and the net acreages in each timber type. The stratified timber types will be sampled (cruised) and a forest inventory constructed. This forest inventory will be capable of summarizing the data in various formats for information analysis and report generation. Additionally, the inventory data will be used to grow (or project) future timber volumes on a year-by-year basis. These future projections will also show timber depletions.

The property will be stratified into various vegetation zones and entered into GIS as polygons. These new strata will enclose various sizes of timber, stream buffers, and any other unique feature that needs to be accounted for with the inventory. Each timber polygon will be sampled by means of a sample cruise. Data from this cruise (merchantable volume, sort and grade, health issues, other tree parameters, and other vegetation indicators) will be compiled and stored in a digital forest inventory system. This information will be the basis for management planning, quality control tracking, and value appraisal.

The digital forest inventory will contain data from each forest type, whether it currently contains merchantable volume or has the potential for conversion to a denser koa forest type. This digital forest inventory provides the foundation for operational planning in the management of the forest. It will provide the data needed to assign tasks and budgets in the pursuit of a healthy, productive, native koa forest ecosystem.

The inventory system will be maintained as the forest grows and is harvested. Periodic cruising will be performed on various timber types as they move into merchantable sizes. Data from these cruises will be used to update the digital forest inventory. Depletions, or removals, will be incorporated into the inventory system on an annual basis. A series of

permanent plots will be installed, and a portion measured each year to develop growth models and to monitor other vegetation, such as invasive species and native species of interest. The exact size and location of the plots will depend on information garnered from the stratified digital inventory.

Forest Regeneration: Every attempt will be made to encourage natural regeneration. Koa seeds are abundant and can survive in the seed bank for a number of years. When ground is disturbed, such as when a tree is removed, seeds from the seed bank will sprout. Survival of one or two of these seedlings to maturity will depend on a number of factors, both biotic and abiotic. Annual forest management activities need to address the agents that reduce seedling survivability.

During harvesting and other ground disturbance activities, soil scarification will be done to stimulate natural regeneration with the least disturbance to existing koa seedlings. Areas where natural koa regeneration is low or lacking will be scarified and interplanted.

Koa seeding or planting will take place in areas with low or no natural regeneration using a local seed source. Koa Timber will survey regeneration areas before conducting any site preparation activities. If any endangered species are found, the activities for the area will be modified based upon recommendations from ~~the Advisory Committee.~~ Dr. Randy Senock and his staff (Including Ron Terry and Wade Lee).

Replanting will attempt to restore the original diversity of the native forest in both species and structure (i.e., unnatural "plantation" uniformity in composition will be avoided). A full range from early regeneration to old growth will be maintained. The introduction of exotic species will be monitored and controlled. The value of "non-economic" native species is recognized as an important component to the overall ecological health of the stand in terms of nutrient balance, erosion control, and pest control.

Six months after planting or seeding, portions of the area that continue to be barren or have suffered animal damage will be re-seeded or replanted with koa. Competing vegetation will be removed when necessary. Approximately five years after planting or seeding, areas that continue to be barren, have animal damage, or have low regeneration, will be replanted with koa. Fertilizer may be applied on a limited basis if it proves to be beneficial.

Management of Invasive Species: The control of non-native invasive plants and feral pigs appears to be the primary factors for successful koa regeneration. Strawberry guava is extremely difficult to kill and is spreading throughout the property. It will be sprayed with ~~glyphosate~~ Triclopyr from a backpack sprayer, directly on the plant foliage. ~~Glyphosate~~ Triclopyr is a broad-spectrum, nonselective, ~~systemic weed and grass~~ woody plant killer. Its mode of action is to translocate through the plant to kill the roots. The herbicide is used to control perennial ~~and annual grasses and~~ broadleaf weeds and brush. ~~Glyphosate~~ Triclopyr is bio-degradable, will not wash or leach to affect nearby vegetation~~, and may be used over root zones of desirable plants. It can be purchased in a ready to use formulation of 1.92% Glyphosate. In addition to being biodegradable, the herbicide becomes rainproof two hours after application. Once a patch of strawberry guava has been killed, it can be mechanically removed and the ground replanted to native vegetation.~~.

Control of feral pigs is a key component in restoring the native forest ecosystem. Three methods of pig control will be used: hunting, trapping, and limited fencing. Currently a few local hunters are taking pigs from the property. Additional recreational hunting will be encouraged by improving access and contacting hunting clubs. The company could sponsor an annual hunt with the participation of hunting clubs and other community groups. Hunting will be augmented by trapping in remote parts of the property that are difficult to access. The extent and location of fencing will be based on detailed planning with the forester and the biology consultant(s)~~, in consultation with the Advisory Committee~~.

Surveying and Monitoring for Rare, Threatened and Endangered Species: Botanical surveys of the most heavily-timbered koa areas have been completed. One endangered plant was identified (see Section 2.4 below). Additional plant surveys will be conducted in the first year of operation during the planned timber cruise of the entire property. Prior to harvesting, trained biologists will survey the planned harvest area(s) for endangered or threatened birds, including the Hawaiian Hawk, and endangered or threatened plant species. Though adequate methods are lacking, pre-harvest surveys will also look for the endangered Hawaiian hoary bat. If any endangered or threatened species are found to be active, then activities for the area will be modified to minimize impact. For more detailed discussion of these issues, see Section 2.4 below.

Land Management Practices: To prevent soil erosion and sedimentation of perennial streams, Koa Timber will follow the "Best Management Practices for Maintaining Water Quality in Hawai'i," published by the Division of Forestry and Wildlife, Department of Land and Natural Resources. In addition to maintaining Streamside Management Zones (SMZs), a minimum ~~75~~ 200-foot no-harvest buffer area will be maintained along all named perennial streams. Although there are no known occurrences of fire on the Site, Koa Timber and its subcontractors will establish and implement contingency plans to address fires, as well as fuel spills.

Organization: Koa Timber ~~will establish an Advisory Committee~~ has hired Dr. Randy Senock, Ron Terry, Wade Lee and consultants to provide ongoing consultation. ~~To be composed of experts in forestry, Hawaiian rainforest ecology, and native Hawaiian cultural practitioner, the Committee will~~ to advise on forestry practices and ecosystem management techniques; review and monitor forest inventory and biological data; and oversee Hawaiian cultural access. The Committee will provide advice on habitat improvement efforts, particularly the use and location of exclosure fencing.

~~A~~ Atterbury Consultant along with Dr. Randy Senock will be the full-time Forest Manager group and will be tasked with planning and organizing all phases of forest management. The Forest Manager will be responsible for overseeing data collection and forest analysis; supervising biologists and field crews working on invasive species control~~; and staffing the Advisory Committee. This position should be filled with a person who has competency in forestry and who is knowledgeable on Hawaiian native species and ecosystems~~.

1.4 Project Chronology

Since its inception, the project has been modified and has had changes in management. Following is a brief chronology:

October 2000	Koa Timber initiates project; consultants undertake assessments of biological, archaeological, and cultural resources.

March 2001	Draft Environmental Assessment (DEA) published, with anticipated Finding of No Significant Impact by DLNR.
April 2001	Board of Land and Natural Resources holds public hearing on CDUA application; Koa Timber withdraws DEA in favor of preparing an Environmental Impact Statement (EIS).
	Lender Metropolitan Mortgage assumes control of project, commissions additional forestry and biological studies.
November 2001	Consultant Wilson Okamoto & Associates submits EIS Preparation Notice for project. Non-contiguous parcel of land under separate ownership (TMK parcel 2-9-005: 002) is dropped from the project
August 2002	Management of project reverts to Koa Timber; consultant PlanPacific contracted to prepare the Draft EIS.
December 2002	Consultant PlanPacific submits Draft EIS for publication and public comment.
June 2003	Consultants Steven Massey and Wade Lee to submit Final EIS for publication.

2. DESCRIPTION OF THE EXISTING ENVIRONMENT, IMPACTS AND MITIGATION MEASURES

2.1 Physical Characteristics

2.1.1 Climate

The Site is located on the wet, windward side of the island. The annual rainfall increases with elevation to 236 inches (6000 mm) mean annual rainfall at elevations ranging from 1800' to 2800', then decreases to 196" (5000mm) at the western (mauka) boundary of the Site at elevation 3600' (see Figure 5). The rainfall is relatively evenly distributed throughout the year. Mean annual temperature is about 65° to 70° F. Wind patterns are diurnal – dominant easterly tradewinds prevail during the day, while in the evening cooler westerly winds sweep down the slope of Mauna Kea.

2.1.2 Topography and Soils

The Site generally slopes at 7% from elevation 3600' to 1600' above mean sea level, but is dissected by many small drainage ways with locally steeper slopes. The U.S. Soil Conservation Service, Soil Survey of Island of Hawai'i classifies the soil at the site as the Akaka soils (rAK). The Akaka soil series consists of moderately well drained silty clay loams that formed in volcanic ash. Although a portion of the Site is in the Sate Land Use Agricultural District, the Site does not include any Agricultural Lands of Importance to the State. The Land Study Bureau overall productivity classification is Class D (Class A and B are considered prime agricultural land).

Impacts and Mitigation

With exception of clearing staging areas for the transport of logs, the project does not involve significant land-disturbing activities. All staging areas will be located in the State Agricultural District, and best management practices will be implemented to control soil erosion.

2.2 Streams and Drainage Basins

Numerous perennial streams and drainages dissect the Site and flow to the ocean. Six major streams are named on the USGS topographic quadrangle map: Honoli'i, Pāhoehoe, Kapue, Hanawī, Kawainui, and Wai'a'ama. Figure 6 shows these streams and their respective drainage basins in relation to the Site.

Only Honoli'i Stream has been monitored for stream flow and/or water quality. Based on more than a decade of monitoring data from a station several miles upstream of the stream mouth, the average flow was estimated at 125 cubic feet per second (cfs) and the median flow at 38 cfs. This qualifies Honoli'i as a "large" stream – one of 11 in the state, and three on the island. All streams listed are perennial streams, and many support perennial tributaries as well.

There is only a limited amount of water quality data for any streams in the area. Honoli'i Stream is known to suffer from excess sediment and bacteria, almost certainly associated with agricultural activities in some of its tributaries, downstream from the Site. Although there are no known water quality studies for project site streams, the pristine nature of the watershed would indicate high water quality within the Conservation District.

Honoli'i Stream is categorized as a "Candidate Stream for Protection" in the 1990 report of the Hawai'i Stream Assessment (HSA). Experts rated it one of the highest-quality streams in the state for aquatic resources. In addition, Honoli'i Stream was rated as having a diversity of aquatic, riparian, and recreational resources. The HSA rated Hanawī Stream as having valuable riparian resources and Kawainui Stream as having valuable recreational resources.

Maintaining the Site as a forest will preserve the watershed functions in terms of recharging groundwater aquifers and tempering surface runoff.

Impacts and Mitigation

Koa Timber will undertake the following mitigation measures to ensure that forestry activities do not adversely impact stream water quality:

Erosion and Sedimentation Control: Cleared staging areas in the Agricultural District will be located ~~away from streams.~~ in 200 feet no harvesting buffer zones. Where such clearings

drain into a stream, best management practices will be followed to control the runoff. No roads will be constructed in the Conservation District.

Stream Management Zones: To avoid erosion and sedimentation of streams, the Project shall observe the best management practices for streams, promulgated by the Division of Forestry and Wildlife, DLNR. This includes maintaining a no-harvest buffer along stream banks.

2.3 Natural Hazards

Since the Project involves no habitable structures, the risks to human life and property will be minimal.

2.3.1 Flood Hazards

According to the Flood Insurance Rate Map, there are no flood hazard zones within the Site.

2.3.2 Volcanic and Earthquake Hazard

The United States Geological Survey (USGS) classifies the Site as being in Lava Flow Hazard Zone 8 on a scale of 1 to 9, where 1 stands for the highest risk. Most of the area in Zone 8 along the slopes of Mauna Kea has not been affected by lava flows for the past 10,000 years. The Building Code designates the entire island of Hawai'i as Earthquake Zone 3 and contains certain structural requirements to address the relative seismic hazards.

2.4 Flora and Fauna

This section summarizes four studies and reports prepared for the project, which address terrestrial flora, terrestrial invertebrates (i.e., insects and snails), terrestrial fauna (i.e., birds and the hoary bat), and aquatic organisms (flora and fauna residing in streams). The full reports are included in this document as Appendixes C, D, E and F. The final part of this section summarizes potential impacts on flora and fauna and proposed mitigation actions.

2.4.1 Terrestrial Flora

This section summarizes the findings of the Koa Timber Project Botanical Report, prepared by Ron Terry, PhD (see Appendix C). The assessment was conducted in two phases, the first

in late 2000, and the second in the summer of 2001. The 2000 effort involved primarily a review of existing information, including Hawai'i Forest Bird Survey (HFBS) maps and various other publications, maps, and data. To supplement this, helicopter reconnaissance enabled a comprehensive overview of the property and the basic forest structure. Following reconnaissance, two partial days of helicopter-drop, on-ground field survey in areas selected for their biological richness were conducted by qualified biologists, followed by laboratory identification of field species.

The 2001 effort was a systematic, eight-day field study carried out by two botanists as part of a larger timber inventory project conducted by Jaakko Poyry Consulting for Koa Timber. The objectives of the field study were as follows:

1. Document all bird and plant species encountered within plots sampled, paying special attention to the presence of any State or federally listed endangered species.

2. Collect quantitative data on species richness, frequency of occurrence, and species density.

3. After data collection, examine how such factors vary with elevation and among plots.

An eight-day botanical and avian field survey of selected areas of the project site and higher elevations was conducted in June and July of 2001. The field surveys focused on portions of the Site with higher concentrations of harvestable koa. Since these potential koa harvest sites were the areas of the forest that would be directly disturbed by heli-logging, they were also a logical focus for assessing birds and plants.

Although considerable field time was expended surveying the property during the two efforts, the sum does not and was not intended to represent a "100 percent" botanical survey of the full area. Because of high rainfall, poor ground conditions, and dense under-story vegetation, surveying this region presents special challenges. A government botanist who conducted transects of the property in the 1970s as part of the HFBS spent several weeks trekking through the area, camping at night. Even then, he was only able to cover a very

limited area, perhaps two percent of the property. Consequently, it is clear that even a full ground survey at the reconnaissance level would be an enormous effort.

Three distinct rainforest zones extend from the edge of the farmland at an elevation of approximately 1,500 feet to approximately 7,000 feet up the slope of Mauna Kea.

- From 1,500 to 3,000 feet, the vegetation may be characterized as sub-montane rain forest dominated by ʻōhiʻa (*Metrosideros polymorpha*) and koa (*Acacia koa*), with koa occupying only the better drained positions in this high-rainfall environment (Mueller-Dombois and Fosberg 1998). This zone has also been identified as koa- ʻōhiʻa Montane Wet Forest with a Montane Wet Sedgeland community occupying forest openings (Gagne and Cuddihy 1990).
- Montane rainforest lies between 3,000 and 5,000 feet (Mueller-Dombois and Fosberg 1998). The lower half of this zone is the area of highest rainfall, and is totally dominated by ʻōhiʻa trees and large patches of uluhe fern (Dicranopteris linearis). The upper half is primarily dominated by ʻōhiʻa and receives less rainfall, but low clouds are frequent and result in substantial fog drip from trees (Juvik and Ekern 1978).
- Between 5,000 and 7,000 feet, the forest may be characterized as upper montane rainforest, with ʻōhiʻa and koa co-dominants (Mueller-Dombois and Fosberg 1998). Because ʻōhiʻa and koa rarely form dense canopies, there is a great diversity of mid-canopy trees, understory shrubs, vines and epiphytes throughout the entire rainforest zone.

With elevations that range from 1,400 to 3,600 feet, the Site consists mostly of sub-montane rainforest, with a smaller portion in montane rainforest.

Historically, very little botanical fieldwork has been conducted on the Site. Much of the available information comes from the U.S. Fish and Wildlife Service Hawai'i Forest Bird Survey (HFBS) conducted during the late 1970s, a landmark mapping project conducted throughout the State of Hawai'i. The project involved foot transects by botanists and ornithologists. Four transects from this survey passed through portions of the Site. Vegetation structure and floristic composition were described at stations set at regular intervals along the transects. Taken together, these descriptions, coupled with systematic interpretation of aerial photos, formed the basis of the detailed vegetation maps that were compiled for the area. As the HFBS maps indicate, the project site, while not pristine,

contains areas of largely intact native forest dominated by koa and ʻōhiʻa, along with patches moderately to heavily invaded by alien species, mainly strawberry guava or waiawī (Psidium cattleianum). Table 1 describes the principal forest types found on the Site, using the Hawai'i Forest Bird Survey (HFBS) typology. Figure 6 shows the vegetation zones as mapped by the HFBS.

A total of 49 flowering plant species, including 31 species native to Hawai'i, were identified within 32 plots surveyed. A single individual of the State and Federally listed endangered "mintless mint" (*Phyllostegia velutina*) was encountered. No other threatened or endangered flowering plant species were detected either within or between plots during the course of the survey. In addition, a total of 40 species of ferns or fern allies, including 37 species native to Hawai'i, were identified, none of which are threatened or endangered. Lists of flowering plants and ferns identified are provided in Tables 3 and 4 respectively of Appendix C.

The survey found that the most frequently occurring native flowering plant species were ʻōhiʻa, koa, ʻōhelo, ʻōlapa, kāwaʻu, and ʻalani. Each of these species was found in 90% of the plots surveyed. The most frequently encountered alien species were carpetgrass (*Axonopus fissifolius*), found in 87% of plots surveyed, and strawberry guava, found in 81% of the plots surveyed. In terms of individuals per acre, strawberry guava was the most abundant tree species, forming a near monoculture in the lower elevations of the project site. The density of strawberry guava decreased linearly, and perhaps exponentially, with elevation. Native tree species generally increased in abundance at higher elevations.

Although sampling focused on areas where koa was abundant, other notable plant communities within the project site include ʻŌhiʻa /Uluhe Montane Wet Forest and Montane Wet Sedgeland. These communities comprised either portions of some surveyed plots, or were encountered when traveling between plots. The ʻŌhiʻa /Uluhe Montane Wet Forest likely encompasses more total acreage within the project site than any other community. This community was characterized by dense mats of uluhe up to 15 feet thick, interspersed with relatively few ʻōhiʻa trees and an occasional ʻalani tree. Very few other plant species encountered in this community. The Montane Wet Sedgeland Community was common in relatively flat, poorly drained, areas adjacent to Montane Wet Forests. The native sedge

Table 2. Vegetation Zones, Hawai'i Forest Bird Survey

HFBS Vegetation Type Code	Tree Canopy Crown Cover	Tree Canopy Height	Overstory Tree Species Composition	Understory Species Composition
122	Closed canopy, most crowns interlocking; >60% cover	Tall stature trees; >10m tall	Koa-'ōhi'a dominant, scrub native trees subdominant	native tree ferns dominant, native shrubs subdominant
139	Open canopy, some or no interlocking crowns; >25-60% cover; many standing dead or defoliated trees	Tall stature trees; >10m tall	Koa-'ōhi'a dominant, scrub native trees subdominant	matted ferns-native shrubs dominant, tree ferns subdominant
142	Open canopy, some or no interlocking crowns; >25-60% cover	Tall stature trees; >10m tall	Koa-'ōhi'a dominant, scrub native trees subdominant	strawberry guava dominant, native shrubs-tree ferns subdominant
146	Open canopy, some or no interlocking crowns; >25-60% cover	Tall stature trees; >10m tall	Koa-'ōhi'a dominant, scrub strawberry guava subdominant	native shrubs-strawberry guava co-dominant
172	Scattered trees; 5-15% cover; many standing dead or defoliated trees	Scrub trees, moderate stature; 5-10m tall	Koa-'ōhi'a-native trees co-dominant	matted ferns-mixed native and introduced grasses-native shrubs co-dominant
175	Scattered/open canopy, many standing dead or defoliated trees	Tall stature trees; >10m tall	'Ōhi'a-scrub 'ōhi'a-native trees co-dominant	matted ferns-mixed native and introduced grasses-native shrubs co-dominant

(*Carex alligata*) was previously abundant in these areas, but disturbance by pigs has resulted in a community dominated by introduced species such as bog rush (*Juncus planifolius*), broomsedge (*Andropogon virginicus*), and carpetgrass.

The U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) maps for the Island of Hawai'i depict a roughly 7,200-acre swath of wetlands (palustrine, scrub-shrub, broad-leaf evergreen, saturated) within the mauka area of the 13,129-acre property. This area comprises the entire 'ōhi'a-uluhe zone (type 175 above) and large portions of other zones. Different agencies employ different criteria for determining whether wetlands are present on a given site. According to the Army Corps of Engineers (COE) *Corps of Engineers Wetlands Delineation Manual* (COE 1987:7), COE methodology requires the presence of positive indicators for three parameters – vegetation, soil and hydrology – while the maps created as part of U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) may be derived from remote sensing methods that detect a positive indicator for any one of the three parameters.

No COE-type wetlands determination, much less delineation, has ever been attempted for the property. Given the situation – thousands of wetlands-like pockets varying in size from a few square feet to several thousand square feet in an extremely challenging environment for walking or visual survey, it is unlikely that the painstaking methodology of delineation would be practical.

The consultant's field experience suggests that a large portion of HFBS Type 175 vegetation zones might indeed meet at least some definitions of a wetland. It is interesting to note, however, that of the two dominants in this vegetation zone, 'ōhi'a is classified as a "facultative" plant (i.e., plants with a similar likelihood of occurring in wetlands and non-wetlands); and >uluhe is classified as a facultative upland plant (i.e., sometimes occurring in wetlands, but occurring more often in non-wetlands) (US-COE 1987:18; USFWS 1988). The steep slopes feature numerous small outcrops that are "high and dry", but the majority of the area contains saturated soil, often with standing water. Such conditions are less universal, but still present, in many scattered locations in other vegetation types of the property, and not only those indicated in the NWI maps. The entire property might be described as complex mosaic of various-sized wetland and upland patches. The environmental variation that this

mosaic provides increases the botanical diversity of the area and may provide habitat for birds such as the native Black-crowned Night Heron (*Nycticorax nycticorax hoachtli*).

The following summarizes study conclusions regarding (1) native plants and (2) alien plants. Based on the results of this study, a number of general observations may be made regarding the current structure and dynamics of the Koa-ʻŌhiʻa Montane rainforest within the project site.

First, the Site would appear to harbor few threatened or endangered plant species. Despite intensive searches by botanists over an eight-day period both within and between sample plots, only one individual endangered plant was found. Similarly, the HFB surveys from the late 1970s identified only one endangered plant species - *Cyanea platyphylla* - and reported the presence of the endangered *Cyrtandra tintinnabula*, last seen in 1933. Of course, endangered plants are by their nature difficult to locate, and their absence from the surveys does not indicate they are not present within the project area. However, the expectation was that at least a few endangered individuals in genera such as *Cyrtandra*, *Cyanea, Phyllostegia* or *Clermontia*, all of which are known to occur at similar elevations along the windward Hawaiʻi coast, would be found. Cuddihy et al (1982) reported three endangered plant species (*Cyrtandra*, *Cyanea,* and *Phyllostegia*) encountered in forest at similar elevations approximately 10 miles to the north in Laupāhoehoe Natural Area Reserve.

It should be noted that the USFWS has proposed that a small portion of the Site be designated as Critical Habitat for the recovery of the endangered plant species *Clermontia peleana*. As shown in Figure 8, the proposed Critical Habitat Unit F lies mostly within the neighboring Hakalau Forest National Wildlife Preserve property but includes a sliver of the Site along their common boundary. Koa Timber intends to maintain a wide buffer along the Preserve boundary, which includes the area proposed as Critical Habitat. The company will not undertake forestry operations in the proposed Critical Habitat.

Second, the Koa-ʻŌhiʻa a forest was relatively homogeneous in terms of species composition throughout the project site. In general, species lists compiled from plots in the lower elevations of the study area looked very similar to species lists from the higher areas. These results were not unexpected because the elevational range represented in this study is not extreme. Similarly, Mueller-Dombois et al. (1981) found the forest at slightly higher

elevations on Kilauea volcano to be essentially homogeneous. The species composition of dominant trees in the canopy and sub-canopy zones is also similar between the two forests. ʻŌhiʻa, koa, kāwaʻu, and ʻōlapa were among the most abundant trees at both sites. However, ʻalani, a dominant in the Koa Timber study area, was relative rare in the Kilauea study area. The dominant tree fern species also differed between sites (*Cibotium menziesii* vs *Cibotium glaucum*), possibly because *C. glaucum* grows better at slightly higher elevations.

While the forest is homogeneous in terms of species composition, there are many strong, and some unexpected, relationships between tree species abundance and elevation. The major expectation was that there would be an increase in abundance of most tree species with increasing elevation because of decreasing levels of disturbance. For koa, ʻōlapa, kōlea, and kāwaʻu, these assumptions were valid, although the rationale may or may not be correct. Most interesting was the decline in density with elevation for hāpuʻu ʻiʻi and hame. The lower elevations apparently still represent better habitat, possibly in terms of rainfall or temperature, than do the upper elevations for these species. Also, hāpuʻu ʻiʻi and hame may be more efficient competitors with the more abundant introduced plants at lower elevations. The observation that hāpuʻu ʻiʻi reaches relatively high densities in areas of heavy guava infestation supports this latter idea.

The most abundant alien plant, in terms of frequency of occurrence, was carpetgrass. This species does not appear to be a major threat to the diversity and abundance of native plants within this forest because although it is widespread, it rarely dominates the vegetation in an area, nor does it appear to substantially prevent the germination or growth of most natives. However, these observations would benefit from controlled experimentation.

Strawberry guava was the second most frequently encountered alien plant species and is of greatest cause for concern because: (1) the fruit of this neotropical tree is known to be spread by pigs, which are ubiquitous throughout the project area; and (2) it can out-compete most native Hawaiian plant species over time wherever it occurs (Smith 1989). Alarmingly, this tree is already the most abundant, in terms of number of individuals per acre, of all tree species in the project area. The decline in guava density with elevation within the study area is a classic illustration of the incipient stages of a major invasion. The lower, more disturbed elevations in certain areas of the study site are already a near monoculture of this tree (with

the exception of hāpu'u 'i'i), and there is no known physical or biological mechanism (other than human intervention) that might prevent the further increase in density of strawberry guava throughout the project area.

Tibouchina herbacea and *Clidemia hirta* were also common within the project area. Both of these Melastomes are known to be highly invasive. *Tibouchina* was among the most frequently encountered plant species during this study (present in 53% of plots), yet it only became established on the Big Island in the late 1970s (Wagner et al. 1990). *Clidemia* was present in fewer areas (15% of plots) but has a long history as a noxious weed throughout Hawai'i and numerous other Pacific islands. Both *Tibouchina* and *Clidemia* can be expected to increase in abundance over time within the project area.

Setaria palmifolia is a highly invasive grass that was found within 50% of plots. In areas where it occurs, it forms a dense ground cover that appears to effectively inhibit germination and growth of most native plants. This grass may be spread by pigs and must be considered a significant threat to the native plant community in this area.

2.4.2 Terrestrial Invertebrate Resources

This section summarizes a study of terrestrial invertebrate resources (insects, mollusks, and other arthropods) prepared by Steven Montgomery, Ph.D., Consulting Biologist, which included field surveys in January and February 2002 (see Appendix D). A listing of all invertebrates encountered is provided in Table 1 of Appendix D.

Although no threatened or endangered species were observed within the areas surveyed, three species on the U.S. Fish and Wildlife Service's Species of Concern List are believed to be present on the project site based on experiences in similar forests. These species include *Drosophila mulli* (a pomace fly), *Nesotocus munroi* (a beetle), and *Plagithymysus claviger* (a beetle).

The survey of the property was not comprehensive. A very small portion of the 13,129-acre property (approximately 120 acres) was covered by the survey within a restricted time period. Although the overall study strategy and site selections were designed to mitigate this

recognized handicap, additional sampling is recommended in selected areas before harvest – particularly around the Onomea pu'u.

The following species of interest were identified by the survey:

ARTHROPODA

Homoptera

Acizzia uncatoides (jumping plant louse). This insect sucks sap from the newest growth of Acacia genus plants. Although there are records of large infestations of this pest, their numbers appear to be controlled by predator insects. Massings were reported in 1970 and 1971 (Beardsley 1971a, 1972) and a "light to moderate build-up" was reported in 1976 (Davis 1979). The damage can be server enough to cause die-back of the young terminal growth in individual trees (Beardsley 1972), but the attacks do not generally cause the death of trees and do not affect many thousands of acres as do the Scotorythra.

Coleoptera

Evidence was found of all three native genera of *Cerambycidae*, long-horned wood-boring beetles. They are termed "long-horned" because most species have extraordinary long antennae, which help in detecting the right location for laying eggs. In the higher forest refuges, beetle grubs are also a nutritious food source for native birds such as the endangered 'Akiapōlā'au (*Hemignathus munroi*). The bird's bill is especially suited to opening bark and skewering and removing beetle grubs.

Paranda puncticeps and *Megopis reflexa*. The first two Cerambycid beetles, *Parandra* and *Megopis*, are monotypic meaning there is only one species in each genus throughout their range. These two large, native beetles are found on all the main Hawaiian Islands and feed in many native trees, but their grubs rarely are found in healthy, living trees. Their usual home is in dead, standing trees, and fallen, rotting logs. Although found in koa, both grubs also are found in several other native trees including *Psychotria*, *Mrysine*, *Myoporum*, *Pipturus*, *Metrosideros*, *Elaeocarpus*, and *Pelea* (Swezey, 1954:11).

Plagithymysus. The third native genus of Cerambycid beetles is a puzzle of evolution. Where *Parandra* and *Megopis* have one species each throughout the

island chain, the 140 *Plagithmysus* species are each island specific (monoinsular). Yet all are descended from a single ancestor. Each keeps to its specific food plant by instinctive behaviors, and so ensures species do not interbreed. Legumes, mostly koa, are the host plant for several species of *Plagithmysus*. Eggs are laid only in damaged or dead wood.

Lepidoptera (butterflies and moths)

Koa is host to at least 36 species of *Lepidoptera* (British Museum: HOSTS), including many obligatory species.

Scotorythra paludicola. This caterpillar and closely related species may experience massive build-ups within the koa forest, defoliate thousands of acres of trees, and be feasted upon by predators. Acreage affected can be a thousand acres or many thousands of acres. Each report of defoliation is accompanied by, or shortly followed by, a report of natural control agents moving in to take advantage of the abundant food resource. The caterpillars provide plentiful food for native and introduced birds, their chicks, and parasitic insects.

Hyles wilsoni wilsoni. This native shingid moth is found only on island of Hawai'i and has a much more restricted distribution than the multi-island *H. Calida.*

Zoraptera

Zorotypus swezeyi. This delicate, white wingless resident of the frass on old koa and 'ōhi'a trunks helps break down decaying wood, aiding in forest recycling. *Zorotoypus*, not fitting in other insect groups, is classified in its own order. The finding of this insect for the project survey was the first record of this species in Hawai'i Island forests.

MOLLUSCA

Succineidae (snails)

The only native terrestrial mollusk encountered was a succineid. It was determined to be *Succinea cf. Thaanumi* (a closely related species). *Succinea* are often endemic to a single island. This snail may be arboreal or ground dwelling, and occupies a wide range of habitats. All *Succinea* feed on decaying plant matter and can be found of tree fern stems, as they are

often covered with bits of decaying plant matter from upper canopy plants. They are not known to eat healthy, growing plants and pose no threat to sprouting koa.

A few species reasonably expected to occur on the property were not found. Several native invertebrates were found in low numbers. Difficulties in sampling a large area for a diversity of invertebrates assure that some species elude even the most experienced collector. Not finding a species does not mean with certainty that it is not present.

Compared to many other Hawai'i sites, this site has many native invertebrates, perhaps because it has moderate native floral diversity due to an absence of grazing and fires. The absence of dominant predatory species like *Pheidole* ants also contributes as they are documented elsewhere as a primary cause of low native mini-wildlife levels.

2.4.3 Terrestrial Vertebrate Resources

This section summarizes information about native birds and the Hawaiian hoary bat drawn from the existing literature as well as from a report prepared for the project by Reginald David, entitled "Analysis of Endangered Terrestrial Vertebrate Species Management Issues" (see Appendix E). It also draws upon avifauna observations made during the 2002 botanical survey of the Site by Geometrician Associates (Appendix C).

Avifauna

As with botany, very little ornithological work has been conducted on the Site. Henshaw (1902) and Perkins (1903) described the native bird communities of the windward slopes of Mauna Kea, but the exact locations of their studies are unknown. In the late 1970s, the USFWS conducted the Hawai'i Forest Bird Survey, which represented the first and only systematic avian study of the region. The distribution and abundance of all bird species detected from windward Mauna Kea, including portions of the Site, were measured.

At least four bird species reported from the area by Perkins and Henshaw in the early 1900s were not detected by the Hawai'i Forest Bird Survey. With few exceptions, all native birds are now found within a narrow band of forest from 2,500 to 7,500 feet in elevation. Distribution and abundance maps for 11 remaining species are presented in Scott et al. (1986). These maps indicate that eight of the 11 native species exist at minimal densities in

the portions of the Site above approximately 2,500 feet elevation. The endangered Hawai'i 'Ākepa (*Loxops c. coccineus*), Hawai'i Creeper (*Oreomystis mana*), and 'Akiapōlā'au (*Hemignathus munroi*), do not range to elevations lower than approximately 5,000 feet.

It is likely that the distribution and abundance of native bird species within the Site have declined in the 22 years since they were last surveyed. Introduced predators, competitors, and disease are among the factors responsible for the decline of Hawaiian forest birds (Warner 1968; Banko and Banko 1976; Atkinson 1977; Van Riper et al. 1982). In low elevation areas (less than 3,000 feet), avian malaria (*Plasmodium relictum*) appears to be the primary reason for the absence of birds (Van Riper et al. 1982). This introduced protozoan parasite is transmitted by the introduced night-biting mosquito (*Culex quinquefasciatus*) and infects peripheral red blood cells and internal tissues. Hawaiian birds apparently evolved a loss of resistance to this parasite, and infection often leads to death (Warner 1968).

The only endangered bird species observed during the botanical field surveys was the Hawaiian Hawk (*Buteo solitarius*), whose Hawaiian name is 'Io. The hawk was seen flying above two of the highest elevation plots (see Appendix C).

Recently completed research conducted by John Klavitter (2000) has shown that Hawaiian Hawks are found in nearly all vegetation habitats that still have some large tree components. Densities are highest in mature native species-dominated forest with grassy under-stories. This habitat with high amounts of forest edge supports large populations of game birds and the four species of introduced *muridae* known from the island; it also provides numerous perches and nesting sites. Much of this habitat has been created by logging, land-clearing and cattle-grazing. It appears that Hawaiian Hawks can coexist with, and may have in fact benefited from anthropogenic land clearing activities – this is not to say that more clearing is going to result in more hawks, but does indicate that the species can coexist with anthropogenic natural resource extraction activities, as long as natural resource management plans ensures the continued recruitment of native trees and the regeneration of native species dominated forests.

Three native passerine species were recorded during the surveys: the 'Elepaio (*Chasiempis s. sandwichensis*), the 'Ōma'o (*Myadestes obscurus*), and the 'Apapane (*Himatione sanguinea*). These three birds were rare to nonexistent in the lower elevation plots and relatively rare

where they occurred in the upper elevation plots. The Short-eared Owl or Pueo (*Asio flammeus sandwichensis*), has also been noted in the past and probably continues to make some use of the area.

Four introduced species, the Japanese White-eye (*Zosterops japonicus*), the Red-billed Leiothrix (*Leiothrix lutea*), the Northern Cardinal (*Cardinalis cardinalis*), and the Melodius Laughing-Thrush (*Garrulax canorus*) were the most widespread and abundant birds within the study area. All of these introduced birds occurred across the entire range of elevations surveyed.

It is quite possible that certain common native forest birds such as the Hawai'i 'Amakihi (*Hemignathus v. virens*) make use of the project site during certain times of the year, especially when 'ōhi'a trees are flowering. It is also possible that endangered forest birds such as the Hawai'i 'Ākepa or the 'Akiapōlā'au (*Hemignathus munroi*) are present in some areas.

Seabirds such as the threatened species Newell's Shearwater (*Puffinus auricularis newelli*) could utilize the upper-elevation, fern-covered slopes for nesting.

Mammals: Hawaiian Hoary Bat

The only native Hawaiian land mammal, the Hawaiian hoary bat or ape'ape'a (*Lasiurus cinereus semotus*), has not been documented on the Site but is probably at least seasonally present, as biologists have detected it from sea level to around 13,000 feet.

First listed as an endangered species by the U. S. Fish and Wildlife Service (USFWS) in 1970, the Hawaiian hoary bat is currently listed as under both the federal and State of Hawai'i's endangered species programs.

Very little is known about the Hawaiian hoary bat. Much of the literature consists of short-duration, localized survey efforts and anecdotal observations. Not surprisingly, with the lack of comprehensive landscape scale surveys and studies, much of the literature is contradictory.

The Hawaiian hoary bat is an insectivore, preying on volent insects. Hawaiian hoary bats appear to be greater generalists in their prey selection. Hawaiian hoary bats have clearly adapted to exploit newly-established alien insect species. Consultant Reginald David (see

report, Appendix E) reports having repeatedly observed bats feeding on swarming termites (*Isoptera* sp.) and volent big-headed ants (*Pheidole megacephala*) on both Hawai'i and Kaua'i. He has also observed bats feeding above introduced orchard crops in the lowlands of Kona which predominately attract alien insect species (R. David, Unpublished field notes 1980-2002).

The breeding biology of the Hawaiian hoary bat has been poorly studied, as have most other life-cycle components of this species. It is generally thought that they breed between September and December, give birth between May and June and nurse young between June and August.

Very few Hawaiian hoary bats have been detected on roost. Various studies report that their roosting is associated (a) exclusively with native vegetation, (b) exclusively with alien vegetation, and with both. During the course of his 22 years of field work in Hawai'i, David reports that he has flushed bats out of both alien and native dominated vegetation.

Current survey techniques available for gathering information on the distribution, abundance and usage of resources within a given area by Hawaiian hoary bats are inadequate and/or time- and cost-prohibitive. To prioritize and fund research to obtain needed information, agencies and landowners have formed the Hawaiian Bat Research Cooperative. The cooperative has successfully raised funds to begin the initial phases of this fundamental research, and is now seeking proposals from qualified individuals or institutions.

The lack of knowledge about the bat's life cycle and the lack of adequate survey techniques make it difficult to assess whether timber harvesting will potentially result in the "taking" of individual bats or adverse modification of habitat essential for their continued survival, which assessment is required under the federal Endangered Species Act (ESA). Furthermore, current knowledge contradicts some of the population-monitoring methods recommended in the USFWS Recovery Plan for the Hawaiian hoary bat, making the interim down-listing criteria, as they are currently written, difficult, if not impossible, to determine. Tree searches for roosting bats and inspecting of individual trees are not considered by the USFWS or other field researchers to be practical survey methods and are not recommended as a means to determine incidental take. The resulting conundrum makes it almost impossible to comply

with the letter of the ESA in addressing possible impacts to this endangered species resulting from timber harvesting on the subject property.

2.4.4 Stream Fauna

This section summarizes the "Aquatic Organism Study" conducted for the project by the Hawai'i Biological Survey (HBS) of the Bishop Museum (see Appendix F). The study reports on aquatic biological surveys conducted at the Site in February 2002. These surveys were conducted to assess native and introduced aquatic organisms, and particularly to determine if sensitive, rare, or Candidate Threatened or Endangered Species would be impacted by the proposed selective commercial harvest of koa. The objectives of the study were (1) to describe baseline distribution of native and introduced fish, crustaceans, mollusk, and aquatic insect species; and (2) to assess potential environmental impacts on native aquatic species from the commercial harvest of koa in Conservation District land.

Surveys were conducted in the six major streams named on the USGS topographic quadrangle maps. From south to north, they are Honoli'i, Pāhoehoe, Kapue, Hanawī, Kawainui, and Wai'a'ama Streams. The lowest and highest elevations accessible by helicopter in the project area for each major stream were surveyed. Streams within the study area were sampled along an altitudinal gradient. Elevations ranged from a low of 1760 feet on lower Honoli'i, to mid-elevations of 2300 feet at Hanawī Stream, to the upper reaches of Kapue (2900 ft) and Honoli'i Streams (3300 ft). The wide range of elevations evaluated during this survey allowed a thorough sample of aquatic habitats available found within the proposed project area.

Overall, native aquatic animal species predominated in aquatic habitats sampled within the proposed project area, indicating one of the most pristine aquatic ecosystems remaining in the Hawaiian Islands. A total of 61 species of aquatic macrofauna were collected in the six streams examined during this study, with 50 native aquatic species (mostly insects) and 11 introduced species. For all stations combined, 82% of the aquatic taxa found during this study were native (either endemic or indigenous), species and 18% were introduced. Fish species composition in the six streams examined in the study area consisted of one species, the native 'o'opu 'alamo'o or 'o'opu hi'u kole (*Lentipes concolor*) being found in Honoli'i, Pāhoehoe, Kapue, and Hanawī Streams. A major finding of this study was the rediscovery of

one population of native aquatic insect that was presumed extinct, the long-legged fly *Sigmatineurum omega*. Despite numerous attempts to find this species in streams around Hilo, it had not been collected since 1971.

In lower elevations of the Site, streamlets flowing through strawberry guava were extremely silted. This silting is a result of a domino effect of the alien invasive, strawberry guava (Staples 2001). Guava secretes an allelopathic chemical that kills off other plant species, and leaves a monoculture with no shrub or brush understory (Stone and Pratt 1994). Lacking this understory, there is nothing to hold the soil in place during heavy rains. The resultant soil erosion in these water drainages renders formerly clear streams cloudy. Feral pigs increase the problem by spreading guava very efficiently through the feeding on fruits and spreading seeds through their fecal material (Kishinami 2001). They also increase soil disturbance in areas both with strawberry guava and in pristine areas by way of rooting up soil for food (usually tubers or roots).

2.4.5 Impacts and Mitigation

Potential Impacts

Successful, long-term execution of a sustainable forestry program, including control of feral pigs and strawberry guava and increased survival and growth of juvenile koa, could help to restore the native rainforest ecosystem. Beneficial effects to the native ecosystem would accrue if strawberry guava is cleared and replanted with koa seedlings in the lower elevations of the project area.

By using helicopters, Koa Timber will avoid the heaviest impacts of timber harvesting – i.e., construction of roads and use of heavy equipment to move felled trees. Physical activities that may cause adverse impact include ~~the landing of light helicopters and~~ crew cages from larger, timber harvest helicopters; creation of pathways through the under-story; and felling of trees. If not monitored properly, ground activities could cause damage to individual plants of rare, threatened or endangered species.

Forestry activities have the potential for spreading alien species. Openings in the forest created by tree harvest could be colonized by alien vegetation, displacing native plants. If disturbed area expands, and pigs' favored alien food sources (e.g., strawberry guava) increase

in parts of the property not currently infested Figure 5; then the frequency of pigs may also increase.

Many invertebrate species that may inhabit koa-'ōhi'a forests in this part of the South Hilo District are not directly linked to *Acacia koa* (see Appendix D). With forest health and diversity maintained, there will be limited effect on their numbers in the project area. Additionally, they are well represented in other forest areas. A good example is the several *Eupithecia* species. *Eupithecia orichloris, E. monticolens*, and *E. staurophragma,* all found within the project area, are also found on several other locations on Hawai'i Island and within the island chain (Montgomery 1983, 1984).

Parandra and *Megopis* beetles are widespread and relatively common in Hawaiian forests. These species play a role in breaking up of wood material and revitalizing the forest soils to raise the next crop of *Acacia koa*. Removal of koa logs as proposed in the Forest Management Plan (Atterbury Consultants 2002) will not have a significant effect on their numbers statewide. Removal of all dead and dying koa trees in the project area, however, would have the effect of reducing the habitat and food of the *Parandra* and *Megopis* beetles at this site. When tree trunks are removed, if the treetops are left on the ground, there should be sufficient habitat in the study area for these native beetles.

Cutting mature and dead and dying koa could result in some damage to populations of koa-obligatory terrestrial invertebrates. *Plagithmysus* populations, for example, unlike *Parandra* and *Megopis*, are very host-specific and in some cases site-specific. Consequently, they can be negatively affected by unrestrained harvesting of dead or dying koa. The Forest Management Plan resolves to leave some dead and dying trees standing to accommodate the needs of *Plagithmysus*, and similar species dependent on this habitat.

Forestry activities could affect native bird species and the Hawaiian hoary bat, to the extent that these species inhabit or use a particular harvest unit. Pre-harvest surveys are necessary to determine the presence of the endangered Hawaiian Hawk and the endangered forest bird species – the 'Akiapōlā'au, Hawai'i Creeper and Hawai'i 'Ākepa. Harvest units that have deep uluhe ground cover need to be searched for nesting colonies of Newell's Shearwater. If presence of any endangered bird species is detected, then harvest activities need to be planned to avoid harm. There is no established method of determining the specific habitat

needs of the Hawaiian hoary bat; but to avoid potential harm, timber harvest activities should be scheduled to avoid the period when bats are caring for their young – i.e., June through August.

The greatest potential negative impact on native aquatic biota would be an increase in sediment input into streams flowing through the Site. Increased sedimentation could occur from two primary pathways: (1) direct disturbance during the actual harvest process; or (2) from an increase in invasive species. Siltation or sediment input has been found to be the greatest single water pollutant in terms of ecological and economic impacts affecting streams in the United States. Not only can silt impair fish reproductive and physiological processes, siltation also directly impacts fish food organisms such as aquatic insects and other invertebrates. Small increases in sediment load can result in drastic changes in aquatic invertebrate species' density and composition.

Mitigation

Without mitigation measures, harvest activities could exacerbate the ongoing degradation of the native forest. With mitigation, together with appropriate pro-active forestry management practices in conjunction with the proposed project, on-going degradation of the native forest can be controlled and potentially reversed. Koa Timber proposes to undertake the mitigation measures listed below.

Management

1. Employ qualified professional biologist(s) to plan and conduct pre-harvest surveys, monitor the condition of native rainforest habitat, and maintain long-term monitoring records.

~~3.2. The project's Advisory Committee will include representation from the USFWS and the State~~ The project's Third party consultants will report to the University of Hawaii, Hilo Dr. Randy Senock and staff, Dr. Ron Terry, Wade Lee will report to ~~Division of Forestry and Wildlife. Establish and~~ to enforce written policies concerning the protection of endangered species and preventing the spread of alien species.

~~4.3. Within one year of~~ Before starting operations, prepare a GIS-based biological inventory of the Site that classifies areas according to native rainforest type, using the HFBS

typology as a starting point; accounts for identification of rare, threatened and endangered species; and establishes permanent forest monitoring plots and stream water quality monitoring points; with measurement of baseline conditions and protocols for ongoing observations.

~~5.~~4. Modify operations and management plans in accordance with new information and recommendations pertaining to the Hawaiian hoary bat and other endangered or threatened species.

Surveying and Monitoring

~~6.~~5. Conduct pre-harvest surveys to determine the presence of endangered species. To survey for endangered plants, perform air and ground inspections of a selected sample of trees. Surveys for the Hawaiian hawk and endangered forest birds shall follow current best practices, as outlined in Appendix E.

~~7.~~6. If an endangered species is found in pre-harvest surveys, its location and characteristics will be recorded by Global Positioning System. If the potential to harm an endangered species exists, the resource should either be protected during timber harvest, or the affected tree(s) should not be harvested.

~~8.~~7. Conduct post-harvest surveys, led by a trained forester, to chart the progress of koa regeneration and monitor the spread of alien species in forest openings. Early spot treatment with herbicide should be employed to eradicate incursions of alien plants.

~~9.~~8. Maintain permanent monitoring plots at representative points of the various forest types. These plots will be preserved from harvest and surveyed at regular intervals to observe baseline conditions.

Timber Harvest

~~10.~~9. Refrain from harvesting June through August, in order to avoid the pup-rearing period of the Hawaiian hoary bat.

~~11.~~10. Plan and implement harvest operations to avoid and maintain an effective buffer around any site where an endangered species has been identified. Maintain a log to record harvest activities relating to endangered species.

~~12.~~11. Maintain a 300-foot buffer around an identified Hawaiian Hawk nest.

~~13.~~12. Preserve some dead and dying trees, in order to provide habitat for native beetle species and potential nesting habitat for the Hawai'i 'Ākepa.

~~14.~~13. Establish a buffer area at least 300 feet wide along the boundary with the Hakalau Forest National Wildlife Preserve, in order to reduce potential impacts of helicopter and harvest noise on the Preserve.

~~15.~~14. Maintain and manage Streamside Management Zones (SMZs) around perennial streams in compliance with "Best Management Practices for Maintaining Water Quality in Hawai'i," published by the Division of Forestry and Wildlife, Department of Land and Natural Resources. In addition, a minimum ~~75~~200-foot no-harvest buffer area will be maintained along all named perennial streams.

Controlling Alien Species

~~16.~~15. Establish and strictly enforce protocols for cleaning of tools, boots and equipment used at lower elevations, in order to ensure that seeds or insects of pest species are not transported to higher-elevation native rainforest.

~~17.~~16. Steam-clean or disinfect and sterilize any forestry equipment (e.g., chainsaws, ropes, etc.) brought in from the mainland prior to use to eliminate any hitchhiking invasive species, especially ants, which can destroy the invertebrate ecosystem in only a few years. Any helicopter brought in from the mainland will have its skids sterilized or disinfected prior to use at the Site.

~~18.~~17. Establish a long-term program for eradication of feral pigs, including hunting, trapping, and selective use of exclosure fencing.

Additional Mitigation

~~19.~~18. ~~Resume~~ Mr. Wade Lee will resume membership on the Hawaiian Bat Research Cooperative and work closely with the Cooperative to identify suitable research that the company is willing to undertake or fund.

~~20.~~19. Consider setting aside a wildlife corridor that is wider than the stream buffer along one of the major perennial streams that runs through the Site. Such a corridor would provide a no-harvest control area that encompasses all elevations and the various forest vegetation zones. It would also afford native birds a continuous route between the mauka and makai portions of the Site.

2.5 Historical and Archaeological Resources

This section summarizes an archaeological inventory survey conducted for the project by Haun & Associates (see Appendix G).

Previous Studies: No previous archaeological studies had been conducted in the project area. The early 1900s surveys by Stokes and Hudson identified a few sites along the coast and reported the former presence of several heiau, none of which are in project area ahupua'a. Hudson's informants reported that Ka'uku Hill in Makahanaloa, partially within the project area, was used as a signal station, but Hudson found no evidence of this use. Subsequent studies elsewhere between the Wailuku River and the Hāmākua District boundary did not identify any traditional Hawaiian sites except two along the north bank of the Wailuku River near Hilo. The absence of sites in most of the previous studies is attributable to historic land modification primarily associated with sugar cane plantation agriculture.

McEldowney's (1979) traditional Hawaiian settlement pattern model for the Hilo area is applicable to the project area, which lies within her Lower Forest Zone between 1,500 ft and 2,500 ft elevation, and the Rainforest Zone between 2,500 ft and 5,000 ft elevation. The Lower Forest Zone was the source for timber and other forest resources such as medicinal plants, olonā, and birds. Predicted site types consist of temporary habitations, trails, shrines, and minor agricultural features in forest clearings and along streams. Sites in the Rainforest Zone are limited to trails and associated temporary habitations. This zone was used for intra-island travel and gathering of resources including hardwoods and birds.

Legendary References; Land Commission Award Testimonies: There are no traditional or legendary references to the project area. Land Commission Award (LCA) claim testimonies indicate that by the early to mid-1800s traditional Hawaiian settlement and agriculture was situated 2.5 to 3.5 miles east of the project area, primarily below 500 ft elevation. The LCA

testimonies document many residential structures and cultivated fields. Named crops consisted of coconuts, bananas, taro, and coffee. Other probable crops included breadfruit, wauke, sugar cane, and sweet potato. Canoe houses are mentioned in Pu'u Moi and Pauka'a indicating access to the ocean and marine resources.

The Boundary Commission testimonies dating to the 1870s and 1880s describe activities conducted in the project area including bird-catching, canoe-building, bullock-hunting, and gathering of olonā and pulu. There is one reference to a probable shrine on the south bank of Wai'a'ama Stream opposite Pu'u Ka'uku, which is a short distance seaward of the project area. Settlements for bird catchers and canoe makers are also described. The settlements were probably occupied on a temporary basis by individuals whose permanent residences were close to the coast.

Three trails following ahupua'a boundaries are described in Boundary Commission testimony. The trails seem to have been primarily associated with the bird hunting and canoe building activity as opposed to transiting the upland forests to reach the upper edge of the forests. Most of the testifiers had little or no knowledge of the uppermost ahupua'a boundaries. In general, the testimonies suggest that the activities, trails, and settlements described in the late 1800s were no longer in use.

Historic Plantation Activities: Historic use of the project area ahupua'a was dominated by sugar cane plantation agriculture beginning in the mid-1800s and continuing in some areas until the 1990s. Diversion structures in the Wai'a'ama, Kawainui, Kalaoa, Pāhoehoe, and other stream drainages were constructed to feed flumes and ditches, which were used to transport wood and sugar cane. The majority of plantation activity was situated seaward of the project are where fields were located. Plantation worker camps were scattered over the countryside connected by roads to the plantation villages at the sugar mills at Pāpa'ikou, Pepe'ekeo, Honomū, and Hakalau. A railroad system connected the mills to the port at Hilo. Plantation-related activities that extended into the lower portion of the project area included the construction of water distribution systems and timber harvesting for lumber and firewood. Diversion structures in the Wai'a'ama, Kawainui, Kalaoa, Pāhoehoe, and other stream drainages were constructed to feed flumes and ditches, which were used to transport wood and sugar cane. An early 1900s map of Pepe'ekeo Sugar Company lands in

Makahanaloa depicts a camp site in the project area that was probably used during construction of a diversion structure and flume.

Inventory Survey: Fieldwork for the archaeological inventory survey consisted of pedestrian survey of six mauka-makai transects totaling approximately 18,655 m (3.53 miles) in length and approximately 100 acres (see Figure 18, Appendix G). No traditional Hawaiian sites were identified. Archaeological evidence for such sites, mostly temporary camps and trails, would be minimal, consisting of food remains and artifacts. Habitation structures were probably made entirely of perishable materials including wood and thatch because surface stones are rare. The combined factors of heavy rainfall, rapidly growing dense vegetation, and ground disturbance by pigs largely preclude the possibility of identifying traditional Hawaiian sites.

The archaeological survey identified one historic site (Site 22534), a water diversion feature and ditch on an unnamed drainage in Pāpa'ikou (see Figures 19-21, Appendix G). A well-preserved example of plantation water system infrastructure probably dating to the late 1800s to early 1900s, the site has yielded information important for understanding historic land use. Assessed as significant under DLNR-SHPD significance Criterion "d" and Criterion "c", the site is recommended for preservation. The specific plans for preservation of the site would be detailed in a Preservation Plan prepared for DLNR-SHPD review and approval. Site 22534 appears to be located within the State Agricultural District.

Impacts and Mitigation

Several portions of the project area have potential to contain prehistoric or historic cultural resources. These areas include Pu'u Ka'uku and the streams and adjacent lands within approximately 10 to 20 meters of the main streams. Historic records indicate the potential presence of old kauhale, temporary camps, or water diversion structures along Wai'a'ama Stream in Makahanaloa, and Kawainui and Pāhoehoe Streams in Pāpa'ikou and Pauka'a. These areas should either be avoided for timber harvesting, or monitored by archaeologists during harvesting.

2.6 Scenic and Recreational Resources

Since the Site will be preserved as a native forest, the scenic qualities of the forest will be preserved. Forestry activities will not be evident from the public highway or any public recreation site.

The Site is not a public hunting area nor does it provide access to any public hunting areas. However, pig hunting has been popular in the lower portions of the Site. Although hunting, hiking, and camping are desirable activities, such activities need to be carefully managed to avoid damage to the forest ecosystem or cause fires. Gathering for customary uses would be permitted in accordance with established procedures.

Impacts and Mitigation

No impact is anticipated. The operations will not affect public access to public hunting or recreational areas. Pig hunters may have increased opportunities to hunt within the Site as part of the management plan to control the pig population.

2.7 Hazardous Substances

The Applicant will hand-apply the herbicide ~~glyphosate~~ Triclopyr in order to control strawberry guava and other invasive species. ~~Glyphosate~~ Triclopyr is not generally active in the soil and is strongly adsorbed in soil particles. It has no known effect on soil microorganisms and is not absorbed by plants from the soil. Based on the results of animal studies, ~~glyphosate~~ Triclopyr does not cause genetic damage or birth defects, and has little or no effect on fertility, reproduction, or development of offspring. Although studies to date have shown that ~~glyphosate~~ Triclopyr is noncarcinogenic in humans, there is not enough information available at this time to determine positively whether it causes cancer. There have been no reported cases of long term health effects in humans due to glyphosate exposure. See Addendum C of the Forest Management Plan, ~~Appendix B~~ for a detailed description of ~~glyphosate.~~ Triclopyr. No broadcast spray methods will be used.

Impacts and Mitigation

No impact is anticipated.

2.8 Social and Cultural Resources

2.8.1 Cultural Resources

This section summarizes a cultural impact assessment conducted for this project (see Appendix H). The assessment followed the OEQC Guidelines for Cultural Assessments and cultural impact assessment guidelines of the Office of Hawaiian Affairs.

The study did not identify any traditional Hawaiian practices still conducted within the Site, although cultural practices were identified makai and outside of the Site, including leina (jumping off point at Makahanaloa), Kane stone, and 'aumākua worship (feeding the sharks at Kahali'i). Today, the only people utilizing the Site are pig hunters who, along with hunting pig, occasionally gather fern shoots, freshwater shrimp, hīhīwai, and prawns as additional food resources. No one indicated they gathered these resources for cultural reasons or that they gathered them on a regular basis. The pig hunters all know each other and because they go out often, they know who uses the trails and the general area. None of them knew of anyone who accesses the Site for cultural reasons.

Boundary Commission records from the 19th century indicate the area was heavily used by Hawaiians for activities such as gathering pulu, olonā, and especially for bird hunting and canoe building. There would have been traditional cultural practices associated with these activities. However, none of these practices seem to have continued up to the present time within the Site. The lack of cultural practices is attributed to changes brought about by the sugar plantation industry that dominated agriculture and land use in the South Hilo District since the mid-19th century. The plantations encroached on and changed the lower forest boundary and provided Hawaiians with a non-traditional, cash-based means of subsistence.

The cultural impact study was not able to identify any knowledgeable Hawaiians with cultural knowledge specific to the Site to interview. Many of the people in the Hawaiian community who were contacted had only limited knowledge related to their personal use, almost all of which occurred outside the Site and near the shoreline. The study did interview two non-Hawaiian informants who were knowledgeable about the Site based on their usage of the area for pig hunting and some gathering of plant and aquatic stream resources. The

informants represented five generations of hunters who have hunted in the vicinity for over 100 years.

Impacts and Mitigation

No impact is anticipated. No traditional practices or gathering are known to occur within the Site. Nevertheless, the forest undoubtedly contains a variety of plants that are used in Hawaiian cultural practices such as ʻieʻie for weaving, olonā used for fishnets and capes, and kukui used for dying fishnets and tapa. Such plants are associated with various native customs, practices and beliefs.

If Hawaiian practitioners come forth in the future, then access to the forest should be permitted for gathering related to cultural and religious practices. ~~The project Advisory Committee will include a community representative who is an expert on native Hawaiian culture.~~

2.8.2 Community and Public Involvement

The Applicant will give employment preference to persons living within the communities in the vicinity of the Site. ~~The proposed Advisory Committee~~ Community members will have ~~at least one community representative to facilitate open communication. Community members may have~~ access to the Site for gathering related to cultural and religious practices~~, under the guidance of the Advisory Committee~~.

Impacts and Mitigation

Employment opportunities and access to the Site by cultural practitioners will be beneficial to the Big Island community.

2.9 Economic Impacts

This section summarizes the Economic Impact report, prepared by Decision Analysts Hawaiʻi, Inc. (see Appendix I). In summary, the Project will provide substantial economic benefits, including: about $12.3 million per year in direct and indirect economic activity; about 49 direct and indirect jobs; payroll of about $1.6 million per year, and State of Hawaiʻi tax revenues of about $263,000 per year. If the Project is not approved, these economic benefits will be lost.

Revenues are expected to average about $7.8 million per year for 1 million board feet of lumber. These figures are based on a price of about $7.80 per board foot of koa when averaged over all forms of the wood, including raw wood, veneer, molding, frames, flooring, etc.

Purchases of goods and services by Koa Timber, by related companies, and by employees of these companies results in an additional $5.6 million per year of sales. These indirect sales, which would be split mostly between the Big Island and O'ahu, are based on economic multipliers developed by the Hawai'i Department of Business, Economic Development and Tourism (DBEDT).

Combined lumber sales and indirect sales will total about $13.4 million. Of this amount, about $1.1 million reflects consumption and about $12.3 million reflects intermediate sales. As discussed below, consumption and intermediate sales are taxed at different rates.

Profits for all affected companies—Koa Timber, related companies involved with harvesting and milling the *koa*, and companies providing goods and services to these companies and employees—are projected to average about $670,000 per year. Profits are estimated at 5% of Total Sales.

Harvesting and milling employment is expected to provide about 28 jobs, about half of which would be on the Big Island and half on O'ahu. The projected job count includes a supervisor, managers, milling crews, a forester, groundsmen, and loggers. Employment associated with the indirect sales will be about 21 jobs, based on economic multipliers developed by DBEDT. Direct plus indirect sales will total about 49 jobs, not including fine woodworkers who use koa. Payroll for all direct and indirect jobs is projected at $1.6 million per year, or an average of about $33,000 per job.

The Hawai'i Forest Industry Association lists 85 companies involved with producing and selling fine wood products in Hawai'i, and lists 478 fine woodworkers: 248 on the Big Island, 166 on O'ahu, 39 on Maui and Moloka'i, and 25 on Kaua'i. An estimated 380 (80%) of these woodworkers use koa in their crafts.

Impacts and Mitigation

As discussed above, the Project will have positive economic impacts, including jobs for Hawai'i residents and tax revenues for the State of Hawai'i. The direct and indirect tax revenue benefits of the Project will exceed costs from project use of public roads, harbors, and other public facilities.

2.10 Roads and Traffic

From the State Hawai'i Belt Road (Highway 19), there are four access routes to the Site. Two of the access routes are easements over private roads. The other two are County roads. To gain road access to the planned staging area, Koa Timber will use a roadway easement that intersects Highway 19 at Mile 9 (see Fig. 4). Trailer trucks will haul cut trees from the helicopter staging area to the Koa Timber sawmill, which is located in a warehouse near the old Pepe'ekeo Mill. To reach the sawmill, the trucks travel about two miles north on Highway 19 and about 0.5 miles east on Pepe'ekeo Mill Road. The processed logs are trucked from the sawmill to Hilo Harbor for shipping via Highway 19. Production is geared to the capacity of Young Brothers' regularly-scheduled barge service to Oahu. Consequently, the sawmill typically processes and ships 10-12 trailer-loads of logs per week.

The planned quantity of truck traffic and use of public roads are practically identical to Koa Timber's current operations, as it has been harvesting koa on the Agricultural District portion of the Site.

Impacts and Mitigation

No impact is anticipated. None of the access roads pass through settlement areas where truck traffic might cause dust or noise concerns. Trucks are typically found on Highway 19, and 10-12 trailer-trucks per week is a small amount of traffic compared to the highway's total volume.

2.11 Air Quality and Noise

Forests help to maintain the ozone layer by producing oxygen and cleansing the air. The project is intended to maintain native rainforest and to increase stands of koa trees.

During harvesting, sources of noise may include helicopters, chainsaws, the sawmill, and vehicular traffic from the sawmill to Hilo Harbor.

Impacts and Mitigation

No significant impact anticipated. Helicopter flight paths ~~are being developed so that they~~ have a one-mile minimum buffer zone to avoid noise sensitive land uses, such as residences and schools. Due to the remote nature of the project site, noise associated project operations are not anticipated to affect any noise sensitive land uses.

2.12 Public Facilities, Utilities, and Services

2.12.1 Water System

~~The Applicant will construct pond systems as necessary for irrigation. The ponds would be designed to serve as wildlife habitats.~~

No impact anticipated.

Impacts and Mitigation

~~Potentially beneficial. The ponds would create new habitats for native wetland birds.~~

No impact anticipated.

2.12.2 Wastewater System

Portable toilets would be provided as necessary.

Impacts and Mitigation

No impact is anticipated.

2.12.3 Drainage System

Since there will be no roads, drainage systems are not necessary.

Impacts and Mitigation

No impact is anticipated.

2.12.4 Electrical/Telephone

No electrical or communications improvements are necessary. Personnel will use short-wave radio or cellular telephone.

Impacts and Mitigation

No impact anticipated.

2.12.5 Police & Fire Protection

The closest County fire station is the Pepe'ekeo Fire Station located approximately 3.5 miles from the Site along a paved County road. The closest fire station with emergency medical services is the central headquarters located on Kino'ole Street in Hilo.

Impacts and Mitigation.

Mitigation required. Fire-fighting readiness and prevention measures should be coordinated with the County Fire Department and the Division of Forestry.

2.13 Secondary and Cumulative Impacts

The Project will add to existing and planned forestry operations along the Hāmākua Coast. However, most of the planted stands are in the North Hilo and Hāmākua Districts, with intended transport to Kawaihae Harbor. The Project is one of few existing or planned forestry operations, besides the State's Waiākea State Forest, that would transport logs to Hilo Harbor.

3. RELATIONSHIP TO PLANS, POLICIES, AND CONTROLS

3.1 State Plan

The Hawai'i State Plan (Chapter 226, Hawai'i Revised Statutes, as amended) provides the overall theme, goals, objectives, policies and priority guidelines for statewide planning. The Hawai'i State Plan also directs the appropriate State agencies to prepare functional plans for their respective program areas. The proposed project supports and is consistent with the following State Plan Objectives

Economy – agriculture

(a) Planning for the State's economy with regard to agriculture shall be directed towards achievement of the following objectives:

(2) Growth and development of diversified agriculture throughout the State.

(3) An agriculture industry that continues to constitute a dynamic and essential component of Hawai'i's strategic, economic, and social well-being.

(b) To achieve the agriculture objectives, it shall be the policy of this State to:

(2) Encourage agriculture by making best use of natural resources.

(9) Enhance agricultural growth by providing public incentives and encouraging private initiatives.

(12) Expand Hawai'i's agricultural base by promoting growth and development of flowers, tropical fruits and plants, livestock, feed grains, forestry, food crops, aquaculture, and other potential enterprises.

Physical Environment – land base shoreline, and marine resources

(a) Planning for the State's physical environment with regard to land-based, shoreline, and marine resources shall be directed towards achievement of the following objectives:

(1) Prudent use of Hawai'i's land-based, shoreline and marine resources.

(2) Effective protection of Hawai'i's unique and fragile environmental resources.

(b) To achieve the land-based, shoreline, and marine resources objectives, it shall be the policy of this State to:

(1) Exercise an overall conservation ethnic in the use of Hawai'i's natural resources.

(4) Manage natural resources and environs to encourage their beneficial and multiple use without generating costly or irreparable environmental damage.

(5) Consider multiple uses in watershed areas, provided such uses do not detrimentally affect water quality and recharge functions.

(6) Encourage the protection of rare or endangered plant and animal species and habitats native to Hawai'i.

(7) Provide public incentives that encourage private actions to protect significant natural resources from degradation or unnecessary depletion.

The proposed project will diversify the economic base while implementing effective practices to sustaining and restore native forest resources, protect native habitats, and maintain water quality.

3.2 State Land Use Designation

The State Land Use Law is intended to preserve, protect, and encourage the development of lands in the State for uses which are best suited to the public health and welfare of Hawai'i's people. The Hawai'i Land Use Law in Chapter 205, Hawai'i Revised Statutes (HRS), classifies all land in the State into four land use districts: Urban, Agricultural, Conservation, and Rural. A lower portion of the Site is in the Agricultural District. Most of the Site is in the Conservation district (see Figure 9).

Forestry is a principal use within the State Agricultural District. No permits are required.

The State Department of Land and Natural Resources (DLNR) has jurisdiction over lands within Conservation District. DLNR has established subzones within the Conservation District. The Site is in the Resource Subzone. The objective of the Resource Subzone is "to develop, with proper management, areas to ensure sustained use of the natural resources of those areas" and encompasses lands "suitable for growing and harvesting commercial timber or other forest products." Commercial forestry operations require a permit issued by the Board of Land and Natural Resources together with a management plan. The Applicant has submitted a Conservation District Use Application.

3.3 Coastal Zone Management

The project is located outside of the Special Management Area (SMA). However, because the "coastal zone management area" includes all lands, whether within or outside the SMA, the Project must still conform with the objectives and policies of the Coastal Zone Management Act. The Project is consistent with the CZM objectives and policies.

3.4 Hawai'i County General Plan

The General Plan Land Use Pattern Allocation Guide (LUPAG) Map designation for the Site is Extensive Agriculture for the portion that is within the State Land Use Agricultural district. The balance of the Site is designated Conservation which is consistent with the State's classification in the Conservation district (see Figure 10).

The Project implements the following General Plan and policies:

ECONOMIC – GOALS

- Economic development and improvement shall be in balance with the physical and social environments of the island of Hawai'i.
- The County of Hawai'i shall strive for diversity and stability in its economic system.
- The County shall provide an economic environment which allows new, expanded, or improved economic opportunities that are compatible with the County's natural and social environment.

POLICIES

- The County of Hawai'i shall assist the expansion of the agricultural industry, especially diversified agriculture, through the protection of important agricultural lands, capital improvements and other programs, and continued cooperation with appropriate State and Federal agencies.
- The County of Hawai'i shall strive for an economic climate which provides its residents an opportunity for choice of occupation.
- The County of Hawai'i shall strive for diversification of its economy by strengthening existing industries and attracting new endeavors.
- The County of Hawai'i's land, water, air, sea, and people shall be considered as essential economic resources for present and future generations and should be protected and enhanced through the use of economic incentives.

- The County shall strive for full employment.
- The County shall identify and encourage primary industries that are consistent with the social, physical, and economic goals of the residents of the County.
- An active liaison between the County and the private section should be encouraged with respect to the County's requirements for establishing business on the island.
- The County shall promote a distinctive identify for the island of Hawai'i to enable government, business and travel industries to promote the County of Hawai'i as an entity separate and unique within the State of Hawai'i.

STANDARDS

- The Island of Hawai'i should be developed into a unique scientific and cultural model. The island should become a model of living where economic gains are in balance with social and physical amenities. Development should be reviewed on the basis of total impact on the residents of the County, not only in terms of immediate short run economic benefits.
- New industries which provide favorable benefit-cost relationships to the people of the County should be encouraged. Benefit-cost relationships as used here include more than fiscal considerations.
- The proposed forestry operations help to diversified the island's economy and provide more job opportunities. A sustainable koa forest industry can be another signature product associated with the Big Island where economic gains strive to be in balance with the social and physical amenities.

NATURAL RESOURCES AND SHORELINE – GOALS

- Protect and conserve the natural resources of the County of Hawai'i from undue exploitation, encroachment and damage.
- Provide opportunities for the public to fulfill recreational, economic, and educational needs without despoiling or endangering natural resources.
- Protect and promote the prudent use of Hawai'i's unique, fragile, and significant environmental and natural resources.
- Protect rare or endangered species and habitats native to Hawai'i.
- Protect and effectively manage Hawai'i's open space, watersheds, and natural areas.
- Ensure that alterations to existing land forms and vegetation, except crops, and construction of structures cause minimum adverse effect to water resources, and scenic and recreational amenities and minimum danger of floods, landslides, erosion, siltation, or failure in the event of earthquake.

POLICIES

- The County of Hawai'i should require users of natural resources to conduct their activities in a manner that avoids or minimizes adverse effects on the environment.
- The County shall encourage a program of collection and dissemination of basic data concerning natural resources.
- The County shall coordinate programs to protect natural resources with other government agencies.
- The County shall promote sound management and development of Hawai'i's land and marine resources for potential economic benefit.
- The County shall encourage public and private agencies to manage the natural resources in a manner that avoids or minimizes adverse effects on the environment and depletion of energy and natural resources to the fullest extent.
- The County shall encourage an overall conservation ethic in the use of Hawai'i's resources by protecting, preserving, and conserving the critical and significant natural resources of the County of Hawai'i.
- Encourage the use of native plants for screening and landscaping.

STANDARDS

- The following shall be considered for the protection and conservation of natural resources.
- Areas necessary for the protection and propagation of specified endangered native wildlife, and conservation for natural ecosystems of endemic plants, fish and wildlife.
- Lands necessary for the preservation of forests, park lands, wilderness and beach areas.
- Lands with a general slope of 20% or more which provide open space amenities or possess unusual scenic qualities.
- Lands necessary for the protection of watersheds, water sources and water supplies.

The Project fulfills the Economic goals, policies and standards by diversifying the County's economic base in a way that will provide stability and which balances economic gain with sustaining the environment. The Project is intended to sustain the native rainforest and will provide a program of ongoing pest eradication and ecosystem monitoring. The Project will also take special measures to preserve endangered species that may be found within the Site and to preserve the water quality and habitat of its streams.

3.5 Hawai'i County Zoning

The existing County zoning for the Site is Agriculture (A-20a) within the portion designated Extensive Agriculture by the General Plan. The zoning is Open for that portion designated Conservation by the General Plan. Forestry is a permitted use within the Agriculture and Open districts. Plan approval is required for any proposed structure within the Open district. Since the Applicant does not propose any structures at this time, no approvals are necessary to conduct forestry activities in either the Agriculture or Open districts.

3.6 List of Required Permits and Approvals

3.6.1 Federal

No stream crossings will be constructed, and no forestry activities will be undertaken in streams or where there is the potential for discharge into a stream. Temporary trails for work crews will avoid boggy areas and will not involve fill activities or discharge of fill. Therefore, no Department of Army permit will be required.

3.6.2 State of Hawai'i

A Conservation District Use Permit is required from the Board of Land and Natural Resources. Commercial forestry is an identified use within the Resource Subzone of the Conservation District. The Applicant has applied for a Conservation District Use Permit.

3.6.3 County of Hawai'i

No permit is required.

4. ALTERNATIVES TO THE PROPOSED ACTION

4.1 No Action Alternative

Under the no-action alternative no harvesting of koa resources in the State Land Use Conservation District would occur. Therefore, there would be no impact, beneficial or adverse, on resources in this area.

The no-action alternative, however, is a deliberate management strategy that may eventually lead to significant degradation of presently healthy native forests. If left unchecked, there is a high likelihood that existing invasive species will spread into native forest areas, adversely impacting native flora and fauna. Active management strategies, such as constructing pig exclosure fences and removing invasive flora species are necessary to restore and protect native forests.

4.2 Conventional Harvesting

Conventional harvesting of timber using trucks rather than helicopters is considered to be infeasible due to the potential for significant environmental impacts. While noise and other impacts associated with helicopter operation would be eliminated in this alternative, significant impacts may occur to water resources and flora and fauna resources.

5. RELATIONSHIP BETWEEN SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

The Project is specifically designed to provide ongoing long-term economic benefits within the framework of sustaining the long-term health of the rainforest. The intent is to harvest a limited amount of koa timber continually, in increments over a long period of time, so that timber re-growth is equal to or exceeds the amount of timber harvested. Project efforts to control invasive plants and animals and to stimulate the regeneration of koa and the native forest will reinforce the objective of sustainability. If no program is undertaken to manage this forest, then it is expected that invasive species will spread and koa, ʻōhiʻa, and other native plants and trees will continue to die back.

6. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS

No irreversible and irretrievable commitment of resources is anticipated. The objective of the project is sustainable forestry; whereby regeneration of koa timber equals or exceeds the volume of timber harvested, and the condition and extent of native forest will is enhanced.

7. UNRESOLVED ISSUES

~~The long-term timber harvest schedule is unresolved. The current proposal (harvesting trees 18 inches or greater on a 10-year cycle) is based on current best estimates of existing koa timber quantities, koa growth rates, and buffer areas. In the first year of~~ Before operation, the Applicant ~~will complete~~ has completed a GIS-based forest inventory. This will provide greater information on the net timber harvest area and existing timber quantities. Growth data collected over the initial 3-5 years will afford improved estimates of koa growth. This additional information will enable foresters to make a better forecast of the sustainable harvest schedule. For this reason, the Applicant anticipates that there will be changes in the amount of timber harvested annually (greater or less than 1.0 million board feet); the long-term harvest cycle (longer or shorter than ~~10~~ 7 years); and the acreage to be visited for harvest each year (greater or less than 1,000 acres).

8. LIST OF REFERENCES

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9. CONSULTATION

The following agencies, organizations and elected officials were consulted, or provided comments, on the Draft Environmental Impact Statement or on the EIS Preparation Notice. All substantive comments received on the EIS Preparation Notice and responses are reproduced herein.

Federal

U.S. Army Corps of Engineers, Honolulu District – Regulatory Branch

U.S. Department of Agriculture, Natural Resources Conservation Service

U.S. Department of the Interior, Fish and Wildlife Service: Hakalau Forest National Wildlife Refuge

U.S. Department of the Interior, Fish and Wildlife Service: Pacific Islands Ecoregion Office

U.S. Department of Interior, Geological Survey, Biological Resources Division

State

Department of Business, Economic Development, & Tourism (DBEDT), Office of Planning

DBEDT, Land Use Commission

Department of Health

DOH, Clean Water Branch

DOH, Office of Environmental Quality Control

Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife

DLNR, Division of Aquatic Resources

DLNR, State Historic Preservation Division

Department of Transportation

Office of Hawaiian Affairs

Hawai'i Forest and Communities Initiative

University of Hawai'i at Hilo, Cooperative Extension Service

University of Hawai'i at Hilo, Geography Department

University of Hawai'i Environmental Center, UH-Manoa

County

Planning Department

Department of Public Works

Department of Water Supply

Fire Department

Police Department

Arborist Advisory Committee

Organizations and Individuals

Adjacent landowners/lessees

Mr. David Caccia

Mr. Patrick Conant

Conservation Council of Hawai'i

Mr. John Flaherty

Earthjustice Legal Defense Fund

Mayor Harry Kim

Hawai'i Forest Industry Association

The Nature Conservancy

Hilo Outdoor Circle

Ms. Theresa Menard

Sierra Club, Hawai'i Chapter

Mr. Mashuri Waite

APPENDICES

Appendix A

Sustained Harvest Estimate

Sustained Harvest Estimate

(Second Revision)
in consultation with
Plan Pacific

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December 5, 2002

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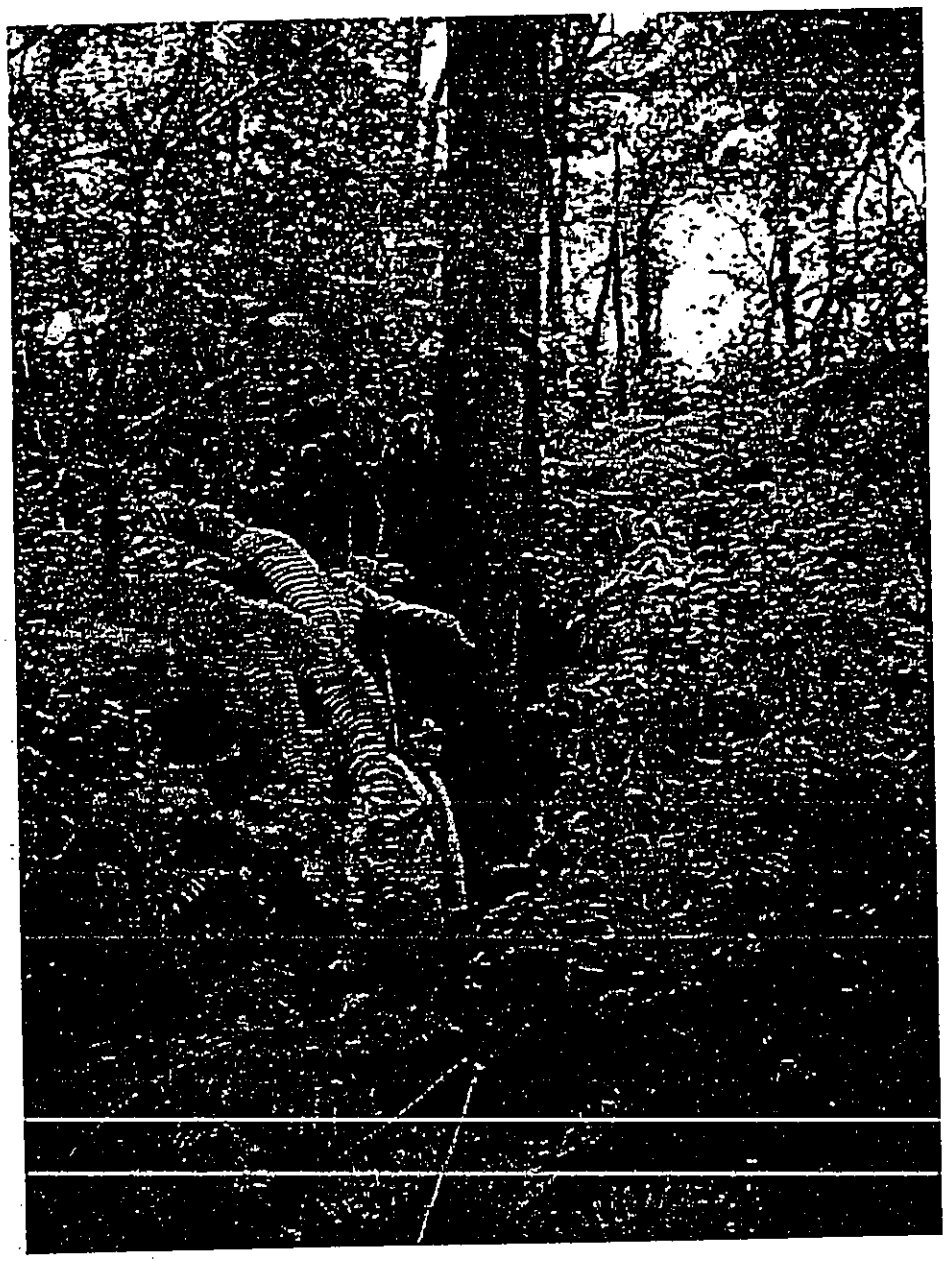
Images of the Property

Location Map

DOCUMENT CAPTURED AS RECEIVED

Photos



Koa Forest on the Island of Hawai'i. This tree is one of the larger trees. Notice the heavy fern cover. Koa trees of various sizes are visible in the background. (December, 2001)

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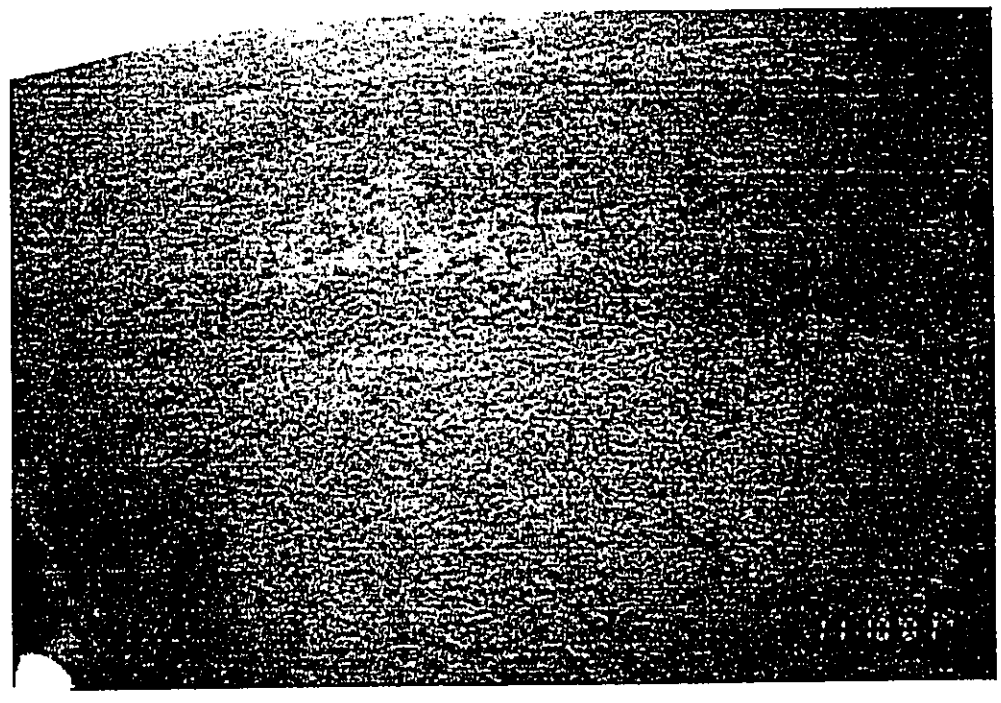
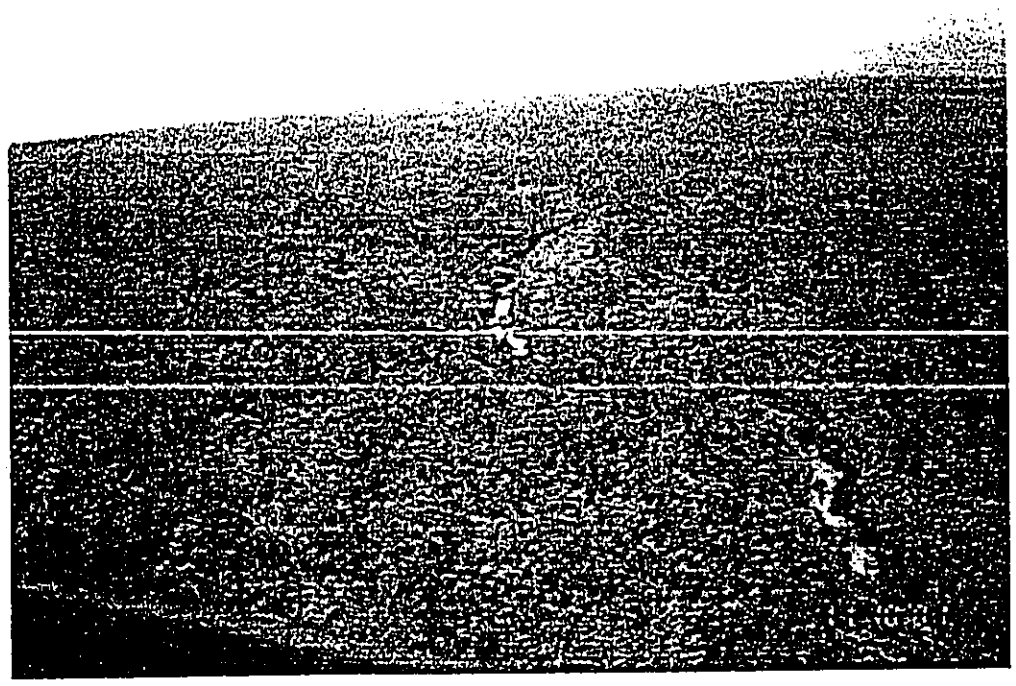


Aerial view of koa forests showing the wetland areas (brown vegetation).



Aerial view of koa forests showing one of the many riparian areas.

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Typical koa tree after felling. Note that the majority of usable wood occurs before the first fork. Volume estimates need to take this into consideration.

Introduction

This report has been written for Kyle Dong of Koa Timber, Inc. The information presented represents our best estimates of a sustainable harvest base given available information and data. This is report will be enhanced when a better forest inventory is completed on this property.

In addition to this report, there have been two other estimates of koa volume on the property. Both reports (Jaakko Pöyry and Northern Tier Forestry) have widely differing estimates for both timbered acres and merchantable volume.

Table 1 Estimated timbered acres and merchantable volume from three different sources

Inventory	Acres	Total Board Feet	Board Feet/Acre
Jaakko Pöyry	14,899	25,237,739	1,694
Northern Tier Forestry	9,800	78,150,000	7,974
ACI	13,129	26,560,000	2,023

Koa Forests Inc. owns approximately 13,129 acres of timber and agricultural lands on the island of Hawai'i. A large elevational gradient on the property has resulted in the delineation of several different forest ecosystems and, subsequently, productivity levels. The current volume merchantable of koa and other hardwoods varies by these ecosystems.

Table 2 Property owned by Koa Forests, Inc. broken down by forest reserve classifications.

Entire Ownership	Acres
Forest Reserve #1	11,394
Forest Reserve #2	1,735
Total ownership	**13,129**

The entire property includes streams and areas that have little or no koa. Ohia is dominant in the upper elevations, and there are groves of eucalyptus in the lower-elevation lands. Deducting 3,000+ acres for stream buffers, non-koa areas and a buffer along the common boundary with the Hakalau National Wildlife Refuge (western boundary), the net timber area is estimated to be 10,000 acres. These acreages will be refined using GIS mapping, when a detailed inventory has been completed.

The management of these forests for the production of koa logs in perpetuity depends on developing a long-term silvicultural program that will ensure the successful reproduction of this species. The largest problem facing any silvicultural program is the reduction or control of agents responsible for the current high rate of mortality. These agents include feral pigs, feral goats, insects, disease, and other competing vegetation. The net impact of each of these agents needs to be assessed for the development of a silvicultural plan.

There is a considerable amount of literature describing the variety of pests and their impact on koa forests; however, there is very little concerning growth data, yield tables, or growth models. This

dearth of inventory information presents the greatest problem in determining a sustainable harvest base.

We have based harvest levels in this report on the best available data from various sources, including information gathered by the author when examining the property in December of 2001.

The forest described in this report is located near Hilo, on the Big Island of Hawai'i. It has regenerated naturally and consists of all-aged stands. This is a typical rainforest on the side of a volcano. The forest is constantly changing with the introduction of invasive species, both flora and fauna. It is suspected that feral pigs are probably spreading the strawberry guava and other non-native species. These exotic species compete for light, water, and growing space with native koa and ohi'a.

The only harvesting to date has been in the agricultural zone. Field examination of this tractor and helicopter logging site has shown little damage and a heavy crop of koa seedlings. Currently, all helicopter logging is planned. This should create a minimum of change in the forest structure. Natural seeding easily fills in open areas very quickly and, with the proper conditions, can grow rapidly the first few years.

Our projection of sustained yield envisions a very light harvest, averaging one to six trees per acre, every seven years. Only the largest mature trees would be harvested and maybe some smaller trees that are merchantable but dying or dead. In our projection, only trees 13 inches DBH and larger will be harvested.

Koa is a rather short lived species. Current literature gives the species maximum merchantable age at about 100 years. Beyond this age, mortality and defect will render most koa trees unusable. Koa forests experience heavy mortality, especially in young ages. Less than 1% of koa seedlings will live to 100 years.

Virtually all trees of merchantable size have two or more tops. Apparently, the wind breaks out the tops when the trees get through the main canopy. This results in trees with a good peeler or sawlog to the first fork. The distance to the fork and the number of stems above the fork create a large statistical variation in the volume of trees in some diameter classes.

To our knowledge, the data currently available on this forest includes:

- The Jaakko Pöyry report
- The Northern Tier Forestry report
- A few 40-year growth plots (not on this forest)
- Regeneration permanent plots
- USGS topographic maps
- Ownership maps
- Various other publications

Forest Inventory

Available Data and Information

Several growth plots have been measured over the last 40 years and provide a good, but limited, record for koa. Additional growth data is needed by forest cover type, elevation, all-aged stands, and other criteria to complete the picture. The growth data presented in the following tables represents even-aged ideal conditions. These even-aged forests show a higher growth rate (more than double) than what can be achieved in a natural forest. Natural forests have openings and a much less uniform stocking.

Table 3 Koa growth data from 3 plots on the Big Island of Hawai'i. Source: State of Hawaii, DLNR.

Averages of the measurements for each year.

				Total		Per Acre				MAI		MAI	
Plot	Year	Age	Spp	DBH	Height	BA	Trees	Cu Ft	G Bd Ft	Cu Ft		Bd Ft	
12	1961	10	Koa	4.2	24	35	360	228	1000	23		100	
	PAI	*5*		*0.3*	*1.6*	*5.3*	*-8.0*	*92*	*620*				
	1966	15		5.9	32	62	320	687	4100	46		273	
	PAI	*6*		*0.3*	*0.2*	*1.7*	*-15.0*	*-92*	*383*				
	1972	21		7.6	33	72	230	133	6400	6		305	
	PAI	*5*		*0.9*	*2.8*	*-13.8*	*-45.4*	*-18*	*-1238*				
	1977	26		12.3	47	3	3	42	210	2		8	
	PAI	*14*		*0.0*	*0.2*	*0.1*	*0.1*	*2*	*11*				
	1985	40		12.1	50	4	5	76	370	2		9	
	PAI	*16*		*0.0*	*-0.3*	*0.1*	*0.1*	*2*	*14*				
	2001	56		12.4	46	6	7	114	600	2		11	
23	1968	10	Koa	2.0	18	34	1540	0	0	0		0	
	PAI	*5*		*0.3*	*1.0*	*11.0*	*-48.0*	*56*	*300*				
	1973	15		3.5	23	89	1300	279	1500	19		100	
	PAI	*4*		*0.3*	*1.3*	*5.8*	*-67.5*	*176*	*1425*				
	1977	19		4.5	28	112	1030	984	7200	52		379	
	PAI	*8*		*0.3*	*2.1*	*4.5*	*-45.0*	*205*	*988*				
	1985	27		6.8	45	148	670	2621	15100	97		559	
	PAI	*16*		*0.3*	*2.1*	*2.0*	*-27.5*	*173*	*969*				
	2001	43		12.0	78	180	230	5389	30600	125		712	
41	1974	10	All	1.7	18	32	2010	0	0	0		0	
	PAI	*11*		*0.3*	*1.5*	*9.3*	*-101.8*	*171*	*1145*				
	1985	21		5.3	34	134	890	1883	12600	90		600	
	PAI	*16*		*0.1*	*0.4*	*2.6*	*-16.3*	*124*	*544*				
	2001	37		7.1	40	176	630	3863	21300	104		576	

Averages of the beginning and ending measurements.

				Total			Per Acre			MAI	MAI
Plot	Year	Age	Spp	DBH	Height	BA	Trees	Cu Ft	G Bd Ft	Cu Ft	Bd Ft
12	1961	10	Koa	4.2	24	35	360	228	1,000	23	100
	PAI	*46*		*0.2*	*0.5*	*-0.6*	*-7.7*	*-2*	*-9*		
	2001	56		12.4	46	6	7	114	600	2	11
23	1968	10	Koa	2.0	18	34	1,540	-	-	-	-
	PAI	*33*		*0.3*	*1.8*	*4.4*	*-39.7*	*163*	*927*		
	2001	43		12.0	78	180	230	5,389	30,600	125	712
41	1974	10	All	1.7	18	32	2,010	-	-	-	-
	PAI	*27*		*0.2*	*0.8*	*5.3*	*-51.1*	*143*	*789*		
	2001	37		7.1	40	176	630	3,863	21,300	104	576

Average of three plots

			Total			Per Acre			MAI	MAI
Plot	Year	Age	Spp	DBH	Height	BA	Trees	Cu Ft	G Bd Ft	Cu Ft	Bd Ft
		45		10.5	55	121	289	3,122	17,500	77	433
	PAI			*0.2*	*1.0*	*3.0*	*-32.8*	*101*	*569*		

We estimate the average annual growth rate for the natural stands on this property to be approximately 100 board feet per year.

Construction of Stand Tables

The construction of stand tables for this property have been based on limited data collected by Toby Atterbury of Atterbury Consultants, Inc. and Jim Todd of Woodward-Stuckart. Observations consisted of 32 plots, encompassing 163 trees. Before a complete sustained harvest plan can be prepared, more data needs to be collected from cruise plots throughout the property. Monitoring reports over time will yield data regarding growth rates in this forest. These data will be used to further refine the sustained harvest plan.

Stand Table Projection

Jaakko Pöyry Report

It appears that the best data to date was collected by Jaakko Pöyry a few years ago. This data is insufficient to produce the necessary stand tables required by a forest management plan. Stand table data was not included in their report.

Critical measurements missing from the Jaakko Pöyry data include tree listing by diameter class, along with height and defect data. For each tree in each plot, the height to the first fork needs to be measured. Without this information, it is literally impossible to make accurate volume estimates.

Table 4 Jaakko Pöyry forest inventory report data, July, 2001.

Elevation	Density	Acres	m^3/ac	CF/ac	BF	BF/ac	BF/CF	CF/MBF
High	High	239	17.1	603.8	779,398	3,261	5.40	185
High	Medium	3,005	7.6	268.4	4,354,680	1,449	5.40	185
High	Low	4,202	5.8	204.8	4,625,828	1,101	5.40	186
Low	High	754	15.9	561.4	2,287,151	3,033	5.40	185
Low	Medium	2,663	11.0	388.4	5,583,858	2,097	5.40	185
Low	Low	4,026	9.9	349.6	7,606,823	1,889	5.41	185
Totals		**14,889**	**8.9**	**314.3**	**25,237,738**	**1,695**	**5.39**	**185**

Standard abbreviations: m^3 = cubic meters; CF = cubic feet; BF = board feet; ac = acres; MBF = thousand board feet.

The statistical confidence interval at the 95% level is between 16,481,231 board feet and 33,994,248 board feet. Cruise measurements were taken in metric, and then later converted to Scribner board feet. The conversion factor developed to make the jump from metric to board feet shows an estimated 212 recoverable board feet per cubic meter. This conversion rate will change by diameter class because more usable wood can be extracted from larger diameter logs. By not varying the conversion factor by diameter class, a systematic error is introduced.

Northern Tier Forestry Report

The cruise report from Northern Tier Forestry expresses volumes in the Doyle Log Rule, a common board foot rule used in the southeast timber regions of the United States. It appears their cruise was conducted by counting trees from a helicopter. The volumes appear to be very high. Consequently, no useful data was taken from this report.

ACI Stand Table

We constructed the following stand table from available data. This table appears as Table 3 in the Forest Management Plan.

Table 5 Stand table summary, Koa Timber Inc.

DBH	Trees per Acre	Cumulative Trees per Acre	Average BF per Tree	Average BF per Acre	Cumulative BF per Acre	Total Board Feet	Cumulative Board Feet
8	0.597	0.597	20	12	12	120,000	120,000
9	0.606	1.203	30	18	30	180,000	300,000
10	0.807	2.010	35	28	58	280,000	580,000
11	0.932	2.942	43	40	98	400,000	980,000
12	1.686	4.628	50	84	182	840,000	1,820,000
13	1.935	6.563	66	128	310	1,280,000	3,100,000
14	3.165	9.728	69	219	529	2,190,000	5,290,000
15	1.456	11.184	93	135	664	1,350,000	6,640,000
16	2.676	13.860	92	247	911	2,470,000	9,110,000
17	1.804	15.664	107	193	1,104	1,930,000	11,040,000
18	1.518	17.182	124	188	1,292	1,880,000	12,920,000
19	1.379	18.561	173	239	1,531	2,390,000	15,310,000
20	0.998	19.559	216	216	1,747	2,160,000	17,470,000
21	0.774	20.333	142	110	1,857	1,100,000	18,570,000
22	0.851	21.184	254	216	2,073	2,160,000	20,730,000
23	0.645	21.829	257	166	2,239	1,660,000	22,390,000
24	0.578	22.407	277	160	2,399	1,600,000	23,990,000
25	0.258	22.665	140	36	2,435	360,000	24,350,000
26	0.258	22.923	461	119	2,554	1,190,000	25,540,000
27	-	23.224	500	-	2,554	-	25,540,000
28	-	23.224	500	-	2,554	-	25,540,000
29	-	23.224	500	-	2,554	-	25,540,000
30	0.301	23.525	339	102	2,656	1,020,000	26,560,000
Totals	**23.224**			**2,656**		**26,560,000**	

The above stand table represents our current "best estimate" as to available merchantable volume on the property. If a timber cruise is conducted that collects the kind of data needed, then the above table will be modified accordingly.

The type of data needed by a cruise needs to address marketing concerns. That is, who is purchasing the merchantable logs and how are these buyers paying for them. Once that is known, then cruise parameters can be specifically designed to address these criteria. This is the most accurate (and only) way to determine forest volume for the development of a management plan and timberland appraisal.

By using the above stand table, we can compute a harvest schedule. We will assume a partial cut prescription for an all-aged stand, only harvesting trees 13 inches DBH and larger over a 7-year harvest cycle. That is, every acre will be visited once every 7 years. During each entry, the number of available trees on a specific acre may vary from zero to ten. Such is the nature of an uneven-aged natural forest.

With the above table, we estimate that there will be 7.56 trees harvested per acre over a -year cutting cycle, amounting to 1,552 board feet per acre. These estimates are computed by adding the trees per acre column and board feet per acre column for diameter classes 13 and 7above. If we assume that only 10,000 total timbered acres are available, there will be 1,000 acres available each year of the cutting cycle. The estimated annual volume is:

1,000 acres * 1,552 BF/acre = 1,552,000 board feet

Please note that this annual harvest volume figure is only an "estimate". The amount will vary by year, and may actually be + or – 25% depending on the availability of new cruise data.

Conclusions

Given the current rough condition of the forest inventory, it is apparently possible to average 1.5 million board feet per year from this property. Please note that this figure is only a rough estimate and cannot be supported statistically due to the lack of adequate inventory data.

The first step in developing a forest management plan is to organize a complete and accurate forest inventory. This is essentially the foundation on which management plans (and needed financing) are based. Without an inventory, timberland owners can only make educated guesses as to the proper sustainable level.

In addition, without a full and accurate inventory, even the current acreage is only a rough estimate.

Local environmental restrictions may preclude many activities without an acceptable management plan.

Monitoring Sustainability

Sustainability of the forest must be insured by closely monitoring the ecosystem. Geographical Information Systems (GIS) should be used to make accurate and updateable maps of the property. These electronic maps should include various layers of information such as Public Land Survey System (PLSS), ownership lines, zoning lines, roads, streams, topographic lines and/or elevational points, stream buffers, timber type lines, harvest history, invasive species locations, invasive species control activities, harvesting plans, forest inventory plot locations, images (geo-referenced and orthographically corrected), and other needed data.

Global Positioning System (GPS) points should be used to pinpoint and record the various locations of monitoring activities. After completing an intensive cruise, permanent growth plots should be established to monitor the changes in the forest. The forest inventory will be used as the foundation or basis for a model that will grow the forest each year and deduct harvested volumes. With a system such as this, adjustments can be made to the harvesting schedule (pest control and reforestation activities) in order to maintain the forest ecosystem in perpetuity.

Cruise plots, both permanent (GIS located) and temporary, would be designated to measure all of the tree species from seedlings to sawtimber. In addition to merchantable vegetation, competing vegetation needs to be monitored.

The high mortality found in these koa forests will make growth projections difficult. Permanent plot data must include data about mortality, including species, rate, and cause. This information could then be used to supplement the growth model and provide valuable information concerning what can be done to reduce this loss.

Permanent monitoring plots, a computerized empirical growth and yield model, and a concerted commitment to address the control of various pests (insects, disease, mammals, and competing vegetation) are important facets to maintaining a good forest management plan.

Assumptions and Limiting Conditions

The information contained in this report is specific to the needs of the client and for the intended use stated in this report. Atterbury Consultants is not responsible for unauthorized use of this report.

A timber cruise was not conducted by Atterbury Consultants. Therefore, the empirical data needed to produce accurate stand tables was not available.

The stand tables in this report were constructed by literally working backwards from the volume estimates provided by Jaakko Pöyry and Northern Tier Forestry. By assuming an all-aged stand, estimates of trees per acre were made for each diameter class. The volume by diameter class was also estimated due to a lack of data on merchantable height. The height that forking occurs is a major determinant of the usable volume in each tree. This data was not collected during the Jaakko Pöyry cruise, or is at least not available at this time.

Atterbury Consultants has relied upon these general stand structure assumptions and does not guarantee or warrant the accuracy of our estimated timber inventory. If the assumptions are found to be in error in any way, the client agrees to release Atterbury Consultants from any liability associated with these estimates.

A complete legal description was not furnished to Atterbury Consultants, and a title policy was not reviewed. Atterbury Consultants assumes no responsibility for matters legal in character, nor does the consultant render any opinion as to title, which is assumed to be marketable. All existing liens, encumbrances, and assessments have not been considered. It is strongly recommended to the client to review a complete title policy affecting the parcels being inventoried to ascertain the existence of any adverse title conditions.

The tables in this report are included to assist the reader in understanding the inventory structure. Atterbury Consultants has not made a timber cruise of the current inventory and assumes no responsibility in connection with such matters or the accuracy of acreage sizes provided. Atterbury Consultants has relied upon acreages provided by the client and we assumed these acreages to be an accurate indication of the subject property size.

Unless otherwise noted, it is assumed that there are no encroachments, zoning, or restrictive violations existing in the subject property.

Atterbury Consultants no responsibility for determining whether the property equires environmental approval by the appropriate governing agencies nor whether it is in violation unless otherwise noted. The property is assumed to be fully harvestable except as noted.

This report shall be used for its intended purpose only and by the parties to whom it is addressed. Possession of this report does not include the right of publication.

Neither all nor any part of the contents of this report shall be conveyed to the public through advertising, public relations, news, sales, or other media without the written consent or approval of the author. This applies particularly to numerical conclusions and to the identity of the consultant. Atterbury Consultants may not be required to give testimony or to appear in court by reason of this report, with reference to the property in question, unless prior arrangements have been made.

The statements of estimated inventory and all conclusions shall apply as of the dates shown. This inventory is subject to change if the physical or legal entity is different than that envisioned in this report.

Atterbury Consultants has no present or contemplated future interest in the property which is not specifically disclosed in this report.

Atterbury Consultants assumes that there are no toxic hidden or unapparent conditions within the property, subsoil, or structures which would render the inventory more or less valuable. The consultant assumes no responsibility for such conditions or for engineering which might be required to discover such factors. Thus, the client assumes all risks and liability concerning any property condition or contaminant problem which may render the property as having less usable volume.

The client agrees that if Atterbury Consultants is named in a legal action, the amount of the consultants total and complete liability is limited only to the amount of the fee agreed upon for these services, less any expenses incurred during the course of this analysis.

If this report is placed in the hands of anyone other than client, the client shall make such party aware of all limiting conditions and assumptions of the assignment and related discussions. Atterbury Consultants is in no way to be responsible for any costs incurred to discover or correct any deficiencies of any type present in the property; physically, financially, and/or legally.

Atterbury Consultants utilized a "best efforts" approach in documenting and verifying the information provided by the client and others. The information presented within this report is considered to be reliable, although it is noted that it has been obtained from numerous data sources including the client, and others. No liability is assumed by this consultant in connection with data not supplied, or withheld, by the principals or agents involved with the subject property which could affect the estimated inventory.

An impractical and uneconomic expenditure of time would be required in attempting to furnish unimpeachable verification in all instances, particularly as to engineering and market related information. It is suggested that the client consider independent verification or contact this consultant with respect to basing a decision on a particular or singularly significant item of data within this report involving sale, lease, or other significant commitment of funds with respect to the subject property.

The client acknowledges the fact that the consultant is not an economic expert but has relied upon other's forecasts concerning future economic events. The client agrees to hold the consultant harmless from any future litigation which may result as a consequence of using opinions rendered by others in the attempt to project future economic effects on the subject property.

The client also agrees to hold the consultant harmless in the event a third party brings suit against the subject property or property owner. This report has been performed in a professional manner and is an opinion of estimated inventory. Political, biological, and/or economic conditions may change which would render the enclosed projections as obsolete.

Atterbury Consultants has not considered the value of any site improvements as this was beyond the scope of this report. Furthermore, this consultant did not retain any outside professionals to assist in determining the value of any mineral deposits, saw mills, rock pits, or other site factors relating to value as this was outside of the scope of this report.

The consultant has assumed the entire property can be harvested except as noted. If portions of the property are affected by the hoary bat or any other threatened or endangered species, except as noted, then this condition could substantially affect the estimated available inventory.

The work performed has enabled the consultant to make a volume conclusion with the understanding that a complete legal description was reviewed, governmental agencies were contacted to ascertain whether or not endangered wildlife exists on the subject, there are ancient Indian burial sites or villages, or other similar matters affecting the inventory.

Any conditions which arise in the future that affect the subject premises may also affect the indicated inventory. The client agrees that, due to these matters and the dynamic nature of real estate, the consultant will not be subjected to any third party lawsuits or changes required in the inventory.

Maps, if they have been included herein, were included to assist the reader in determining the location of the subject property. This consultant assumes no liability for any deviations from actual property locations.

This consultant has relied upon verbal statements and other data provided by third parties. This data has been assumed to be correct with no responsibility claimed by the consultant for this information.

It has been assumed that the subject property can be logged as of the date of this report. Future events and conditions (such as new threatened or endangered species, litigation from conservation groups, etc.) could reduce the amount of logging activity which could occur on the premises. The client and any third party lender agree to release the consultant from any liability associated with any adverse future events concerning the subject property.

The stand tables in this report were constructed by making general assumptions as to the average number of trees per acre by diameter class. Empirical data for this parameter was not available, therefore, we made the best possible estimate based on contemporary techniques for computing a **Stand Density Index**. These stand tables can be updated with actual data when this becomes available.

The volume estimates used in these stand tables are from the Scribner Log Rule. This is the standard log rule used in the western United States.

Appendix B

Forest Management Plan

Forest Management Plan

Koa Timber, Inc.

Prepared for:

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Summary

Property description

Koa is a large evergreen hardwood indigenous to Hawai'i. It is a member of the Legume family (*Fabaceae*). It grows at elevations between 1,200 to 6,500 feet and generally favors 40 inches to 200 inches of mean annual rainfall. On the Island of Hawai'i, koa is found naturally at two distinct elevations; a lower forest zone between 1,200 and 2,600 feet and a upper koa belt between 3,500 and 6,500 feet. Koa occurs in both pure and mixed forest stands and is commonly associated with native ferns[1]. Today, koa stands are fragmented and concentrated in the mid-elevations. Lower elevation lands have been cleared for sugar and pasture lands.

The Koa Timber, Inc. property consists of 13,226 acres of fee simple forestland and is located above Papaikou and Pepeekeo on the Island of Hawai'i, overlooking the city of Hilo and the harbor that borders the Hilo Forest Reserve. Tax lot numbers are TMK 3-2-7-01:1 and 3-2-8-01:2. The property gently slopes from west to east, with the northwest corner having the highest elevation at approximately 3,650 feet, and the southwest corner an elevation of 3,300 feet above sea level. The northern boundary drops from 3,650 feet on the western edge to 1,600 feet on the eastern boundary. This is a 7.5% slope (4.27°). The southern boundary drops from 3,300 feet on the western edge to 1,700 feet on the eastern boundary. This is a 6.5% slope (3.65°).

Access from the City of Hilo is from the Hawai'i Belt Road. According to an agreement with an adjacent landowner, a 60-foot easement provides access from the highway to the parcels. There are three access roads to parcel TMK 2-7-01:01 and none to parcel TMK 2-8-01:02.

Access to TMK 2-8-01:02 is pending successful negotiation regarding locations and width of an easement with Mauna Kea Sugar (C. Brewer), the adjacent landowner. Alternative locations are also being considered.

The subject property's general terrain is characterized by dense, mature rainforest vegetation. Located on the wet, windward side of the island, the property has high rainfall. Mean annual precipitation ranges from 236 inches at 2,800 feet elevation in the central part of the property to 196 inches at 3,600 feet elevation on the western (mauka) boundary. The rainfall is distributed evenly throughout the year. Mean annual temperature is 65 to 70 degrees F. Drainage is good, and the general downward topography is marked by a number of significant streams and deep gulches.

The property consists mostly of open forest, with very little closed canopy. Dominant canopy trees are koa (*Acacia koa*) and ohi'a (*Metrosideros macropus*). The upper portion of the site (generally above 3,000 feet) is dominated by dense uluhe fern (*Dicranopteris emarginata*), with patches of wet open sedge lands. Very few koa trees survive in these areas. Dense strawberry guava (*Psidium cattleianum*) is found at lower elevations and along the southern (Hilo) boundary. Some eucalyptus (*Eucalyptus spp.*) is also found at lower elevations.

Due to existing property conditions of land use classification, access, utilities, terrain, topography, and rainfall, the subject property is not considered to have feasible economic uses other than what is being proposed in this plan. **If the property continues to be maintained as an**

[1] Burns, R.M. and B.H. Honkala. 1990. Silvics of North America, volume 2, hardwoods. USDA Forest Service, Washington, DC. Agriculture Handbook 654. 877pp.

undeveloped and undisturbed resource, the loss of the native koa forest to invasive, exotic weeds will continue to progress.

The management of these forests for the production of koa logs in perpetuity depends on developing a long-term silvicultural program that will ensure the successful reproduction of this species. The largest problem facing this program is the reduction or control of agents responsible for the current forest's demise. These agents include feral pigs, insects, disease, and competing exotic vegetation.

There is a considerable amount of literature describing the variety of pests and their impact on koa forests; however, there is very little concerning growth data, yield tables, or growth models. This dearth of growth and yield information presents the greatest problem in determining a sustainable harvest base.

The forest described in this report has regenerated naturally and consists of all-aged stands. The forest is constantly changing with the introduction of invasive species, both flora and fauna. It is suspected that feral pigs are probably spreading the strawberry guava and other non-native species. These exotic species compete for light, water, and growing space with native koa and ohi'a.

The only harvesting to date has been in the agricultural zone. Field examination of this tractor and helicopter logging site shows very little site damage and a subsequent heavy crop of koa seedlings. Currently, all helicopter logging is planned for the remaining operable acres. This will minimize site impact while allowing us to improve koa stocking while eliminating unwanted competing vegetation. Natural seeding easily fills in open areas and, with the proper conditions, seedlings can grow rapidly the first few years. This will be supplemented with planted trees.

Our projection of sustained yield envisions a light harvest, averaging one to six trees per acre, every seven years. Economics demands that only the largest mature trees would be harvested and maybe some smaller trees that are merchantable but dying, dead, cull, or growing at an inhibitory stocking level. In our projection, only trees 13.8 inches dbh[2] and larger will be harvested.

Koa is a rather short lived species. Current literature gives the species maximum merchantable age at about 100 years. Beyond this age, mortality and defect will render most koa trees unusable. Koa forests experience heavy mortality, especially in young ages. If left untouched, less than 1% of koa seedlings will live to 100 years.

Virtually all trees of merchantable size have two or more tops. Apparently, the wind breaks out the tops when the trees get above the main canopy. This results in trees with a good peeler or sawlog only to the first fork. The distance to the fork and the number of stems above the fork create a large statistical variation in the volume of trees in some diameter classes. This condition will confound the modeling of expected merchantable volume and the timing of operational cash flows.

Management objectives

The primary goal of Koa Timber is to harvest koa in a way that sustains and enhances the koa forest and native ecosystems. This will be accomplished by implementing specific silvicultural activities to manage stocking and improve growth of the residual koa trees. **By selectively logging a limited number of koa trees each year, we expect to generate a sufficient**

[2] Diameter breast height, or 4.5 feet above the root collar.

amount of cash flow to cover the cost of koa forest ecosystem rehabilitation. Rehabilitation activities will consist of controlling alien plant species and creating conditions that will enhance regeneration of koa trees and other plants native to the area. Logging activities will be planned and carried out in a manner that does not damage the site or create unfavorable conditions for endangered plants and animals.

Koa Timber will endeavor to achieve a sustainable long-term forest resource by protecting, enhancing, and expanding the native koa forest. Harvesting will only be done in the seven timber units located between the riparian zones, while leaving at least a 200-foot buffer to all perennial streams. Our current GIS estimate of riparian set-asides is 3,686.94 acres, or 27.9% of the property.

Sustained yield is defined as: "Management of the koa forest to provide harvesting on a continuing basis without major prolonged curtailment or cessation of the harvest." Harvesting operations must be conducted to prevent degradation of the forest (allowing exotic plants to take over), senescence and loss of mature koa trees, and to generate the cash flow needed for ecosystem restoration.

Currently, it appears that strawberry guava is consuming more and more acres at the expense of native species. The survey by Jaakko Pöyry found more strawberry guava on their plots than koa. If this situation is left unchecked, it is very likely that the koa cover type will be eliminated over the next few decades.

It is imperative that an active management plan be implemented to save this koa forest. The reduction of strawberry guava (preferably elimination), the control of pigs (preferably elimination), and the increased stocking of koa through successful regeneration will take both time and money. Due to the high value of koa in the furniture and art markets, silvicultural activities necessary to save this koa forest can be financed through the selective harvesting of high quality koa trees.

It is our intention to manage these forests in perpetuity. We will base each silvicultural project on the current condition of the forest, with an end goal of creating a healthy, growing forest. We will review all silvicultural plans with the State of Hawai'i's Department of Land and Natural Resources, Division of Forestry and Wildlife (DOFAW).

An **"Adaptive Management"** strategy will be implemented for the maintenance and enhancement of this forest. Koa Timber, along with his consultant, Randy Senock PHD, Ron Terry PHD, and Wade C. Lee M.S. will provide continuing evaluation of silvicultural activities and report to DOFAW the group shall issue advice and recommendations as to whether any project modifications are warranted. This evaluation will include a periodic review of operational compliance to set guidelines.

Koa Timber's primary objectives with this Forest Management Plan are:

- Foster regeneration of koa trees at a stocking level adequate to maintain a healthy uneven-aged forest.
- Control alien plant species, especially strawberry guava.
- Protect endangered plants and animals through ecosystem restoration.
- Achieve a sustainable harvest level, in an uneven-aged forest, while improving the native koa ecosystem.

- Log high value, dead, or cull koa trees while maintaining minimum impact to adjacent trees and regeneration through the use of heli-logging. Product removal will generate the cash flow needed for ecosystem rehabilitation.

It is important to note that natural disasters can occur at anytime. Hurricanes, lava flows, insect infestation, droughts, invasive weeds, or a forest fire can have a major impact on the health and survival of the forest. Due to the unpredictability of these events, it is impossible to incorporate response activities into our project plans. In the event that a natural disaster occurs, the current forest management plan will be evaluated and amended to reflect the changed conditions of the forest. This is part of the "adaptive management" approach to this property.

Location Map

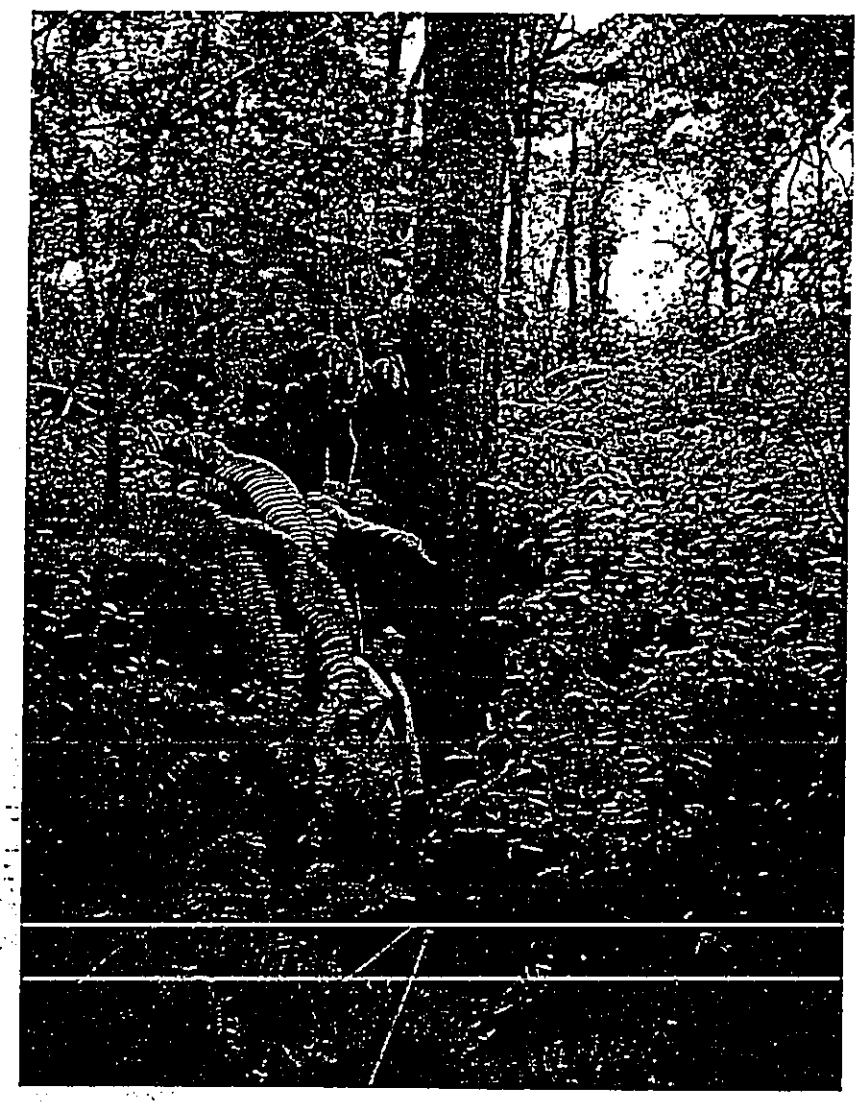
This Forest Management Plan represents responsible stewardship of a unique resource that is at risk. Successful koa regeneration is vital to perpetuate this native forest. Many degraded

portions of the native forest will continue to decline over time if not addressed by an active management plan. Other portions of the native forest that are currently in good condition are likely to experience hastened deterioration due to the aggressive nature of exotic competing vegetation. The benefits of establishing and adhering to a Forest Management Plan are:

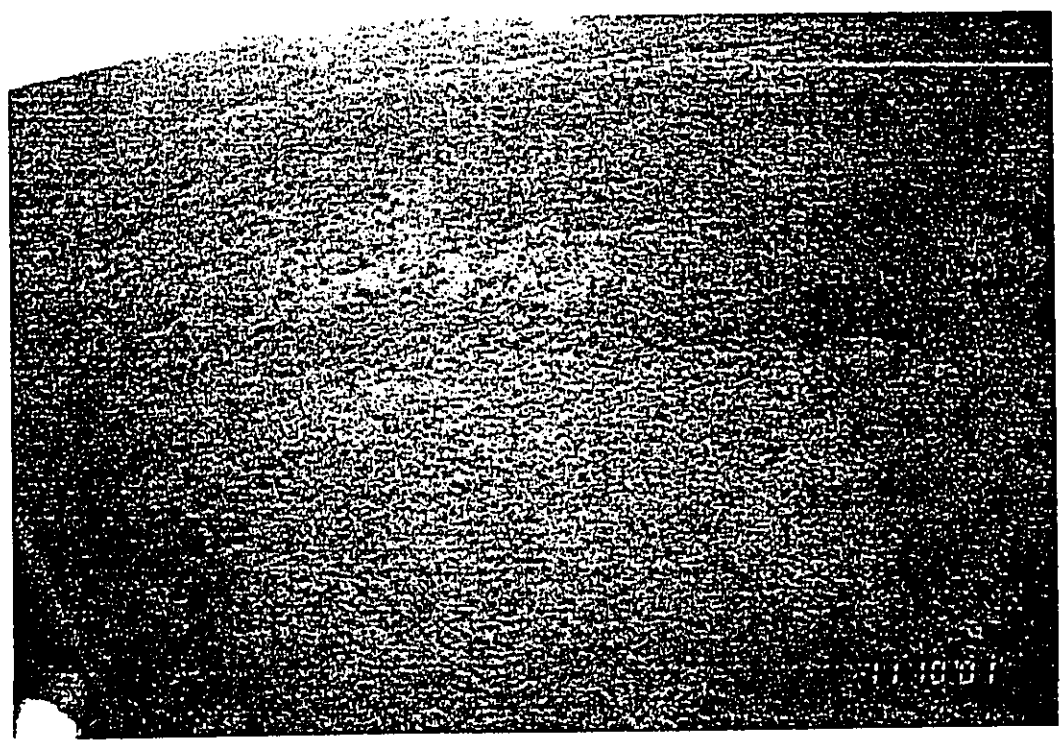
- Jobs for local Hawai'i residents within the forest products industry. A sustainable, quality supply of koa will help to expand opportunities in global markets and support small business in Hawai'i. An estimated 5,000 board feet per month of milled lumber will be allocated to Big Island craftspeople. With a reliable supply of koa, artists and businesses can expand the market for this uniquely Hawaiian wood.

- Establishment of a healthy koa forest ecosystem in perpetuity.

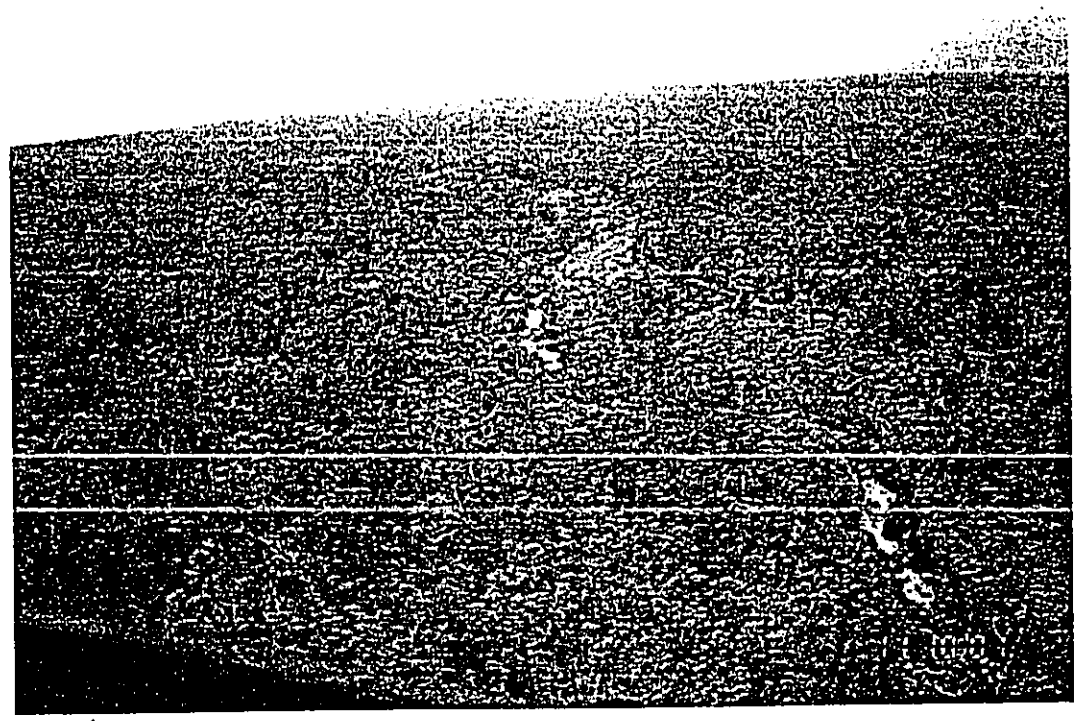
Photos



Koa Forest on the Island of Hawai'i. This tree is one of the larger trees. Notice the heavy fern cover. Koa trees of various sizes are visible in the background. (December, 2001)



Aerial view of koa forests showing the non-stocked areas (brown vegetation).



Aerial view of koa forests showing one of the many riparian areas.

Typical koa tree after felling. Note that the majority of usable wood occurs before the first fork. Volume estimates need to take this into consideration.

Forest Inventory and Monitoring

Inventory data were developed by using the gross parameters of trees per acre and volume per tree developed and published by Jaakko Pöyry[3], in combination with the strata GIS acres developed by Atterbury Consultants, Inc. The Jaakko Pöyry data showed a mean volume of 25 million board feet with a 95% confidence limit ranging from 16.5 million to 33.9 million board feet.

Sustainability of the forest must be insured by closely monitoring the ecosystem. Geographical Information Systems (GIS) will be used to make accurate and updateable maps of the property. These electronic maps should include various layers of information such as Public Land Survey System (PLSS), ownership lines, zoning lines, roads, streams, topographic lines and/or elevational points, stream buffers, timber type lines, harvest history, invasive species locations, invasive species control activities, harvesting plans, forest inventory or monitoring plot locations, images (geo-referenced and orthographically corrected), and other needed data.

The projections presented here represent our best estimate of a sustainable harvest base given available information and data. These projections will be updated annually when additional information is available from aerial photographs and monitoring plots.

Building the Current Inventory

General

The forest inventory used in this report, for the initial planning, was built by stratifying aerial photographs into the same strata as used by Jaakko Pöyry, and then using the volumes per acre by strata type. While we do not have the Jaakko Pöyry GIS maps, or their plot data, the strata measurements by size class and volumes per acre are the best inventory data available at this time.

Developed acres by strata type.

Koa Timber Company supplied ACI with 1992 infrared digital imagery and a black and white print of the 1977 U.S.G.S. 15 minute Akaka Falls orthoquadrangle. The orthoquadrangle was scanned and referenced as a basis for referencing the 1992 infrared digital imagery. After the infrared imagery was referenced it was loaded, along with the Hawai'i state GIS hydrology dataset, into ACI's ForestVIEW™ (an extension for ESRI's ArcVIEW™ GIS software). Koa Timber Company ownership and classifications zones (Agriculture, Logged Agriculture, Low Elevation, High Elevation) were delineated as separate GIS layers. The koa density strata and non-stocked areas were then delineated utilizing "heads up" digitizing based on photo interpretation of the 1992 infrared imagery.

Atterbury Consultants strata delineation was interpreted from the developed GIS layers. The delineation was based on the three Koa density level categories established by the Jaakko Pöyry Consulting inventory report. These three categories are broken-down further by high and low altitude. The altitude break occurs at the 2,750 ft. elevation contour. In the low altitude zone, a third and fourth zone was classified as agricultural land and logged agricultural land. The western

[3] Pöyry, J. 2001. Koa forest inventory – Hawai'i. Prepared for Metropolitan Mortgage & Securities Co., by Jaakko Pöyry Consulting. 54pp.

boundary for the agricultural and logged agricultural zones are defined by the eastern Forest Reserve Boundary as delineated on the 1981 U.S.G.S. 15 minute Akaka Falls quadrangle. The northern boundary for the logged agricultural zone is delineated by the Kawainui Stream watercourse.

The resulting 14 strata classifications are defined as follows:

1. AGHD	Agricultural High Density
2. AGLD	Agricultural Low Density
3. AGMD	Agricultural Medium Density
4. AGNS	Agricultural Non-Stocked
5. HILD	High Altitude Low Density (> 2,750 ft. elevation)
6. HIMD	High Altitude Medium Density (> 2,750 ft. elevation)
7. HINS	High Altitude Non-Stocked (> 2;750 ft. elevation)
8. LAHD	Logged Agricultural High Density
9. LALD	Logged Agricultural Low Density
10. LAMD	Logged Agricultural Medium Density
11. LOHD	Low Altitude High Density (< 2,750 ft. elevation)
12. LOLD	Low Altitude Low Density (< 2,750 ft. elevation)
13. LOMD	Low Altitude Medium Density (< 2,750 ft. elevation)
14. LONS	Low Altitude Non-stocked (< 2,750 ft. elevation)

The Hawai'i state hydrology dataset was classified into perennial and intermittent streams based on the 1981 Akaka Falls quadrangle. The perennial streams and pools were buffered with a Stream Management Zone (SMZ) width of 200 feet on a side and assumed an average streambed width of 15 feet. The intermittent streams were buffered with a SMZ width of 160 feet on each side of the stream centerline. The resulting three GIS layers (zone, strata, hydrology buffers) were overlaid processed to produce a fourth layer with calculated acreages for the 14 strata classifications listed above. These acres were then used in the final inventory report.

Recomputed new volume estimates by strata from the new acreage estimates

We applied the volume assumptions described in the Jaakko Pöyry report to these new acreage-estimates. In the following tables, the estimated "Trees per Acre" and "Cubic meters per Tree" were taken directly from the Jaakko Pöyry report. Additionally, we use the 212 board feet per cubic meter stated by Jaakko Pöyry for trees 35 centimeters dbh and larger. By applying the Jaakko Pöyry estimates to the new acreage estimates, we conclude a final net volume of 15,804,503 board feet (for trees over 13.8 inches dbh) for the 13,226 acres.

In 2000, an estimated 86,944 board feet were removed during logging operations. In 2001, an estimated 270,539 board feet were removed during logging operations. With these depletions, the current estimate of net volume is 15,804,503 board feet. This equates to an average volume of 1,195 board feet per acre for the total 13,226 property acres, or 1,657 board feet per acre for the operational acreage. Regeneration in the agriculture area has been monitored in 18 regeneration trial plots: See Supplement A Regeneration Data.

Note that this volume is for trees 13.8 inches diameter and larger (35 centimeters). Also note that this estimate was made by assuming the trees per acre estimate put forth by Jaakko Pöyry is reasonably correct.

Table 1 Estimated volume of Koa trees, greater than 35 cm in diameter, on the operable acres.

Strata	Acres	Pct Acres	Trees Per Acre	Cubic meters per tree	Board Feet per tree	Board Feet per acre	Total Board Feet
1. Ag area High density	66.22	0.5%	12.6	1.3	248.04	3,125	206,958
2. Ag area Low density	300.78	2.3%	8.9	1.1	209.88	1,868	561,837
3. Ag area Medium density	418.69	3.2%	9.0	1.2	228.96	2,061	862,769
4. Ag area Non-stocked	5.93	0.0%	-	-	-	-	-
5. High altitude Low density	2,638.70	20.0%	6.5	0.9	171.72	1,116	2,945,264
6. High altitude Medium density	1,211.12	9.2%	8.1	0.9	171.72	1,391	1,684,586
7. High altitude Non-stocked	432.82	3.3%	-	-	-	-	-
8. Ag logged High density	7.43	0.1%	12.6	1.3	248.04	3,125	23,221
9. Ag logged Low density	2.35	0.0%	8.9	1.1	209.88	1,868	4,390
10. Ag logged Medium density	271.46	2.1%	9.0	1.2	228.96	2,061	559,381
11. Low altitude High density	97.76	0.7%	12.6	1.3	248.04	3,125	305,530
12. Low altitude Low density	1,633.13	12.3%	8.9	1.1	209.88	1,868	3,050,576
13. Low altitude Medium density	2,891.08	21.9%	9.0	1.2	228.96	2,061	5,957,475
14. Low altitude Non-stocked	379.09	2.9%	-	-	-	-	-
15. Riparian management zone	2,869.09	21.7%	-	-	-	-	-
Sub-Totals	**13,225.65**	**100.0%**				**1,222**	**16,161,986**
		2000 volume depletions by logging					**86,944**
		2001 volume depletions by logging					**270,539**
Grand Totals						**1,195**	**15,804,503**

High Altitude	4,282.64	32.4%	1,081	4,629,850
Low Altitude	5,001.06	37.8%	1,862	9,313,581
Ag area	1,072.86	8.1%	2,068	2,218,556
Stream Buffers	2,869.09	21.7%		
Removals				357,483
Sub-Totals	**13,225.65**	**100%**		**15,804,503**

The koa forest appears to be old and to have very little natural regeneration. Many of the existing merchantable koa trees were probably established prior to the influx of invasive species. The invasive species are now interfering with natural regeneration of the koa forest.

The Jaakko Pöyry data contains an estimate of trees per acre for trees under 13.8 inches dbh. The following table adds the volumes and basal areas by strata type for these smaller trees, plus the percentage of plots with reproduction and strawberry guava. This is the best total inventory we can build at this time.

Table 2 Estimate of koa inventory by strata and size class[4].

Strata	Species and Acres	Pct Acres	DBH (inches)	Avg DBH	Trees per Acre	BA/ Acre	CuFt/ tree	CuFt/ acre	Total CCF	BF/ tree	BF/ acre	Total MBF	Total trees	Pct of species
1. Agricultural, High Density	Strawberry Guava													67%
	Koa		0 to 1.9	0.5										63%
			2 to 7.9	5.0	3.2	0.44	5.0	16	11	1	3	0	212	
			8 to 13.8	10.0	10.0	5.45	28.0	280	185	36	360	24	662	
			13.9+	16.0	12.6	22.27	45.9	578	383	212	2,671	177	834	
Subtotals	66.22	0.5%		14.1	25.8	28.16		874	579		3,034	201	1,708	
2. Agricultural, Low Density	Strawberry Guava													75%
	Koa		0 to 1.9	0.5										31%
			2 to 7.9	5.0	2.3	0.31	5.0	12	35	1	2	1	692	
			8 to 13.8	10.0	9.0	4.91	28.0	252	758	36	324	97	2,707	
			13.9+	16.0	8.9	15.73	38.8	345	1,039	212	1,887	568	2,677	
Subtotals	300.78	2.3%		13.8	20.2	20.95		609	1,831		2,213	666	6,076	
3. Agricultural, Medium Density	Strawberry Guava													34%
	Koa		0 to 1.9	0.5										24%
			2 to 7.9	5.0	3.7	0.50	5.0	19	77	1	4	2	1,549	
			8 to 13.8	10.0	9.7	5.29	28.0	272	1,137	36	349	146	4,081	
			13.9+	16.0	9.0	15.90	42.4	382	1,598	212	1,908	799	3,768	
Subtotals	416.69	3.2%		13.3	22.4	21.70		672	2,812		2,261	947	9,379	
5. High Altitude, Low Density	Strawberry Guava													25%
	Koa		0 to 1.9	0.5										50%
			2 to 7.9	5.0	6.8	0.93	5.0	34	897	1	7	18	17,943	
			8 to 13.8	10.0	11.5	6.27	28.0	322	8,497	36	414	1,092	30,345	
			13.9+	16.0	6.5	11.49	31.8	207	5,451	212	1,378	3,636	17,152	
Subtotals	2,638.70	20.0%		11.8	24.8	18.69		563	14,844		1,799	4,748	65,440	
6. High Altitude, Medium Density	Strawberry Guava													23%
	Koa		0 to 1.9	0.5										34%
			2 to 7.9	5.0	5.6	0.78	5.0	28	339	1	6	7	14,777	
			8 to 13.8	10.0	10.9	5.95	28.0	305	3,696	36	392	475	28,762	
			13.9+	16.0	8.1	14.31	31.8	257	3,118	212	1,717	2,080	21,373	
Subtotals	1,211.12	9.2%		12.5	24.6	21.02		591	7,153		2,116	2,562	64,912	
8. Agricultural Logged, High Density	Strawberry Guava													93%
	Koa		0 to 1.9	0.5										41%
			2 to 7.9	5.0	3.2	0.44	5.0	16	1	1	3	0	24	
			8 to 13.8	10.0	10.0	5.45	28.0	280	21	36	360	3	74	
			13.9+	16.0	12.6	22.27	45.9	578	43	212	2,671	20	94	
Subtotals	7.43	0.1%		14.1	25.8	28.16		874	65		3,034	23	192	
9. Agricultural Logged, Low Density	Strawberry Guava													75%
	Koa		0 to 1.9	0.5										31%
			2 to 7.9	5.0	2.3	0.31	5.0	12	0	1	2	0	5	
			8 to 13.8	10.0	9.0	4.91	28.0	252	6	36	324	1	21	
			13.9+	16.0	8.9	15.73	45.9	409	10	212	1,887	4	21	
Subtotals	2.35	0.0%		13.8	20.2	20.95		672	16		2,213	5	47	
10. Agricultural Logged, Medium Density	Strawberry Guava													34%
	Koa		0 to 1.9	0.5										24%
			2 to 7.9	5.0	3.7	0.50	5.0	19	50	1	4	1	1,004	
			8 to 13.8	10.0	9.7	5.29	28.0	272	737	36	349	95	2,633	
			13.9+	16.0	9.0	15.90	45.9	413	1,121	212	1,908	518	2,443	
Subtotals	271.46	2.1%		13.3	22.4	21.70		703	1,909		2,261	614	6,081	
11. Low Altitude, High Density	Strawberry Guava													93%
	Koa		0 to 1.9	0.5										41%
			2 to 7.9	5.0	3.2	0.44	5.0	16	16	1	3	0	313	
			8 to 13.8	10.0	10.0	5.45	28.0	280	274	36	360	35	978	
			13.9+	16.0	12.6	22.27	45.9	578	585	212	2,671	261	1,232	
Subtotals	97.76	0.7%		14.1	25.8	28.16		874	855		3,034	297	2,522	
12. Low Altitude, Low Density	Strawberry Guava													75%
	Koa		0 to 1.9	0.5										31%
			2 to 7.9	5.0	2.3	0.31	5.0	12	188	1	2	4	3,756	
			8 to 13.8	10.0	9.0	4.91	28.0	252	4,115	36	324	529	14,698	
			13.9+	16.0	8.9	15.73	38.8	346	5,645	212	1,887	3,081	14,535	
Subtotals	1,633.13	12.3%		13.8	20.2	20.95		609	9,949		2,213	3,614	32,989	
13. Low Altitude, Medium Density	Strawberry Guava													34%
	Koa		0 to 1.9	0.5										24%
			2 to 7.9	5.0	3.7	0.50	5.0	19	535	1	4	11	10,697	
			8 to 13.8	10.0	9.7	5.29	28.0	272	7,852	36	349	1,010	28,043	
			13.9+	16.0	9.0	15.90	42.4	381	11,025	212	1,908	5,515	26,020	
Subtotals	2,891.08	21.9%		13.3	22.4	21.70		671	19,412		2,261	6,536	64,760	
Total Timber	9,538.72	72.1%		11.9	26.6	20.74	23.4	823	59,425	294	2,119	20,210	254,106	
Stream Buffers	2,869.09	21.7%												
Ag. Logged wet	5.93	0.0%												
High wet	432.82	3.3%												
Low wet	379.09	2.9%												
Non-Forest	3,688.93	27.9%												
Grand Total	13,225.65	100.0%												

4 Agricultural lands were not sampled by JP. We assume that they are similar to adjacent low elevation area.

Table 3 Estimate of koa inventory by strata and size class for the agriculture and reserve areas.

Strata	Species and Size Class	Acres	Pct	DBH	Avg DBH	Trees per Acre	BA/Ac	Cu Ft/Tree	Cu Ft/Acre	Total Cu Ft	BF/Tree	BF/Acre	Total MBF	Total Trees
Reserve	Strawberry Guava													
	Koa			0 to 1.9	0.5									
				2 to 7.9		5.6		23	1,975	5	39	47,486		
				8 to 13.8		12.1		288	24,434	371	3,142	102,826		
				13.9+		9.5		305	25,804	1,720	14,575	80,311		
Subtotals		8,471.79	64.1%			27.2		616	52,213	2,096	17,756	230,623		
Agriculture	Strawberry Guava													
	Koa			0 to 1.9	0.5									
				2 to 7.9		3.3		16	174	3	3	3,486		
				8 to 13.8		9.5		267	2,845	343	368	10,159		
				13.9+		9.2		393	4,193	1,955	2,085	9,837		
Subtotals		1,066.93	8.1%			22.0		676	7,212	2,301	2,455	23,483		
Total Timber		9,538.72	72.1%			26.6		623	59,425	2,119	20,210	254,106		
Non-Forest		3,686.93	27.9%											
Grand Total		13,225.65	100.0%											

Growth

Several growth plots have been measured over the last 40 years and provide a good, but limited, record for koa. Additional growth data is needed by forest cover type, elevation, all-aged stands, and other criteria to complete the picture. The growth data presented in Tables 4, 5, and 6 represents even-aged ideal conditions. These even-aged forests show a growth rate that is somewhat more than can be achieved in a natural forest. Natural forests have openings and a much less uniform stocking.

Growth will be computed from the permanent monitoring plots. Growth models should be able to expand the monitoring data to each type acre to develop a working inventory. Therefore, the growth presented in these tables is only being used as a starting point.

Table 4 Koa growth data from 3 plots on the Big Island of Hawai'i.

Averages of the measurements for each year.

				Total			Per Acre			MAI	MAI
Plot	Year	Age	Spp.	DBH	Height	BA	Trees	Cu Ft	G Bd Ft	Cu Ft	Bd Ft
12	1961	10	Koa	4.2	24	35	360	228	1000	23	100
	PAI	*5*		*0.3*	*1.6*	*5.3*	*-8.0*	*92*	*620*		
	1966	15		5.9	32	62	320	687	4100	46	273
	PAI	*6*		*0.3*	*0.2*	*1.7*	*-15.0*	*-92*	*383*		
	1972	21		7.6	33	72	230	133	6400	6	305
	PAI	*5*		*0.9*	*2.8*	*-13.8*	*-45.4*	*-18*	*-1238*		
	1977	26		12.3	47	3	3	42	210	2	8
	PAI	*14*		*0.0*	*0.2*	*0.1*	*0.1*	*2*	*11*		
	1985	40		12.1	50	4	5	76	370	2	9
	PAI	*16*		*0.0*	*-0.3*	*0.1*	*0.1*	*2*	*14*		
	2001	56		12.4	46	6	7	114	600	2	11
23	1968	10	Koa	2.0	18	34	1540	0	0	0	0
	PAI	*5*		*0.3*	*1.0*	*11.0*	*-48.0*	*56*	*300*		
	1973	15		3.5	23	89	1300	279	1500	19	100
	PAI	*4*		*0.3*	*1.3*	*5.8*	*-67.5*	*176*	*1425*		
	1977	19		4.5	28	112	1030	984	7200	52	379
	PAI	*8*		*0.3*	*2.1*	*4.5*	*-45.0*	*205*	*988*		
	1985	27		6.8	45	148	670	2621	15100	97	559
	PAI	*16*		*0.3*	*2.1*	*2.0*	*-27.5*	*173*	*969*		
	2001	43		12.0	78	180	230	5389	30600	125	712
41	1974	10	All	1.7	18	32	2010	0	0	0	0
	PAI	*11*		*0.3*	*1.5*	*9.3*	*-101.8*	*171*	*1145*		
	1985	21		5.3	34	134	890	1883	12600	90	600
	PAI	*16*		*0.1*	*0.4*	*2.6*	*-16.3*	*124*	*544*		
	2001	37		7.1	40	176	630	3863	21300	104	576

Table 5 Averages of the beginning and ending measurements.

				Total			Per Acre			MAI	MAI
Plot	Year	Age	Spp.	DBH	Height	BA	Trees	Cu Ft	G Bd Ft	Cu Ft	Bd Ft
12	1961	10	Koa	4.2	24	35	360	228	1,000	23	100
	PAI	*46*		*0.2*	*0.5*	*-0.6*	*-7.7*	*-2*	*-9*		
	2001	56		12.4	46	6	7	114	600	2	11
23	1968	10	Koa	2.0	18	34	1,540	-	-	-	-
	PAI	*33*		*0.3*	*1.8*	*4.4*	*-39.7*	*163*	*927*		
	2001	43		12.0	78	180	230	5,389	30,600	125	712
41	1974	10	All	1.7	18	32	2,010	-	-	-	-
	PAI	*27*		*0.2*	*0.8*	*5.3*	*-51.1*	*143*	*789*		
	2001	37		7.1	40	176	630	3,863	21,300	104	576

Table 6 Average of three plots

				Total			Per Acre			MAI	MAI
Plot	Year	Age	Spp.	DBH	Height	BA	Trees	Cu Ft	G Bd Ft	Cu Ft	Bd Ft
		45		10.5	55	121	289	3,122	17,500	77	433
	PAI			*0.2*	*1.0*	*3.0*	*-32.8*	*101*	*569*		

This data can be used to calculate a growth percent, which can then be applied to the subject forest. The growth percent using mean annual increment (MAI)[5] is 2.4% (433 BF/ac divided by 17,500 BF/ac). This equates to 2,119 board feet per acre average for the subject, or 52 board feet per acre annually.

Growth should increase through time as more koa trees per acre are established. Each cycle of harvesting will increase the number of koa trees per acre.

Monitoring and Forest Inventory

The inventory database will be developed from permanent monitoring plots installed during the first year. These stations, canvassing each of the seven harvest units, will be maintained as the forest grows and is harvested. Additional monitoring plots may be established as deemed necessary. Depletions, or removals, will be incorporated into the inventory database on an annual basis.

Biologists, such as botanists and omithologists, can make use of these permanent monitoring plots to measure annual changes in various species of flora and fauna. This monitoring will be contracting to Ron Perry PHD information collected will be reported to DOWFA annually.

Each of the seven operable harvesting zone (areas between perennial streams) will be monitored with a series of permanent fixed-area nested plots. Each plot will be located with a center stake and GPS coordinates. At this time we are planning for three nested plots, each designed to measure a different vegetation size class. The smallest plot (e.g. 1/100 acre) will be used to measure seedlings and inventory herbs. The middle plot (e.g. 1/10 acre) will be used to measure trees under 8-inches diameter. All measurable trees (> 3-inches diameter) will be numbered and marked at dbh so that a continuous record can be maintained for growth and survival. The largest plot may be a variable size plot, depending on the cruise requirements and structure of the koa forest. The exact plot size installed within a unit may vary due to the stocking and forest structure of the unit.

There will be ±424 monitoring plots, with three nested plots around each plot center. The number of plots located in each unit is a function of the size of the unit. The actual number of plots installed may vary depending on the ground conditions, helicopter landing spots, and budget.

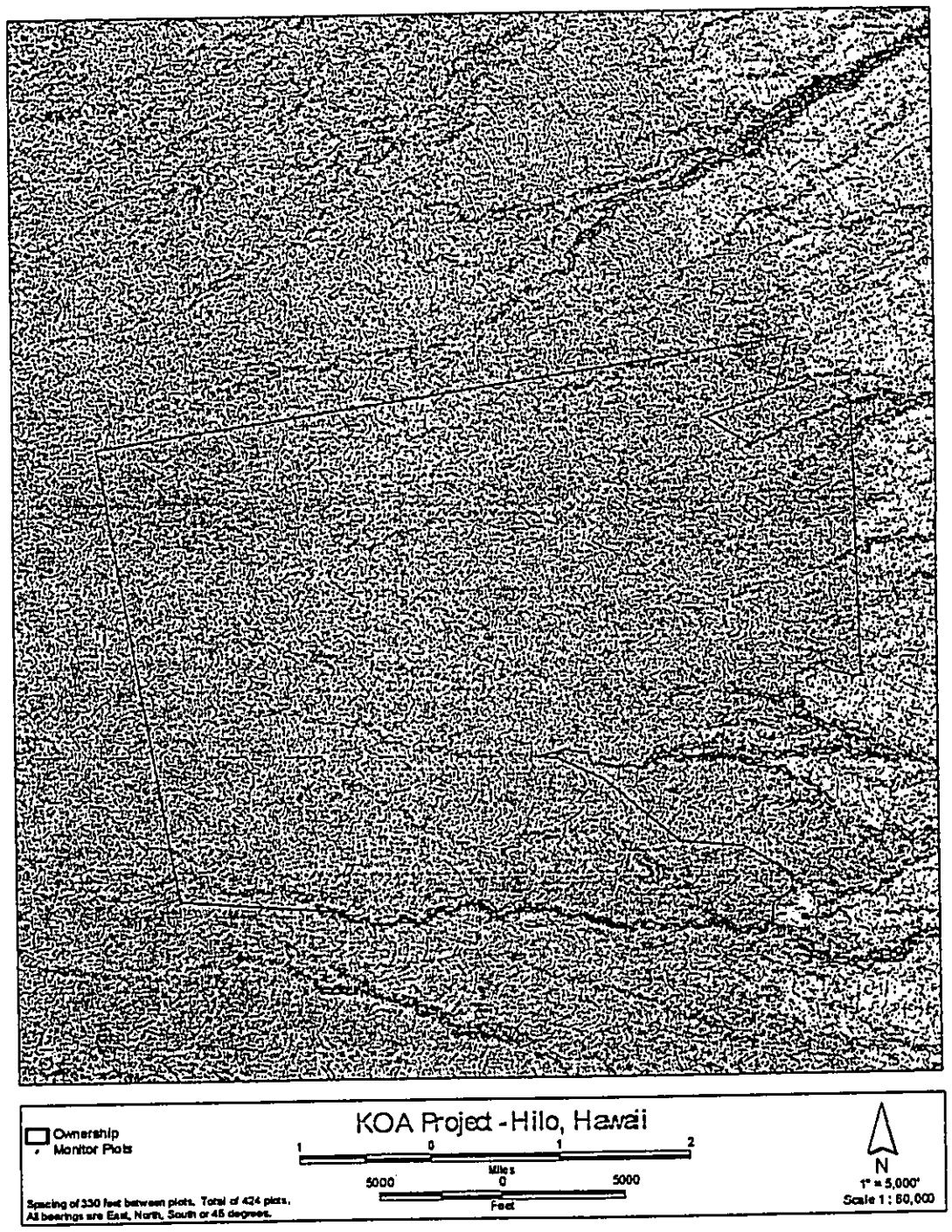
[5] Mean annual increment (MAI) is the total increment of a tree or stand (standing crop plus thinnings) up to a given age divided by that age.

Table 7 Number of permanent monitoring plots that will be installed within each harvest unit.

Harvest Unit	Installed Monitoring Plots
1	44
2	55
3	65
4	70
5	70
6	65
7	55
Total	**424**

Each plot will be re-measured before and after harvesting during each cutting cycle. In addition to size and density parameters for koa trees, other information collected shall include koa regeneration, survival of koa regeneration, in-growth, native understory vegetation, insects and disease problems, and invasive plants.

A forest inventory of the property will be constructed through repeated measurements of the monitoring plots. Data from these measured plots will be maintained in digital format. All data and information needed for planning and tracking will be included in these files and linked to the GIS.



The above map for this property provides our suggested location of the monitoring plots.

A photographic record will also be kept for each plot. A single photograph will be taken 15 feet south of the plot center. These photos will become part of the permanent database of information for the plot. Additional photos may be needed to record special situations, such as an

mation for the plot. Additional photos may be needed to record special situations, such as an endangered species.

Results from the monitoring will be used to adjust harvesting strategies, including intensity, size, and frequency, so that sustainability can be achieved, and, to the best of our ability, the native koa forest be restored to its original condition.

It should be noted that if nothing is done, viz. no silvicultural activities (including harvesting), the koa forest in many areas will continue to decline until completely eliminated by invasive, competitive vegetation.

The forest inventory, developed from the permanent monitoring plots, will be used as the foundation or basis for a model that will grow the forest each year and deduct harvested volumes. With a system such as this, adjustments can be made to the harvesting schedule, pest control, and reforestation activities in order to rehabilitate and maintain the forest ecosystem in perpetuity.

The high mortality currently found in these koa forests will make growth projections difficult. Permanent plot data must include data about mortality, including species, rate, and cause. This information could then be used to supplement the growth and yield model and provide valuable information concerning what can be done to reduce this loss.

Permanent monitoring plots, a computerized empirical growth and yield model, and a concerted commitment to address the control of various pests (*insects, disease, mammals*, and competing vegetation) are important facets to maintaining a good forest management plan.

The digital monitoring data is literally the foundation for operational planning, and adaptive management, in the management of the forest. It will provide the data needed to assign tasks and budgets in the pursuit of a healthy, productive, native, koa forest ecosystem.

Harvest Levels and Scheduling

Harvest Levels and Scheduling

The management of this koa forest will be accomplished by means of **"Adaptive Management"**. This means that silvicultural operations will be constantly updated to allow for special conditions and new knowledge garnered from past operations, pre- and post-harvest surveys, and data gathered from a series of permanent monitoring plots.

There are seven harvest units, numbered 1 to 7, corresponding to the seven areas between each riparian management zone. One harvest unit will be visited each year. In order to minimize impact to the riparian areas, the harvest units will be staggered. That is, unit 1 will be harvested first, unit 3 second, unit 5 third, and so forth. The order of 1, 3, 5, 7, 2, 4, and 6 will repeat for every 7-year cutting cycle. The harvest plan will be a partial cut prescription for all-aged timber, only harvesting trees 13.8 inches dbh and larger. During each entry, the number of available trees on a specific acre may vary from zero to six or seven. Such is the nature of an uneven-aged natural forest.

At the end of each harvest year, the volume's removed will be digitized into the GIS and saved as a layer. This layer will be useful in updating the annual and rolling 7-year management plans, along with updating the digital inventory. Additionally, other activities, such as planting or stocking control, will be input into the GIS as a layer.

The inventory database will be updated annually.

All reports to regulatory agencies will be prepared as needed.

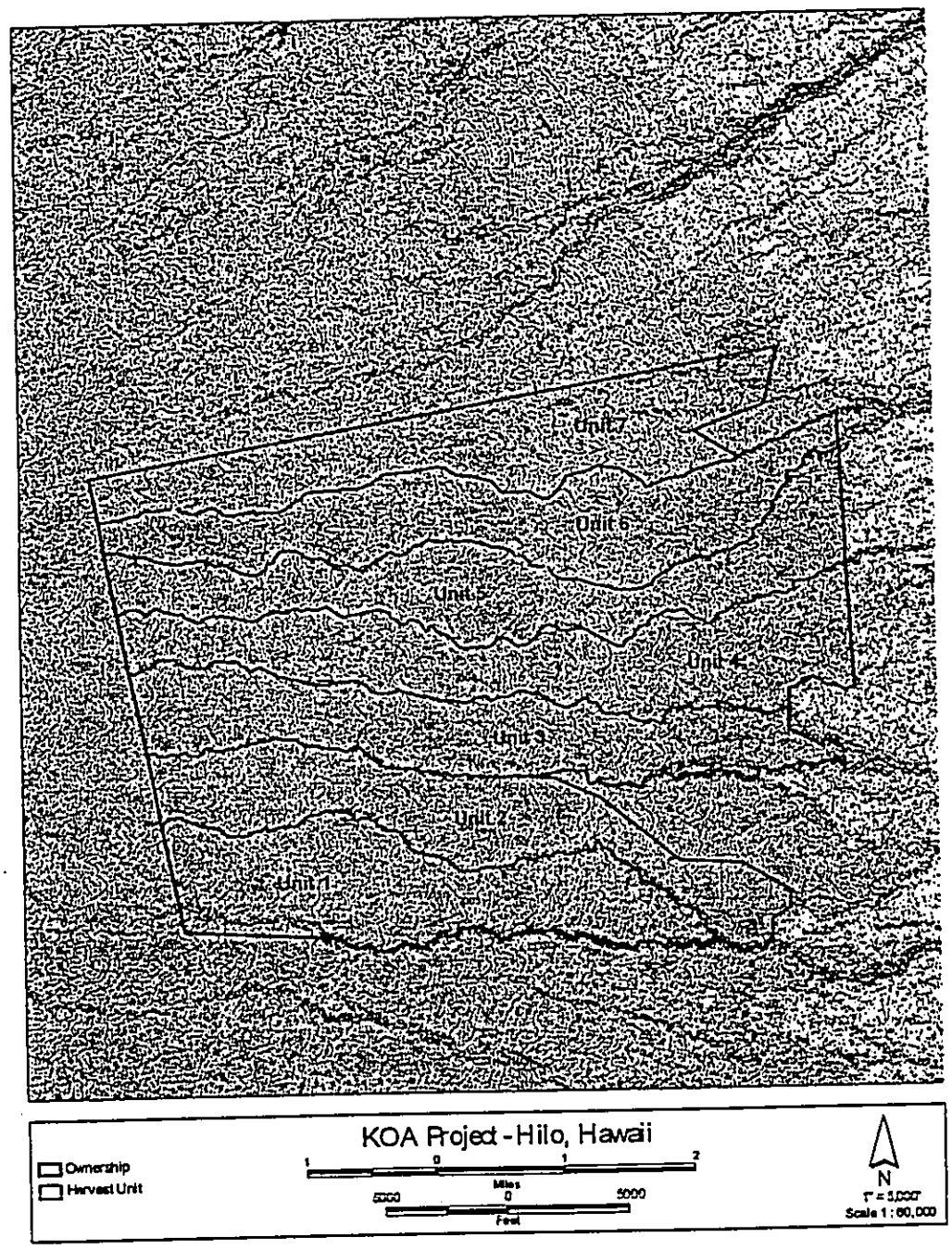
Harvesting the mature koa and killing invasive, competitive species should allow koa to regenerate itself. Additionally, protecting seedlings and small trees should begin to increase the stocking of trees and the amount of annual timber growth.

Table 8 Acreage and estimated volume of koa trees 13.8-inches dbh and larger for the seven harvest units.

Harvest Unit	Acreage	Volume (MBF)
1	1,509.63	2,538.93
2	1,307.49	2,137.42
3	1,329.94	2,221.31
4	1,536.86	2,562.16
5	1,049.72	1,959.56
6	1,399.33	2,535.73
7	1,405.97	2,384.14
Totals	**9,538.94**	**16,339.24**

In order to estimate a volume that will be removed each year, some broad assumptions need to be made due to the current lack of detailed, reliable inventory data. The inventory presented

in this FMP is assumed to be reasonably correct. We understand that as data is accumulated through the monitoring plots, this inventory will be updated.



The second assumption we need to make is about growth. Our estimate is 52 board feet per acre per year for the first cutting cycle. Again, this figure will be updated when accurate inventory and growth data become available. As the koa forests are thinned, and competing vegetation reduced, we expect this growth estimate to rise. For the second cutting cycle (years 8 to 14) we assume the growth to be 57 board feet per acre per year. For the third cutting cycle (years 15 to 21) we assume the growth to be 62 board feet per acre per year.

With data gathered from the monitoring plots, we will be able to fine tune the growth estimate for specific strata and harvest units. For now, our broad and conservative estimate will suffice.

Finally, we need to make a harvest intensity assumption. We set this rate at 30%. This will generate enough income to allow vegetation control and regeneration measures to take place. Also, monitoring plots will be established during this first year.

Again, this cutting intensity will be fine tuned when inventory and growth data becomes available. For now, the following tables give a general estimate of what we can expect from the management of this property over the first three cutting cycles.

Table 9 Harvest Schedule for Cutting Cycle #1, 2004 to 2010. Estimated growth: 52 BF/acre/year. Harvest intensity: 30%.

Activity	Harvest Unit 3	5	7	2	4	6	RMZ
Year	2004	2005	2006	2007	2008	2009	2010	no cut
Percent of property	11.4%	10.1%	7.9%	10.6%	9.9%	11.6%	10.6%	27.9%
Initial Inventory (BF)	2,538,926	2,221,305	1,959,560	2,384,143	2,137,419	2,562,156	2,535,730	4,194,878
Acreage	1,510	1,330	1,050	1,406	1,307	1,537	1,399	3,687
Growth (BF)	78,501	138,314	163,756	292,442	339,947	479,500	509,356	1,342,072
Pre-harvest Inventory (BF)	2,617,427	2,359,619	2,123,316	2,676,585	2,477,366	3,041,656	3,045,086	5,536,950
Pre-harvest Inventory (BF/acre)	1,734	1,774	2,023	1,904	1,895	1,979	2,176	1,502
Harvest (BF)	785,228	707,886	636,995	802,975	743,210	912,497	913,526	-
Post Harvest Inventory (MBF)	1,832,199	1,651,733	1,486,321	1,873,609	1,734,156	2,129,159	2,131,560	5,536,950

Table 10 Harvest Schedule for Cutting Cycle #2, 2011 to 2017. Estimated growth: 57 BF/acre/year. Harvest intensity: 30%.

Activity	Harvest Unit 3	5	7	2	4	6	RMZ
Year	2011	2012	2013	2014	2015	2016	2017	no cut
Percent of property	11.4%	10.1%	7.9%	10.6%	9.9%	11.6%	10.6%	27.9%
Initial Inventory (BF)	1,832,199	1,651,733	1,486,321	1,873,609	1,734,156	2,129,159	2,131,560	5,536,950
Acreage	1,510	1,330	1,050	1,406	1,307	1,537	1,399	3,687
Growth (BF)	602,342	530,646	418,838	560,982	521,689	613,207	558,333	1,471,117
Pre-harvest Inventory (BF)	2,434,541	2,182,379	1,905,160	2,434,591	2,255,845	2,742,367	2,689,893	7,008,067
Pre-harvest Inventory (BF/acre)	1,613	1,641	1,815	1,732	1,725	1,784	1,922	1,901
Harvest (BF)	730,362	654,714	571,548	730,377	676,753	822,710	806,968	-
Post Harvest Inventory (MBF)	1,704,179	1,527,665	1,333,612	1,704,214	1,579,091	1,919,657	1,882,925	7,008,067

Table 11 Harvest Schedule for Cutting Cycle #3, 2018 to 2024. Estimated growth: 62 BF/acre/year. Harvest intensity: 30%.

Activity	Harvest Unit							RMZ
	1	3	5	7	2	4	6	
Year	2018	2019	2020	2021	2022	2023	2024	no cut
Percent of property	11.4%	10.1%	7.9%	10.6%	9.9%	11.6%	10.6%	27.9%
Initial Inventory (BF)	1,704,179	1,527,665	1,333,612	1,704,214	1,579,091	1,919,657	1,882,925	7,008,067
Acreage	1,510	1,330	1,050	1,406	1,307	1,537	1,399	3,687
Growth (BF)	655,179	577,194	455,578	610,191	567,451	666,997	607,309	1,600,162
Pre-harvest Inventory (BF)	2,359,358	2,104,859	1,789,190	2,314,405	2,146,542	2,586,654	2,490,234	8,608,229
Pre-harvest Inventory (BF/acre)	1,563	1,583	1,704	1,646	1,642	1,683	1,780	2,335
Harvest (BF)	707,807	631,458	536,757	694,321	643,963	775,996	747,070	-
Post Harvest Inventory (MBF)	1,651,551	1,473,402	1,252,433	1,620,083	1,502,580	1,810,658	1,743,164	8,608,229

The above tables show that 15,233,722 board feet of koa can be harvested over the next 21 years (3 cutting cycles). This represents an average of 725,415 board feet per year, or 3.5% of the total inventory. This harvest will provide the funding needed to reduce competitive and destructive exotic species (both flora and fauna), successfully regenerate an uneven-aged forest, and reverse the current decline in native, healthy koa forest ecosystems.

The exact amount harvested will be adjusted each year based on information gained form the monitoring plots. New knowledge about inventory, growth, regeneration, and problems encountered during silvicultural operations will provide the input to this on-going adaptive management plan.

Planning for the following year's harvest schedule will take place in October and November. This planning will include the designation of harvest areas, along with other treatment areas such as reforestation or vegetation control operations. The analysis of areas to harvest will encompass several considerations, including value of removal volume, operational costs, ecosystem rehabilitation efforts, current and expected markets, and activities from the previous year that remain incomplete.

All annual planning will rely heavily on information gathered from:

1) monitoring plots.

2) pre and post harvesting surveys; and

3) new information provided by the scientific community through peer-reviewed journals.

The digital forest inventory and GIS will provide, as best as possible, descriptive data of merchantable volume by species, size, sort, grade, and location. The inventory will be updated each year based on growth and other information garnered from the monitoring plots. This dataset will be one of the cornerstones of the annual planning effort, since it provides the knowledge base that planners have to work with. Additional criteria include market conditions, changes in local regulations, new research, and adjustments to the planning effort based on information gained from pre- and post-harvest surveys.

A cash flow projection of next year's plan will be done during the first part of December. This analysis will require an estimate of expected extraction costs; price breakout by species, sort, and grade; predicted volume removal; and other pertinent market conditions. Several iterations of the cash flow analysis may have to be done to align management operations with budget constraints. The first year budgets for Forestry Management see Addendum__.

The following table provides a rough example of an annual schedule. This table needs to be supplemented with a detailed plan of action for each activity. The action plan should address the who, what, when, where, and how each activity will be accomplished. Details will cover such things as costs of services and equipment, names of contractors that will perform the activity and any associated contracts, expected markets and prices, operational considerations such as crew transport to and from the job site, and so forth.

Field activities will be minimized during the lactation period of the Hawaiian Hoary Bat (June, July, and August).

Each plan should also contain a "What if..." analysis. This level of planning attempts to address unforeseen problems by formulating alternative actions. For example, what if the company contracted to heli-log a unit has to back out due to equipment failure? The plan should have an alternate company identified that can be contacted to help complete the logging operation.

Table 12 Sample schedule for annual forest management activities.

Month	Harvesting	Silviculture	Other
Jan			
Feb		Conduct a regeneration survey for harvest units from prior year	Do a pre-harvest survey for schuduled units
Mar		Correct any regeneration failures	Compile and analyze monitoring and survey data.
Apr			
May			
Jun	No Harvesting		Collect post-harvest data from monitoring plots
Jul	No Harvesting		Compile and analyze data.
Aug	No Harvesting		
Sep		Spray or mechanically remove *P. cattleianum* and other undesireable brush	
Oct		Regenerate harvested units	Plan next year's harvesting and silvicultural operations
Nov		Regenerate harvested units	Collect pre-harvest data from monitoring plots
Dec		Spray or mechanically remove *P. cattleianum* and other undesireable brush	Compile and analyze data. Continue planning process.

In addition to the annual management plan update, a rolling 7-year cutting cycle plan will be maintained and updated. This 'look ahead' analysis will be beneficial in making adjustments to annual operations that have multiple year consequences. For example, current market conditions may warrant a reduction in annual removals, only to be made up when prices return to an acceptable level.

Ecosystem rehabilitation, such as the removal of strawberry guava, may take several years to show a complete response. The 7-year cutting cycle plan can take this into account by budgeting funds to rehabilitation efforts. This cutting cycle plan needs to be updated annually as new information is obtained.

Harvest Methodology

1. **Selection of Trees**

   Trees will be selected and marked for harvest with both a butt mark and a dbh mark. Marking will be done when the bark is dry. Selection will include mature trees, deformed trees, trees that are dead or dying but still usable, and trees that are diseased or infested with insects. Some cull, dead, and dying trees will be retained as habitat for various native fauna, and as directed by ornithologists for nesting. Selection will also seek to optimize spacing around residual crop trees in order to maximize growth. It is imperative to select trees that will create openings in the canopy large enough for sunlight to reach the forest floor or a minimum of three hours a day. (See Supplement A Regeneration Data)

   Crop tree selection will emphasize the retention of veneer quality logs, whenever possible, until an adequate size is obtained.

   Only trees above the 13.8-inch diameter limit will be considered for harvest.

   All trees under the 13.8-inch diameter limit will be retained, unless removal would help to provide better stocking and reduce competition for the residual stand.

   Foot trails to selected trees will be built and covered with ferns for soil protection. This will allow easier access for felling and yarding crews.

   It may be worthwhile for an ornithologist to accompany the timber markers if there is concern about nesting areas.

2. **Felling and bucking**

   Trees will be felled using chainsaws. Logs will be bucked to maximize utilization standards. Down woody debris will be retrieved if marketable.

   In addition to utilization standards, the size of logs bucked will be a function of the load carrying capacity of the helicopter.

3. **Transport to a staging area.**

   All logs will be moved from felling areas to a staging area by helicopter to minimize land impact. Flight routes will avoid populated areas. Details of helicopter logging are given below.

4. **Slash**

   Slash from harvesting operations will be lopped to lay within 36 inches of the ground. If the debris could interfere with planting or natural regeneration, then it will be left in piles. Small crown branches and leaves shall be scattered to hasten the natural decomposition. This will also provide organic matter for the soil.

5. **Production schedule**

   There are seven harvest units on the property. Each unit will be visited once during a 7-year cutting cycle.

Harvest units will be planned annually. They will be marked on the ground and plotted in the GIS.

The determination of volume to be removed from harvest units will be part of the "adaptive management" strategy. Such strategy will make annual adjustments to the Forest Management Plan based on information gathered during the year from 1) monitoring plots 2) pre and post harvesting surveys; and 3) new information provided by the scientific community through peer-reviewed journals.

Harvesting by Helicopter

To minimize environmental damage while logging, our strategy will be to utilize helicopters (heli-logging) for all log extraction. This is the most appropriate approach to achieving a low impact logging operation. Felled trees will be bucked into manageable logs, then lifted to a staging area located on former sugar cane lands in the Agricultural District.

a. Mechanics

The economics of helicopter harvesting depend on maximizing "turn around efficiency" which is largely a function of haul distance, descent rate, flight speed, payload weight, and payload value. Other variables include changes in elevation between log pick-up and landing, logging efficiency, staging area layout, skill of ground crews, and communications. Experience in the western United States suggests that a maximum of only 70 percent of a helicopters flight time is available for extraction operations, and 50 to 60 percent is considered to be normal.

b. Operation

A forester will designate the trees to harvest and a ground crew will build trails covered with ferns to each tree.

Heli-logging consists of deploying an extraction crew to the harvest unit and establishing a staging area where the logs will be dropped. The extraction crew will fell and buck the tree, then set chokers during each turnaround. Another crew will be needed at the staging area to release the chokers. Heavy equipment at the staging area will remove and stack the logs before the next turnaround.

c. Log Extraction

A flight pattern will be established for each harvest unit. Helicopters will use this corridor during their daily transportation of workers as well as for log extraction. The flight pattern will seek to minimize potential noise by using a route that provides the minimum buffer one-mile. Flight paths will not go over homes or buildings.

During log extraction, the flight corridor from the harvest unit will vary slightly based on the location of the felled trees and weather conditions. The flight pattern will always end within the property boundary.

d. Economics

The commercial viability of heli-logging rests on detailed planning and a high-value product. Efficient, well-trained crews should be at both the harvest unit and the staging area. A safety margin must be maintained while maximizing helicopter payload

weight. To maximize economic efficiency, the heli-logging plan should include flexibility in delivering the logs to more than one staging area.

Income received from the harvested units will be used to regenerate and rehabilitate the forest. Therefore, efficiency during harvesting is essential.

Stocking Control

Stocking control involves the expected or desired trees per acre at various ages and diameter classes over the rotation age of a stand. The optimal level of stocking has not yet been determined due to a lack of data. Monitoring plots, for measuring both growth and stocking, will provide the necessary input for developing stocking standards for the property.

The number of trees planted, or naturally seeded, in an area will depend on how much bare dirt and sunlight are exposed with the harvesting operations and invasive species control. As the forest matures, an ideal target would be to have 200 trees per acre of all ages and sizes.

Additional Concerns

Fire Prevention

There are no known occurrences of fire in the project area. Nonetheless, companies contracted to perform heli-logging will be required to show knowledge of combating fires in the course of operations, and provide a contingency plan to be implemented in the event of a fire.

One potential contractor is Columbia Helicopters, Inc. Columbia maintains several 12-man fire boxes that can be flown to ground personnel near a fire. Also, Columbia maintains a 1000-gallon bucket to dump water directly on any fire. The helicopter can drop approximately 10 to 15, 1000-gallon loads per hour on an operational fire. Columbia also fights fires for the Federal and State Government and flew over 2,400 hours on wildfires during 2002. Additionally, Columbia has established a "Fuel Spill Prevention and Cleanup Plan".

In addition to the fire fighting resources and procedures outlined in a heli-logger's Fire Contingency Plan, the following rules are recommended:

1. The forest and work areas shall be kept in a neat and orderly condition free from unmanaged piled waste and debris.
2. Gates that lead to the property will be kept locked to deter unauthorized visitors on the property.
3. Storage of flammable fuel is not allowed within the harvesting areas.
4. Trash and other waste is not allowed on the property.

Soil Erosion

To minimize erosion and damage to the soil, the following precautions will be taken:

1. Best Management Practices (BMP) will be applied through all phases of harvesting, site preparation, and general land management activities to minimize soil erosion.
2. All heavy equipment will be located at the landing site. Helicopter harvesting will be the only means of log extraction. Mitigation measures will be implemented when ground conditions show evidence of excessive soil erosion, whether such results are directly attributable to operational activities or not.
3. Following silvicultural activities such as planting or harvesting, any damage that may cause accelerated soil erosion or reduce the productive capacity of the soil shall be mitigated.
4. Wide stream buffers will be maintained.

Water Quality Protection

Water quality will be monitored before and after harvesting operations, along with a general review of riparian species and soil stability within the buffer zone. If necessary, the 200-foot buffer can be increased to help mitigate any undesirable logging residue.

Rare and Endangered Species

Prior to harvesting, professional biologists (botanists, ornithologists, etc.) will survey the harvest area for (1) endangered or threatened birds, including the Hawaiian hawk; (2) the endangered Hawaiian Hoary Bat; and (3) endangered or threatened plant species. If any endangered or threatened species are found to be active, then activities for the area will be modified to minimize impact.

Reforestation

Site Preparation

To ensure that harvesting and silvicultural activities will not jeopardize endangered plants and animals, Koa Timber will survey operational areas before conducting any "vegetation impact" activities, such as harvesting or site preparation. If endangered species are found, the activities for the area will be modified based upon recommendations from the Advisory Committee.

During harvesting and other ground disturbance activities, some soil disturbance will occur which, in turn, will stimulate natural regeneration of koa seedlings. When bare soil is exposed to the sun, the warming stimulates the germination of koa seed within the seed bank.

If it appears that competing vegetation will interfere with koa seedlings or regeneration, these competing plants will be removed within a 30-foot radius. Removal will be mechanical, with chemical application occurring either before as a basal drip application, or afterward as a stump applicator. The specific method employed will be determined from data collected at the monitoring plots and on-the-ground experience in an adaptive management scenario.

Without the use of herbicides, the mechanical removal of competing vegetation will act as a stimulant, creating suckering and more competing vegetation.

After a period of six months, areas where natural koa regeneration is low or lacking will be interplanted.

Note: One of the main objectives of this management plan is to re-establish a koa canopy and eliminate invasive species. To accomplish this objective, pro-active measures need to be taken to direct the flora community back to a native forest. Without activities such as harvesting, stocking control, and the use of herbicides, the koa will not be replaced and we will lose this entire tract of land to non-native vegetation.

We have determine that several entries into a prior harvest unit will be necessary to control the competing vegetation and assure the establishment of koa as the dominant species.

Seeding and Planting

Koa seeding or planting will take place in areas with low or no natural regeneration using a local seed source. The *Eucalyptus Robusta* in the agriculture area of the property will be replaced with koa. The koa will be used as a seed bank and inventory for future stocking. (See Supplement A Regeneration data)

Regeneration Maintenance

One year after planting or seeding, portions of the area that continue to be barren or have suffered animal damage will be re-seeded or replanted with koa. Competing vegetation will be removed when necessary.

Approximately three years after planting or seeding, areas that continue to be barren, have animal damage, or have low regeneration, will be replanted with koa. If the lack of successful regeneration is due to animal damage, then fencing may be the only option. However, due to the lack of adequate access to much of the area, alternatives to fencing may be more economically feasible and produce less site impact.

Each time the monitoring plots are remeasured, the forest will be examined for overstocking. Stands that are overstocked will be precommercially thinned. We will attempt to maintain a forest density of 200 trees per acre by removing

- Trees with poor growth form.
- Trees leaning more than eight degrees.
- Suppressed, dying, diseased, or insect infested trees.
- Exposed trees that have a high probability of wind breakage.

The figure of 200 trees per acre is a target at this time. Data from the monitoring plots will show what the optimal stocking level is for different age classes. Once this data is compiled, we can modify our stocking activities accordingly.

General Information

Every attempt will be made to encourage natural regeneration. Koa seeds are abundant and can survive in the seed bank for a number of years. When the ground is disturbed, such as when a tree is removed, seeds from the seed bank will sprout. Survival of one or two of these seedlings to maturity will depend on a number of factors, both biotic and abiotic. Annual forest management activities will attempt to limit the agents that reduce seedling survivability.

The control of competing vegetation and the reduction of feral pigs appear to be the primary factors for successful koa regeneration. The control of competing species can be done with a crew using a chain saw and backpack chemical spray for plant-specific application.

The control of feral pigs can be done with persistent hunting and/or trapping. Fencing will also be used to protect seedlings and small trees in regeneration areas where success has been limited. Because installing and maintaining fences is expensive, the extent of fencing may be limited.

Soil scarification in preparation for regeneration will consist of soil disturbance in the areas where trees are felled and yarded. Unlike standard forestry operations that use heavy equipment to accomplish this task, it appears that site preparation will only be done by hand. This will in-

volve clearing a small area for the seedling, along with eliminating adjacent competing vegetation.

Permanent monitoring plots will have small regeneration plots nested within the larger volume plots. Data from these small plots should provide information needed to modify management activities that will help increase regeneration success.

Invasive Species Control

Flora

Controlling non-native species will be done using two basic methods, mechanical removal and/or use of Triclopyr a legally acceptable herbicide. Chemicals will be used to kill those species that usually sprout when cut (mechanically removed).

Strawberry guava

Strawberry guava is extremely difficult to kill and is spreading throughout the property. It will be sprayed with Triclopyr (Garlon) from a backpack sprayer, drizzled directly on the plant foliage or painted on stumps annually for three years. Appendix C contains a summary of the herbicide Triclopyr.

Fauna

Feral pigs

Control of feral pigs is a key component in restoring the native forest ecosystem. Three methods of pig control will be used: hunting, trapping, and limited fencing.

Currently, a few local hunters are taking pigs from the property. Additional recreational hunting should be encouraged by improving access and notifying hunting clubs. Bounties have proven extremely successful in eliminating undesirable animals in other forest and agricultural areas throughout the country.

Hunting should be augmented by trapping in remote parts of the property that are inaccessible to hunters. Koa Timber should collaborate with conservation organizations in educating the public concerning the damage done by feral pigs in uprooting native vegetation and spreading invasive species.

Fencing will be used selectively to protect koa regeneration areas. Because of the size of the property, it is not feasible to rely on fencing as the primary method of pig control. The cost of fencing would simply be too high for installation and maintenance.

Organization

Forestry Management

A full-time Forest Manager will be tasked with planning and organizing all phases of forest management. The Forest Manager will be responsible for overseeing data collection and forest analysis; supervising biologists and field crews working on invasive species control. The position will be filled by Dr. Randy Senock who will report to DOWFA on an annual basis.

Biological Monitoring

For surveys of prospective harvest sites and monitoring of rare and endangered species, *Koa Timber* will employ Dr. Ron Perry of JEO Metrician on a contractual basis. The biological data will reported to DOWFA on an annual basis.

Field Staff

This will be a part time crew, employed as needed. Various duties will include herbicide spraying of invasive exotic plants; fencing, trapping and other control measures against feral pigs; planting of harvested areas; logging set-up such as landing zones and log extraction facilities; and any other field related duties as needed.

Assumptions and Limiting Conditions

The information contained in this report is specific to the needs of the client and for the intended use stated in this report. Atterbury Consultants is not responsible for unauthorized use of this report.

Atterbury Consultants did not conduct a timber cruise, and as a result the inventory was based on estimates derived from available data. Estimates of trees per acre were taken from the Jaakko Pöyry report. The volume by tree, greater than 35 cm, was also taken from the Jaakko Pöyry report.

Atterbury Consultants has relied upon these general stand structure assumptions and does not guarantee or warrant the accuracy of our estimated timber inventory. If the assumptions are found to be in error in any way, the client agrees to release Atterbury Consultants from any liability associated with these estimates.

A complete legal description was not furnished to Atterbury Consultants, and a title policy was not reviewed. Atterbury Consultants assumes no responsibility for matters legal in character, nor does the consultant render any opinion as to title, which is assumed to be marketable. All existing liens, encumbrances, and assessments have not been considered. It is strongly recommended to the client to review a complete title policy affecting the parcels being inventoried to ascertain the existence of any adverse title conditions.

The tables in this report are included to assist the reader in understanding the inventory structure. Atterbury Consultants has not made a timber cruise of the current inventory and assumes no responsibility in connection with such matters. Atterbury Consultants has relied upon maps and photos provided by the client to estimate acreages by strata. We assume these acreages are an accurate indication of the subject property.

Unless otherwise noted, it is assumed that there are no encroachments, zoning, or restrictive violations existing in the subject property.

Atterbury Consultants assumes no responsibility for determining whether the property requires environmental approval by the appropriate governing agencies nor whether it is in violation unless otherwise noted. The property is assumed to be fully harvestable except as noted.

This report shall be used for its intended purpose only and by the parties to whom it is addressed. Possession of this report does not include the right of publication.

Neither all nor any part of the contents of this report shall be conveyed to the public through advertising, public relations, news, sales, or other media without the written consent or approval of the author. This applies particularly to numerical conclusions and to the identity of the consultant. Atterbury Consultants may not be required to give testimony or to appear in court by reason of this report, with reference to the property in question, unless prior arrangements have been made.

The statements of estimated inventory and all conclusions shall apply as of the dates shown. This inventory is subject to change if the physical or legal entity is different than that envisioned in this report.

Atterbury Consultants has no present or contemplated future interest in the property which is not specifically disclosed in this report.

Atterbury Consultants assumes that there are no toxic hidden or unapparent conditions within the property, subsoil, or structures, which would render the inventory more or less valuable. The consultant assumes no responsibility for such conditions or for engineering, which might be required to discover such factors. Thus, the client assumes all risks and liability concerning any property condition or contaminant problem, which may render the property as having less usable volume.

The client agrees that if Atterbury Consultants is named in a legal action, the amount of the consultants total and complete liability is limited only to the amount of the fee agreed upon for these services, less any expenses incurred during the course of this analysis.

If this report is placed in the hands of anyone other than client, the client shall make such party aware of all limiting conditions and assumptions of the assignment and related discussions. Atterbury Consultants is in no way to be responsible for any costs incurred to discover or correct any deficiencies of any type present in the property; physically, financially, and/or legally.

Atterbury Consultants utilized a "best efforts" approach in documenting and verifying the information provided by the client and others. The information presented within this report is considered to be reliable, although it is noted that it has been obtained from numerous data sources including the client, and others. No liability is assumed by this consultant in connection with data not supplied, or withheld, by the principals or agents involved with the subject property, which could affect the estimated inventory.

An impractical and uneconomic expenditure of time would be required in attempting to furnish unimpeachable verification in all instances, particularly as to engineering and market related information. It is suggested that the client consider independent verification, or contact this consultant, with respect to basing a decision on a particular or singularly significant item of data within this report involving sale, lease, or other commitment of funds with respect to the subject property.

The client acknowledges the fact that the consultant is not an economic expert but has relied upon other's forecasts concerning future economic events. The client agrees to hold the consultant harmless from any future litigation, which may result as a consequence of using opinions rendered by others in the attempt to project future economic effects on the subject property.

The client also agrees to hold the consultant harmless in the event a third party brings suit against the subject property or property owner. This report has been performed in a professional manner and is an opinion of estimated inventory. Political, biological, and/or economic conditions may change which would render the enclosed projections as obsolete.

Atterbury Consultants has not considered the value of any site improvements as this was beyond the scope of this report. Furthermore, this consultant did not retain any outside professionals to assist in determining the value of any mineral deposits, saw mills, rock pits, or other site factors relating to value as this was outside of the scope of this report.

The consultant has assumed the property can be harvested, except as noted. If portions of the property are affected by the Hawaiian Hoary Bat or any other threatened or endangered species, except as noted, then this condition could substantially affect the estimated available inventory.

The work performed has enabled the consultant to make a volume conclusion with the understanding that a complete legal description was reviewed, governmental agencies were contacted to ascertain whether or not endangered wildlife exists on the subject, there are ancient native Hawaiian burial sites or villages, or other similar matters affecting the inventory.

Any conditions which arise in the future that affect the subject premises may also affect the indicated inventory. The client agrees that, due to these matters and the dynamic nature of real estate, the consultant will not be subjected to any third party lawsuits or changes required in the inventory.

Maps, if they have been included herein, were included to assist the reader in determining the location of the subject property. This consultant assumes no liability for any deviations from actual property locations.

This consultant has relied upon verbal statements and other data provided by third parties. This data has been assumed to be correct with no responsibility claimed by the consultant for this information.

It has been assumed that the subject property can be logged as of the date of this report. Future events and conditions (such as new threatened or endangered species, litigation from conservation groups, etc.) could reduce the amount of logging activity which could occur on the premises. The client and any third party lender agree to release the consultant from any liability associated with any adverse future events concerning the subject property.

Addendum A

Hawai'i's most invasive horticultural plants

This is a list of the worst invasive horticultural plants in Hawai'i as put forth by the Hawai'i State Alien Species Coordinator (Department of Land & Natural Resources [DLNR], Division of Forestry & Wildlife [DOFAW]).

Species (Family)	Common Name	Other names
Acacia confusa (Fabaceae)	Formosan koa	
Angiopteris evecta (Marattiaceae)	mule's foot fern	giant fern
Antigonon leptopus (Polygonaceae)	Mexican creeper	mountain rose, coral bells, confederate vine, chain-of-love, hearts-on-a-chain
Ardisia crenata (Myrsinaceae)	Hilo holly	hens eyes, *Ardisia crispa*, *Ardisia crenulata*
Ardisia elliptica (Myrsinaceae)	shoebutton ardisia	*Ardisia humilis*, *Ardisia solanacea*, *Ardisia squamulosa*
Artabotrys hexapetalus (Annonaceae)	climbing ylang-ylang	lanalana
Arthrostema ciliatum (Melastomataceae)	arthrostemma	*Arthrostemma latifolia*, *Arthrostemma fragile*
Asparagus densiflorus (Liliaceae)	asparagus fern	sprengeri fern, foxtail asparagus, Asparagus sprengeri Regel
Asparagus setaceus (*Liliaceae*)	climbing asparagus fern	plumosa, Asparagus plumosus Baker, Protasparagus plumosus
Azolla (all species) (Azollaceae)	mosquito fern	ferny azolla
Buddleja davidii (Buddlejaceae)	orange-eyed butterfly bush	summer lilac, buddleia
Buddleja madagascariensis (Buddlejaceae)	butterfly bush	smoke bush, buddleia
Carmona retusa (Boraginaceae)	Fukien tea	Philippine tea, *Carmona microphylla*, *Ehretia buxifolia*, *Ehretia microphylla*
Casuarina (all species) (Casuarinaceae)	ironwood	Australian pine, she-oak, beefwood, toa
Cestrum diurnum (Solanaceae)	day cestrum	makahala, Chinese inkberry
Cestrum nocturnum (Solanaceae)	night cestrum	night-blooming jasmine, 'Ala-aumoe, kupaoa, onaona-lapana
Chrysophyllum oliviforme (Sapotaceae)	satin leaf	caimitillo; *Chrysophyllum monopyrenum*
Cinnamomum burmannii (Lauraceae)	Padang cassia	cinnamon tree
Cissus nodosa (Vitaceae)	grape ivy	
Citharexylum caudatum (Verbenaceae)	fiddlewood	juniper berry
Citharexylum spinosum (Verbenaceae)	fiddlewood	*Citharexylum quadrangulare*
Clerodendrum buchanani (Verbenaceae)	pagoda flower	lau'awa, *Clerodendrum fallax*, *C. speciosissimum*
Clerodendrum chinense (Verbenaceae)	glory bower	*Clerodendrum philippinum*, *Clerodendrum fragrans*
Clerodendrum macrostegium (Verbenaceae)	(no common name)	
Clusia rosea (Clusiaceae)	autograph tree	copey, Scotch attorney
Coccinia grandis (Cucurbitaceae)	ivy gourd	scarlet-fruited gourd
Conocarpus erectus (Combretaceae)	buttonwood	sea mulberry, button mangrove
Cortaderia jubata and Cortaderia selloana (Poaceae)	pampas grass	
Cotoneaster pannosus (Rosaceae)	cotoneaster	
Cryptostegia (all species) (Asclepidaceae)	rubber vine, India rubber vine	(includes *Cryptostegia grandiflora* and *Cryptostegia madagascariensis*)
Cupaniopsis anacardioides (Sapindaceae)	carrotwood	
Delairea odorata (Asteraceae)	German ivy	*Senecio mikanioides*, Italian ivy, African ivy, Cape ivy, climbing groundsel
Dillenia suffruticosa (Dilleniaceae)	shrubby simpoh	
Duranta erecta (Verbenaceae)	golden dewdrop	duranta, pigeon berry, *Duranta repens*
Eichhornia crassipes (Pontederiaceae)	water hyacinth	
Elaeagnus umbellata (Elaeagnaceae)	oleaster	autumn olive
Erigeron karvinskianus (Asteraceae)	daisy fleabane	Mexican daisy
Eriobotrya japonica (Rosaceae)	loquat	Japanese medlar
Ficus cf. platypoda (Moraceae)	Port Jackson fig (local name)	(this plant is commonly referred to in Hawai'i incorrectly as *Ficus rubiginosa*)
Ficus microcarpa (Moraceae)	Chinese banyan	Malayan banyan, *Ficus retusa*, *Ficus nitida*
Fuchsia boliviana (Onagraceae)	fuchsia	lady's eardrops

Fuchsia magellanica (Onagraceae)	hardy fuchsia	lady's eardrops, earring flower, kulapepeiao
Fuchsia paniculata (Onagraceae)	fuchsia	Lady's eardrops
Furcraea foetida (Agavaceae)	Mauritius hemp	maguey, *Furcraea gigantea*
Grevillea robusta (Proteaceae)	silk oak	she oak, he oak, silver oak, kahili flower, spider flower, ha'iku-ke'oke'o
Hedychium coronarium (Zingiberaceae)	white ginger	butterfly lily, ginger lily, garland flower, 'awapuhi-ke'oke'o
Hedychium flavescens (Zingiberaceae)	yellow ginger	cream ginger, 'awapuhi-melemele
Hedychium gardnerianum (Zingiberaceae)	kahili ginger	
Heterocentron subtriplinervium (Melastomataceae)	pearl flower	
Hiptage benghalensis (Malpighiaceae)	hiptage	
Hydrilla verticillata (Hydrocharitaceae)	hydrilla	water thyme, Florida elodea
Jasminum fluminense (Oleaceae)	jasmine	*Jasminum azoricum*
Kalanchoe delagoensis (Crassulaceae)	chandelier plant	*Kalanchoë tubiflora*, *Bryophyllum tubiflorum*, *Kalanchoe verticillata*
Kalanchoe pinnata (Crassulaceae)	air plant	life plant, 'oiiwa ku kahakai, *Bryophyllum pinnatum*, *Cotyledon pinnata*
Lantana camara (Verbenaceae)	lantana	lakana, mikinolia-hihiu, sage
Lemna (all species) (Lemnaceae)	duckweed	
Leptospermum scoparium (Myrtaceae)	New Zealand tea	manuka
Ligustrum lucidum (Oleaceae)	tree privet	broadleaf privet
Ligustrum sinense (Oleaceae)	Chinese privet	hedge privet, small-leaved privet
Lonicera japonica (Caprifoliaceae)	Japanese honeysuckle	honekakala
Medinilla cumingii (Melastomataceae)	medinilla	
Medinilla venosa (Melastomataceae)	medinilla	
Melaleuca quinquenervia (Myrtaceae)	paperbark	cajeput tree
Melastoma candidum (Melastomataceae)	Indian rhododendron	*Melastoma malabathricum*, Malabar melastome
Melastoma sanguineum (Melastomataceae)	fox-tongued melastoma	
Melia azedarach (Meliaceae)	Chinaberry	pride-of-India, margosa tree
Miconia calvescens (Melastomataceae)	miconia	velvet tree, purple plague
Montanoa hibiscifolia (Asteraceae)	tree daisy	
Najas (all species) (Najadaceae)	naiad	pondweed
Nymphaea (all species) (Nymphaceae)	water lily	
Ochna thomasiana (Ochnaceae)	Mickey Mouse plant	ochna, *Ochna kirkii*
Olea europaea (Oleaceae)	olive	'oliwa
Passiflora laurifolia (Passifloraceae)	yellow granadilla	yellow water lemon, bell apple
Pennisetum setaceum (Poaceae)	fountain grass	*Pennisetum ruppelii*
Philadelphus karwinskyanus (Hydrangeaceae)	mock orange	philadelphus, syringa
Photinia davidiana (Rosaceae)	photinia	*Stranvaesia davidiana*, *Cotoneaster frigidus*
Pimenta dioica (Myrtaceae)	allspice	*Pimenta officinalis*
Pimenta racemosa (Myrtaceae)	bay-rum	malagueta, bay tree, *Pimenta acris*
Pinus patula (Pinaceae)	Mexican weeping pine	jelecote pine, patula pine, pino triste
Pistia stratiotes (Araceae)	water lettuce	
Pittosporum pentandrum (Pittosporaceae)	mamalis	
Pittosporum undulatum (Pittosporaceae)	Victorian box	Victorian laurel, orange pittosporum
Pittosporum viridiflorum (Pittosporaceae)	Cape pittosporum	
Platycerium bifurcatum (Polypodiaceae)	elkhorn fern	common staghorn fern
Psidium cattleianum (Myrtaceae)	strawberry guava	waiawi-'ula'ula
Pyracantha angustifolia (Rosaceae)	firethorn	
Rhodomyrtus tomentosa (Myrtaceae)	rose myrtle	downy myrtle
Rubus (all species) (Rosaceae)	blackberry, raspberry	thimbleberry, brambles, 'ohelo 'ele 'ele
Ruellia devosiana (Acanthaceae)	Ruellia	
Salvinia (all species) (Salviniaceae)	floating fern	
Schefflera actinophylla (Araliaceae)	octopus tree	*Brassaia actinophylla*, umbrella tree
Schinus molle (Anacardiaceae)	pepper tree	California pepper tree
Schinus terebinthifolius (Anacardiaceae)	Christmas berry	Brazilian pepper, wilelaiki, nani-o-hilo
Solandra maxima (Solanaceae)	cup-of-gold	golden cup, chalice vine
Spathodea campanulata (Bignoniaceae)	African tulip tree	fountain tree, fire bell
Sphaeropteris cooperi (Cyatheaceae)	Australian treefern	*Cyathea cooperi*
Sphagneticola trilobata (Asteraceae)	wedelia	Wedelia trilobata
Stapelia gigantea (Asclepiadaceae)	carrion flower	starfish flower, Zulu-giant, giant toad plant
Tamarix (all species) (Tamaricaceae)	?	
Terminalia catappa (Combretaceae)	tropical almond	Indian almond, false kamani, kamani-haole

Tetrazygia bicolor (Melastomataceae)	(no common name)	
Thunbergia grandiflora (Acanthaceae)	Bengal trumpet	blue trumpet vine, large-flowered thunbergia
Thunbergia laurifolia (Acanthaceae)	laurel-leaved thunbergia	
Tibouchina herbacea (Melastomataceae)	cane tibouchina	glorybush
Tibouchina urvilleana (Melastomataceae)	glorybush	princess flower, lasiandra
Verbascum thapsus (Scrophulariaceae)	common mullein	woolly mullein, velvet plant

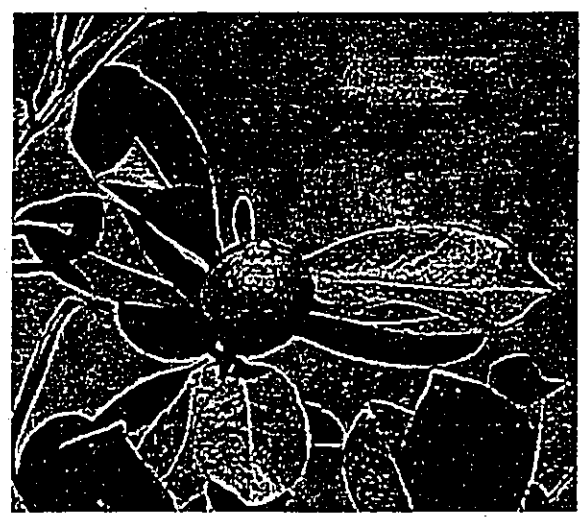
Addendum B

Strawberry Guava

(information provided by The Nature Conservancy)

NATIVE RANGE: Atlantic Coast of Brazil

DESCRIPTION: Strawberry guava (*Psidium cattleianum* Sabine), also called purple guava and pineapple guava, is a shrub or small tree reaching up to 15 feet in height. It has a smooth trunk and dark green, shiny, egg-shaped leaves that are arranged oppositely on the stem. The aromatic leaves are 2-4 inches long and 1-2 inches wide. Strawberry guava flowers are white with numerous stamens (pollen-bearing structures) and the edible purple fruits are about the size of a golf ball. Some forms of this species have yellow fruits.



ECOLOGICAL THREAT: Strawberry guava is a very serious, habitat-altering pest in many parks and preserves in Hawai'i where it poses a major threat to Hawai'i's rare endemic flora and fauna. It forms shade-casting thickets with dense mats of surface feeder roots that make it difficult for other species to coexist. Characteristics that promote strawberry guava's success as an invader include its prolific fruiting and aggressive vegetative growth, its tolerance of shade and heavy leaf litter, and possibly through production of toxic chemicals in its leaves that prevent the growth of other plant species.

DISTRIBUTION IN THE UNITED STATES: Strawberry guava occurs on the six largest Hawaiian islands and in subtropical Florida.

HABITAT IN THE UNITED STATES: Strawberry guava exhibits broad environmental tolerances, occurring in dry to moist forests, and in tropical and subtropical climates. It occurs in disturbed areas and along roadsides and may invade undisturbed, intact forests. On the Hawaiian islands, strawberry guava infests moist, lowland and submontane forests, usually dominated by 'ohi'a trees (*Metrosideros polymorpha*). In Hawai'i, this species is often found in sites disturbed by feral pigs.

BACKGROUND: Originally introduced to Hawai'i in the early nineteenth century for its edible fruit, strawberry guava quickly escaped cultivation. It is now widely cultivated and naturalized outside its native range and is found in many tropical regions of the world.

METHODS OF REPRODUCTION & DISPERSAL: Regeneration of strawberry guava is by seed and by root sprouts, which allow it to undergo expansive vegetative reproduction. Strawberry guava produces an abundance of fruits, the seeds of which are dispersed by birds and feral pigs.

CURRENT MANAGEMENT APPROACHES: Because of the huge quantities of seed that are dispersed by feral pigs, another exotic invasive species, feral pig management is a practical and necessary-first step in strawberry guava management. Pig control must be followed by manual, mechanical, or chemical control measures. These methods have proven successful when tested on a small scale. Reinfestation by strawberry guava is low in pig-free, intact forests. No biological control agents are currently available for management of strawberry guava.

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Addendum C

Triclopyr

This information on Triclopyr was prepared for the U.S. Department of Agriculture, Forest Service by Information Ventures, Inc.

This fact sheet is one of a series issued by the Forest Service, the Bureau of Land Management, and the Bonneville Power Administration for their workers and the general public. It provides information on forest and land management uses, environmental and human health effects, and safety precautions for the herbicide triclopyr and its formulations. Unless otherwise stated, the toxicity data presented in this fact sheet refer to the active ingredient, triclopyr. When included, data on formulated products will be specifically identified. A list of definitions is included in Section VIII of the fact sheet.

I. Basic Information

Common name: Triclopyr

Chemical name: [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid

Common Product names: Garlon®, Grazon®

Pesticide classification: herbicide

Registered Use Status: "General Use"

Formulations: Commercial triclopyr products generally contain one or more inert ingredients. An inert ingredient is anything added to the product other than an active ingredient. Because of concern for human health and the environment, the U.S. Environmental Protection Agency (EPA) announced its policy on toxic inert ingredients in the Federal Register on April 22, 1987 (52 FR 13305). The intent of this policy is the regulation of inert ingredients. EPA's strategy for the implementation of this policy included the development of four lists of inerts based on toxicological concerns. Inerts of toxicological concern were placed on List 1. Potentially toxic inerts/high priority for testing were placed on List 2. Inerts of unknown toxicity were placed on List 3 and inerts of minimal concern were placed on List 4.

For pesticides containing List 1 inerts, the EPA has given the pesticide registrant the opportunity to reformulate the product to remove the List 1 inerts. If the registrant chooses not to reformulate the product, then the List 1 inerts must be identified on the product label. For List 2 inerts, the EPA is monitoring ongoing testing and gathering existing information on the potential adverse effects of these chemicals to determine if further regulatory action is required. The EPA has no particular regulatory plans for List 3 and List 4 inerts. The Forest Service will incorporate new data on inerts into updated fact sheets as it becomes available.

The contents of two triclopyr formulations are listed below.

Garlon® 3A: triclopyr (44.4%), and inert ingredients (55.6%) including water, emulsifiers, surfactants, and ethanol (1%)

Garlon® 4: triclopyr (61.6%), and inert ingredients (38.4%) including kerosene

Residue assay methods: Gas/liquid chromatography methods are available for residue assay.

II. Herbicide Uses

Registered forestry, rangeland, right-of-way uses: control of woody plants and broadleaf weeds on rights-of-way, non-crop areas, non-irrigation ditch banks, forests, wildlife openings, rangeland and permanent grass pastures

Operational details:

Target Plants: Triclopyr is used to control woody plants and broadleaf weeds.

Mode of action: Triclopyr acts by disturbing plant growth. It is absorbed by green bark, leaves and roots and moves throughout the plant. Triclopyr accumulates in the meristem (growth region) of the plant.

Method of application: ground or aerial foliage spray, basal bark and stem treatment, cut surface treatment, tree injection

Use rates: Use at 0.25 to 9 pounds acid equivalent per acre

Special Precautions:

Always read all of the information on the product label before using any pesticide. Read the label for application restrictions.

Timing Of Application: For foliar treatment, apply triclopyr during active plant growth. Basal bark and cut surface treatments can be done at any time of year. Dormant stem application can only be done when trees and brush are dormant.

Drift Control: Apply triclopyr only when there is little or no hazard of spray drift. Do not allow spray to come in contact with broadleaf crops. Spray only when wind speed is low. Avoid fine spray, which may drift.

III. Environmental Effects/Fate

Soil:

Residual Soil Activity: Triclopyr is active in the soil, and is absorbed by plant roots.

Adsorption: Triclopyr is adsorbed by clay particles and organic matter particles in soil.

Persistence and Agents of Degradation: Microorganisms degrade triclopyr rapidly; the average half-life in soil is 46 days. Triclopyr degrades more rapidly under warm, moist conditions.

Metabolites/Degradation Products and Potential Environmental Effects: 3,5,6-Trichloro-2-pyridinol is the major initial product of degradation. It has a half-life of 30 to 90 days, and degrades to carbon dioxide and organic matter.

Water:

Solubility: moderate to low

Potential For Leaching Into Ground-Water: The potential for leaching depends on the soil type, acidity and rainfall conditions. Triclopyr should not be a leaching problem under normal conditions since it binds to clay and organic matter in soil. Triclopyr may leach from light soils if rainfall is very heavy.

Surface Waters: Sunlight rapidly breaks down triclopyr in water. The half-life in water is less than 24 hours.

Do not allow triclopyr to pollute irrigation ditches or water used for irrigation or domestic use.

Air:

Volatilization: very low

Potential For By-Products From Burning of Treated Vegetation: Information is not currently available.

IV. Ecological Effects

Non-Target Toxicity:

Soil Microorganisms: Triclopyr is slightly toxic to practically non-toxic to soil microorganisms.

Plants: Triclopyr is toxic to many plants. Even very small amounts of spray may injure some plants.

Aquatic Animals: Triclopyr is low in toxicity to fish. The ester form of triclopyr, found in Garlon 4, is more toxic, but under normal conditions, it rapidly breaks down in water to a less toxic form. Triclopyr does not accumulate in fish. Triclopyr is slightly toxic to practically non-toxic to invertebrates. Triclopyr and its formulations have not been tested for chronic effects in aquatic animals. Acute toxic level:

Table 13 Lethal concentrations of Triclopyr for several aquatic species.

Species	LC50
trout	117 ppm
bluegill	148 ppm
daphnia	1,140 ppm

Terrestrial Animals: Triclopyr is slightly toxic to mammals. In mammals, most triclopyr is excreted, unchanged, in the urine. Triclopyr and its formulations have very low toxicity to birds. Triclopyr is non-toxic to bees. Triclopyr and its formulations have not been tested for chronic effects in terrestrial animals. Acute toxic level:

Table 14 Lethal concentrations of Triclopyr for several non-aquatic species.

Species	LD50
mammals	310-713 mg/kg
ducks	1,698 mg/kg
bee	<60 micrograms/bee

In eight day dietary studies in birds, the LC50 ranged from 2,935 to greater than 5,000 ppm.

Threatened and Endangered Species: Triclopyr may be a hazard to endangered plant species if it is used in areas where they live. The hazard to endangered animal species has not been determined.

V. Toxicology Data

Acute toxicity:

Acute oral toxicity: In tests in rats, the acute oral LD50 was 630 to 729 mg/kg.

Acute dermal toxicity: The acute dermal (skin) LD50 was greater than 2,000 mg/kg in rabbits.

Primary irritation score: In laboratory tests, triclopyr was a slight to moderate irritant.

Primary eye irritation: In laboratory tests in rabbits, triclopyr was a slight eye irritant.

Acute Inhalation: In a laboratory test in rats, exposure to 5.34 ppm for 1 hour caused no adverse effects.

Chronic toxicity:

Carcinogenicity: Laboratory tests in mice and rats fed up to 30 mg/kg per day for 2 years did not show any evidence of carcinogenicity.

Developmental: Laboratory studies with triclopyr in pregnant rats (at dose levels up to 200 mg/kg per day) and rabbits (at dose levels up to 100 mg/kg per day) indicated no evidence of teratology (birth defects). In pregnant rats at the 200 mg/kg per day dose level, there were signs of mild toxicity to the fetus.

Reproduction: A three-generation reproduction study in rats did not show any adverse effects on fertility or reproduction at doses up to 30 mg/kg per day.

Mutagenicity: Triclopyr was negative in several laboratory tests for mutagenicity (the ability to cause genetic damage), but was weakly positive in a test in rats.

The data reported above are results of animal studies which have been evaluated by the Forest Service. These data are used to make inferences relative to human health.

HAZARD: Based on the results of animal studies, triclopyr does not cause birth defects or cancer, and has little or no effect on fertility, or reproduction. Triclopyr is mildly fetotoxic. There is not enough information available to determine whether triclopyr causes genetic damage. There have been no reported cases of long term health effects in humans due to triclopyr exposure.

VI. Human Health Effects

Acute toxicity (poisoning):

Reported effects: No reported effects.

Chronic toxicity:

Reported effects: No reported effects.

Potential for adverse health effects from contacting or consuming treated vegetation, water or animals: The exposure levels a person could receive from these sources, as a result of routine operations, are below levels shown to cause harmful effects in laboratory studies.

Potential for adverse health effects from inert ingredients contained in the formulated product: Inert ingredients found in triclopyr products may include water, petroleum solvents, kerosene, surfactants, emulsifiers, and methanol. Water is not toxic. Methanol, kerosene and petroleum solvents may be a toxic hazard if the pesticide is swallowed. Surfactants and emulsifiers are generally low in toxicity.

Health effects of exposure to formulated products: The formulated products are generally less toxic than triclopyr. Garlon® 3A is a skin irritant and a severe eye irritant.

Health effects associated with contaminants: No known major contaminants

Health effects associated with other formulations: Some formulations of triclopyr also contain the herbicides 2,4-D or picloram. **The information in this fact sheet does not apply to 2,4-D or picloram.** Please consult other sources for information on these herbicides.

Health risk management procedures: The Forest Service has evaluated health effects data in the development of both pesticide background statement documents and environmental impact statements for pesticide use on forestlands. These health effects evaluations have taken into consideration the potential for both worker and public exposure from Forest Service operations. This information has been used in assessing health risks and consequently in formulating protective measures to reduce risk to forest workers and to the public. Section VII of this fact sheet, Safety Precautions, provides guidance for the safe handling and use of triclopyr.

VII. Safety precautions:

Signal word and definition:

Grazon® ET - **CAUTION** - HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.

Garlon® 4 - **CAUTION** - HARMFUL IF SWALLOWED, INHALED OR ABSORBED THROUGH SKIN.

Garlon® 3A - **WARNING** - CAUSES EYE DAMAGE AND SKIN IRRITATION; HARMFUL IF SWALLOWED.

Protective Precautions for Workers: Avoid contact with eyes, skin, or clothing. Avoid contamination of food. Wash thoroughly after handling. For Garlon 3A, wear goggles or face shield and rubber gloves when handling. For Garlon 4 and Grazon ET, avoid breathing mists or vapors. Remove and wash contaminated clothing before reuse.

Medical Treatment Procedures (Antidotes): There is no specific antidote known; treat the symptoms. If swallowed, get medical attention. For exposure to the skin, flush with plenty of water. Get medical attention if irritation persists. For eye exposure to Garlon 3A, flush with plenty of water for at least 15 minutes. Get medical attention. **In case of emergency, call your local poison control center for advice.**

Handling, Storage, And Disposal: Avoid contact with eyes, skin or clothing. Do not ship or store with food, animal feeds, drugs or clothing. Triclopyr formulations are combustible. Do not use or store near heat or open flame. Do not cut or weld container. Triclopyr is stable for at least 2 years under normal storage conditions. Do not contaminate water by disposal. Dispose of this pesticide according to Federal, state or local procedures.

Emergency (Spill) Hazards And Procedures: Dike large spills. Keep the spill out of streams and water supplies. Absorb small spills with sand or other inert material. Bury material from small spills of Garlon 4 in an approved landfill. Bury material from small spills of Garlon 3A in non-crop area away from water supplies. For large spills, contact the manufacturer for instructions. Observe all local, State and Federal rules for disposal. **In case of a large spill, call CHEMTREC at 1-800-424-9300 for advice.**

VIII. Definitions

adsorption - the process of attaching to a surface

avian - of, or related to, birds

carcinogenicity - ability to cause cancer

combustible - able to burn

dermal - of, or related to, the skin

ecotoxicology - the study of the effects of environmental toxicants on populations of organisms originating, being produced, growing, or living naturally in a particular region or environment.

ecotoxicological - related to the study of the effects of environmental toxicants on populations of organisms originating, being produced, growing, or living naturally in a particular region or environment.

formulation - the form in which the pesticide is supplied by the manufacturer for use

half-life - the time required for half the amount of substance to be reduced by natural processes

herbicide - a substance used to destroy plants or to slow down their growth

LC50 - the concentration in air, water, or food which will kill approximately 50% of the subjects

LD50 - the dose which will kill approximately 50% of the subjects

leach - to dissolve out by the action of water

meristem - growth region in plants

mg/kg - milligrams of the substance per kilogram of body weight

microorganisms - living things too small to be seen without a micro-scope

mutagenicity - ability to cause genetic changes

non-target - animals or plants other than the ones which the pesticide is intended to kill

persistence - tendency of a pesticide to remain active after it is applied

ppm - parts per million

residual activity - the remaining amount of activity as a pesticide

volatility - the tendency to become a vapor at relatively low temperature

Addendum D

Budget for 1st Harvestable Year (Monitoring for Environmental Management)/Bonded

University of Hawaii, Hilo Dr. Randy Senock (College of Agriculture, Forestry and Resource Management) Independent Forester Monitor.....$100,000

Dr. Ron Terry (Geometrician Associates) Biological Resource Monitor.....$10,000

Dr. Reginald E. David (Rana Productions) Terrestrial Vertebrate Species Monitor....$10,000

Wade Lee (Invertebrate Terrestrial Resources and Biological Monitoring).....$30,000

Atterbury Consultants, Inc. (Monitoring For Forest Inventory Management Plan).....$30,000

Environmental Mitigation Measures.....$45,000

Addendum E

Supplement to Koa Timber Forest Management Plan
Koa Regeneration Trials
Hawaii Forest Preservation Property South Hilo (Agricultural Zone)
By: Wade C. Lee MS

Objective: To determine the optimal methodology for controlling invasive weeds while increasing survival and productivity of *Acacia koa* on selectively logged sites and minimizing the number of maintenance visits and subsequent expenditure by the management team.

Treatment protocol of trial plots: Six different treatment protocols replicated in three different trial plots will constitute the eighteen total trial plots. The herbicide and mechanical procedures used in these trials come from literature research (Site Preparation Affects Survival, Growth of Koa on Degraded Montane Forest Land, Scowcroft and Adee, 1991) (Disturbance During Logging Stimulates Regeneration of Koa, Scowcroft and Nelson, 1976) as well as recommendations made by Dr. J. B. Friday (Assistant Specialist, Tropical Forestry, College of tropical Agriculture & Human Resources, University of Hawaii at Manoa), Dr. Randy S. Senock (Assistant Professor of Tropical Forestry, College of Agriculture, Forestry and Natural Resource Management, University of Hawaii at Hilo) and David Valentine (Tropical Forestry Specialist, Jaakko Poyry Consulting) . The Herbicide used is Garlon 3A (trychlopyr ((3,5,6-trichloro- 2-pyridinyl)oxy)acetic acid) and is approved for forestry use, this herbicide has been used to control invasive forest plants in Hawaii for years. The trial plots are 10m X 10m square, each will be treated by one of the following protocols:

Treatment #

#1 - 3 Trial Plots = Mechanical removal (chain saws and hand tools) of invasive species after koa tree has been harvested.
Trial Plot #s - 6, 7, 15

#2 - 3 Trial Plots = Mechanical removal of invasive species after koa tree has been harvested, manually applied Garlon 3A.
Trial Plot #s - 4, 5, 13

#3 - 3 Trial Plots = Mechanical removal of invasive species after koa tree has been harvested scarification of top soil 10cm deep with hand tools.
Trial Plot #s - 14, 2, 10

#4 - 3 Trial Plots = Mechanical removal of invasive species after koa tree has been harvested scarification of the top soil 10cm deep, manually apply Garlon 3A.
Trial Plot #s -1, 3, 8

#5 - 3 Trial Plots = No disturbance other than that caused by the felled tree.
Trial Plot #s - 16, 12, 18

#6 - 3 Trial Plots = No disturbance other than that caused by the felled tree, manually apply Garlon 3A.
Trial Plot #s - 9, 11, 17

Koa Regeneration Trial Data
Established 06/23/01
Data Last Collected 5/17/03

Trial # 1 *Description of Trial Activity* Garlon 3A 1cup/gal. 6/23/2001

Cut weeds till soil 10cm deep
N 19°46.044'
W 155°09.465'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 8, 11, 3, 10, 14
Comments from 5/17/03, Strawberry guava 4' tall, Koa 4'-18' tall dbh 3"-1.5" picture

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Trial # 2 Description of Trial Activity Garlon 3A 1cup/gal. None

Cut weeds till soil 10cm deep
N 19°46.064'
W 155°09.548'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 11, 13, 5, 11, 1
Comments from 5/17/03, 2 small Koa trees in plot dbh 12" and 13" picture

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Trial # 3 Description of Trial Activity Garlon 3A 1cup/gal. 6/23/2001

Cut weeds till soil 10cm deep
N 19°46.058'
W 155°09.544'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 48, 42, 21, 93, 18
Comments from 5/17/03, Koa 1'-6' tall dbh 1"-2" picture.

Trial # 8 Description of Trial Activity Garlon 3A

1cup/gal.
6/23/2001

Cut weeds till soil 10cm deep
N 19°46.064'
W 155°09.580'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 17, 60, 41, 67, 50
Comments from 5/17/03, Koa 8'-10' tall, dbh 2"-3" strawberry guava 2' tall, picture

---

Trial # 10 Description of Trial Activity

Garlon 3A
1cup/gal.
None

Cut weeds till soil 10cm deep
N 19°46.036'
W 155°09.494'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 9, 24, 11, 26, 18
Comments from 5/17/03, Koa 1'-6' tall, strawberry guava < 2'

Trial # 14 Description of Trial Activity

Garlon 3A
1cup/gal.
None

Cut weeds till soil 10cm deep
N 19°46.008'
W 155°09.528'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 31, 34, 8 pig, 26, 14
Comments from 5/17/03, Koa 4'-8' tall dbh .5"-1", pig activity, new hapuu growth, strawberry guava 4" tall, picture

---

Trial # 4 Description of Trial Activity

Garlon 3A
1cup/gal.
6/23/2001

Cut weeds
N 19°46.066'
W 155°09.554'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 19, 19, 5, 12, 22
Comments from 5/17/03, Koa 2'-8' tall, dbh 1", strawberry guava 4' tall, picture

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Trial # 5 Description of Trial Activity

Garlon 3A
1cup/gal.
6/23/2001

Cut weeds
N 19°46.059'
W 155°09.582'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 2, 2, 1, 0, 0
Comments from 5/17/03, strawberry guava covering plot 2' tall, picture

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Trial # 6 Description of Trial Activity

Garlon 3A
1cup/gal.
None

Cut weeds

N 19°46.030'
W 155°09.608'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 17, 14, 13, 18, 10
Comments from 5/17/03, Koa 1'-4' tall, pig activity, picture

Trial # 7 Description of Trial Activity — Garlon 3A 1cup/gal. None

Cut weeds
N 19°46.043'
W 155°09.584'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 36, 47, 28, 40, 20
Comments from 5/17/03, Koa 3'-10' tall dbh 1"-3", picture

Trial # 13 Description of Trial Activity — Garlon 3A 1cup/gal. 6/23/2001

Cut weeds
N 19°46.048'
W 155°09.436'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 5, 5, 1, 1, 0
Comments from 5/17/03, 1 older tree in plot, dbh 11", strawberry guava 5' tall, picture

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Trial # 15 Description of Trial Activity — Garlon 3A 1cup/gal. None

Cut weeds
N 19°46.014'
W 155°09.548'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 33, 43, 43, 48, 10
Comments from 5/17/03, Koa 1'-5' tall. dbh .5" picture

Trial # 9 Description of Trial Activity — Garlon 3A 1cup/gal. 6/23/2001

No extra disturbance
N 19°46.014'
W 155°09.548'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 105, 104, 98, 103, 88
Comments from 5/17/03, koa 1'-6' tall, picture

Trial # 11 Description of Trial Activity — Garlon 3A 1cup/gal. 6/23/2001

No extra disturbance
N 19°46.020'
W 155°09.414'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03

# of koa seedlings: 56, 27, 8, 20, 5
Comments from 5/17/03, 1'-7' tall, dbh 1"-2"

Trial # 12 Description of Trial Activity — Garlon 3A 1cup/gal.

No extra disturbance — None
N 19°46.014'
W 155°09.548'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 1, 3, 3, 3, 3
Comments from 5/17/03, Koa 8' tall, strawberry guava 6' tall

Trial # 16 Description of Trial Activity — Garlon 3A 1cup/gal.

No extra disturbance — None
N 19°46.086'
W 155°09.622'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 168, 168, 90, 121, 82

Trial # 17 Description of Trial Activity — Garlon 3A 1cup/gal.

No extra disturbance — 6/23/2001
N 19°46.093'
W 155°09.594'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 2, 2, 1, 0, 7
Comments from 5/17/03, Koa 4'-.5' picture

Trial # 18 Description of Trial Activity — Garlon 3A 1cup/gal.

No extra disturbance — None
N 19°46.161'
W 155°09.673'
Date data collected: 6/23/01, 7/07/01, 7/21/01, 8/04/01, 5/17/03
# of koa seedlings: 76, 76, 52, 86, 10
Comments from 5/17/03, Koa .5"-4', strawberry guava 6 'tall

Results as of 8/4/01:

Treatment #1 - average number of Koa seedlings replacing the adult tree. 35.3
Treatment #2 - average number of Koa seedlings replacing the adult tree. 3.3
Treatment #3 - average number of Koa seedlings replacing the adult tree. 18.3

Treatment #4 - average number of Koa seedlings replacing the adult tree. 49.0
Treatment #5 - average number of Koa seedlings replacing the adult tree. 70.0
Treatment #6 - average number of Koa seedlings replacing the adult tree. 41.0

Results as of 5/17/03:

Treatment #1 - average number of Koa seedlings replacing the adult tree. 13.3
Treatment #2 - average number of Koa seedlings replacing the adult tree. 7.3
Treatment #3 - average number of Koa seedlings replacing the adult tree. 6
Treatment #4 - average number of Koa seedlings replacing the adult tree. 27.3
Treatment #5 - average number of Koa seedlings replacing the adult tree. 36.7
Treatment #6 - average number of Koa seedlings replacing the adult tree. 33.3

Constraints:
Trial sights are limited to those areas that have been logged. These areas only represent one forest type (the agricultural zone).
Access is extremely limited to the trial plots but can be reached by helicopter, foot paths do exist.

Observations:
There is more regeneration occurring in trial plots where the sun is able to reach the forest floor for more than three hours a day. There are three trial plot that have shown signs of pig damage, this may or may not affect seedling numbers. Where the soil has good drainage and no standing water the koa seedlings seem to grow faster. These variable need to be taken into consideration in subsequent regeneration trials.
The koa seedlings are able to out compete the invasive species in these trial plots but the strawberry guava is able to smother many of the trees within three years if allowed to grow unabated. The strawberry guava that was poisoned in the plots remain dead for a full year but by the end of the second year the invasive species returned.

Discussion:
There is definite regeneration of Koa seedlings in all protocols in the regeneration trial plots. The regeneration data in terms of number of seedlings seems to be more directly influenced by sunlight penetrating the canopy as well as drainage of any standing water. There are several trial plots where strawberry guava is out performing the koa (trial plots #18, 12, and 14).

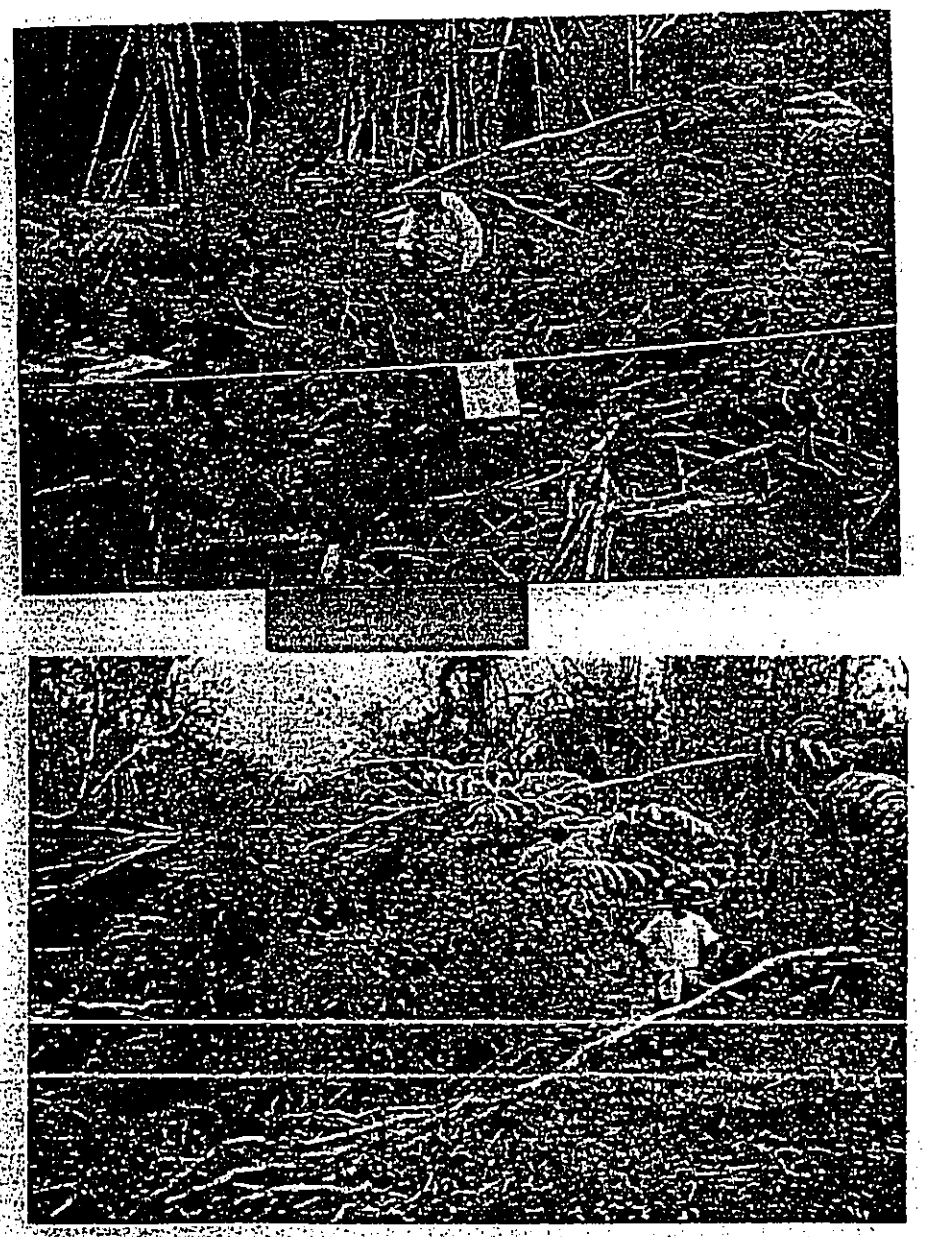
Implications to Forest management Plan:
Selection of Trees: The harvesting of several trees in an area would create a larger opening in the canopy and allow more regeneration to occur as sunlight reaches the forest floor for a longer period during the day. The harvest area should be revisited and herbicide applied annually for three years after removal of harvested trees. In the event that there is no regeneration occurs in a particular plot within one year, then koa seedlings or seeds from a

seed bank in the area should be planted. Harvesting in well drained areas would also be preferable to areas containing standing water. The *Eucalyptus robusta* located on ~100 acres of land in the agriculture zone should be replaced with koa in order to provide additional koa stock and be used as a seed bank.

DOCUMENT CAPTURED AS RECEIVED

Regeneration Photos:

Trial Plot #4, #1 7/07/01

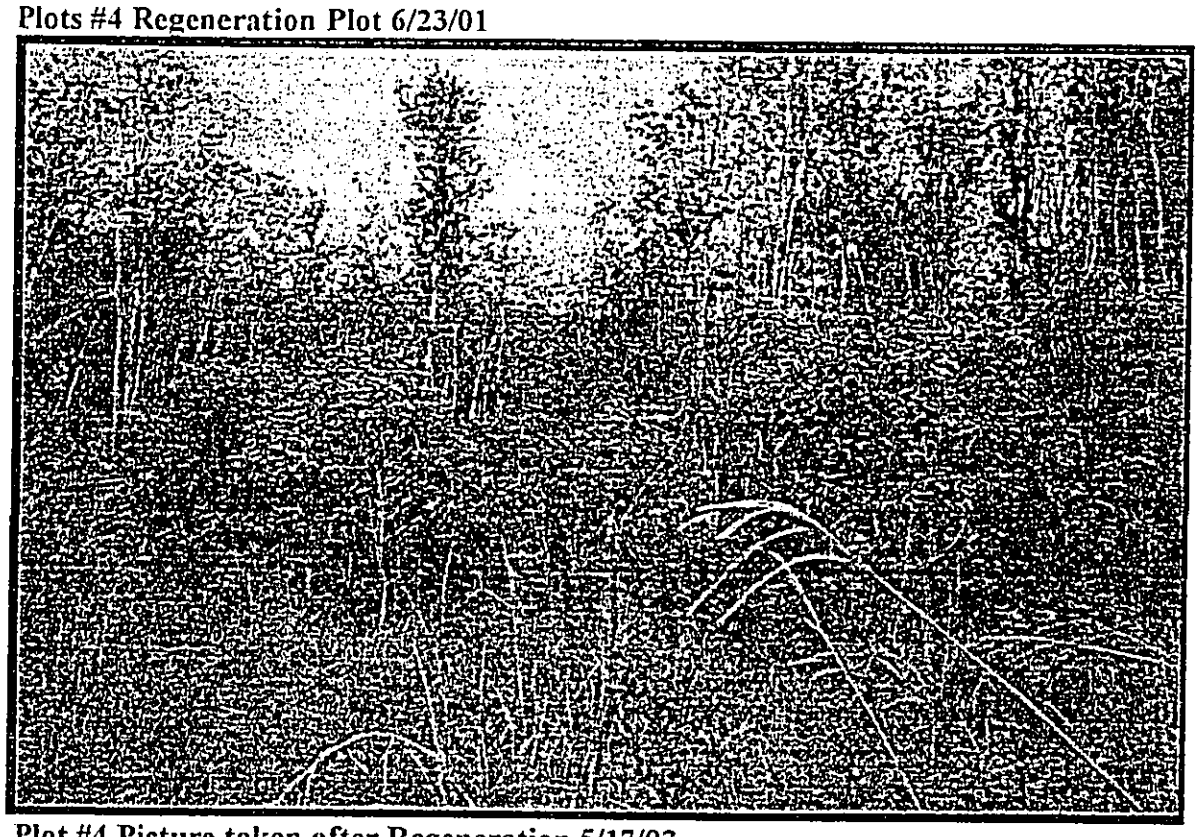


Young Koaregenerating post harvest

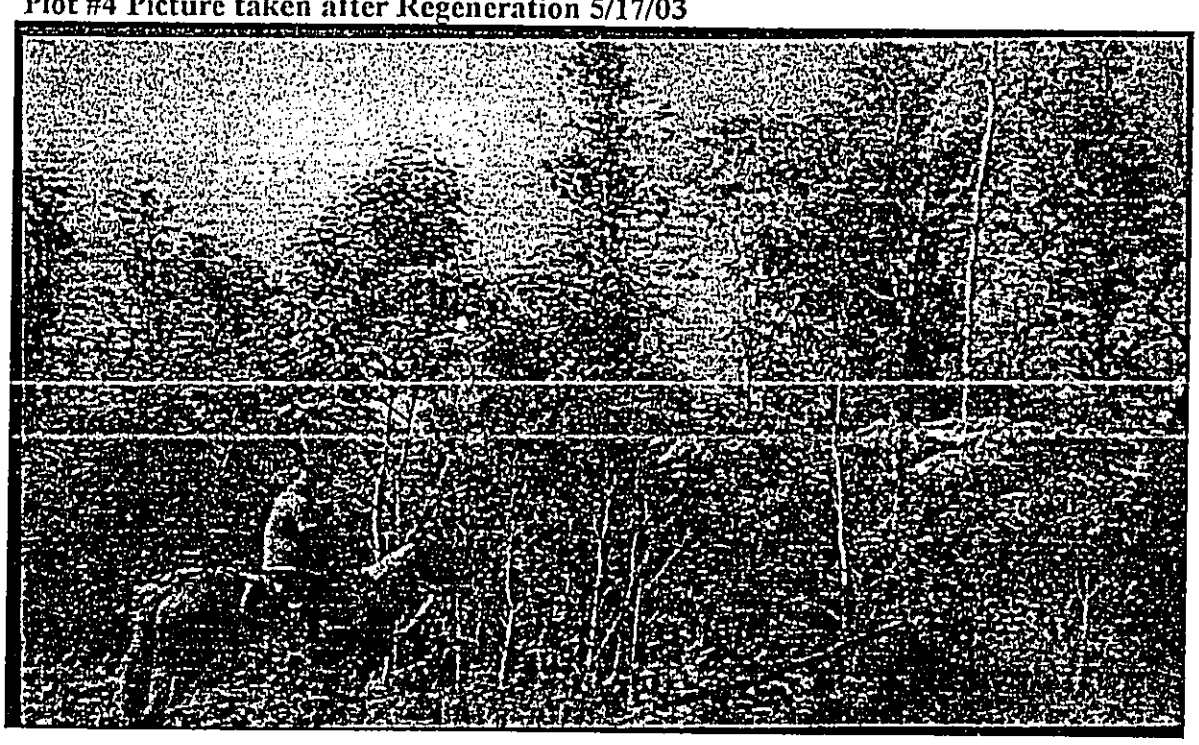
DOCUMENT CAPTURED AS RECEIVED

Trial Plot Photos

Plots #4 Regeneration Plot 6/23/01



Plot #4 Picture taken after Regeneration 5/17/03



References:

Motooka, Philip. Ching, Lincoln. Nagai, Guy., Herbicidal Weed Control Methods for Pastures and Natural Areas of Hawaii, CTAHR publication, Weed Control, WC-8, 2002.

Motooka, Philip. Ching, Lincoln. Nagai. Powley, John. Teves, Glenn. and Arakaki, Alton, Woody Plant Control for the Home, Pasture, and Forest, CTAHR publication, Weed Control, WC-4, 1999

Scowcroft, Paul G. and Adee, Kenneth T., Site Preparation Affects Survival, Growth of Koa on Degraded Montane Forest Land, USDA Forest Service Res. Paper PSW-205. 1991.

Scowcroft, Paul G. and Nelson, Robert E., Disturbance During Logging Stimulates Regeneration of Koa., USDA Forest Service Res. Note PSW-306. 1976

Appendix C

Botanical Report

KOA TIMBER PROJECT BOTANICAL REPORT
(With Observations on Avian Fauna)

District of South Hilo
TMK 3rd/2-7-01:01 & 2-8-01:02

by Ron Terry, Ph.D.
Geometrician Associates
November 2002

1 INTRODUCTION

Report Scope and History

Koa Timber proposes to conduct a koa (*Acacia koa*) forestry operation on an 13,129-acre property on the island of Hawai'i. This report discusses the botanical environment, evaluates the impacts of the project, and then recommends a series of measures to mitigate impacts. It is meant to accompany an Environmental Impact Statement (EIS) that project planners have prepared for the project. Readers are referred to the EIS for maps of the area and further information concerning the property and the project.

This report follows up on two previous studies of the area. First, a biological assessment (Terry 2001) provided an overview, based principally on consultation of published literature, of the biological environment, issues, and impacts associated with the area and project site. This study accompanied a Draft Environmental Assessment (DEA) and a subsequent Environmental Impact Statement Preparation Notice (EISPN) for the project A second report, completed in 2001 but never published, presented and analyzed sample data from plots located within representative areas of the forest planned for logging activity.

It is important to clarify the scope of the current study in relation to the two previous efforts. Stream biota, birds and the endangered Hawaiian Hoary Bat, which were discussed in overview in the first two reports, are now the subject of separate investigations and are not covered here. This report is restricted to a discussion of botanical resources, and treats with zoological resources only in the sense of habitat provided by vegetation types and particular plant species.

Project Site

The project site consists of two parcels totaling 13,129 acres, situated between 1,400 and 3,600 feet in elevation, ten miles north of the City of Hilo, and mauka of the towns of Pauka'a, Papa'ikou, and Pepe'ekeo (***Fig. 1***). The project site is entirely within the South Hilo District, and encompasses portions of the ahupua'a of Makahanaloa, Onomea, Alakahi, Pu'u Moi, Aleamai, Papa'ikou, and Paukaa. Most of the land is in native forest classified within the State Land Use Conservation District (CD).

The dense vegetation, steep and dissected topography, and saturated, muddy soils make the area highly inaccessible. In fact, apart from a handful of field biologists, few have ever walked even a small part of this land, at least in modern times.

Project Activities

The assessment contained in this document is based upon project information presented in the Forestry Management Plan (FMP) for the EIS. According to this plan:

> "The primary goal of Koa Timber is to improve the health of the koa stands by controlling competing vegetation, removing some mature and unhealthy trees, and controlling the stocking and growth of residual stands. Our secondary goal is to expand the total acreage of forestland by reforesting understocked, or non-stocked areas. Non-native trees will be removed and replaced with koa in the agricultural and conservation zones" (Atterbury Consultants 2002:4).

In overview, the project would use helicopters to log selected koa trees from certain areas of the forest. The stated goal is to practice sustainable forestry, preserving important biological and physical resources, maintaining the essential character and habitat value of the forest, and promoting rapid regeneration of logged areas to their natural condition. Herbicide use would be minimal and confined to controlling alien species. No roads would be built in the CD, and logs would be milled on adjacent Agricultural District land formerly used for sugar cane cultivation.

Despite considerable data-gathering conducted as part of this and previous environmental studies for the proposed project, knowledge of the biological resources of the area is incomplete. Furthermore, koa silviculture is basically in an infant state. Accordingly, the FMP refrains from overly specific practices and instead stresses adaptive management in the areas of harvest volume, regeneration, alien species control, and other aspects.

Limitations of This Report

The botanical information for this report is derived in large part from large scale, remote-sensing assessments done over the course of the last three decades, supplemented by intensive survey in various plots and transects. The vegetation and terrain preclude "complete" survey of the property within a reasonable time frame and budget. Although all vegetation types in the property have been examined, and general conclusions are drawn concerning the frequency of common species - and the rarity of uncommon species - there can be no conclusive statement about many aspects of the botanical environment on the property, e.g., the presence or absence of any particular endangered species.

This report is meant to assist project planners, forestry operators and regulators in assessing the existing botanical resources, evaluating impacts, and deriving flexible but effective mitigation measures. Substantial uncertainty is inherent in a new technology working in an area in which the biological resources are only partly understood. The implication of working with uncertainty is that the project must exercise extraordinary caution in implementing – and vigilance in monitoring – all project activities. This concept is elaborated upon in the sections on impacts and mitigation.

Coordination

The author gratefully acknowledges the patient assistance of scientists and managers from the U.S. Geological Survey's Biological Resources Division; the U.S. Fish and Wildlife Service's Hakalau Forest National Wildlife Refuge; the Hawai'i State Division of Forestry and Wildlife; the Hawai'i Division of Aquatic Resources; the U.S. Fish and Wildlife Services Pacific Island Ecoregion Office; and the Geography Department of the University of Hawai'i at Hilo. Each attended a detailed description of the proposed project, and then shared concerns and mitigation ideas, many of which have been addressed or adopted as part of the project. Their participation, however, should not be construed as endorsement by any individual or agency of the project as a whole or any component of it, including impact evaluation or mitigation proposals.

2 EXISTING BOTANICAL ENVIRONMENT

2.1 Overview

The assessment was conducted in two phases, the first in late 2000, and the second in the summer of 2001.

The 2000 effort involved primarily a review of existing information, including Hawai'i Forest Bird Survey (HFBS) maps and various other publications, maps, and data. To supplement this, helicopter reconnaissance enabled a comprehensive overview of the property and the basic forest structure. Following reconnaissance, two partial days of helicopter-drop, on-ground field survey in areas selected for their biological richness were conducted by qualified biologists, followed by laboratory identification of field species.

The 2001 effort was a systematic, eight-day field study carried out by two botanists as part of a larger timber inventory project conducted by Jaakko Poyry Consulting for Koa Timber. The objectives of the field study were to:

1. Document all bird and plant species encountered within plots sampled, paying special attention to the presence of any State or federally listed endangered species.
2. Collect quantitative data on species richness, frequency of occurrence, and species density.
3. After data collection, examine how such factors vary with elevation and among plots.

Although considerable field time was expended surveying the property during the two efforts, the sum does not and was not intended to represent a "100 percent" botanical survey of the full area. A government botanist who conducted transects of the property in the 1970s as part of the HFBS spent several weeks trekking through the area, camping at night. Even then, he was only able to cover a very limited area, perhaps two percent of the property. It is clear that even a full ground survey at the reconnaissance level would be an enormous effort.

It can be argued that in one sense, intensive survey is not appropriate at this time, not only because the large geographic area makes it impractical but also because the time scale involves decades of gradual use of the property. The landowner, the state agency regulating the land use,

and the resource agencies monitoring the natural resources will all face a constantly changing situation. On the biological end, there will be shifting sets of important species to protect and noxious alien organisms to confront. From the legal perspective, the State and federal governments will add and subtract various species to the threatened and endangered species list, entirely new environmental laws will be enacted, different agencies and agency responsibilities will develop, and refined protocols for integrating various laws will emerge. Technologically, improved methods of locating and monitoring biological resources and nuisances will emerge, and logging techniques themselves are also likely to revolutionize.

Accordingly, the botanical assessment presented within this report is intended only to initiate, and not conclude, an integrated program of biological monitoring. The mitigation section of this document suggests directions for future monitoring.

2.2 Existing Botanical Information

Vegetation Mapping

The eastern slope of Mauna Kea is of considerable interest to biologists because of its large gradients in elevation (0-13,796 ft), temperature, and rainfall, and because much of the land remains relatively untraveled by humans. The gradients have led to great differences and variety in flora from sea level to Mauna Kea's summit. One of the first botanists to be fascinated with this area was David Douglas, who described hiking the eastern slope of Mauna Kea in 1834:

> The path was in a dreadful state, numerous rivulets overflowed it in many places, and, rising above the banks, rushed in foam through the deep glens still, violent as was the rain and slippery and dangerous the path, I gathered a truly splendid collection of ferns, of nearly 50 species, with a few other plants, and some seeds and in spite of all the disadvantages and fatigue that I underwent, still the magnificence of the scenery commanded my frequent attention, and I repeatedly sat down in the course of the day, under some huge spreading tree fern and contemplated with delight the endless variety of form and structure that adorned the objects around me (quoted in Valier 1995).

More recently, Mueller-Dombois and Krajina (1968) described eleven distinct vegetation zones along a transect extending from sea level to above 13,000 feet. Three distinct rainforest zones extend from the edge of the farmland at an elevation of approximately 1,500 feet, to approximately 7,000 feet. From 1,500 to 3,000 feet, the vegetation may be characterized as sub-montane rain forest dominated by 'ohi'a (*Metrosideros polymorpha*) and koa (*Acacia koa)*, often heavily invaded by strawberry guava (*Psidium cattleianum*), with koa occupying only the better drained positions in this high-rainfall environment (Mueller-Dombois and Fosberg 1998). This area has also been identified as *Koa-'Ohi'a Montane Wet Forest* with a Montane Wet Sedgeland community occupying forest openings (Gagne and Cuddihy 1990). Much of the Koa Timber project site occurs within this zone. Montane rainforest lies between 3,000 and 5,000 feet (Mueller-Dombois and Fosberg 1998). The lower half of this zone includes the upper elevation areas of the project site, is the area of highest rainfall, and is totally dominated by 'ohi'a trees and large patches of 'uluhe fern (*Dicranopteris linearis*). The upper half is primarily dominated by 'ohi'a and receives less rainfall, but low clouds are frequent and result in substantial fog drip from trees (Juvik and Ekern 1978). Between 5,000 and 7,000 feet, the forest may be characterized as upper montane rainforest, with 'ohi'a and koa again as co-dominants

(Mueller-Dombois and Fosberg 1998). Because 'ohi'a and koa rarely form dense canopies, there is a great diversity of mid-canopy trees, understory shrubs, vines, and epiphytes throughout the entire rainforest zone.

Surprisingly little botanical fieldwork has been conducted on the project site. Much of our knowledge comes from the U.S. Fish and Wildlife Service Hawai'i Forest Bird Survey (HFBS) conducted during the late 1970s, a landmark mapping project conducted throughout the State of Hawai'i. The project involved foot transects by botanists and ornithologists. Three transects from this survey passed through portions of the project site (dashed lines in ***Fig. 2***). Vegetation structure and floristic composition were described at stations set at regular intervals along the transects. Taken together, these descriptions, coupled with systematic interpretation of airphotos, formed the basis of the detailed vegetation maps that were compiled for the area (***Fig. 3***). As the HFBS maps indicate, the project site, while not pristine, contained areas of largely intact native forest dominated by koa and 'ohi'a, along with patches moderately to heavily invaded by alien species, mainly strawberry guava or waiawi (*Psidium cattleianum*). Table 1 below describes the principal vegetation types found on the project site.

TABLE 1
Hawai 'i Forest Bird Survey Map Vegetation Classification

HFBS Forest Type Code	Tree Canopy Crown Cover	Tree Canopy Height	Overstory Tree Species Composition	Understory Species Composition
122	Closed canopy, most crowns interlocking; >60% cover	Tall stature trees; >10m tall	Koa- 'ohi'a dominant; scrub native trees subdominant	Native tree ferns dominant, native shrubs subdominant
139	Open canopy, some or no interlocking crowns; >25-60% cover; many standing dead or defoliated trees	Tall stature trees; >10m tall	Koa- 'ohi'a dominant, scrub native trees sub-dominant	Matted ferns- native shrubs dominant, tree ferns sub- dominant
142	Open canopy, some or no interlocking crowns; >25-60% cover	Tall stature trees; >10m tall	Koa- 'ohi'a dominant, scrub native trees sub-dominant	Strawberry guava dominant, native shrubs- tree ferns subdominant
146	Open canopy, some or no interlocking crowns; >25-60% cover	Tall stature trees; >10m tall	Koa- 'ohi'a dominant, scrub strawberry guava subdominant	Native shrubs- strawberry guava co-dominant
172	Scattered trees; 5- 25% cover; many standing dead or defoliated trees	Scrub trees, moderate stature; 5- 10m tall	Koa- 'ohi'a- native trees co-dominant	Matted ferns-mixed native and introduced grasses- native shrubs co- dominant
175	Scattered/ open canopy; many standing dead or defoliated trees	Tall stature trees; >10m tall	'Ohi'a- scrub 'ohi'a- native trees co-dominant	Matted ferns- mixed native and introduced grasses native shrubs co- dominant

Wetlands

Wetlands are defined under federal guidelines as:

> "Those areas that are inundated or saturated by surface of ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Federal Register 1982).

Wetlands in Hawai'i may be endowed with abundant native plants and high-quality animal habitat. Some are vital for tempering floods and removing sediment and other contaminants. In particular, coastal wetlands support native and migratory birds, and mountain bogs often contain unique native plants.

Different agencies employ different criteria for determining whether wetlands are present on a given site. According to the Army Corps of Engineers (COE) *Corps of Engineers Wetlands Delineation Manual* (COE 1987:7), COE methodology requires the presence of positive indicators for three parameters – vegetation, soil and hydrology – while the maps created as part of U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) may be derived from remote sensing methods that detect a positive indicator for any one of the three parameters.

The issue of wetlands in hyper-humid, high-slope Hawaiian forests is complex. Certain bogs are have unique assemblages of rare and endangered plants, while many wetlands have a species composition almost identical to adjacent upland areas. A systematic delineation of wetlands in partially native forests along a highway corridor in Hilo (Gerrish 1998) found that certain lava-soil types supported wetlands that were large and discrete enough to be capable of delineation. Other wetlands occurred as highly scattered pockets, in which delineation was impractical and area estimates more suitable. Some of the wetlands in parts of upper Hilo are in reality artificial products of human impedance of drainage, and often have few positive or even negative (e.g., feral pig wallows, alien plant patches) wetlands functions and values (Terry 2001). Montane wetlands in Hawai'i clearly require a greater level of study.

The U.S. Fish and Wildlife NWI maps for the island of Hawai'i depict a roughly 7,200-acre swath of wetlands (palustrine, scrub-shrub, broad-leaf evergreeen, saturated) within the mauka area of the 13,129-acre property. This area comprises the entire 'ohi'a-'uluhe zone (type 175 above) and large portions of other zones.

No wetlands determination, much less delineation, has ever been attempted for the property. Given the situation – thousands of wetlands-like pockets varying in size from a few square feet to several thousand square feet in an extremely challenging environment for walking or visual survey – it is unlikely that the painstaking methodology of delineation would be practical.

Our field experience suggests that a large portion of type 175 might indeed meet at least some definitions of a wetlands. It is interesting to note, however, that of the two dominants in this vegetation zone, 'ohi'a is classified as a "facultative" plant (i.e., plants with a similar likelihood of occurring in wetlands and non-wetlands) and 'uluhe, a facultative upland plant (i.e.,

sometimes occurring in wetlands, but occurring more often in non-wetlands) (US-COE 1987:18; USFWS 1988). The steep slopes feature numerous small outcrops that are "high and dry", but the majority of the area contains saturated soil, often with standing water. Such conditions are less universal, but still present, in many scattered locations in other vegetation types of the property, and not only those indicated in the NWI maps. The entire property might be described as complex mosaic of various-sized wetland and upland patches. The environmental variation that this mosaic provides increases the botanical diversity of the area and may provide habitat for birds such as the native Black-crowned Night Heron (*Nycticorax nycticorax hoachtli*). These wetlands therefore have biological as well as flood-buffering and watershed values.

Forest Bird Habitat

As explained in the introduction, this report's scope is restricted to vegetation, and includes discussion of birds only in the sense of general habitat. With few exceptions (the Hawaiian Hawk, *Buteo solitarius*, for example), all native forest birds are now found within a narrow band of forest from 2,500 to 7,500 feet in elevation. Distribution and abundance maps for eleven extant species are presented in Scott et al. (1986). These maps indicate that eight of the eleven native species exist at minimal densities in the portions of the property site above approximately 2,500 feet elevation. The endangered Hawai'i 'Akepa (*Loxops coccineus coccineus*), Hawai'i Creeper (*Oreomystis mana*), and 'Akiapolaau (*Hemignathus munroi*), do not range to elevations lower than approximately 5,000 feet. It is likely that the distribution and abundance of native bird species within the project area have declined in the 22 years since they were last surveyed.

Introduced predators, competitors, and disease are among the factors responsible for the decline of Hawaiian forest birds (Warner 1968; Banko and Banko 1976; Atkinson 1977; Van Riper et al. 1982). In low elevation areas (<4,500 feet), avian malaria (*Plasmodium relictum*) appears to be the primary reason for the absence of birds (Van Riper et al. 1982). This introduced protozoan parasite is transmitted by the introduced night-biting mosquito (*Culex quinquefasciatus*) and infects peripheral red blood cells and internal tissues. Hawaiian birds apparently evolved a loss of resistance to this parasite, and infection often leads to death (Warner 1968).

In summary, from the standpoint of general bird habitat, it is important for the project to avoid removal of koa trees in such quantities that the forest's value as food, cover and potential nest sites is substantially diminished. Continuous corridors with at least minimal koa density should be encouraged and maintained for mauka-makai travel by birds. Furthermore, the project should avoid or mitigate any impacts that increase the density of predators such as cats, rats or mongooses, or the prevalence of pigs (and thus mosquitos).

2.3 2000 Field Survey

Field Survey Methods

Field surveys for the 2000 effort were conducted by biologist Patrick Hart, Ph.D., on December 14 and December 21, 2000, at four locations (Sites 0,1,2, and 3; ***Fig. 2***) within the Koa Timber property. Since systematic botanical inventories had not been conducted on this parcel since the late 1970s, the primary goal was to obtain a detailed sample of the current vegetation within

selected areas. The specific objectives of the surveys were to: 1) list all species encountered; 2) identify threatened or endangered species; and 3) compare species composition between the sites.

Survey sites were selected based on their location within the koa-ʻohi ʻa closed canopy vegetation area (type 122 on the HFBS maps), and on their proximity to a suitable helicopter landing area. This zone contains the most diverse and undisturbed areas of sub-montane wet forest within the subject parcel. The lower elevation areas (type 142) that are dominated by the introduced strawberry guava were intentionally avoided during this survey. Similarly, the upper elevation areas (type 175) dominated by ʻohiʻa and ʻuluhe were avoided, primarily because suitable landing sites could not be found during the limited survey opportunities.

Within type 122, Sites 0,1, and 2 included inclusions of bogs that allowed the helicopter to land. At Site 3, the helicopter landed on a rocky outcrop in a stream and no bog species were included in the survey areas. The elevation of the sites ranged from 2,200 – 2,800 feet. Surveys generally lasted two hours and covered approximately two acres. Species were identified in the field and, as necessary, collected and keyed out in the laboratory. Special attention was given to the possible presence of the numerous federally listed endangered plant species (USFWS 2000; Table 3) that were determined through consultation with resource agencies to grow in the general vicinity, and to the presence of highly invasive alien plant species such as strawberry guava and palmgrass (*Setaria palmifolia*).

TABLE 2.
Endangered Plant Species Known to Occur in Vicinity of Project Site.

Adenophorus periens	Cyanea tritomantha
Asplenium fragile var. insulare	Cyrtandra giffardii
Clermontia lindseyana	Cyrtandra tintinnabula
Clermontia peleana	Phyllostegia racemosa
Clermontia pyrularia	Phyllostegia velutina
Cyanea copelandii ssp. copelandii	Phyllostegia vestita
Cyanea platyphylla	Phyllostegia warshaueri
Cyanea shipmanii	

Field Survey Findings

All species encountered at the four sites are listed in Tables 3-4. The dominant trees at all sites were ʻohiʻa and koa. These two species composed much of the upper forest canopy. The most abundant native mid-canopy trees included hame (*Antidesma platyphyllum*), kolea (*Myrsine lessertiana*), pelea (*Melicope clusiifolia*), olapa (*Cheirodendron trigynum*) and hapuʻu (*Cibotium* spp.). Common native understory and shrub species included kanawao (*Broussaisia arguta*), ʻala ʻala wai nui (*Peperomia hypoleuca*), *Clermontia parviflora* and numerous ferns. ʻIe ʻie vines (*Freycinetia arborea*) were a notable component of the forest at all locations. No federally listed endangered plant species were identified during the limited survey period.

TABLE 3.

Flowering Plants Identified During 2000 Survey of Koa Timber Parcel.

Species (* signifies native status)	Common Name
*Acacia koa	Koa
*Adenostemma lavenia	Kamanamana
Ageratum conyzoides	Ageratum
*Alyxia oliviformis	Maile
Andropogon virginicus	Broomsedge
*Antidesma platyphyllum	Hame
Arundina bambusifolia	Bamboo orchid
*Astelia menziesiana	Kaluaha
*Broussaisia arguta	Kanawao
*Carex alligata	Carex
*Cheirodendron trigynum	Olapa
*Clermontia parviflora	Clermontia
Clidemia hirta	Koster's curse
*Coprosma rhyncocarpa	Pilo
Cyperus halpan	Umbrella sedge
*Deschampsia nubigena	Hairgrass
Erechtites valerianifolia	Fireweed
*Freycinetia arborea	'Ie 'ie
*Hedyotis hillebrandii	Manono
*Ilex anomala	Kawa'u
*Isachne distichophylla	Ohe
Juncus effusus	Japanese mat rush
Juncus planifolius	Bog rush
*Machaerina mariscoides	Uki
*Melicope clusiifolia	Pelea
*Metrosideros polymorpha	'Ohi'a
*Myrsine lessertiana	Kolea
*Myrsine sandwicensis	Kolea lau lii
Paspalum conjugatum	Hilo grass
*Peperomia hypoleuca	'Ala 'ala wai nui
Psidium cattleianum	Strawberry guava (Waiawi)
*Rhyncospora rugosa	Pu'ukoa
Sacciolepis indica	Glenwood grass
Setaria palmifolia	Palm grass
*Smilax melastomifolia	Hoi kuahiwi
*Styphelia tameiameiae	Pukiawe
Tibouchina herbacea	Tibouchina
*Trematolobelia grandiflorum	Trematolobelia
*Vaccinium calycinum	'Ohelo
*Wikstroemia sandwichensis	'Aki

TABLE 4.
Ferns and Fern Allies Identified During 2000 Survey of Koa Timber Parcel.

Species (* signifies native status)	Common Name
*Adenophorus hymenophylloides	Pai
*Adenophorus pinnatifidus	Palai laʻau
*Adenophorus tamariscinus	Wahine noho mauna
*Asplenium contiguum	Spleenwort
*Asplenium monanthes	Spleenwort
*Athyrium microphyllum	ʻAkolea
Blechnum occidentale	Blechnum
*Cibotium glaucum	Hapuʻu
*Cibotium hawaiiense	Hapuʻu meʻu
*Cibotium menziesii	Hapuʻu ʻiʻi
*Dicranopteris linearis	Uluhe
*Diplazium sandwichianum	Hoʻiʻo
*Diplopterygium pinnatum	Uluhe lau nui
*Elaphoglossum crassifolium	ʻEkaha
*Elaphoglossum hirtum	Hairy stag's tongue
*Grammitis hookeri	Finger fern
*Grammitis tenella	Mahinalua
*Isoetes hawaiiensis	Water fern
*Lycopodium cernuum	Club moss
*Lycopodium phyllanthum	Club moss
*Lycopodium polytrichetes	Club moss
*Mecodium recurvum	ʻOhiʻa ku
*Nephrolepis cordifolia	Kupukupu
*Ophioglossum pendulum	Puapuamoa
*Psilotum nudum	Moa
*Pteris cretica	Cretan brake
*Sadleria pallida	Amaʻu
*Sphaerocionium lanceolatum	Palai hinahina
*Sphenomeris chinensis	Palaʻa
*Vandenboschia cyrtotheca	Palai hihi

The native species composition was remarkably similar between sites. All tree species, and most ferns, were seen at each survey location. Notable exceptions included *Trematolobelia grandifolia*, a rare lobeliad shrub, which was present only at only Site 3, and the rare water fern *Isoetes hawaiiensis*, which was only found at Site 0.

All sites were heavily impacted, both directly and indirectly, by pigs. Pig wallows, trails, and rooting areas were common, especially in the bog areas. The native sedges and grasses that once dominated these bogs have been replaced by introduced species such as bog rush (*Juncus planifolius*), Glenwood grass (*Sacciolepis indica*), Hilo grass (*Paspalum conjugatum*), and

umbrella sedge (*Cyperus halpan*). Strawberry guava, an alien tree that is known to be spread by pigs, was found at all survey sites. Based on the density of seedlings and saplings in the understory, this species appears to be quickly invading areas where it was recently absent.

There was a notable difference among sites in the degree of severity of recent pig damage. Site 0 was criss-crossed with pig trails and had numerous pig wallows, whereas Site 1 had far fewer of each. The other two sites had intermediate levels of pig damage. The severity of invasion by strawberry guava appeared correlated with pig presence. Guava density was greatest at Site 0, intermediate at Sites 2 and 3, and lowest at Site 1. Palmgrass, another highly invasive species which may be spread by pigs, was found only at Sites 0 and 3, where it was common.

Conclusions of 2000 Field Survey

Although the survey scope was highly limited, some conclusions were tentatively made regarding the structure and dynamics of this forest. First, invasive plant and animal species may be a threat throughout the entire area. It was surprising to find so many alien species in a forest that was partially chosen for its potential "pristine" quality. It appeared possible that there were no forested areas left on this property that have not been disturbed by pigs and invaded to varying degrees by strawberry guava, palmgrass, *Tibouchina*, and others noxious plants. Second, invasion by these species is still in the early stages in many areas, and the forest within the sampled type 122 remains predominantly native and diverse. Unfortunately, when alien species such as strawberry guava become established in low elevation Hawaiian forests, they often completely out-compete the native plant species over time. The lower elevation portions of the subject parcel (type 142) appear to be nearing this state. If no action is taken to reduce disturbance by pigs and remove invasive plants species, native plant diversity will continue to decrease and much of this forest will likely be dominated by alien species. The most effective method to slow the degradation of this forest would be to install pig exclosures in selected areas, remove pigs from within the exclosures, and actively remove alien weeds within the exclosures that have already become established. This method has been used successfully in numerous sub-montane wet forests throughout the state.

2.4 2001 Field Survey

Time limitations in the 2000 field survey allowed sampling at only four sites. The purpose of the supplemental 2001 survey was to augment this, particularly for areas that were likely to experience the most direct project effects of harvest, replanting and alien species control.

Methods

Sampling

The general sampling area and the number and size of the sample plots were designed by Jaakko Poyry Consulting as part of its timber inventory project for Koa Timber, in consultation with Geometrician Associates. The primary purpose was to inventory the standing koa, and therefore the areas sampled reflected areas that had been earlier determined through analysis of satellite

images and oblique aerial photography to have harvestable koa. As these potential koa harvest sites were the areas of the forest would be directly disturbed through heli-logging, they were also a logical focus for assessing birds and plants. It should be emphasized that other HFBS vegetation types in the forest – particularly types **146** (guava-dominated) and **175** ('ohi'a and 'uluhe-dominated) listed in Table 1 – were not sampled, and this report does not contain detailed information about their structure. As long as no logging, support activities, or other activities with the potential to directly disturb these low-diversity areas occurs, the lack of detailed vegetation data may not be critical. However, if the project proceeds, such areas should be monitored to gauge any possible indirect effects.

Inside the area considered for harvest, Jaakko Poyry stratified the area into six zones supporting similar koa characteristics. A total of 56 plots, each comprised of a cluster of four 25m radius subplots with centers separated by 100m, were randomly positioned within the six strata (***Fig. 4***). The elevations of the plots sampled ranged from 2,160 to 3,300 feet, and included land north of the property near Hakalau that was originally considered for inclusion in the project and later withdrawn. The environments in this withdrawn area are highly similar to those on the property, and the inclusion of data from this area does not affect the general observations and conclusions.

The surveys were conducted by two biologists who separately accompanied two 2-person koa forest inventory crews during eight days in June and July, 2001. The biologists visited 32 of the 56 different plot clusters, which were located using Global Positioning System (GPS) units. Sites were accessed by helicopter drop to the nearest clearing, followed by hiking. Flora surveys were conducted within one subplot per cluster (species list) and between subplots (transects for abundance); birds were detected and identified during all activities in and around the plots.

Determining Plant Species Composition

All flowering plants, ferns, and fern allies found within the sample subplot (hereafter referred to as plot) at each of the 32 plot clusters were identified to species level. Identification of flowering plants followed Wagner et al. (1990). Ferns and fern allies were classified according to Wagner and Wagner (unpublished manuscript), Valier (1995), R. Warshauer (pers. comm.), and L. Pratt (pers. comm.). Time spent within each subplot ranged from 0.5 to 2.0 hours, and varied according to the density of vegetation and diversity of species. The decision to stop sampling within a plot was made when the observer was confident that all portions of the plot had been surveyed and when no additional species had been recorded for at least 15 minutes. Special attention was given to the potential presence of any State or federally listed plant species that occurred within the plots or that might be encountered when traveling between plots.

Determining Plant Distribution and Abundance

Species richness is a measure of the number of different species that exist within a given area. When examined with respect to other variables such as elevation, important patterns within the community may be revealed. Species richness here refers to the number of different species (native flowering plants, alien flowering plants, and ferns) that were found within each plot.

Frequency of occurrence is a measure of the way a particular species is dispersed throughout its environment. Regardless of the number of individuals present, if sampling reveals a species is present in only a few locations, then it has a low frequency of occurrence. This variable was measured here as the total number of plots in which a particular species was found, divided by the total number of plots surveyed.

Density is a measure of the number of individuals of a particular species that inhabit an area of known dimensions. The number of individuals were counted for each of 10 tree species greater than 2m tall and growing within approximately 2m of either side of a 100m long transect running between plot centers within a cluster. Density (trees/acre) was calculated as the number of individuals within each of two 3,600 square foot transects surveyed per cluster (= 7,200 total square feet), multiplied by 6.25.

Statistical Analyses

Simple linear regression (SYSTAT, Version 10) was used to test for negative or positive trends in the relationships between species richness and elevation and between species density and elevation. Residual plots and residual statistics indicated that the assumptions of linear regression were generally met. ANOVA F statistics are indicated along with corresponding P values. In general, large F values (>1.0) and small P values (< 0.05) are evidence against the null hypothesis that there is no linear relationship between the two variables being compared (Moore and McCabe 1993).

Data Results

Vegetation

The 13,129-acre project site comprises a mosaic of at least three major native plant communities. Because sampling design was stratified to include habitat with the greatest abundance of koa, the vegetation within most of the plots consisted primarily of Koa/'Ohi 'a Montane Wet Forest (Gagne and Cuddihy, 1990), which corresponds to types 122 and 172 in the HFBS maps. These two species comprised much of the upper forest canopy in these areas, attaining heights of up to 25m. The mid-canopy in these plots was dominated by tree ferns, primarily the hapu'u 'i'i (*Cibotium menziesii*). Other common mid-canopy trees included hame (*Antidesma platyphyllum*), kolea (*Myrsine lessertiana*), 'alani (*Melicope clusiifolia*), and olapa (*Cheirodendron trigynum*). Most of these species were between 5 and 15m in height. Common native understory and shrub species included 'ohelo (*Vaccinium calycinum*), kanawao (*Broussaisia arguta*), 'ala 'ala wai nui (*Peperomia hypoleuca*), *Clermontia parviflora*, 'uluhe (*Dicranopteris linearis*), and numerous other ferns. Maile (*Alyxia oliviformis*) and 'ie 'ie (*Freycinetia arborea*) vines were common components of the forest at all locations. The koli'i (*Trematolobelia grandifolia*), a lobelioid that was previously thought to be relatively rare, was unexpectedly common at many sites within the Koa/'Ohi'a Montane Wet Forest. This species is listed by the U.S. Fish and Wildlife Service's Honolulu office as a "Species of Concern", a classification that has no legal definition with respect to protection but indicates a degree of rarity and threat. Wagner et al. (1990) noted that this species has been collected only twice since 1958.

As discussed above, although sampling focused on areas where koa was abundant, other notable plant communities included 'Ohi'a/'Uluhe Montane Wet Forest and Montane Wet Sedgeland (Gagne and Cuddihy, 1990), which correspond roughly to type 175 in the HFBS maps. These communities comprised either portions of some plots, or were encountered when traveling between plots. The 'Ohia/'Uluhe Montane Wet Forest likely encompasses more total acreage within the project lands than any other community. This community was characterized by dense mats of 'uluhe up to 15 feet thick, interspersed with relatively few 'ohi 'a trees and an occasional 'alani tree. Very few other plant species were encountered in this community. The Montane Wet Sedgeland community was common in relatively flat, poorly drained, areas adjacent to Montane Wet Forests. The native sedge (*Carex alligata*) was previously abundant in these areas (R. Warshauer pers. comm.), but disturbance by pigs has resulted in a community dominated by introduced species such as bog rush (*Juncus planifolius*), broomsedge (*Andropogon virginicus*), and carpetgrass (*Axonopus fissifolius*).

Species Composition

A total of 49 flowering plant species, including 31 Hawai'i natives, were identified within 32 plots surveyed in the proposed project area (***Fig. 5***). A single individual of the State and federally listed endangered "mintless mint" (*Phyllostegia velutina*) was encountered in plot 64. No other threatened or endangered flowering plant species were detected either within or between plots during the course of the survey. In addition, a total of 40 species of ferns or fern allies, including 37 Hawai'i natives, were identified within the 32 plots surveyed, none of which are threatened or endangered species (***Fig. 6***).

Distribution and Abundance

Species richness of native flowering plants (number of native plant species per plot) increased significantly with elevation ($F_{1,30}$ = 15.41, $P < 0.001$; (***Fig. 7***). There was no relationship between elevation and species richness of native ferns ($F_{1,30} = 1.11$, $P = 0.3$), nor between elevation and richness of alien species ($F_{1,30} = 0.18$, $P = 0.7$).

Frequency of occurrence of native flowering plants (number of plots in which a particular species was found, divided by the total number of plots surveyed) ranged from 0.03 – 1.0 for natives and from 0.15 - 0.87 for aliens (***Figs. 8-9***). The most frequently encountered native flowering plant species (found in > 90% of plots) were 'ohi'a, koa, 'ohelo, 'olapa, kawa'u (*Ilex anomala*), and 'alani. The most frequently encountered aliens were carpetgrass (87% of plots) and strawberry guava (81% of plots).

The density of 10 tree species attaining heights of 2m+ ranged from 0 trees/ac. (all species except koa) to 3337.0 trees/ac. for strawberry guava. Mean tree density was highest for strawberry guava (572.38/ac.), followed by 'ohi 'a (336.38/ac.) and hapu'u 'i'i (154.6/ac.; (***Fig. 10***).

There was a significant increase in tree density with elevation for four out of ten native tree species sampled (koa, $F_{1,27} = 5.0$, $P = 0.03$; olapa, $F_{1,27} = 17.86$, $P < 0.001$; kawa'u, $F_{1,27} = 6.20$, $P = 0.01$; kolea, $F_{1,27} = 15.56$, $P < 0.001$;(***Figs. 11-12***). There was no apparent

relationship between tree density and elevation for three native species ('ohi 'a, $F_{1,27} = 2.08$, $P = 0.16$; 'alani, $F_{1,27} = 0.35$, $P = 0.55$; manono, $F_{1,13} = 0.11$, $P = 0.73$;). In contrast, there was a significant decrease in density with elevation for hapu'u 'i'i, ($F_{1,27} = 15.69$, $P < 0.001$), hame ($F_{1,27} = 17.26$, $P < 0.001$), and strawberry guava ($F_{1,27} = 28.93$, $P < 0.001$; (***Figs. 13-14***).

Birds

Although the scope of this report does not include zoology, it is perhaps useful to note that all native and introduced bird species seen or heard within each plot were recorded by a qualified ornithologist during the eight days of plant surveys (***Fig. 15***).[1] One of the most striking biological aspects of the study area was the scarcity of birds. The endangered Hawaiian Hawk (*Buteo solitarius*) was observed flying above two of the highest elevation plots. No other endangered bird species were seen or heard during the course of the surveys. Three native passerine species were recorded: the 'Elepaio (*Chasiempis sandwichensis sandwichensis*), the 'Omao (*Myadestes obscurus*), and the 'Apapane (*Himatione sanguinea*). These three birds were rare to non-existent in the lower elevation plots and relatively rare where they occurred in the upper elevation plots. Four introduced species, the Japanese White-eye (*Zosterops japonicus*), the Red-billed Leiothrix (*Leiothrix lutea*), the Northern Cardinal (*Cardinalis cardinalis*), and the Melodious Laughing-thrush (*Garrulax canorus*), were the most widespread and abundant birds within the study area. All of these birds, with the exception of the Northern Cardinal, occurred across the entire range of elevations surveyed. Although the Northern Cardinal was not detected in the upper elevation plots, it is expected to occur there, as it is found within much higher elevation forests within Hakalau Forest National Wildlife Refuge. The detections of the Japanese Bush-Warbler (*Cettia diphone*) reported here are the first from this elevational range on the windward side of Mauna Kea (J. Foster pers. comm.). This introduced species has only recently colonized the Big Island, and is expected to become much more abundant in windward forests in the future.

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[1] All native and introduced bird species seen or heard within each plot were recorded. Special attention was paid to the possible presence of any State or federally listed threatened or endangered passerine species. No systematic listening protocol was observed, no effort was made to obtain estimates of bird density, nor were any nighttime surveys made to detect the presence of the threatened Newell's Shearwater (*Puffinus auricularis newelli*) or endangered Hawaiian Petrel (*Pterodroma phaeopygia sandwichensis*). Time spent per plot varied between 0.5 and 2.0 hours. In addition, birds were opportunistically surveyed when walking between plots. Although the methods reported here were not necessarily systematic, the accuracy of the results (presence-absence for a particular location) is likely high due to the large amounts of time spent within each survey location.

Conclusions of 2001 Survey

Native Plants

Based on the results of this study, a number of general observations may be made regarding the current structure and dynamics of the Koa/'Ohi'a Montane rainforest within the project site. First, this area would appear to harbor few threatened or endangered plant species. Despite intensive searches by botanists over an eight-day period both within and between sample plots, only one individual endangered plant was found. Similarly, the HFB surveys from the late 1970's identified only one endangered plant species - *Cyanea platyphylla* - and reported the presence of the endangered *Cyrtandra tintinnabula*, last seen in 1933. Of course, endangered plants are by their nature difficult to locate, and their absence from the surveys does not indicate they are not present within the project area. However, the expectation was that at least a few endangered individuals in genera such as *Cyrtandra*, *Cyanea*, *Phyllostegia* or *Clermontia*, all of which are known to occur at similar elevations along the windward Hawai'i coast, would be found. Cuddihy et al (1982) reported three endangered plant species (*Cyrtandra*, *Cyanea*, and *Phyllostegia*) encountered in forest at similar elevations approximately 10 miles to the north in Laupahoehoe Natural Area Reserve.

Second, the Koa/'Ohi'a forest was relatively homogeneous in terms of species composition throughout the project site. In general, species lists compiled from plots in the lower elevations of the study area looked very similar to species lists from the higher areas. These results were not unexpected because the elevational range represented in this study is not extreme. Similarly, Mueller-Dombois et al. (1981) found the forest at slightly higher elevations on Kilauea volcano to be "essentially homogeneous". The species composition of dominant trees in the canopy and sub-canopy zones is also similar between the two forests. 'Ohi'a, koa, kawa'u, and 'olapa were among the most abundant trees at both sites. However, 'alani, a dominant in the Koa Timber study area, was relative rare in the Kilauea study area. The dominant tree fern species also differed between sites (*Cibotium menziesii* vs *Cibotium glaucum*), possibly because *C. glaucum* grows better at slightly higher elevations.

While the forest is homogeneous in terms of species composition, there are many strong, and some unexpected, relationships between tree species abundance and elevation. The major expectation was that there would be an increase in abundance of most tree species with increasing elevation because of decreasing levels of disturbance. For koa, 'olapa, kolea, and kawa'u, these assumptions were valid, although the rationale may or may not be correct. Most interesting was the decline in density with elevation for hapu'u i'i and hame. The lower elevations apparently still represent better habitat, possibly in terms of rainfall or temperature, than do the upper elevations for these species. Also, hapu'u i'i and hame may be more efficient competitors with the more abundant introduced plants at lower elevations. The observation that hapu'u i'i reaches relatively high densities in areas of heavy guava infestation supports this latter idea.

Alien Plants

The most abundant alien plant, in terms of frequency of occurrence, was carpetgrass (***Fig. 9***). This species does not appear to be a major threat to the diversity and abundance of native plants within this forest because although it is widespread, it rarely dominates the vegetation in an area, nor does it appear to substantially prevent the germination or growth of most natives. However, these observations would benefit from controlled experimentation.

Strawberry guava was the second most frequently encountered alien plant species and is of greatest cause for concern because: 1) the fruit of this neotropical tree is known to be spread by pigs, which are ubiquitous throughout the project area, and 2) it can out-compete most native Hawaiian plant species over time wherever it occurs (Smith 1989). Alarmingly, this tree is already the most abundant, in terms of number of individuals per acre, of all tree species in the project area (***Fig. 10***). The current linear (and perhaps exponential) decline in guava density with elevation within the study area (***Fig. 14***), is a classic illustration of the incipient stages of a potential major invasion. The lower, more disturbed elevations in certain areas of the study site are already a near monoculture of this tree (with the exception of hapu'u i'i), and there is no known physical or biological mechanism (other than human intervention) that might prevent the further increase in density of this tree throughout the project area.

Tibouchina herbacea and *Clidemia hirta* were also common within the project area. Both of these Melastomes are known to be highly invasive. *Tibouchina* was among the most frequently encountered plant species during this study (present in 53% of plots), yet it only became established on the Big Island in the late 1970s (Wagner et al. 1990). *Clidemia* was present in fewer areas (15% of plots) but has a long history as a noxious weed throughout Hawaii and numerous other Pacific islands. Both *Tibouchina* and *Clidemia* can be expected to increase in abundance over time within the project area.

Setaria palmifolia is a highly invasive grass that was found within 50% of plots. In areas where it occurs, it forms a dense ground cover that appears to effectively inhibit germination and growth of most native plants. This grass may be spread by pigs and must be considered a significant threat to the native plant community in this area.

3 Impacts

The evaluation of impacts is based on the essential concepts as presented in the introduction: the project would use helicopters to log selected koa trees from certain areas of the forest. The stated goal is to practice logging in a sustainable manner, in which operations preserve important plant, animal or water resources, maintain the essential character and habitat value of the forest, and promote rapid regeneration of logged areas to their natural condition. Herbicide use would be minimal and confined to hand applications to control alien species only. No roads would be built in the CD, and logs would be milled on adjacent Agricultural District land formerly used for sugar cane cultivation.

This impact assessment should be considered preliminary in the sense that as additional data about the distribution of species, ecosystem dynamics, and the effects of logging are obtained; impact assessment will continue to evolve – as will, according to the project's stated goals, techniques to avoid or mitigate unforeseen impacts.

All conclusions regarding impacts must be interpreted in the context of substantial uncertainty, which derives from several sources:

- Incomplete knowledge of the resources of the area;
- The novelty of the helicopter harvesting and monitoring techniques that will be used to extract the timber and protect botanical resources; and
- The inherent difficulty of monitoring and confirming that mitigation measures have been accomplished and are effective.

The project has the potential to lead to the following adverse impacts:

- If logging areas are not properly selected and logging activities properly monitored, they may cause inadvertent damage to individuals of rare, threatened or endangered plant species from helicopter landings, ground activities, and treefall.
- If not actively mitigated, operations may induce the spread of alien plants around logged areas, through introduction of seeds or vegetative material, decrease of canopy shading, and alteration of the ground surface.
- If disturbed area expands and pigs' favored alien food sources increase in parts of the property not currently highly infested with pigs, the frequency of pigs may also increase. In addition to direct damage (e.g., feeding on hapu 'u starch, rooting up seedlings), pig damage also fosters mosquito increase, and associated avian malaria.
- Disturbance of the forest, direct feeding and littering may lead to increases in bird predators such as cats, rats and mongooses.
- If koa harvest of mature trees exceeds recruitment of younger trees, the size class distribution may change, leading to loss of bird, epiphyte and understory habitat. Furthermore, .the substantial reduction in the koa component of the forest would reduce any potential habitat value of the area for mauka-makai bird habitat corridors.
- If logging occurs adjacent to streams, sedimentation and treefall may harm the water quality of streams.
- Impacts to wetlands vegetation and habitat are possible, but likely to be minor. Project activities would not cause dredge or fill, and would also be unlikely to cause any measurable sediment, chemical or similar pollution. It should be noted that Section 404(f)(1)(A) of the Clean Water Act, which regulates activities that may affect waters of the U.S., states that, except where water circulation may be impaired or effluent standards violated, "the discharge of dredge or fill material" (which, in any case, is not an outcome of the project) "from normal farming, silviculture... activities such as...harvesting for the production of food, fiber, and

forest products...is not prohibited by or otherwise subject to regulation under this section..." This evaluation of few impacts assumes implementation of a program ensuring proper care regarding handling of fuels, herbicides and machinery during harvest, replanting, alien control and transport activities. Finally, it is important to note that the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency, which jointly administer Section 404, are ultimately responsible for determining whether impacts are likely.

The project has the potential to lead to the following beneficial impacts:

- Project activities aimed at suppressing aliens (particularly waiawi) to assist in koa regeneration could improve the quality of the forest.
- Project activities aimed at pig exclosure and eradication could slow or reverse the rate of forest ecosystem.

4 Mitigation

Mitigation recommendations are based fundamentally on the criteria of avoiding, reducing or compensating for identified adverse impacts. However, it bears repetition that a great deal of uncertainty is inherent in a new technology working in an area in which the biological resources are only partly understood. Because of this lack of certainty, the rationale for mitigation proposed here is broader than the above criteria and also incorporates the following:

- Effective monitoring measures supervised by an independent, outside body, and
- The requirement of the project to provide substantial, demonstrably beneficial impacts in the form of habitat enhancement.

Accordingly, recommended mitigation measures are as follows:

4.1 Advisory Committee

Koa Timber should set up a volunteer advisory committee of independent biological and forestry experts with a dedicated budget to assist it in accomplishing:

- Formulation and periodic re-evaluation of forestry and ecosystem management techniques.
- Monitoring of forestry and ecosystem data, to which the committee should have full and open access.
- Provision of access and assistance for scientists who want to conduct research on the Koa Timber lands. Opportunities for investigations of botany, ornithology, aquatic biology, meteorology, and other fields of study are considerable.
- Supervision of habitat enhancement programs (see Section 4.5).

4.2 Sustainable Forest Practices

In order to preserve the ecosystem values of the existing forest, the project should incorporate professional sustainable forest management. The following list is not intended as a prescription for sustainable forestry, but rather a sample of minimum standards focused on botanical resources:

- Harvest volumes over time should be carefully compared with seedling regeneration and recruitment of younger trees into larger size classes in order to preserve koa age structures and maintain a full range of stands from early regeneration to old growth. It should be recognized that many areas of the forest currently lack healthy stand structures and that balanced input/output will only be possible after sufficient regeneration and growth. Replanting/regeneration should be an integral part of the logging operation
- A key factor in monitoring should be the existing and future states of species diversity near harvest sites. Replanting/regeneration activities should take care to not disrupt and/or restore the original diversity of the native forest in both species and structure. Unnatural "plantation" uniformity should also be avoided because of the important role diverse species play in the overall ecological health of the forest, for nutrient balance, erosion prevention, and pest control.
- The spread of alien plant and animal species should be prevented at the outset by proper cleaning of clothing and tools prior to entering the forest and precautions to avoid littering with food products. Biological monitoring during and after harvest should inspect for and treat alien infestations, with special care for new records in sub-areas of the property. The techniques used to regenerate the forest and retard alien species spread should be developed through cooperation and consultation with the University of Hawai'i at Hilo, Hawai'i State Division of Forestry and Wildlife, the Hawai'i State Department of Agriculture, and silviculture operators, with the goal of developing the most appropriate methods for particular environments.

4.3 Harvest Areas

The following are recommendations for the harvest areas:

- Harvest areas for the first years of operation area should concentrate on low-sensitivity areas (in general, the makai half of the parcels). This should allow operators to test and perfect harvest methods in areas with less likelihood of encountering endangered plant species and disturbing intact ecosystems. These areas should be selected in consultation with the Advisory Committee.
- No harvesting should be allowed within a buffer zone makai of the Hakalau Forest National Wildlife Refuge, except as directly permitted by Refuge authorities, in order to avoid accidental intrusion into the Refuge.
- Stream buffers extending around the upper bank of streams should be established in order to avoid treefall into stream and any sedimentation.

4.4 Biological Monitoring

A program of biological monitoring should be an integral part of project activities:

- After the selection of trees for harvest, but before logging, biologists should perform air and ground inspections of trees to ensure that no endangered plant species or other sensitive botanical resources will be affected by logging. If found, their location and characteristics should be logged by GPS. If the potential to harm any such resources exists, the resource should either be protected during logging, or, as appropriate, the tree should not be logged.
- Logging crews should be trained to identify endangered species and other potentially sensitive biological resources during harvest activities, and should implement a protocol to report and protect such resources.
- After harvest, a continual routine of biological monitoring should chart not only koa regeneration but also the spread or retreat of invasive species, with inspection reports logged in the G.I.S.

4.5 Habitat Preservation and Enhancement Actions

The project, in close consultation with the Advisory Committee, should implement the following:

- Define a " no-logging" preservation corridor extending from the makai to the mauka border of the property of sufficient size to include substantial portions of the basic environmental zones. It would also provide a potential habitat corridor for native birds, and would preserve portions of nearly intact native forest in the mauka areas. This corridor could also be used to provide a control area in which to test the success or failure of management actions in adjacent areas.
- Construct systematic fenced pig-exclosures and conduct pig eradication within them in selected areas within high quality forests at roughly the 3,000-foot elevation. Such areas should enclose a minimum significant size and should be completed within a specified period of time after the granting of the permit. It is expected that the exclosure area should increase through time, as proceeds of the koa harvest can finance such growth.

4.7 Geographic Information System

In order to optimize monitoring, the project should input and maintain natural resources data and harvest and regeneration records in a project Geographic Information System (GIS). The State of Hawai'i GIS digital base maps should form the map foundation. These should be enhanced by layers representing U.S. Geological Survey topographical data and Hawai'i Forest Bird Survey (HFBS) maps habitat data. Logging operations and biological assessments and monitoring operations should employ Global Positioning System (GPS) units, and these points should be entered into the GIS along with their associated database records. Such records should be fully accessible to the Advisory Committee.

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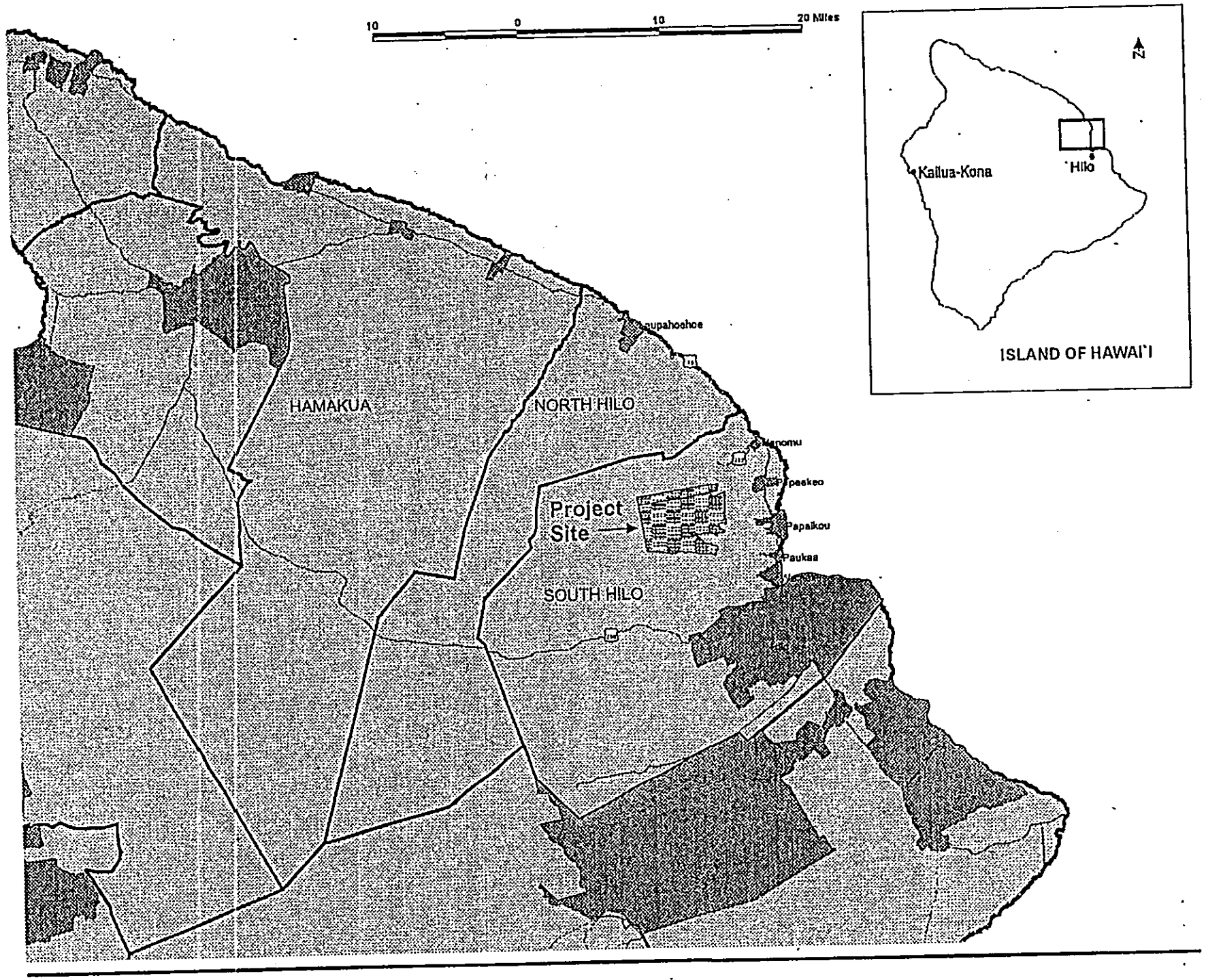
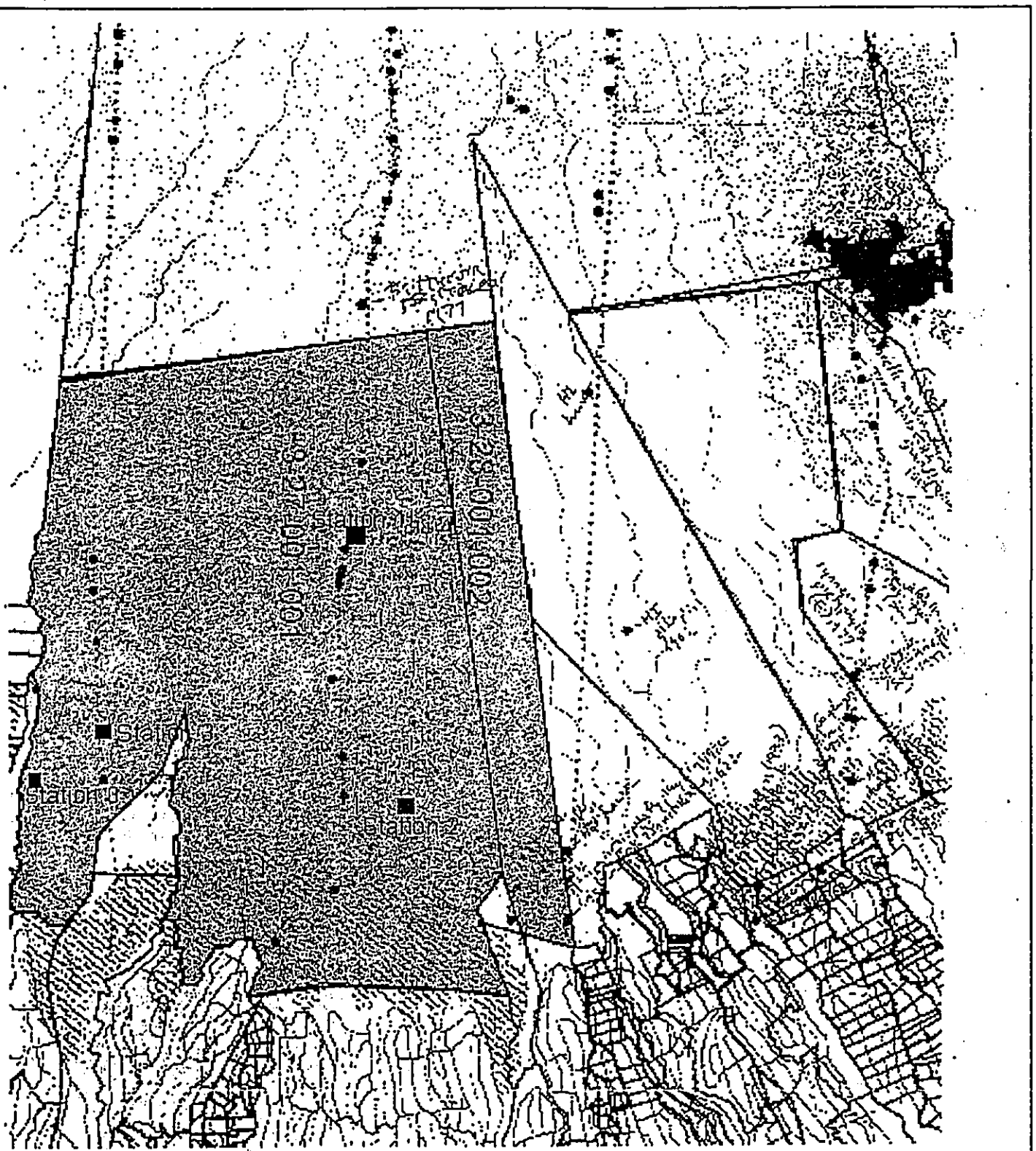


FIGURE 1: Location Map



Source: Wade Lee

	KOA TIMBER OPERATIONS	FIGURE 2
	Biological Transects and Survey Stations, 2000	

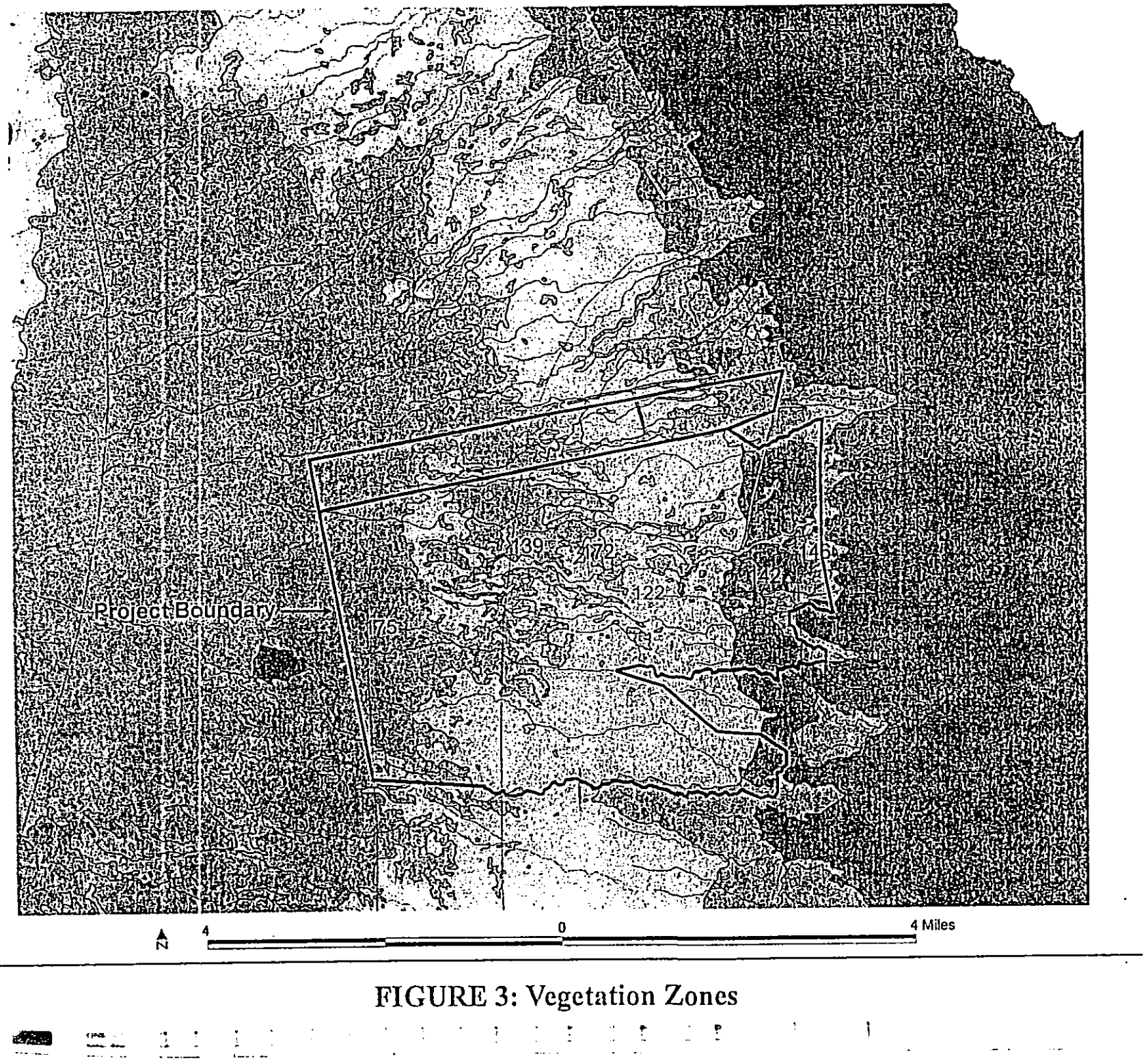


FIGURE 3: Vegetation Zones

Figure 4 2001 Timber/Botanical Survey Plot Locations

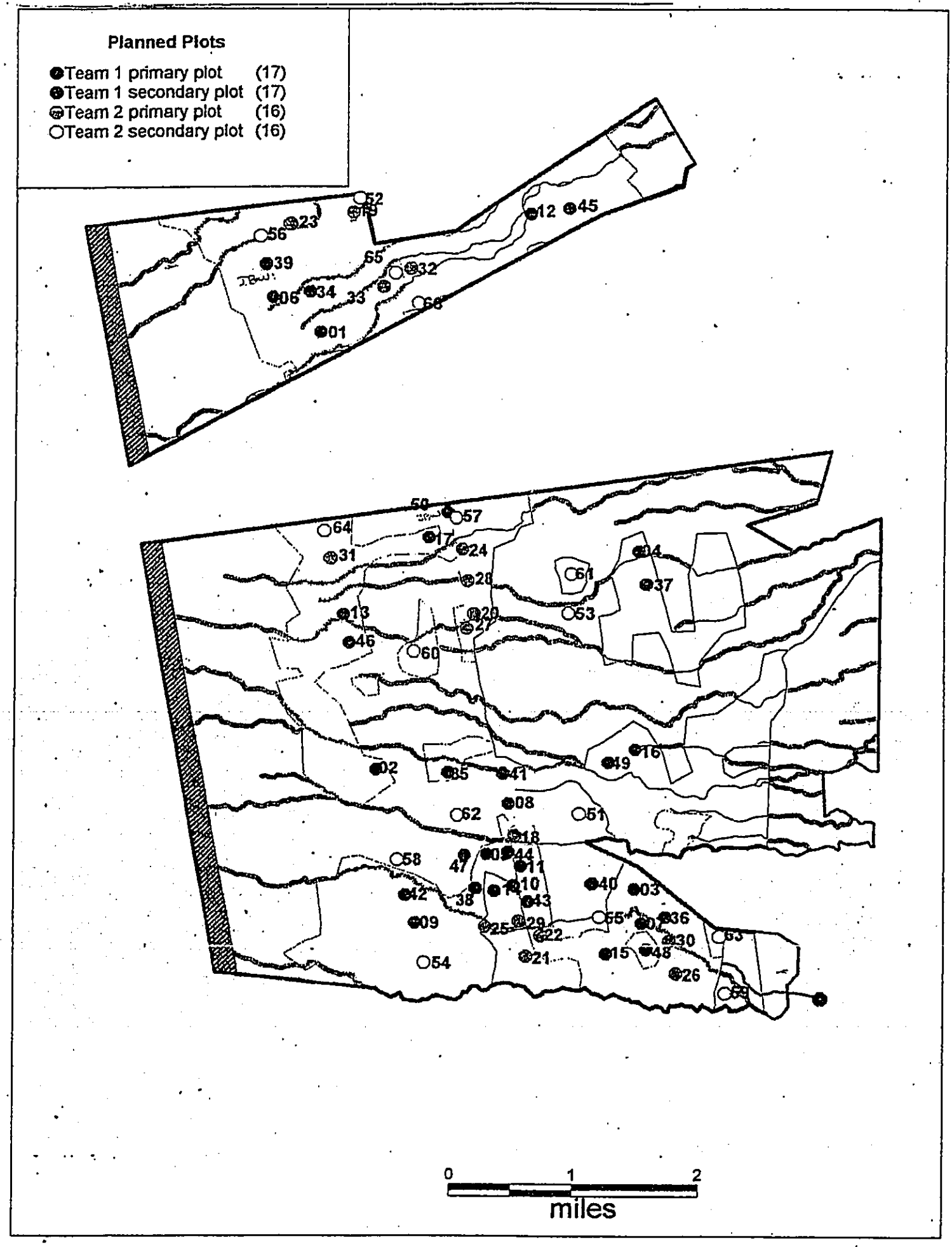


Fig. 5 Native and introduced flowering plants found within 32 plots surveyed on the Koa Timber parcel. * signifies native status

	Plot																														
Species	2	3	6	7	10	11	15	16	17	19	21	22	23	25	27	29	31	35	36	39	43	44	48	49	50	52	54	56	57	60	61	64
Acacia koa																																
Ageratum conyzoides			x																		x											x
Alyxia olivaeformis*																																
Andropogon virginicus		x											x																		x	
Antidesma platyphyllum*																																
Arundina bambusifolia								x				x		x						x											x	
Astelia menziesiana*																																
Axonopus fissifolius	x	x	x			x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x	x	x	x	x	x	x	x	x	x
Broussaisia arguta*																																
*Carex alligata													x															x				x
Cheirodendron trigynum*																																
*Clermontia parviflora	x		x	x	x	x	x	x			x	x		x		x					x		x				x		x		
Clidemia hirta																																
*Coprosma rhynocarpa								x													x											
Cuphea carthaginensis																																
*Cyanea pilosa	x																															
Cyperus haspan																																
*Deschampsia nubigena																													x			
Ehrharta stipoides																																
Erechtites valerianifolia		x			x			x		x		x	x		x				x				x			x	x	x		x	x	x
Freycinetia arborea*																																
*Hedyotis hillebrandii	x	x		x	x	x					x	x		x						x	x		x								x
Hedyotis terminalis																																
*Ilex anomala	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x
Isachne distichophylla																																
Juncus effusus			x							x										x							x				
Juncus planifolius																																
*Labordia hedyosmifolia													x				x															x
Melastoma candidum																																
*Melicope clusiifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x
*Melicope pseudoanisata																																
*Metrosideros polymorpha	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Myrsine lessertiana																																
*Myrsine sandwicensis	x		x		x	x			x	x			x	x	x		x	x		x	x	x			x	x	x	x	x	x	x	x
Nertera granadensis																																
Paspalum conjugatum	x	x	x											x		x		x			x											x
Peperomia hypoleuca																																
*Phyllostegia velutina																																x
Psychotria hawaiiensis*																																
Psidium cattleianum	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x		x	x	x	x	x	x			x	x		x	x		x
*Rubus hawaiiensis																												x				
Rubus rosifolius																																
Sacciolepis indica		x								x		x	x		x							x				x		x	x	x	x	x
Setaria palmifolia																																
*Smilax melastomifolia	x												x		x												x		x		•	x
Styphelia tameiameiae*																																
Tibouchina herbacea		x	x	x	x	x	x				x	x		x	x	x			x		x		x				x			x	x	
Treinalobelia grandifolia*																																
*Vaccinium calycinum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x

Fig. 6 . Native and introduced ferns found within 32 plots surveyed on the Koa Timber parcel. * signifies native status

	Plot																															
Species	2	3	6	7	10	11	15	16	17	19	21	22	23	25	27	29	31	35	36	39	43	44	48	49	50	52	54	56	57	60	61	64
*Adenophorus hymenophylloides	x	x	x	x		x	x		x			x	x			x	x	x		x	x		x		x	x		x		x	x	x
*Adenophorus pinnatifidus																																
*Adenophorus tamariscinus	x		x	x	x		x							x		x	x	x		x	x	x	x		x			x		x		x
*Adenophorus tripinnatifidus																																
Angiopteris evecta																			x		x											
*Asplenium contiguum																																
*Asplenium normale			x	x		x	x			x	x	x		x		x		x		x	x		x	x		x	x	x		x		x
*Athyrium microphyllum																																
*Callistopteris baldwinii								x				x		x	x		x			x									x	x		
*Cibotium glaucum																																
*Cibotium hawaiiense			x				x						x							x	x		x					x				
*Cyrtomium menziesii																																
Deparia petersenii								x																								
*Dicranopteris linearis																																
*Diplazium sandwichianum																						x										
*Dryopteris fuliginosa																																
*Dryopteris glabra			x																	x								x				
*Dryopteris unidentata																																
*Elaphoglossum crassifolium	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x	x		x		x	x	x	x	x	x	x	x
*Elaphoglossum hirtum																																
*Grammitis tenella	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
*Lepisorus thunbergianus																																
*Lellingeria saffordi				x								x	x			x	x			x		x				x		x		x		x
*Lycopodiella cernua																													x			
*Huperzia phyllantha				x	x		x																									
*Huperzia polyticheides																																
*Huperzia serrata																x													x		x	
*Metzgeria furcata																																
*Nephrolepis cordifolia	x	x		x	x	x	x		x	x	x	x	x	x		x			x	x	x				x				x			x
*Nephrolepis exaltata																																
*Ophioglossum pendulum		x		x		x	x	x		x	x	x		x		x			x	x	x	x	x	x		x	x	x	x	x		
*Pleopeltis thunbergiana																																
*Psilotum nudum																						x	x	.		x		x				
*Psilotum complanatum																																
*Pteris cretica												x				x			x									x				
*Sadleria pallida																																
*Sphaerocionium lanceolatum		x	x	x	x	x	x	x	x	x		x	x	x	x	x	x		x		x		x	x		x	x	x	x	x	x	x
*Sphenomeris chinensis																																
*Sticherus owyhensis									x											x												
*Vandenboschia cyrtotheca																																

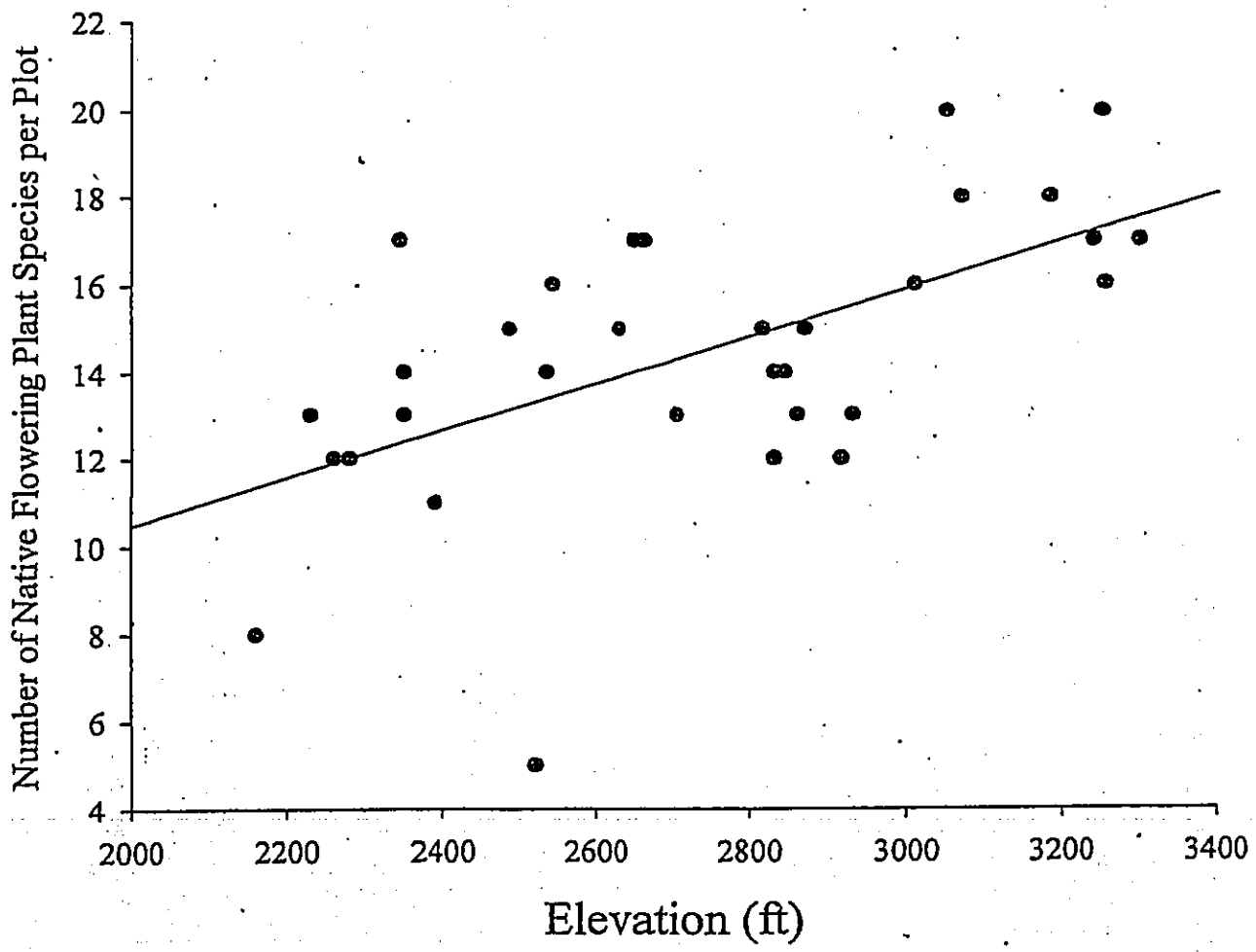


Figure 7. The relationship between the number of native flowering plant species per plot and elevation.

Fig. 8. Native flowering plant frequencies within 32 plots surveyed.

Species	*Frequency*	*Species*	*Frequency*
*Acacia koa	1.0	*Freycinetia arborea	0.37
*Metrosideros polymorpha	1.0	*Styphelia tameiameiae	0.34
*Vaccinium calycinum	0.96	*Isachne distichophylla	0.28
*Melicope clusiifolia	0.93	*Smilax melastomifolia	0.18
*Ilex anomala	0.93	*Carex alligata	0.09
*Cheirodendron trigynum	0.93	*Labordia hedyosmifolia	0.09
*Astelia menziesiana	0.87	*Coprosma rhyncocarpa	0.06
*Peperomia hypoleuca	0.84	*Cyanea pilosa	0.03
*Myrsine lessertiana	0.78	*Deschampsia nubigena	0.03
*Antidesma platyphyllum	0.78	*Hedyotis terminalis	0.03
*Myrsine sandwichensis	0.68	*Melicope pseudoanisata	0.03
*Hedyotis hillebrandii	0.66	*Nertera granadensis	0.03
*Broussaisia arguta	0.53	*Phyllostegia velutina	0.03
*Trematolobelia grandifolia	0.53	*Psychotria hawaiiensis	0.03
*Clermontia parviflora	0.46	*Rubus hawaiiensis	0.03
*Alyxia oliviformis	0.40		

Fig. 9. Alien flowering plant frequencies within 32 plots surveyed

Axonopus fissifolius	0.87
Psidium cattleianum	0.81
Cyperus halpan	0.75
Tibouchina herbacea	0.53
Setaria palmifolia	0.50
Erechtites valerianifolia	0.46
Sacciolepis indica	0.31
Juncus planifolius	0.31
Paspalum conjugatum	0.25
Rubus rosifolius	0.18
Clidemia hirta	0.15
Arundina bambusifolia	0.15
Juncus effusus	0.12
Cuphea carthaginensis	0.12
Ageratum conyzoides	0.09
Ehrharta stipoides	0.09
Andropogon virginicus	0.09

Fig. 10. The minimum, maximum, and mean (± SD) number of individuals per acre for the 10 most abundant tree species sampled within the study area.

	Koa	Ohia	Hapuu	ʻAlani	Olapa	Kawaʻu	Kolea	Hame	Manono	Guava
Minimum	4	32.0	0	0	0	0	0	0	0	0
Maximum	125.0	800.0	456.0	418.0	412.0	100.0	131.25	150.0	100.0	3337.0
Mean	**49.93**	**336.38**	**154.6**	**100.51**	**94.55**	**23.30**	**23.25**	**29.28**	**14.16**	**572.38**
SD	25.93	200.40	148.07	97.55	101.18	24.19	34.59	40.33	26.14	896.61

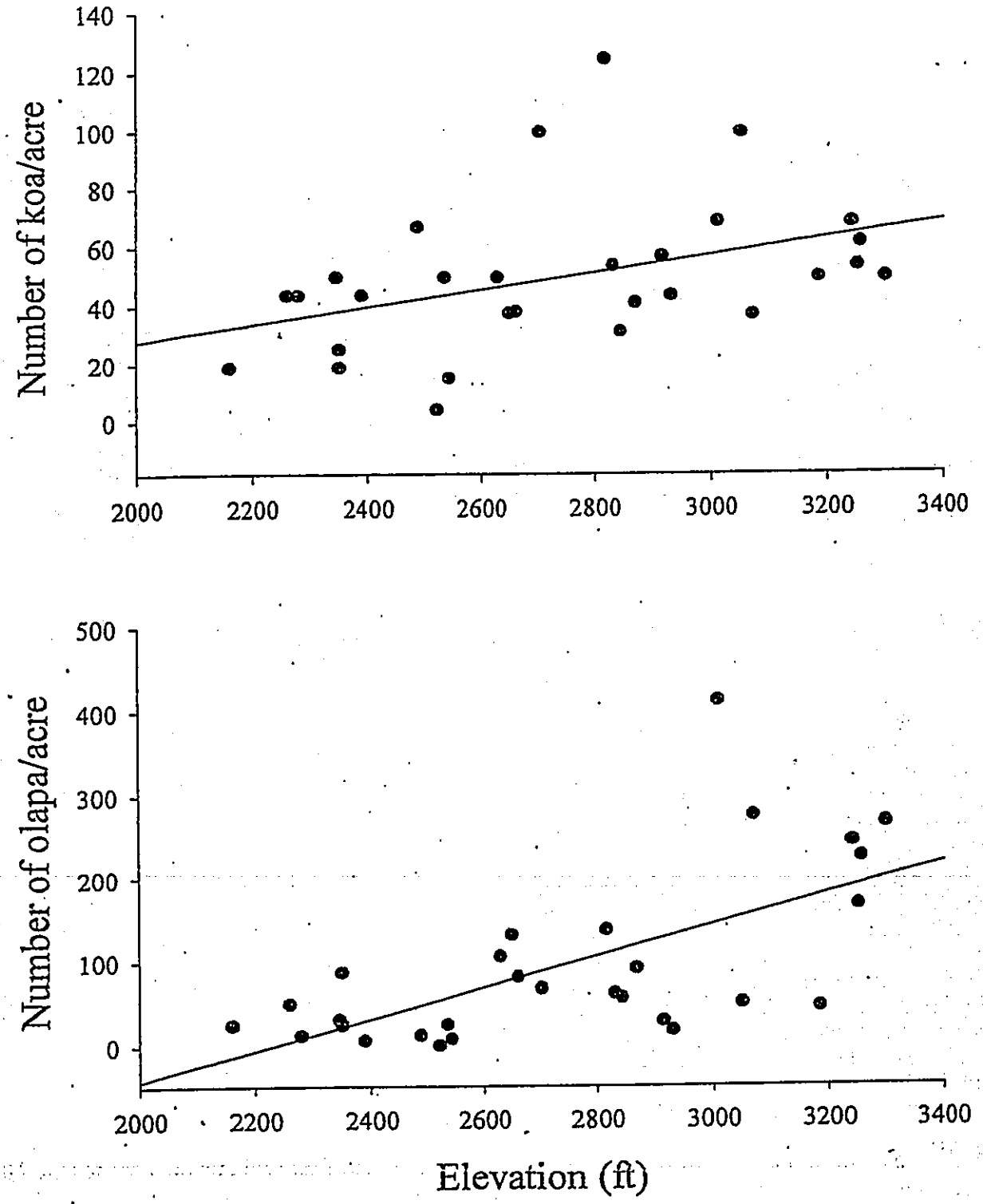
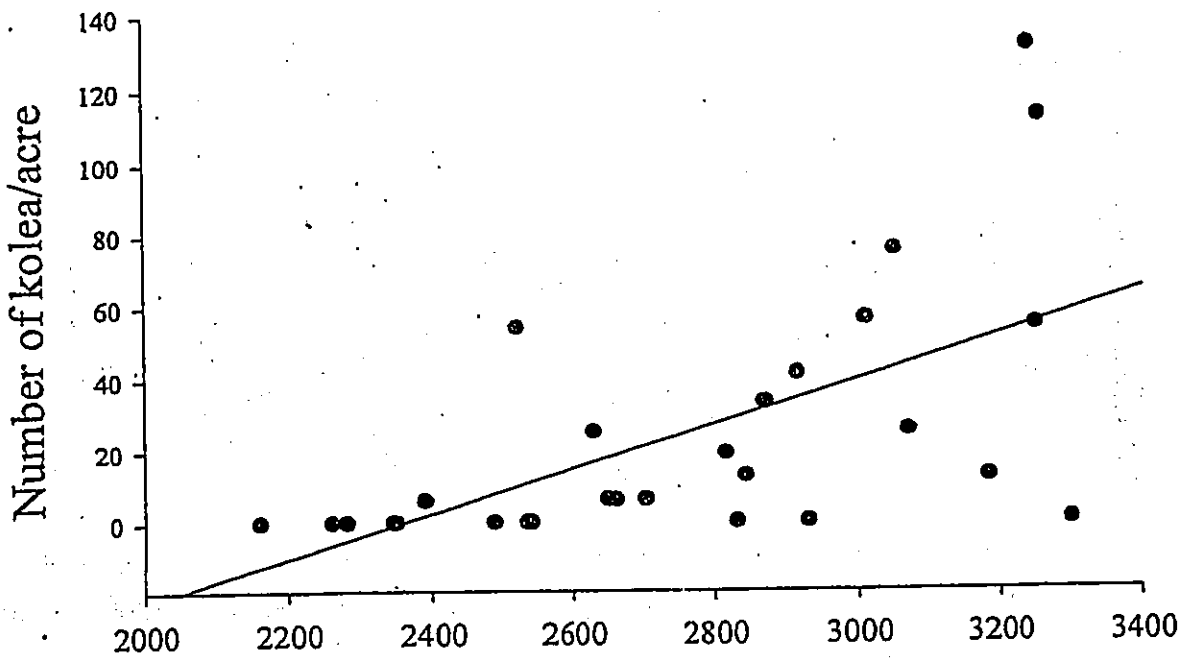


Fig. 11 The increase in koa density and olapa density with elevation.



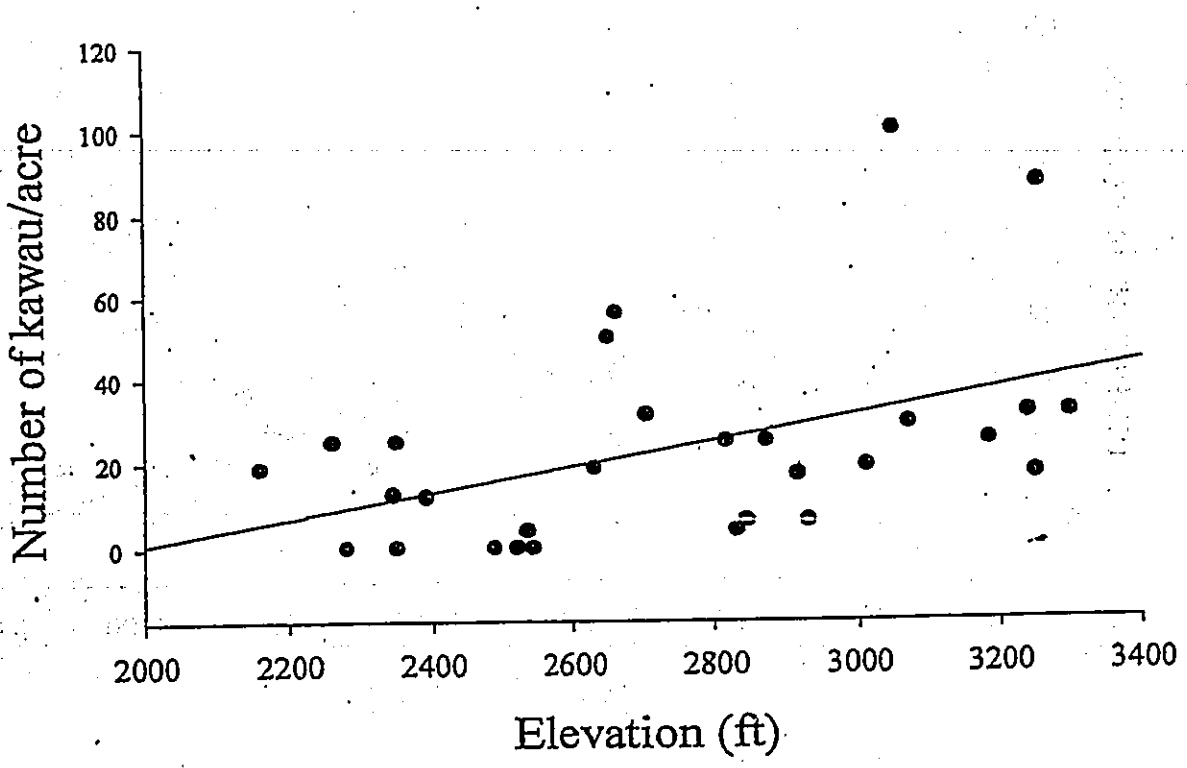
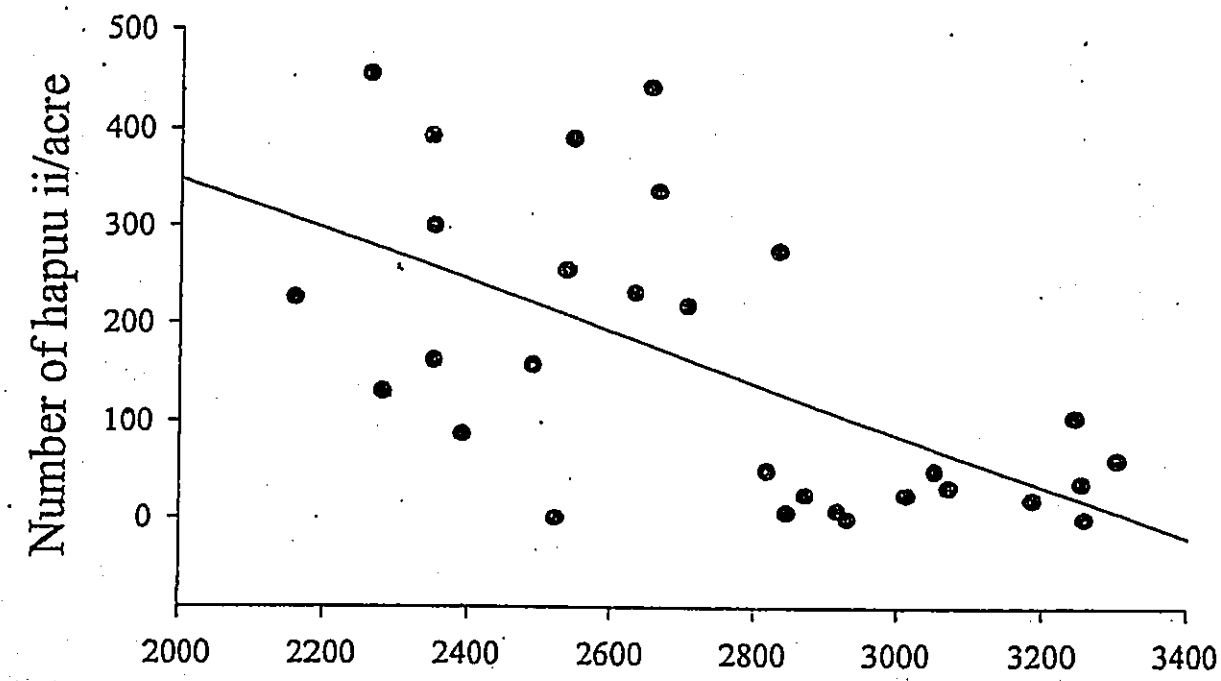


Fig. 12 . The increase in kolea density and kawau density with elevation.



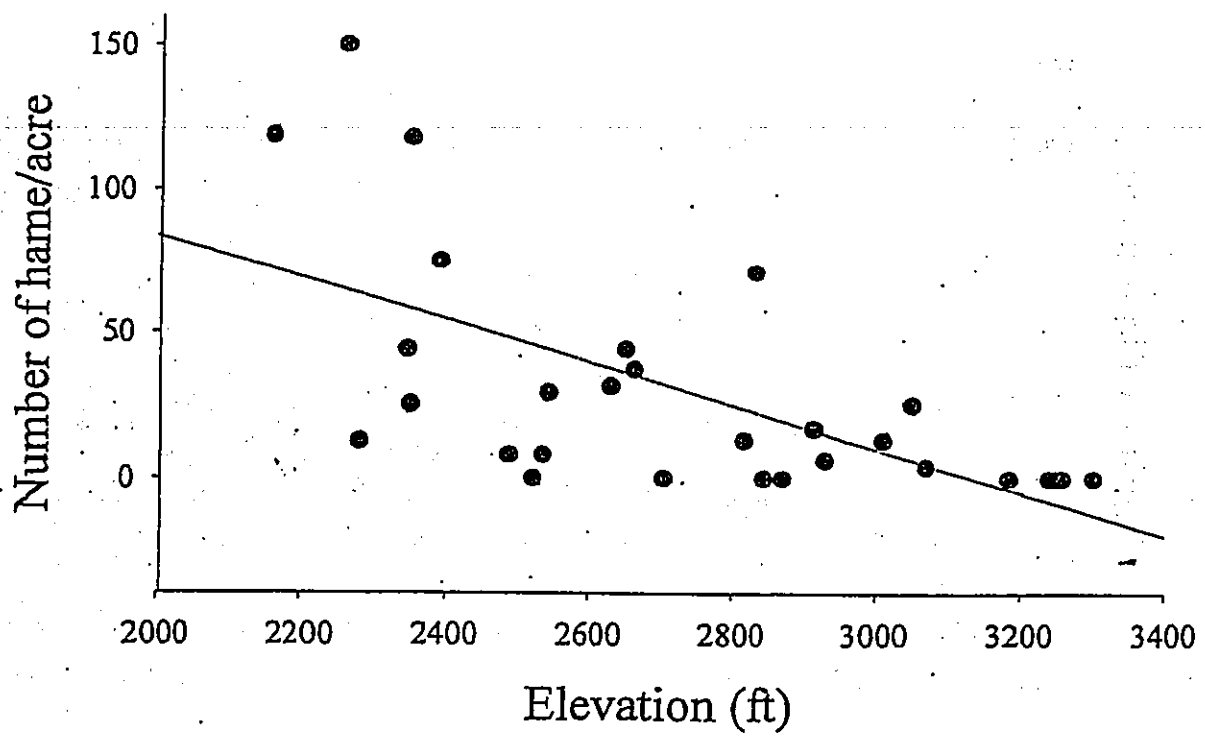


Fig. 13 The decrease in hapu'u i'i density and hame density with elevation.

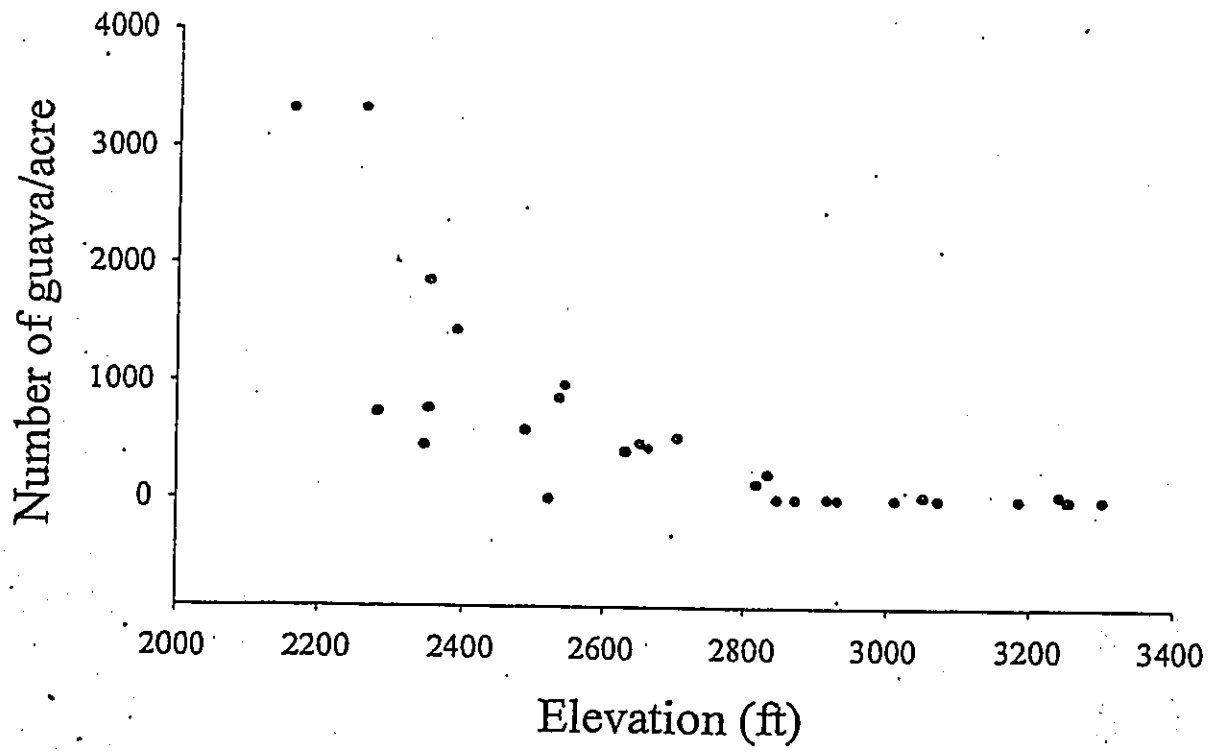


Fig. 14 The relationship between strawberry guava density and elevation.

Fig. 15. Bird species seen or heard in the vicinity of 18 plots within the study area. * signifies native species

Species (Common name)	Plot # and Elevation (ft)																	
	36 (2160)	48 (2230)	7 (2260)	3 (2280)	43 (2345)	15 (2350)	11 (2350)	49 (2390)	10 (2630)	11 (2650)	44 (2704)	57 (2830)	50 (2844)	35 (2860)	17 (2930)	2 (3050)	39 (3240)	6 (3300)
Zosterops japonicus Japanese White-eye	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Leiothrix lutea Red Billed Leiothrix	x	x	x	x	x		x	x	x	x	x	x				x	x	x
Garrulax canorus Melodious Laughing Thrush	x			x	x											x		x
Cardinalis cardinalis Northern Cardinal			x	x	x		x	x		x	x							
Cettia diphone Japanese Bush Warbler	x											x	x		x		x	x
**Chasiempis sanwichensis* *Elepaio					x										x	x	x	x
Lophura leucomelana Kalij Pheasant									x								x	x
**Myadestes obscurus* Omao														x				x
**Himatione sanguinea* Apapane																	x	x
**Buteo solitarius* Hawaiian Hawk ('Io)																	x	x

Appendix D

Survey of Terrestrial Invertebrate Resources

Survey of Terrestrial Invertebrate Resources (Insects, Mollusks, and other Arthropods), mid-slope Mauna Kea, South Hilo District, Island of Hawai'i

October 23, 2002

Submitted to
Koa Timber, Inc., Honolulu, Hawai'i

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Killer Caterpillar
(*Eupithecia* new species #8)

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INTRODUCTION

Koa Timber, Inc. proposes sustainable koa log harvesting limiting impact upon the native forest ecosystem. The proposal for minimum impact koa harvesting is an interesting alternative to traditional logging practices. Koa Timber Inc. is wise to consider the invertebrate fauna in assessing the impact of their project on the forest. Entomologists estimate that *Acacia koa* has more endemic insects attached or dependent on it than any other tree (Swezey 1954:1). Adult Kamehameha butterflies (*Vanessa tameamea*) use the sweet, yeasty sap of koa as a source of nourishment (Weber 1936). Native bees (*Hylaeus anomala*) and other insects visit the koa flower for nectar (Williams 1927:427). Some insects use koa resources rarely or in only one life stage. Conversely, many insects associated with koa use only native Acacia as their host. Those insect - plant relationships are extremely ancient and intertwined (Swezey 1925).

The scope of work for this element of "Koa Timber Commercial Forestry Operations Draft Environmental Impact Statement" is to conduct a field survey of terrestrial invertebrate resources with emphasis on native species, especially any having legal status under the Endangered Species Act and listed by the U.S. Fish & Wildlife Service (USFWS). Additional tasks included a review of relevant literature and preparation of this report. The initial survey was conducted by Steven Lee Montgomery, Ph. D. with coordination by Wilson Okamoto & Associates, Inc. The final draft report was coordinated by PlanPacific, Inc.

GOALS OF SURVEY

In koa bearing lands effort was focused on location and identification of rare, threatened, endangered, and endemic or indigenous 'keystone' species. For example, native *Drosophila* or pomace flies, which are among several USFWS Species of Concern, are an overall indicator of forest vigor. Terrestrial invertebrate resources include insects, spiders, amphipods, and snails, among others.

Healthy native Hawaiian invertebrate populations depend mostly upon host plant availability and the absence or low levels of alien predators. Consequently, botanical resources and alien invertebrates were noted during the survey. The survey also sought invertebrates that could present a health risk to project personnel (*e.g.*, western yellow jacket wasps).

Bishop Museum staff conducted an aquatic organism survey of the area. Their findings indicate a rich aquatic invertebrates community (Englund, et al. 2002).

GENERAL SITE DESCRIPTION

The two plots in the project area are portions of the land sections of Makahanaloa, Onomea, Alakahi, Pu'u Moi, Aleamai, Päpa'ikou, and Pauka'a, South Hilo District, Hawai'i Island (TMK 3rd/2-7-01:01 and 2-8-01:02). They cover an area of approximately 13,129 acres ten miles north of Hilo, Hawai'i. Bordering forests and upslope habitat are Hakalau Forest National Wildlife Refuge to the west and Hilo Forest Reserve (State of Hawai'i property). See **Figure 1** (pg. A 1).

PREVIOUS SURVEYS

A search of library resources shows no published invertebrate surveys or studies of the specific area. Snail surveys have been conducted in areas around the project site (Hadway and Hadfield 1999), but not within it. Historical biological collection location data are often not exact enough to determine if a particular specimen came from within the project area.

F. R. Warshauer conducted a corridor walk-through of the project area in 1978, but did not make invertebrate collections. (personal communication).

METHODS

Field surveys were conducted between January 7, 2002, and February 10, 2002. A reconnaissance was conduct November 19, 2001, with 6 hours on the ground, including a hike to nearby fan palms. During the survey, generally representative locations were chosen within the limitations of time and the helicopter's ability to land. Forest type and apparent plant inventory were considered in making site decisions to adequately represent different ecosystems. All sites were reached by helicopter.

Many Hawaiian insects that live in rain forest habitats time their emergence and breeding to overlap or follow the wettest season to coincide with growth spurts in their food plants. During the surveys, winter weather was between "kona storm" fronts of heavy down pours with low moonlight nights presenting good collecting opportunities.

The survey included visual and auditory identification of vertebrates. Invertebrate searches[1] were conducted during 10 days using visual identification, day and night sampling of invertebrates. Techniques used included:

- baiting
- trapping
- fogging
- beating
- visual inspection of potential host plants and resting sites
- removing bark
- sweeping with net
- turning over stones and logs

Light trapping of invertebrates using an electric generator and a mercury vapor bulb was conducted for 6 nights.

[1] **Appendix 2** describes search methods.

A survey of insects abroad at night is vital to a complete record of the fauna. Many insects are only active at night to evade birds, avoid desiccation and high temperatures, or access food sources like night opening flowers. Light assisted nocturnal collecting is most important where streambanks and other nearly inaccessible sites shelter intact native ecosystem including invertebrates.

The schedule for **fieldwork and general observations** are described below.
See **Figure 2** (pg. A 2) for collecting locations within the project area.

Site L - 1
November 19, 2001
Hawai'i, South Hilo, South Honoli'i, elevation 3000 ft.

A familiarization day-trip (approximately 8 hours) was made to plan fieldwork. Visual searches included examination of a *Tetraplasandra meiandra*, and 3 decomposing *Pritchardia* palm trunks, and under tree bark. Pig damage to fruits was apparent.

Site P - 1
January 7-8, 2002, and 6 night hours
Hawai'i, South Hilo, Pauka'a, elevation 2000-2300 ft

The forest consisted of mostly native koa (*Acacia koa*) with strawberry guava (*Psidium cattleianum*) as the dominant alien. Small amounts of Koster's curse (Clidemia hirta) were seen. Native plants included häpu'u tree fern (*Cibotium glaucum* and *C. chamissoi*), alani (*Melicope*); 'olapa (*Cheirodendron trigynum*); hame (*Antidesma platyphyllum*); 'ohi'a lehua (*Metrosideros polymorpha*), uluhe ferns (*Dicranopteris* sp.), and 'ie'ie (*Freycinetia arborea*). The 'Io, Hawaiian hawk (*Buteo solitarius*) was observed; the alien Japanese white-eye (*Zosterops japonicus*) was heard. **Rats and pigs were observed or heard at this and all other sites.**

I surveyed invertebrates on living young and mature koa trees, including under bark, on trunks, and leaves. I examined leaf litter, rotting wood, dead and dying trees. I swept with net or beat leaves and foliage. I used baits to attract native Drosophila. At night, the insect fauna was sampled using a UV bulb and sheet, a pattern repeated at each location.

Site O - 1
January 13-14, 2002, and 10 night hours
Hawai'i, South Hilo, Mauka of Onomea, upper Päpa'ikou, elevation 3000 ft.

The forest consisted of mostly native koa, with only a small percentage of strawberry guava. Native plants included - hapu'u fern, alani, 'olapa, hame, 'ohi'a lehua, 'ie'ie, uluhe fern, one *Trematolobelia*, one loulu palm (*Pritchardia* sp.). Birds seen or heard included the native 'Apapane (*Himatione sanguinea*), 'Oma'o (*Myadestes obscurus*), and 'Elepaio (*Chasiempis s. sandwichensis*), and the alien Red-billed Leiothrix (*Leiothrix lutea*), and Melodious Laughing-thrush (*Garrulax canorus*). Also observed were rat sign and feral cat scat.

In addition to collecting methods described above, a small can of pyrethrum spray was used to fog for insects on 2 mossy logs and epiphytic foliage.

Site O - 2
January 14-15, 2002 (4:00 p.m. - 12:00 noon)
Hawai'i, South Hilo, Onomea, 100 yd. south of cone, elevation 2200 ft.

This mostly native forest is wetter than other locations, has lesser amounts of alien strawberry guava and *Tibouchina herbacea*. The native plants included tree fern, alani, 'olapa, hame, 'ohi'a lehua, 'ie'ie, one *Trematolobelia*. Tree ferns showed evidence of rats chewing on fronds. The uluhe fern is very thick and tall making it harder to negotiate access. Birds seen or heard included the alien Northern Cardinal (*Cardinalis cardinalis*), Japanese white-eye, and Melodious Laughing-thrush.

Site H - 1
February 7-8, 2002 and 8 night hours
Hawai'i, South Hilo, Honoli'i, elevation 3200 ft.

The forest was a typical native koa forest. The Hawaiian 'Apapane, and 'Oma'o were heard as was the Japanese white-eye. I observed evidence of rats, pigs (ferns eaten, rooting for worms, chewing on sedges and 'ie'ie).

Site O - 2
February 8, 2002, 13 night hours only
Hawai'i, South Hilo, Onomea 100 yd. south of cone, elevation 2200 ft.

A prior sampling visit on January 14, 2002, was not complete due to the strong undergrowth that impeded progress to the rim of the cone. At night the insect fauna was sampled using a UV bulb and sheet. No birds were seen, but a Barn owl (*Tyto alba*) was heard. The strong undergrowth, particularly uluhe ferns, again prevented full exploration and made this a frustrating site. The area is, however, important due to the extremely different geological characteristics compared to surrounding lava fields (extremely old, ashy, eroding scoria cone) that can be expected to yield a differing invertebrate fauna on flora not adequately sampled at the other sites.

Site K - 1
February 9, 2002
Hawai'i, South Hilo, Kapue, elevation 2900 ft.

The forest was a koa -'ohi'a mix. A fruiting *Trematolobelia* plant was examined. Nearby was a sterile *Clermontia* sp. (no flower or fruit) for which species could not be determined. Both rare plants were surviving despite pigs in the area due to their location atop a 10 ft. diameter 'ohi'a tree trunk fork. Having sprouted in this pocket, they live epiphytically above the level where pigs' rooting can topple them. Rats advertised their presence by chewing into my fly bait (plastic banana baby food container).

In addition to collecting methods described, a pyrethrum spray was used to fog for insects.

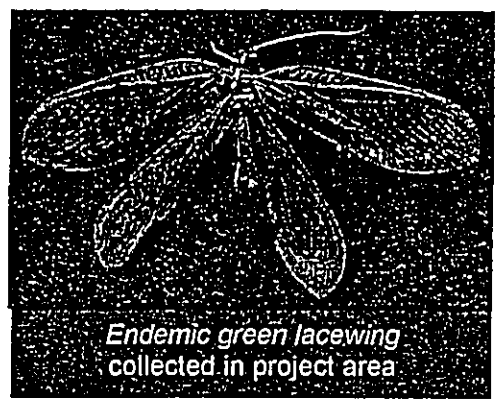
RESULTS
Table 1 (pg. A 3) lists all invertebrates (insects and other arthropods, snails and slugs) encountered and identified to date.

SPECIES OF INTEREST
ARTHROPODA
Homoptera - *Acizzia* (*Psylla*) *uncatoides*

Recovered in my survey was the alien acacia psyllid, *Acizzia uncatoides* (jumping plant louse). This insect sucks sap from the newest growth on *Acacia* genus plants.

Although there are records of large infestations of this pest, their numbers appear to be controlled by predator insects. Massings are reported in 1970 and 1971, (Beardsley 1971a, 1972) and a "light to moderate build-up" was reported in 1976 (Davis 1979). The damage can be severe enough to cause die-back of the young terminal growth in individual trees (Beardsley 1972), but the attacks do not generally cause the death of trees and do not affect many thousands of acres as do the *Scotorythra* (See pg. 8).

There are several predators which now give biological control of this pest (Leeper and Beardsley 1976) including an **endemic green lacewing**, *Anomalochrysa hepatica*, an alien brown lacewing, *Hemerobius pacificus*, and a syrphid fly, *Allograpta obliqua* (Beardsley 1971a, b), and the purposefully introduced Australian coccinellid beetle, *Harmonia conformis* (Leeper and Beardsley 1975). In the event of a massing of these alien pests, consultation with state DOA entomologists is advised.


Endemic green lacewing collected in project area

Coleoptera - Beetles - Cerambycidae or long-horned woodborers:
In the study area, **evidence was found of all three native genera of cerambycid beetles**. They are termed "long-horned" because most species sport extraordinarily long antennae (to help in sniffing out just the right location for egg laying). Females lay their eggs by boring into wood with a specially adapted ovipositor. Eggs are deposited into solid wood or just under the bark depending on a species' favored location. For protection, the larvae feed below the bark, leaving long flat grooves or tunnels under the bark or in the sapwood. The grubs seldom go deep into the living tree, except the *Megopis* in older trunks, and appear to do little damage to harvestable timber. Adults feed little, depending on stored fat from the larval stage.

These beetles are the mulching machines of the forest. The grubs reduce dead or dying trees to small bits of frass that eventually land on the forest floor, where it rots, releasing stored nitrogen to nourish existing plants and new growth of future koa forests. Additionally, in shallow volcanic soils, humus serves to hold moisture and promote new growth.

Parandra puncticeps killed by *Beauveria*

There are no records of these beetles massing or destroying large areas of koa forest. Generally, parasites and pathogens act to control the size of the beetle populations. Naturally occurring controls include insect pathogenic fungi such as *Beauveria.*

In the higher forest refuges, beetle grubs are also a nutritious food source for native birds such as the endangered 'Akiapola'au *Hemignathus munroi.* The bird's bill is especially suited to opening bark and skewering and removing beetle grubs. Long-time bird observers, R. C. L. Perkins, George C. Munro, and Andrew Berger (1972:145-146), all report field observations of the bird on search-and-eat missions in koa forests. The 'Akiapola'au is found upslope from the study area in the Hakalau Forest National Wildlife Refuge.

Parandra puncticeps* and *Megopis reflexa

Parandra and *Megopis* are monotypic, meaning there is only one species in each genus throughout their range. These two large, native beetles are found on all the main Hawaiian Islands and feed in many native trees, but their grubs rarely are found in healthy, living trees. Their usual home is in dead, standing trees, and fallen, rotting logs. Although found in koa, both grubs also are found in several other native trees: *Psychotria*, *Myrsine*, *Myoporum*, *Pipturus*, *Metrosideros*, *Elaeocarpus*, and *Pelea* (Swezey, 1954:11). In the survey area, these beetles or their grubs and tunnels were in a broad range of host plants, including *Acacia koa*, *Metrosideros,* and a dead *Pritchardia* palm trunk.

Plagithmysus

The third native genus of Cerambycid beetles is *Plagithmysus*, a puzzle of evolution. Where *Parandra* and *Megopis* have one species each throughout the island chain, the 140 *Plagithmysus* species are each island specific (monoinsular). Yet all are descended from a single ancestor. Each keeps to its specific food plant by instinctive behaviors, and so ensures species do not interbreed. Legumes, mostly koa, are the host plant for several species of *Plagithmysus.* Eggs are laid only in damaged or dead wood, giving off just the right scent (those long antennae smell their way to the right location).

In the survey area, distinctive tunnels of *Plagithmysus* sp. grubs were seen. No adults were collected or observed. They do not come to lights or baits and are well known as difficult to locate. Dr. J. L. Gressitt (1978:145) wrote: "Scarcity of adults has been noted by all field workers. Many entomologists long in Hawaii have never observed a plagithmysine beetle in the field. Sharp [1900] and Perkins [1896, 1921, etc.] have remarked at length on this." Consequently, not encountering them in this short survey period is typical of their reclusive behavior.

Lepidoptera - butterflies and moths
Koa is host to at least 36 species of Lepidoptera (British Museum: HOSTS), including many obligatory species. See **Table 2** (pg. A 10) for a listing.

Scotorythra sp.

Koa canopy defoliating by Lepidoptera:
Among the species collected was *Scotorythra paludicola.* Historically, this caterpillar, and closely related species, may experience massive buildups within the koa forest, defoliate thousands of acres of trees, and be feasted upon by predators. In the 1890s, Dr. R. C. L. Perkins recorded several of the buildup and crash cycles. As an exploratory zoologist and founding scientist of the Entomology Section of Hawaiian Sugar Planters' Association Experiment Station, Perkins' experience with the whole fauna in Hawaiian forests made him an ideal observer.

Dr. Perkins wrote: "In the early days of my collecting, I saw the koa trees stripped almost every year in one locality or another. In 1892 the trees of the wet belt in Kona - presumably by [S.] *idolias*...; .... in 1894 and 1895 the Haleakala forest of koa, 4000-5,000 ft, was stripped for miles by [S.] *paludicola*; and in the latter year also all the dry koa forest near Kilauea (as also again in some later years) by *idolias*, though there may have been some *paludicola* also. In 1895 or 1896 all the koas at 3,500 feet were again stripped in Kona. In 1900 the koa trees on Tantalus were many of them quite stripped..." (Perkins 1926)

Insect buildup and defoliating of forests was also reported from O'ahu, Maui, and Hawai'i in 1926, 1946, 1953, 1965, 1978, 1982-1983. (Davis 1955; Swezey 1927; Fullaway 1947; Davis 1966; Stein 1981; Davis 1985a, b) The majority of the native caterpillar attacks are reported in wet winter months (September - February). The attacks may begin much earlier. An outbreak reported in September 1953, was found to have been most severe in July and August (Davis 1955).

Acreage affected can be a thousand acres or many thousands. Although the 1953 attacks defoliated nearly 1,300 acres (Davis 1955), a 1977 infestation involved over 18,000 acres, with heavy effects on 4,550 acres, and light to moderate defoliation on 14,140 acres (Stein 1981).

Each report of defoliation is accompanied by or shortly followed by a report of natural control agents moving in to take advantage of the abundant food resource. The caterpillars provide plentiful food for native and introduced birds, and their chicks. (Perkins 1913; Perkins 1926; Davis 1985a) Parasitic insects move in as well. Of the 1982 attack it was reported "Foliar damage ranged from 50 to 75% under a canopy of *Acacia koa* and *Sophora chrysophylla*. ... Parasitic cocoons were readily observed on the damaged leaves, petioles and twigs..." (Davis 1985a). Among the recorded predators, two wasps (*Apanteles*) were collected in this survey.

The speed of koa canopy recovery varies. A 1977 report of East Maui attacks, in an area repeatedly defoliated over the decades, states: "It took three months before epicormic buds began to expand. At the end of six months less than one percent of the original crown canopy had refoliated." (Stein 1981) In summarizing the 1953 attack, however, Davis states, "A reconnaissance ... two months later indicated that the forests ... were recovering from caterpillar depredation..." (1955:401)

Should this phenomenon occur in the privately owned acreage under Koa Timber's care, it would be important to monitor for natural predators. Any immediate chemical response to kill the caterpillars would also kill predator insects and could injure or poison birds attracted to the bountiful prey. Careful consultation between foresters and entomologists would be important to assess the situation. Only a small number of trees are ever described as dying as a result of the defoliating. **Trees defoliated in this way, even those 100% defoliated, should never be considered dead.** Experience shows only sick or damaged trees cannot recover from the temporary onslaught. Swezey reported of the 1926 outbreak: ".... branches of many trees died back for from one to three feet, many entire branches died, and some of the older trees succumbed, but their death may have been due partially to other causes..." (Swezey 1954:3) Forests on Maui, repeatedly defoliated since Perkins' first reports in 1892, are still productive, testifying to the cycle of attack, predator response and koa recovery. The phenomenon certainly is thousands of years old. History shows the cycle will run its course and the forest will restore itself with little or no action by humans.

Hyles wilsoni wilsoni, a **native sphingid moth** is found only on Hawai'i Island. It has a much more restricted distribution than the multi-island *H. calida*.

The most prominent alien insect present in the lower areas was the **black witch moth** (*Ascalapha odorata*), using the lower elevation monkey pod (*Samanea saman*) trees.

Zoraptera
Zorotypus swezeyi is a cryptic, delicate, white, wingless resident of the frass on old koa and 'öhi'a trunks. *Zorotypus*, not fitting in other insect groups, is classified in its own order. It is a small creature that helps break down decaying wood, aiding in forest recycling. This find is the first record of this species in Hawai'i Island forests.

OTHER INSECTS
The following insects on the USFWS Species of Concern list are **believed to occur** on site based on many experiences in similar forests:

- > *Drosophila mulli* (a pomace fly)
- > *Nesotocus munroi* (a beetle)[2]
- > *Plagithmysus claviger* (a beetle)

[2] For images of this and many other arthropods mentioned in this report see Howarth and Mull 1992 and Howarth, Montgomery, Mull 1998.

MOLLUSCA
Snails
Succineidae
The only **native terrestrial mollusk** encountered was a succineid. It was determined to be *Succinea* cf. *thaanumi* (a closely related species). Since the project area has not been explored in the past, historic data and comparative material are limited.

Succinea were observed usually on fan palms. This snail may be arboreal or ground dwelling, and occupy a wide range of habitats. They are often endemic to a single island. All *Succinea* feed on decaying plant matter. (Zimmerman 1948). They are found on tree fern stems (these are often covered with bits of decaying plant matter which has fallen from upper canopy plants). They are not known to eat healthy, growing plants and pose no threat to sprouting koa (R. Cowie, personal communication).

Succinea spp. are listed as a Species of Concern by the USFWS (Fed Reg 1999-2000).

Two widely distributed, alien mollusks were also collected: *Oxychilus alliarius,* or Garlic Snail in reference to its scent, and *Limax maximus,* a large slug.

INVERTEBRATES NOT PRESENT
Drosophila
Native *Drosophila* or pomace flies, typically present in both variety and frequency in similar wet forests, were seen in very small numbers in this survey. The forest types present originally supported far more lobeliad and soft bark trees as host plants for the associated *Drosophila*. The relative absence of *Drosophila* is due to low levels of host plants. Alien rats and pigs (see above Site P - 1 and 4 and below MITIGATION) are the most likely agents of host plant extermination. *Drosophila* and other native insects are an important source of food for native birds and their absence from the forest ecosystem affects its overall health. (Hardy 1960-1985; Montgomery 1975)

Manduca blackburni
Blackburn's hawk moth *Manduca blackburni*, an endangered species (Fed Reg 1999-2000), was not found in this survey. The solanaceous host plants, especially 'aiea (*Nothocestrum latifolium* and relatives) and an alien tree tobacco (*Nicotiana glauca*), were not present at any location in the survey, nor is the latter known historically from windward high forests. (Riotte 1987)

Snails on the federal or state endangered / threatened species list were not found (however, see SURVEY LIMITATIONS below). At least one survey located *Partulina physa*, as "rare" in the adjacent Hakalau Forest National Wildlife Refuge (Hadway and Hadfield 1999). Both *Partulina* and *Succinea* are USFWS Species of Concern (Fed Reg 1999-2000). Although SOC have no official status under the Endangered Species Act, the designation is an alert that the species may become imperiled.

Alien predatory ants like *Pheidole megacephala* are well documented as a primary cause of low levels of native arthropods at lower elevations (Perkins 1913). They were not collected in the survey area. Their absence in the project area most likely results from the high elevation and overall wet environment of the property. Nevertheless, vigilance against the introduction of *Pheidole* or other predatory ants is prudent.

SURVEY LIMITATIONS

My ability to form advisory opinions is limited in the following ways:

Sample size: The survey of the property was not comprehensive. A very small portion of the 13,129 acre property (approximately 120 acres) was covered by the survey within a restricted time period. Although the overall study strategy and site selections were designed to mitigate this recognized handicap, additional sampling is recommended in selected areas before harvest (see Atterbury, Harvest Planning and Biological Monitoring). In particular, the area where collecting was attempted on January 14-15, 2002 and on the night of February 8, 2002, at the **Onomea cone** or pu'u deserves further study. In the time allotted, it was not possible to reach the inside of this crater, or even adequately explore the rim. This area has an ashy soil type and older geology, 4 times older than surrounding locations, and so is likely to yield invertebrates not represented in collections at the other locations (Wolfe and Morris 1996). The loulu palms here would be important host plants to a differing list of native insects.

A few species reasonably expected to occur on the property were **not found**. Several native invertebrates were found in low numbers. Difficulties in sampling a large area for a diversity of invertebrates assure that some species elude even the most experienced collector. Not finding a species does not mean with certainty that it is not present, as it might be collected with further survey in a longer or geographically broader survey of the property. Others are beyond the physical reach of this survey (e.g., living only in high palm tree canopy).

Seasons: Arthropod life cycles or seasonal changes would affect the species collected. Monitoring at a different season might produce a longer or different arthropod list. Examples are those more active in the summer season. Many arthropods time their emergence and breeding to overlap or follow a particular weather pattern or to coincide with growth spurts of an important plant food.

Common alien species: No attempt was made to collect or document the many common alien arthropod species such as cockroaches. Their absence from Table 1 does not mean they are not present in the study areas.

Aquatic Invertebrates: Many invertebrates make use of the aquatic environment and are not covered in this study. See Englund, et al. 2002.

Medically important species: Absence in this survey does not mean medically important species are not present in the work area. Employees should always be alert for centipedes, scorpions, widow spiders, western yellow jacket wasps, and common paper wasps. These may pose a serious risk to some individuals, and supervisors should be aware of any special sensitivity by employees. When moving stones and logs, use of gloves and long sleeves will greatly reduce the risk of accidental contact and bites. Some individuals can experience anaphylactic reactions to venom. Please see *What Bit Me?* (Nishida and Tenorio 1993).

CONCLUSIONS

PROJECT EFFECTS ON INVERTEBRATES

Compared to many other Hawai'i sites, this site has many native invertebrates, perhaps because it has moderate native floral diversity due to an absence of grazing and fires. The absence of dominant predatory species like *Pheidole* ants also contributes as they are documented elsewhere as a primary cause of low native mini-wildlife levels.

E. monticolens on *Metrosideros*

Many species listed in Table 1 are not directly linked to *Acacia koa* (Stein 1983, Williams 1931). With forest health and diversity maintained, there will be limited effect on their numbers in the project area. Additionally, they are well represented in other forest areas. A good example is the several *Eupithecia* species. *Eupithecia orichloris, E. monticolens*, and *E. staurophragma,* all found within the project area, are also found on several other locations on Hawai'i Island and within the island chain (Montgomery 1983, 1984).

Parandra and *Megopis* beetles are widespread and relatively common in Hawaiian forests. These species play a role in breaking up of wood material and revitalizing the forest soils to raise the next crop of *Acacia koa.* Removal of koa logs as proposed by the project prospectus will not have a significant effect on their numbers statewide. Removal of all dead and dying koa trees in the project area, however, would have the effect of reducing the habitat and food of the *Parandra* and *Megopis* beetles at this site. When tree trunks are removed, if the treetops are left on the ground, there should be **sufficient habitat in the study area** for these native beetles.

Cutting mature, and dead and dying koa, could result in some damage to populations of koa-obligatory terrestrial invertebrates. *Plagithmysus* populations; for example, unlike *Parandra* and *Megopis*, are very host specific and in some cases site specific. Consequently, they can be negatively affected by unrestrained harvesting of dead or dying koa. The Forest Management Plan (Atterbury Consultants 2002) resolves to **leave some dead and dying trees** standing to accommodate the needs of *Plagithmysus*, and similar species dependent on this habitat.

Any activity that involves repeated entry by people, equipment, and supplies into largely isolated forest areas creates an **opportunity for the introduction** or spread of predatory or invasive alien species. The initial invasive event is rarely large or attention getting. Consequently, good work methods are important in prevention of a forest-altering, accidental introduction (see MITIGATION: Work Methods below).

MITIGATION

In their prospectus, Koa Timber, Inc. has outlined protective and preventive actions to strive for minimum impact by their proposed project. The suggestions below aim to build on those suggestions. See also the advice on response to canopy defoliating (pg. 9) and on protecting *Plagithmysus* (pg. 12).

Given this survey's time and geographic restrictions and the scope of the proposed activity, **on-going monitoring** of the project area should be conducted for the life of the project. This would allow Koa Timber, Inc. to gauge the effectiveness of their preventive and protective measures. Monitoring could be scheduled to coincide with planned activity (see Forest Management Plan, Harvest Planning and Biological Monitoring) to minimize disruption and cost.

WORK METHODS

Cleaning tools, boots, and equipment used at lower elevations to ensure seeds (like *Clidemia* and *Tibouchina*) or pest insects are not transported to higher elevations is always a good practice. Soil packed in tires, on helicopter runners, or workers' boots can transport seeds, insect or snail eggs. Ants, snails and slugs, and many other invertebrates can hide in boxes or equipment resting at lower elevations and later be carried upland.

Pet **dogs or cats should never be allowed**, under any circumstances, to accompany workers into the area.

SPECIES OF CONCERN

Care should be taken during the proposed project activity to **avoid host plants** closely associated with invertebrates listed as Species of Concern (*e.g.*, fan palms - *Succinea*). The planned survey for rare and endangered species, done by a Hawai'i-experienced biologist, is an important protective measure.

ALIEN SPECIES

Control of alien pest or predatory species would assist in maintaining a healthy forest. By far the most damaging alien in the forest is the **feral pig** (*Sus scrofa*) derived from hybrids of Polynesian and European pigs introduced first by Capt. Cook and reintroduced by Capt. Vancouver. Signs of pig damage to the forest understory were seen at every collecting location in this survey. Rooting in soil, making resting locations or wallows, rubbing on tree trunks, and chewing on native plants, especially tree ferns (see description in Site H - 1 above) are common and easily seen manifestations of destructive pig activity in the forest. Pigs eat *Acacia koa* shoots as a minor part of their

diet. Among the more important factors in koa forest health are destruction of the understory (which provides shade for developing seedlings), soil erosion, (Cooray and Mueller-Dombois 1981) and opening up areas where strawberry guava (*Psidium cattleianum*), or other alien species will reduce koa acreage (guava fruit is spread in pig feces). The low number of lobeliads in the study area is likely a result of pig activity. Starchy fern trunks are a favorite food. In discussing the activity of pigs in the Kīlauea forest one study concluded: "Increased pig density also has the potential of disrupting the reproduction cycle of *Acacia koa* ..." (Cooray and Mueller-Dombois 1981:317). Control of pigs in the study area, as planned by Koa Timber, is good stewardship and highly recommended for the overall health of the forest and preservation of invertebrates.

Rats and Cats

Rats reduce invertebrate host plants by eating seeds and are well known predators on snails (Hadway and Hadfield 1999). Good sanitation around work sites (removal of garbage) will ensure rat populations do not increase using food items brought in by work crews. Coordination with State of Hawai'i control and monitoring programs is recommended. Should rare snail populations be located in the future, consultation with malacologists on programs for monitoring and pest elimination would be especially important.

The presence of cat scat was observed at Site O - 1. **Cats should be trapped** and removed whenever and wherever they are noted. Cats will attack native and alien birds and reduce their role in controlling insect populations.

Strawberry guava (*Psidium cattleianum*)

Strawberry guava is a serious pest. It inhibits sprouting of other species' seeds, creating bare soil, speeding erosion, and stream and offshore silting. Englund (2002) provides a detailed description of this degradation. Feral pig control is important in control of strawberry guava, as noted in the Forest Management Plan (Addendum, p. 40-41): "Because of the huge quantities of seed that are dispersed by feral pigs, another exotic invasive species, pig management is a practical and necessary first step in strawberry guava management." Pig-strawberry guava control will improve the overall health of the forest, reduce soil erosion and silting, and provide for improved koa habitat.

Wasps

Wasps in large numbers are a threat to employees and are predators on many native insects. Should ground nests of the western yellow jacket be located, coordination with State DOH Vector Branch programs is recommended for their removal.

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Steven Lee Montgomery, Ph. D, conducted all collecting and is responsible for all conclusions. Anita Manning helped with curation of the specimens, historical data research, web searches, writing and editing this report, and provided administrative support.

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Appendix 1. Abbreviations and Glossary

ABBREVIATIONS

DOA Department of Agriculture, State of Hawai'i

DOH Department of Health, State of Hawai'i

cf. confer or closely related to

n. new

SOC species of concern

sp. species

spp. more than one species

USFWS United States Fish and Wildlife Service

GLOSSARY[3]

Adaptive radiation: the emergence of numerous species from a common ancestor introduced to an environment presenting a diversity of conditions. Hawaiian endemic *Drosophila* flies are a good example with founder flies that gave rise to new species after island hopping.

Alien: occurring in the locality it occupies ONLY with human assistance, accidental or purposeful; not native. Both Polynesian introductions (e.g., coconut) and post-1778 introductions (e.g., guava, mosquito, and pig) are aliens.

Amphipod: a small flat crustacean 'hopper' living in aquatic or terrestrial habitats

Arachnida: arthropods with eight legs no antenna (spiders)

Arthropod: insects and related invertebrates (e.g., spiders, scorpions) with an external hard skeleton and jointed legs.

Canopy: the highest vegetation layer. In closed canopies, foliage forms a continuous layer. In open canopies, there are gaps in the foliage, allowing more light to reach lower layers and the ground.

Endemic: naturally occurring, without human assistance, ONLY in the locality it occupies. Hawai'i has a high percentage of endemic plants and animals. Some occur only in very small microenvironments.

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[3] Glossary based largely on definitions in *Biological Science: An Ecological Approach*, 7th ed., Kendall/Hunt Publishing Co., Dubuque, a high school text; on the glossary in *Manual of Flowering Plants of Hawai'i*, Vol.2, Wagner, et al., 1990, Bishop Museum Press, and other sources.

Feral: living in a wild state, especially reverted from domestication or cultivation. (e.g., goats, or pigs in Hawai'i forests)

Indigenous: naturally occurring without human assistance in the locality it occupies; may also occur outside the Hawaiian Islands. (e.g., Naupaka kahakai (*Scaevola sericea*) occurs in Hawai'i and throughout the Pacific).

Insects: arthropods with six legs, and bodies in 3 sections

Invertebrates: animals without backbones (insects, spiders, snails / slugs, shrimp, etc.)

Keystone Species: Keystone species are basic to ecosystem health. For example, caterpillars are food for baby birds and act to keep a particular plant in check. Removal of the insect could lead to one plant dominating a forest, while bird populations crashed.

Larva: an immature stage of development in many types of animals.

Leaf litter: organic debris (mostly plant parts) lying on top of soil. Litter is the home of *many forest mini-wildlife.*

Mollusk: invertebrates in the phylum Mollusca. Common representatives are snails, slugs, mussels, clams, oysters, squids, and octopuses.

Native: organism that originated in the area where it lives without human assistance. May be indigenous or endemic.

Species: all individuals and populations of a particular type of organism, maintained by biological mechanisms that result in their breeding mostly with their kind.

Species of concern [SOC]: rare species, not formally listed as endangered or threatened by USFWS, but are considered under observation as they may become imperiled.

Subspecies: a subdivision of a species, associated with geographic region or ecological niche.

Appendix 2. Explanation of collecting methods

These explanations are provided for the non-scientific reader to better understand the methods used to sample the area's arthropods.

Baiting: Baits are used to attract insect species that are linked to specific tastes or smells. For example, some flies lay their eggs on host plants with a specific 'flavor' and some scavengers come to dead or dying plants with a specific 'scent'. Baits can mimic that smell and taste and so attract those insects. Baits are placed at likely locations or inserted in bottle traps and checked periodically. Any insects at the bait are then collected. This is much more efficient than roaming the forest to find the host plant and hoping an insect shows up at that precise time. Just as a salesman finds calling on regular clients more productive than cold calling, bait stations are an efficient method of sampling. Since the scent does not travel far, baiting does not inflate the population in an area. Rather, area insects are enticed from hiding by the bait's 'advertisement.' Baits are not sticky and do not trap insects indiscriminately. They wash away in the first big rain.

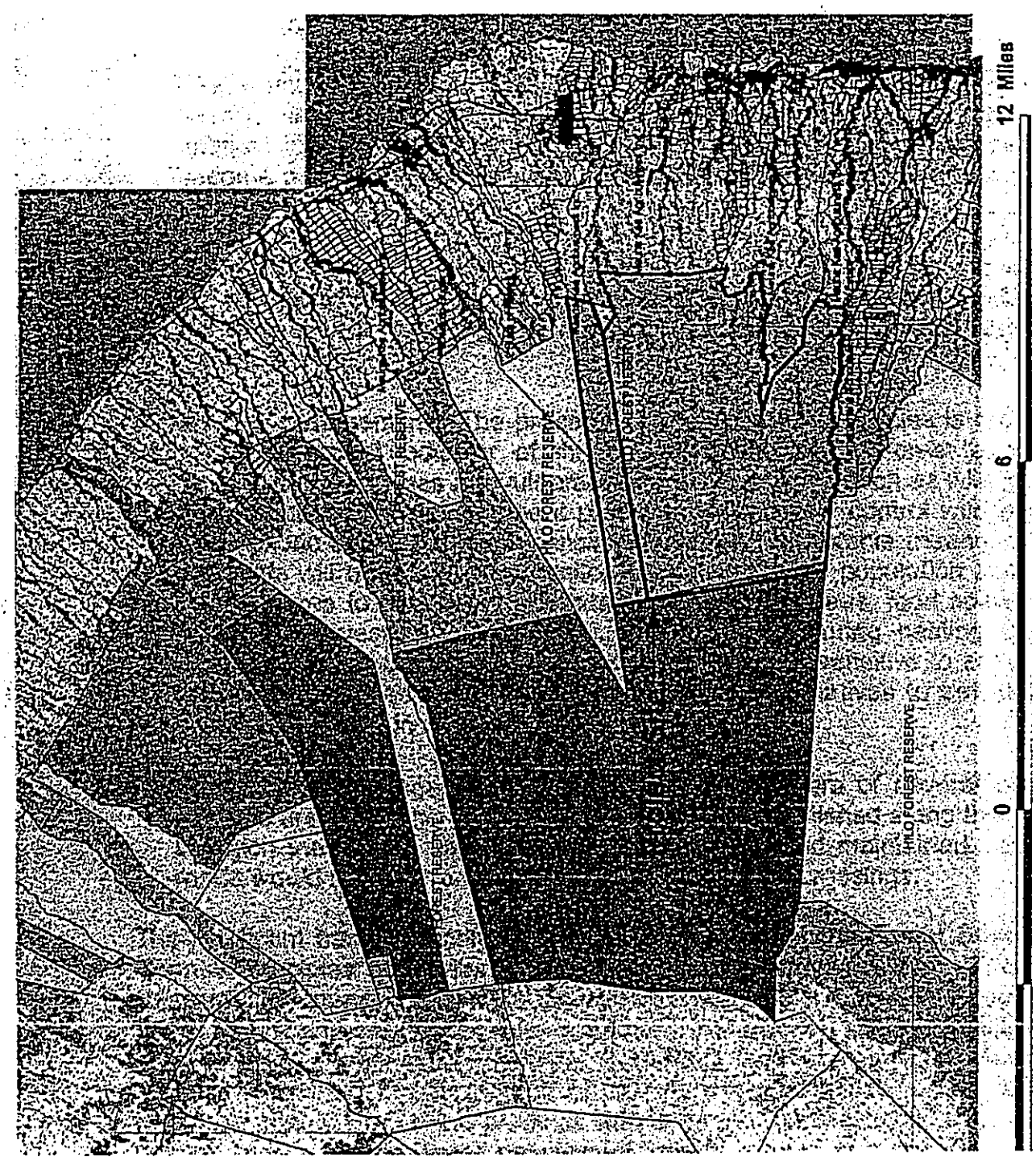
Beating: A net, net handle, or stick is used to beat shrubbery, ferns, trees, and branches to knock arthropods onto a sheet or into a net for easy collecting. Usually not much pressure is needed and no permanent damage is done to plants.

Fogging: A fogger spray containing pyrethrum is used to knock out cryptic arthropods living in mosses and crevices of tree trunks, foliage, and fallen logs. A sheet laying on the ground below the sample site catches the falling arthropods. Pyrethrums have quick knock down power, but no residual killing capability. They are commonly used in household foggers and are safe for vertebrates and for use in the natural environment in small sites.

Light sampling: Light sampling uses a Mercury Vapor light or other bright light source in front of a white sheet or cloth. Night active insects mistake the collecting light for the light of the moon - which they use to orient themselves. In attempting to navigate by the collecting light, confused insects are drawn toward and land on the cloth. This type of collecting is most successful during the dark phase of the moon under clouds blocking starlight.

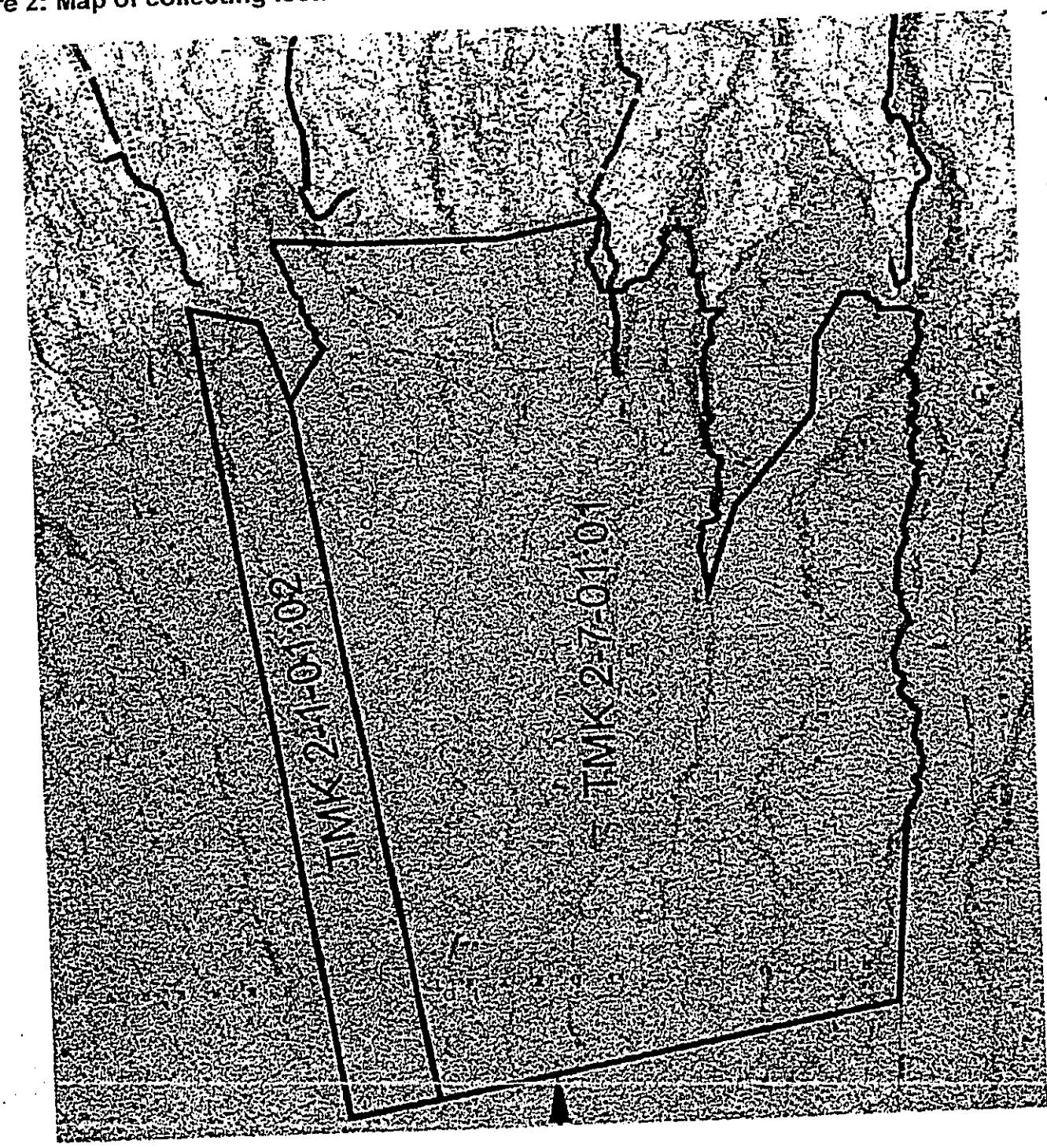
Light collecting is most important where cliffs and other inaccessible sites shelter remaining bits of native ecosystem including invertebrates. The forest usually blocks the light from being seen over long distances, and most moths and other night fliers are not capable of very long-distance flight. Consequently, light sampling does not call in insects from outside the survey area.

Figure 1: Map showing adjacent forestry reserves



Source: Environmental Impact Statement Preparation Notice
Koa Timber Commercial Forestry Operations, Figure 3
Nov. 2001

Figure 2: Map of collecting locations



Source: Environmental Impact Statement Preparation Notice
Koa Timber Commercial Forestry Operations, Figure 1
Nov. 2001

Table 1: Checklist of Koa-'Ohi'a Forest Invertebrates in the middle slope of Mauna Kea, South Hilo District, Hawai'i Island

Status of each species appears in the first column: End—endemic (only in the Hawaiian Islands); Ind—indigenous (naturally in the Hawaiian Islands but also elsewhere); Adv—adventive (inadvertently introduced); Pur—purposeful (deliberately introduced). (Authority: Haw. Bio. Survey 1997; Liebherr & Zimmerman 2000; Nishida 2002; Zimmerman 1948-80; Bishop Museum entomology collections)

PHYLUM MOLLUSCA		
CLASS GASTROPODA		
ORDER PULMONATA		**SNAILS AND SLUGS**
		Succineidae
	End	*Succinea* sp. cf. *thaanumi*
		Zonitidae
	Adv	*Oxychilus alliarius* (garlic snail)
		Limacidae
	Adv	*Limax maximus* (giant slug)

PHYLUM ARTHROPODA		
CLASS ARACHNIDA		**MITES, SPIDERS, AND RELATIVES**
ORDER ACARI		**mites**
	?	Not yet identified
ORDER ARANEAE		**spiders**
		Araneidae (orb weavers)
	End	*Cyclosa* sp.
		Linyphiidae
	End	*Labula* species 1
		Salticidae (jumping spiders)
		Unidentified species 1
		Tetragnathidae (long-jawed spiders)
	End	*Tetragnatha quasimodo* Gillespie nocturnal, common
	End	*Tetragnatha brevignapha*
	End	*Tetragnatha* species 1
	End	*Tetragnatha* species 2
	End	*Tetragnatha* species 3
	End	*Tetragnatha* species 4
		Theridiidae (widows, comb-footed spiders)
	End	*Argyrodes* species 1
		Thomisidae (crab spiders)
	End?	*Mecaphesa*? species

TABLE 1: Checklist of Invertebrates (continued)

CLASS INSECTA	**INSECTS**	
ORDER COLLEMBOLA	**springtails**	
		Entomobryidae
	End?	*Entomobrya* species 1
	Adv	*Tomocerus minor* (Lubbock, 1862) common, leaf litter, on trunks
	Adv	*Salina celebensis* (Schaeffer)
ORDER ODONATA	**damselflies**	
		Coenagriidae
	End.	*Megalagrion* sp.
ORDER ORTHOPTERA	**grasshoppers, katydids, crickets**	
		Gryllidae (Crickets)
	End	*Laupala* species 1 on shrubs
	End	*Leptogryllus* species on trunk, nymph only
ORDER PSOCOPTERA	**bark lice**	
	End	*Kilauella psylloides* (Perkins) on Cheirodendron
ORDER ZORAPTERA		
		Zorotypus swezeyi Caudell new island record
ORDER HETEROPTERA	**true bugs**	
		Miridae (plant bugs)
	End	*Nesiomiris* species 1 "olapa leaf bug"
		Nabidae (damsel bugs)
	End	*Nabis* cf. *oscillans* Blackburn
	End	*Nabis pele* 5
		Reduviidae (kissing bugs)
	End	*Saicella n. sp.* assassin bug
ORDER HOMOPTERA	**leafhoppers, planthoppers**	
		Cixiidae (planthoppers)
	End	*Oliarus* species 1 nocturnal
		Delphacidae (planthoppers)
	End	*Nesodryas swezeyi* Zimmerman on fan palm leaf
		Psyllidae
	Adv	*Acizzia uncatoides* (Ferris & Klyver)
ORDER NEUROPTERA	**lacewings, antlions**	
		Chrysopidae (green lacewings)
	End	*Anomalochrysa* species 1 rare
		Hemerobiidae (brown lacewings)
	End	*Nesomicromus vagus* Perkins
ORDER COLEOPTERA	**beetles**	
		Anobiidae
	End	*Holcobius affinis* Perkins
	Adv	*Ozognathus* sp.
	End	*Xyletobius* species 1

TABLE 1: Checklist of Invertebrates (continued)

		Carabidae (ground Beetles)
	End	*Bembidion* species 1 on mossy log, uncommon
	End	*Blackburnia* species 1
	End	*Mecyclothorax* species 1 on mossy logs, common
		Cerambycidae
	End	*Megopis reflexa*
	End	*Parandra puncticeps*
	End	*Plagithmysus* sp.
		Cisidae
	End	*Cis* species 1
		Colydiidae
	Adv	*Penthelispa rufipennis* (Montrouzier)
		Curculionidae (weevils)
	End	*Achalles* species 1 rare species, on mossy logs leaf litter
	End	*Dryophthorus modestus* Sharp
	End	*Dryophthorus squalidus* Sharp
	End	*Dryophthorus insignis* Sharp
	End	*Dryophthorus* sp.
		Cucujidae
	Adv	*Psammoechus insularis* (Sharp)
		Nitidulidae (souring beetles)
	End	*Eupetinus* species 1
	End	*Goniothorax perkinsi* Sharp
		Scolytidae (bark beetles)
	Adv	*Xylosandrus crassiusculus* (Motschulsky)
	End	*Xyleborus hawaiiensis* Perkins
	End	*Xyleborus kauaiensis* Perkins "olapa shot hole borer"
		Staphylinidae (rove beetles)
	End?	Unidentified species 2
		Tenebrionidae
	Adv	*Tagalus fordi* Kulzer 9 in rotted koa wood
ORDER LEPIDOPTERA		**butterflies, moths**
		Carposinidae (fruit moths)
	End	*Carposina inscripta* (Walsingham) host: ohelo fruit
	End	*Carposina* species 1
	End	*Carposina* species 2
		Cosmopterygidae (casebearer micro-moths)
	End	*Hyposmocoma exornata* (Walsingham) "tuxedo micro-moth"; 6
	End	*Hyposmocoma* species 1 nocturnal, rare at MV light
	End	*Hyposmocoma* species 2
	End	*Hyposmocoma* species 3
	End	*Hyposmocoma* species 4
	End	*Hyposmocoma* species 5

TABLE 1: Checklist of Invertebrates (continued)

		Cosmopterygidae (cont.)
	End	*Hyposmocoma* species 6
	End	*Hyposmocoma* species 7
		Crambidae (micro-moths)
	End	*Eudonia balanopsis* at MV light
	End	*Eudonia melichlora* on moss
	End	*Eudonia meristis* on moss
	End	*Mestolobes abnormis* (Butler)
	End	*Mestolobes* species 1 brown
	End	*Mestolobes* species 2 yellow spot
	End	*Omiodes accepta* (Butler) sugarcane leafroller, common; 6
	End	*Omiodes localis* 1 on grasses
	End	*Omiodes scotaea* (Hampson) uncommon , on Astelia; 5
	End	*Orthomecyna metalycia* Meyrick uncommon species
	Adv	*Spoladea recurvalis* (Fabricius) the beet webworm, sparse
	End	*Udea pyranthes* (Meyrick) abundant on ohelo
	Adv	*Paraponyx fluctuosalis* (Zeller) on aquatic grass
		Geometridae (geometer moths and inchworms)
	End	*Eupithecia monticolans* Butler common, larvae feed on *Metrosideros polymorpha* flowers
	End	*Eupithecia orichloris* (Meyrick) common; larvae on leafblades; predacious
	End	*Eupithecia staurophragma* (Meyrick) common; larvae perch on stems; predacious
	End	*Scotorythra apicalis* Swezey "gold-tinged geometer moth"
	End	*Scotorythra corticea* (Butler) abundant on koa; 9
	End	*Scotorythra euryphaea* Meyrick common
		Scotorythra goniastis Meyrick silver-gray; 2
	End	*Scotorythra oxyphractis* Meyrick common; 5
	End	*Scotorythra rara* (Butler) common
	End	*Scotorythra paludicola* (Butler) *"koa moth"*
	End	*Scotorythra* species 1 (ochre)
		Lycaenidae (Blues)
#	End	*Udara blackburni* (Tuely) Blackburn's butterfly
		Noctuidae (underwings, cutworms, and relatives)
	End	*Agrotis ceramophaea* Meyrick 2
	End	*Agrotis charmocrita* (Meyrick) 2
#	Adv	*Agrotis ipsilon* (Hufnagel) the greasy cutworm.
	Adv	*Ascalapha odorata* (Linn.) the black witch, transient
	Adv	*Elydna nonagrica* (Walker)
	End	*Haliophyle* sp. cf. *euclidias* (Meyrick) common fern eating larva
	End	*Haliophyle compsias* (Meyrick) rare, local endemic; 2 at Onomea cone

TABLE 1: Checklist of Invertebrates (continued)

		Noctuidae (cont.)
	Adv	*Pseudaletia unipuncta* (Haworth) common pest, "armyworm"; 8
	End	*Schrankia* species 1 Onomea 3000 ft.
	End	*Schrankia* species 2 Onomea 2200 ft.
		Oecophoridae (Oecophorid moths)
	End	*Thyrocopa* species 1 uncommon
	End	*Thyrocopa decipiens* larva eats 'ie'ie spindle
		Sphingidae (hawkmoths)
	Adv	*Agrius cingulata* (Fabricius) the sweet potato hornworm
	End	*Hyles wilsoni wilsoni* (Rothschild) common "Wilson sphinx"
		Tineidae (clothes moths)
	Adv	*Opogona omoscopa* (Meyrick)
		Tortricidae (leaf rollers, leaf tiers)
	Adv	*Amorbia imigratella* Busck "Mexican leaf roller"
	Adv?	*Cryptophlebia illepida* (Butler) "koa seed worm"
	End	*Cydia walsinghamii* (Butler) "koa twig borer"; 5 at MV light
	End	*Eccoptocera* species 1
	Adv	Epiphyas postvittana (Walker) "light brown apple moth; green leaf roller
	End	*Pararrhaptica fusco cinerea* (Swezey) "kolea shoot moth"
	End	*Spheterista pleonectes* (Walsingham) larvae in webbed *Cheirodendron* leaves
	End	*Spheterista* species 1 orange irridescent
	End	*Spheterista* species 2 green irridescent
ORDER DIPTERA		flies
		Anisopodidae
	Adv	*Sylvicola cinctus* (Fabricius)
		Calliphoridae (blow Flies)
	Adv	*Calliphora vomitoria* (Linnaeus) bluebottle fly
	End	*Dyscritomyia* species 1 rare
	End	*Dyscritomyia* species 2
	Adv?	*Lucilia* species 1
		Ceratopogonidae (biting midges)
	End	*Forcipomyia hardyi* Wirth & Howarth common
		Chironomidae (midges)
	End	*Orthocladius davisi*
		Dolichopodidae (long-legged Flies)
	End	*Eurynogaster* species 1 uncommon

= presence extremely likely

TABLE 1: Checklist of Invertebrates (continued)

		Drosophilidae (pomace Flies)
	End	*Drosophila hawaiiensis* Grimshaw (Heed 1968)
	Adv	*Drosophila immigrans* Sturtevant larvae in sap flux
	End	*Drosophila ochracea* Grimshaw 'ie'ie picture-wing pomace fly;
	End	*Drosophila reducta* Hardy 1 seen at bait
	End	*Drosophila setosimentum* Hardy & Kaneshiro 1
	End	*Drosophila sordidapex* Grimshaw common
	Adv	*Drosophila sulfurigaster* Duda uncommon
	End	*Drosophila tanythrix* (Hardy) common; eggs in 'ōlapa-leaf litter
	End	*Scaptomyza articulata basiloba* Hardy
	End	*Scaptomyza basiloba* Hardy on koa leaf
	End	*Titanochaeta* species 1 larva in Astelia fruit
	End	*Titanochaeta* species 2 larva in Trematolobelia fruit
		Muscidae (house flies and relatives)
	End	*Lispocephala* species 1 predator on smaller flies
		Psychodidae (moth flies)
	End?	*Psychoda* species common
		Sciaridae (black fungus gnats)
	End	*Sciara hawaiiensis*
		Sciomyzidae (snail flies)
	Pur	*Sepedon oriens* Steyskal second record; snail control introd.
		Sphaeroceridae
	Adv	*Leptocera* species common in Malaise traps
		Tachinidae
	Pur	*Archytas cirphis* Curran
		Tipulidae (crane flies)
	End	*Limonia* species 1
ORDER HYMENOPTERA		**wasps, bees, ants**
		Apidae (honey bees)
	Pur	*Apis mellifera* Linnaeus
		Braconidae (Braconid wasps)
	Adv?	*Apanteles* species 1
		Ichneumonidae (Ichneumon wasps)
	End	*Enicospilus* species 1
	End	*Enicospilus* species 2
	Adv	*Trathala flavoorbitalis* (Cameron)
		Platygasteridae
	Adv	*Platygaster* species 1
		Sphecidae
	End	*Ectemnius* species 1
		Vespidae (paper wasps, potter wasps, yellow-jacket wasps)
	Adv	*Vespula pensylvanica* (Saussure) few seen in area

TABLE 1: Checklist of Invertebrates (continued)

CLASS CRUSTACEA		**CRUSTACEANS**
SUBCLASS MALACOSTRACA		**CRABS AND RELATIVES**
ORDER AMPHIPODA		**scuds, sandhoppers**
		Talitridae (landhoppers)
	Adv	*Talitroides topitotum* Burt
ORDER ISOPODA		**pill bugs, slaters**
		Porcellionidae (sow bugs)
	Adv	*Porcellio scaber* Latreille
		Styloniscidae
	Adv	*Styloniscus mauritiensis* (Barnard)
	Adv	*Styloniscus spinosus* (Patience)
CLASS CHILOPODA		**CENTIPEDES**
ORDER GEOPHILOMORPHA		
	Adv?	Unidentified species 3 uncommon
CLASS DIPLOPODA		**MILLIPEDES**
ORDER POLYDESMIDA		**flat-backed millipedes**
		Paradoxosomatidae
	Adv	*Oxidus gracilis* Koch common in leaflitter

Table 2. World List of Koa Caterpillars

Note the large number of insects in a single order dependent on *Acacia koa*. An inquiry to the British Museum (Natural History) HOSTS* database on Lepidoptera hostplants returned the following list of moths and butterflies whose caterpillars use *Acacia koa*.

Hostplant and Range: Leguminosae: *Acacia koa* in the Hawaiian Islands

Lepidoptera families and species

Cosmopterigidae
- *Aphthonetus kauaiensis*
- *Hyposmocoma alliterata*
- *Hyposmocoma auripennis*
- *Hyposmocoma bitincta*
- *Hyposmocoma blackburnii*
- *Hyposmocoma candidella*
- *Hyposmocoma chilonella*
- *Hyposmocoma corvina*
- *Hyposmocoma cryptogamiella*
- *Hyposmocoma jugifera*
- *Hyposmocoma palmifera*
- *Hyposmocoma semiusta*
- *Hyposmocoma unicolor*
- *Hyposmocoma vicina*

Geometridae
- *Macaria abydata*
- *Scotorythra caryopis*
- *Scotorythra corticea*
- *Scotorythra metacrossa*
- *Scotorythra paludicola*
- *Scotorythra rara*

Lycaenidae
- *Vaga blackburni*

Oecophoridae
- *Thyrocopa abusa*
- *Thyrocopa argentea*
- *Thyrocopa indecora*

Pyralidae
- *Uresiphita polygonalis*

Sphingidae
- *Hyles calida*
- *Hyles wilsoni*

Tineidae
- *Erechthias minuscula*
- *Opogona omoscopa*

Tortricidae
- *Adenoneura conspicua*
- *Adenoneura rufipennis*
- *Cryptophlebia illepida*
- *Cydia conspicua*
- *Cydia rufipennis*
- *Cydia walsinghamii*
- *Epiphyas postvittana*

* HOSTS - The Hostplants and Caterpillars Database
Connect at <http://flood.nhm.ac.uk/cgi-bin/perth/hosts/index.dsml>
maintained by the Department of Entomology, The Natural History Museum (BM NH), London;
By.G. Robinson, P. Ackery, I. Kitching, G. Beccaloni, L. Hernández

Appendix E

Analysis of Endangered Terrestrial Vertebrate Species Management Issues

An Analysis of Endangered Terrestrial Vertebrate Species Management Issues for the Proposed Koa Timber Project, South Hilo District, Island of Hawai'i, Hawai'i

TMK 3rd/2-7-01:01 & 2-8-01:02

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Introduction

Koa Timber, Inc. proposes to conduct a *koa* (*Acacia koa*) forestry operation on an 13,129-acre parcel of land contained within TMK 3rd/2-7-01:01 & 2-8-01:02, located in the District of South Hilo, Island of Hawai'i, Hawai'i.

In this report we address the presence of endangered vertebrate species on the proposed Koa Timber Project. We also discuss management issues associated with these species, and make recommendations on additional efforts that we recommend be implemented by the developer if the project does come to fruition. This report is meant to accompany an Environmental Impact Statement (EIS) that project planners have prepared for the project. Readers are referred to the EIS for maps of the area and further information concerning the property and the aims and goals of the project. We did not conduct any fieldwork in conjunction with this report, but rather reviewed the results of two previous surveys conducted on the subject property, as well as the pertinent published literature, and the authors extensive field notes collected on the Island of Hawai'i over the past 22 years.

Mammalian Species: *Hawaiian hoary bat*

With the exception of the endangered endemic (i.e., native and unique to Hawai'i) Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *'ōpe'ape'a,* as it is known locally, all other terrestrial mammals found on the Island of Hawai'i are alien (i.e., introduced to Hawai'i by humans).

Background:

The Hawaiian hoary bat was first listed as an endangered species by the U. S. Fish and Wildlife Service (USFWS), in 1970 (Federal Register 1970). Currently it is listed as an endangered species under both the federal and State of Hawai'i's endangered species programs (DLNR 1998, Federal Register 1999a, 1999b, 2001).

The Hawaiian hoary bat has not been documented from within the Koa Timber project parcels to date (Terry 2001, 2002). This species has been documented from lands to the west, east and south of the proposed project area (R. David, unpublished field notes 1980-2002, Theresa Menard, pers. comm.). Given this species wide distribution in the windward areas of the Island of Hawai'i, it is probable that bats utilize resources within the proposed project area on at least a seasonal basis.

The Hawaiian hoary bat was formerly considered a full species (*Lasiurus semotus*) but following work conducted by Sandborn and Crespo (1957), it was lumped with the American hoary bat (*Lasiurus cinereus*). The Hawaiian endemic sub-species, though closely related to the continental forms, is well isolated from the nominate race (Tomich 1986). At least two researches have suggested that morphological measurements of bats occurring in Hawai'i differ sufficiently from the other two recognized sub-species of American hoary bats found in North America (*Lasiurus c. cinereus*), and South America (*Lasiurus c. vilosissimus*), that the

Hawaiian hoary bat should in fact be raised to full species level (Findley and Tomich 1983, Jacobs 1993). For a contrary opinion see Morales and Bickham (1995).

Hawaiian hoary bats have been recorded on the islands of Kaua'i, O'ahu, Maui, Moloka'i, Hawai'i and hypothetically from Kaho'olawe (Tomich 1986, USFWS 1998, Hawaii Heritage Program 1999). The bat is most frequently encountered on Kaua'i and Hawai'i (R. David, unpublished field notes 1980-2002). Although this species was first mentioned in the western literature by Peale in 1848, and scientifically described by Gray in 1862, very little systematic scientific work has been conducted on this species to date (Peale 1884, Gray 1862, Tomich 1986, USFWS 1998). The lack of systematic studies of this species reflects the reality that Hawaiian hoary bats, like all lasiurine bats primarily lead a solitary existence "over-dispersed", and generally roost cryptically in foliage, making them difficult to study (Carter *et al.* 2000).

The current paucity of systematic survey data detailing the distribution and population densities of this species in Hawai'i, makes it particularly difficult to make sensible, scientifically credible decisions regarding management and harvesting of natural resource components within areas frequented by bats. Much of the literature, both published and unpublished tends to report on limited aspects of the life history of this species, short duration localized survey efforts or anecdotal observations. Not surprisingly, with the lack of comprehensive landscape scale surveys, and studies, much of the literature is contradictory.

Current survey techniques available for gathering information on the distribution, abundance and usage of resources within a given area by Hawaiian hoary bats are inadequate and / or time and cost prohibitive. This is documented in the recent bat literature, and backed up by both Theresa Menard's and my field work using currently accepted field techniques (O'Shea and Bogen 2000, T. Menard, personal communication) The two main methods currently being used to monitor lasiurine bats are; heterodyne echolocation detector surveys and mist netting. We currently have no understanding of detection probabilities associated with either method (Carter *et al.* 2000). It may be impossible to standardize detection probabilities among surveyors, studies, or over time (O'Shea and Bogen 2000). The inability to estimate detection probability, limits the usefulness of data collected using uncalibrated indices produced by either mist netting or echolocation surveys. To calibrate these indices, appropriate population parameters must be estimated. Using current technology, these indices can only be estimated using mark-resight/recapture techniques. To complicate the issue, mark-resight techniques have not yet been developed, or applied to estimate population parameters in any lasiurine bat species (O'Shea and Bogen 2000). Coupling these limitations with the practical impossibility of detected roosting lasiurine bats, using current technology and methodologies available, presents a major conundrum in gathering adequate field data to answer questions about the distribution, abundance and habitat needs on either a spatial, seasonal or temporal basis for this and other lasiurine bat species.

After reviewing the published and unpublished literature, anecdotal information, and the above outlined limitations of current technology and survey methodologies, one might well ask - what can be stated about the distribution, abundance and habitat needs of the Hawaiian hoary bat on the Island of Hawai'i with any degree of certainty. The following briefly outlines the key areas of information that we can speak to regarding this species on the Island of Hawai'i and more specifically in regards to the proposed Koa Timber project site.

Distribution:

Hawaiian hoary bats have an island wide distribution, occurring seasonally from sea level to over 11,000 feet (Tomich 1986, Fujioka and Gon III 1988, David 1992a, 1992b, 1992c, 1995a, 1995c, 1996, 1997, 1998a, 1988b, 1999a, 1999b, 2002a, David *et al,* 1993, Jacobs 1994, Cooper *et al.* 1995, Montgomery and David 2000, Menard 2001, R. David, unpublished field notes 1980-2002). Bats have not been documented from within the Koa Timber project parcels to date; though they have been documented from lands to the west, east and south of the proposed project area. It is likely that Hawaiian hoary bats utilize resources within parts of the proposed project area on a seasonal basis.

Abundance:

As mentioned in the introduction, the current technology and survey methodologies available to researches represent major limitations in our ability to measure or even model population densities and general abundance for this species at any spatial scale. Until new surveys methodologies are developed and implemented no quantitative abundance estimates can extrapolated for this species with any statistical rigor (Carter 2000, O'Shea and Bogan 2000).

Seasonal activity:

There appears to be a drop in foraging activity between February and August (Jacobs 1993, 1994, Menard 2001). Whether this drop in detectable foraging activity represents a seasonal altitudinal migration as suggested by Menard (2001), or merely a greater dispersal by the bats when volent insect biomass are lower at sample sites on the nights sampled is currently unresolved (Jacobs 1994). What is clear is that there are both altitudinal and seasonal differences in bat activities, exactly what these differences indicate is not (Tomich 1986, Kepler and Scott 1990, Jacobs 1994, USFWS 1998, Menard 2001).

Breeding:

The breeding biology of the Hawaiian hoary bat has been poorly studied as have most other life cycle components of this species. It is generally thought that they breed between September and December, give birth between May and June and nurse young between June and August (Baldwin 1950, Tomich 1986, Kepler and Scott 1990, USFWS 1998, T. Menard, pers. comm.).

Roost sites:

Very few Hawaiian hoary bats have been detected on roost. The anemic literature on this species variously reports that this species is most frequently associated with native vegetation (Bellwood and Fullard 1984, Jacobs 1993, 1994), with alien vegetation (Kepler and Scott 1990) and with both (Tomich 1986). During the course of 22 years of field work in Hawaii the author has flushed bats out of both alien and native dominated vegetation (R. David, Unpublished field notes 1980-2002).

Feeding:

Hawaiian hoary bats are insectivores, feeding on volent insects. Hawaiian hoary bats appear to be greater generalists in their prey selection. In a study of 57 individual bats collected on Hawaii, Whitaker and Tomich (1983) found that moths made up only 12% of the diet of the individuals examined. Hawaiian hoary bats have clearly adapted to exploit newly established alien insect species. The author has repeatedly observed bats feeding on swarming termites (*Isoptera* sp.) and volent big headed ants (*Pheidole megacephala*) on both Hawai'i and Kaua'i, and watched bats feeding above introduced orchard crops in the lowlands of Kona which predominately attract alien insect species (R. David, Unpublished field notes 1980-2002).

Implications for the proposed Koa Timber Project:

From the perspective of the proposed Koa Timber Project how does the current lack of knowledge of the distribution and life cycle of the Hawaiian hoary bat relate to the project, and what ought to be done to address issues arising from the interaction of the two? It is probable that there is utilization of resources within the subject property by Hawaiian hoary bats, at least on a seasonal basis. If we accept this premise, the next logical question is what impacts will the harvesting of selected trees have on the bats within the area, and how should the project reduce deleterious impacts, and mitigate for any unavoidable impacts to bats?

The sampling constraints referred to in the above paragraphs make it difficult to answer even the basic question of whether timber harvesting will result in the "taking" of individual bats or habitat essential for their continued survival as required under the Endangered Species Act on 1973, as amended (ESA). Furthermore, he sampling constraints contradict some of the population-monitoring methods recommended in the USFWS Recovery Plan for the Hawaiian hoary bat, making the interim down-listing criteria difficult – if not impossible – to determine as they are currently written (USFWS 1998, Taylor 2000). Tree searches for roosting bats and inspecting of individual trees are not considered by the USFWS or other field researchers to be practical survey methods and are not recommended as a means to determine incidental take (USFWS 1997). The resulting conundrum makes it almost impossible to comply with the letter of the ESA in addressing possible impacts to this endangered species resulting from timber harvesting on the subject property.

Many of the issues about dispersed bats, their monitoring, and the problems inherent in same were identified and summarized at a workshop on monitoring trends in U.S. bat populations: Problems and prospects, held by the USGS Biological Resources Division in the fall of 1999 (O'Shea and Bogen 2000). The full text of the report is available on the internet at http://www.mesc.usgs.gov/BPD/ireport.htm.

In the time between the release of the initial Draft Environmental Assessment for this project and the preparation of this document, federal and state agencies and landowners in Hawai'i have formed a group called "The Hawaiian Bat Research Cooperative". The stated goal of the Cooperative is to assist in the creation of a sustainable forestry industry while also protecting bat populations and facilitating species recovery. In order to meet these goals and develop appropriate policy for land use practices and bat recovery, detailed information on the bat's distribution, abundance, and habitat use must be obtained. The cooperative was formed to

prioritize and fund research that would generate this information. The cooperative has successfully raised funds to begin the initial phases of this work and is now seeking proposals from qualified individuals or institutions to carry out this fundamental research (Hawaiian Bat Research Cooperative 2002). Koa Timber, Inc was an early participant in the formation of the Cooperative.

Recommendations:

Koa Timber, Inc., should not harvest timber during the period that bats are caring for young, namely between the months of June and August.

Koa Timber, Inc., should fill its currently vacant seat on the Hawaiian Bat Research Cooperative with a representative who is authorized to make fiscal and policy commitments on behalf of the company.

Koa Timber, Inc., should work closely with the Hawaiian Bat Research Cooperative to identify suitable research and/or funding opportunities that the project is willing to undertake or fund.

Koa Timber, Inc., should modify its operations and management plans as new information and recommendations for management and monitoring protocols are developed by the Hawaiian Bat Research Cooperative.

Avian Species

The avifauna of the lower elevation areas of the project are dominated by alien species, almost to the exclusion of native species (Terry 2002). Upper elevations do support a number of native species, though the majority of the birds found even in the upper areas are aliens. During the course of botanical surveys conducted on the property, incidental observations were recorded for birds seen by Pat Hart, a trained ornithologist. He recorded four endemic (i. e., native and unique to Hawai'i) avian species. The species he recorded were; Hawaiian Hawk, or 'Io (*Buteo solitarius*), 'Elepaio (*Chasiempis s. sandwichensis*), 'ōma'o (*Myadestes obscurus*), and 'Apapane (*Himatione sanguinea*) (Terry 2002). One of these, the Hawaiian Hawk, is an endangered species (DLNR 1998, Federal Register 1999a, 1999b, 2001).

Hawaiian Hawk

Background:

The Hawaiian Hawk (*Buteo solitarius*), or 'Io as it is known in Hawaiian, is the only extant falconiform in Hawaii. It is currently endemic to the island of Hawai'i. Sub-fossil remains indicate that it was also formerly found on Moloka'i, and Kaua'i (Olsen & James 1982, 1997). Several incidental unconfirmed sightings of this species exist from Kaua'i (Dole 1879, Beaglehole 1980) and Mau'i (Banko 1980). The species was first mentioned in the western literature by Cook and King in 1784, and it was scientifically described by Peale in 1848 from a specimen collected in "Kealakekua" (Cook and King 1784, Medway 1981).

The Hawaiian Hawk was first listed as endangered by the U.S. Fish and Wildlife Service (USFWS) in 1967 (Federal Register 1967). The USFWS published a proposal to down-list the species from endangered to threatened in 1993 (Federal Register 1993), and without down-listing the species retracted their 1993 proposal in 1994. Currently it is listed as an endangered species under both the federal and State of Hawai'i's endangered species programs (DLNR 1998, Federal Register 1999a, 1999b, 2001).

Distribution:

Recently completed research conducted by John Klavitter (2000), has shown that Hawaiian Hawks are found in nearly all vegetation habitats that still have some large tree components. Densities are highest in mature native species dominated forest with grassy under-stories. This habitat with high amounts of forest edge supports large populations of game birds, and the four species of introduced *muridae* known from the island; it also provides numerous perches and nesting sites (Klavitter 2000). Much of this habitat has been created by logging, land clearing and cattle grazing. It appears that Hawaiian Hawks can coexist with, and may have in fact benefited from anthropogenic land clearing activities – this is not to say that more clearing is going to result in more hawks, but does indicate that the species can coexist with anthropogenic natural resource extraction activities, as long as natural resource management plans ensures the continued recruitment of native trees and the regeneration of native species dominated forests.

Abundance:

Current population estimates based on Klavitter's research project that there are 1,457 hawks, which in his estimation is equal to, or higher than what was present in pre-contact times (Klavitter 2000). His recommendation is to down-list the species to threatened, but not to delist it, since its small population and single island occurrence makes the species vulnerable to stochastic events (Klavitter 2000).

Recommendations:

Since the Hawaiian Hawk was detected within the project site, and it is likely that the species also nests there; it is recommended that audio playback nesting activity surveys be conducted by a qualified ornithologist in each area planned for timber extraction prior to the commencement of harvesting activities. The currently approved protocols for conducting such a survey are based on those developed by John Klavitter during his multi-year island wide survey of Hawaiian Hawks (Klavitter 2000). Several such surveys have been conducted on the windward slopes of the Island of Hawai'i (David 2002b, 2002c). If nesting activity is detected within the proposed harvesting unit, all harvesting activity should be halted within a 100-meter buffer of the nest tree, and the project should consult with the U. S. Fish & Wildlife Service prior to conducting further harvesting activity within the buffer zone.

Other Avian Issues

Although no other endangered or threatened avian species were detected during the course of the botanical surveys conducted within the project area, the possibility remains that there is at

lease incidental utilization of resources within the parcel by endangered avian species. There is a small possibility that one or more of the following four endangered or threatened species may use resources within the project area at least occasionally:

Newell's Shearwater	(*Puffinus auricularis newelli*)
Akiapola'au	(*Hemignathus munroi*)
Hawai'i Creeper	(*Oreomystis mana*)
Hawai'i Akepa	(*Loxops c. coccineus*)

Recommendations:

Newell's Shearwater: Although not detected during the botanical surveys, this threatened species may use areas within the project area with deep uluhe (*Dicranopteris linearis*) ground cover as nesting habitat. It is recommended that in harvest units which have heavy uluhe ground cover that prior to the commencement of harvesting activities and timber extraction that a search be made for nesting activity. Said searches will need to be conducted between late June and the end of September, since this species is not present over land during the non-breeding season. If breeding activity is detected, no disturbance of the nesting colony should be allowed, and measures to protect the colony should be implemented. If a colony is found, consultation with the U. S. Fish & Wildlife Service should be initiated immediately.

Akiapola'au, Hawai'i Creeper and Hawai'i Akepa: Although not detected during the botanical surveys, all three of these critically endangered forest birds are known from areas adjacent to the project site. It is recommended that, prior to harvesting in any harvest unit which still supports a relatively intact koa and or koa/ō'hia (*Metrosideros polymorpha*) forest, the company employ a qualified ornithologist to conduct an avian species survey concentrating on finding these three species. Variable circular plot, transect surveys, the standard methodology used to survey for forest dwelling birds in Hawai'i and other tropical Pacific Islands, is not an effective tool for detected extremely rare birds (Reynolds and Snetsinger 2001). More intensive surveys using audio playback and intensive searches have proven to be much more effective in detecting these relic populations. Because at least one of these species, the Hawai'i Akepa, is a cavity obligate nester, it is imperative that an adequate number of older, dying and dead trees be left in place, so as to provide nesting habitat for this species.

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Appendix F

Aquatic Organism Study

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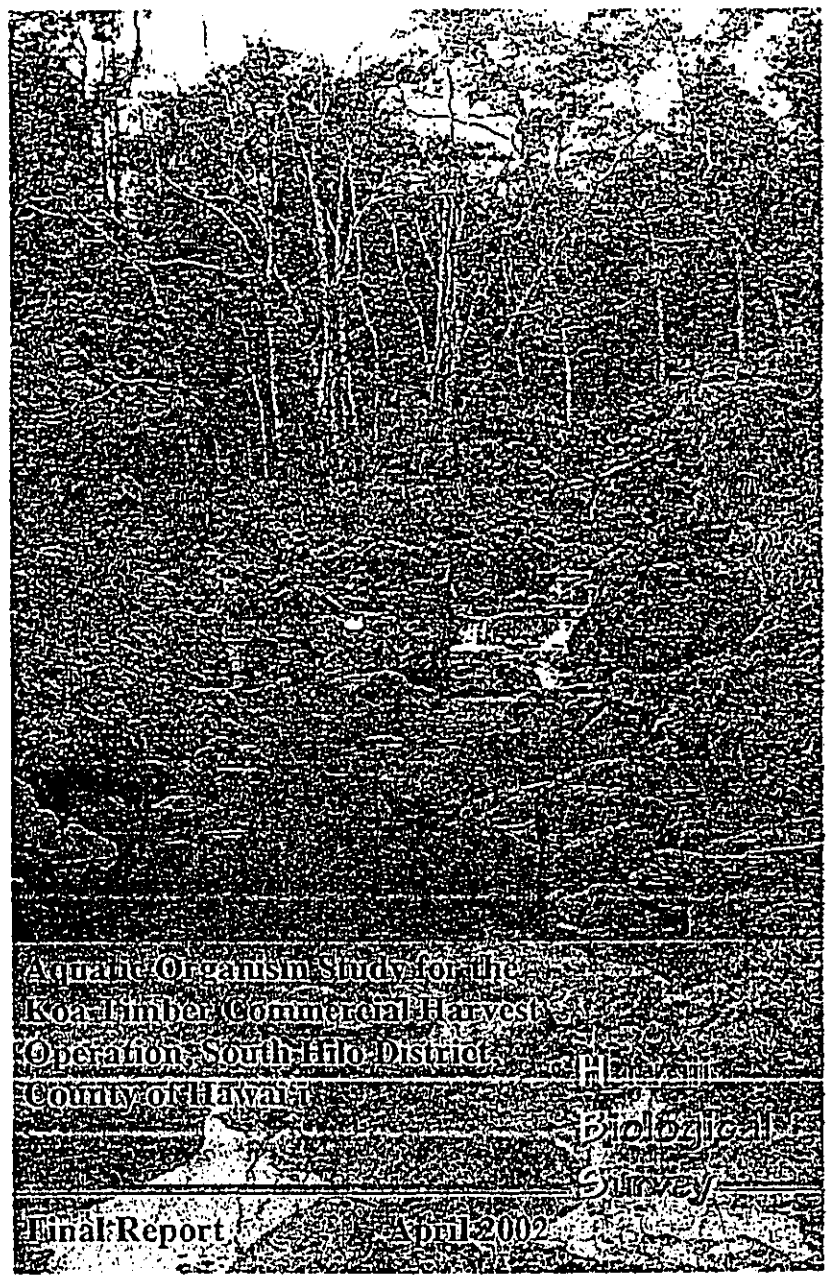

DOCUMENT CAPTURED AS RECEIVED

Aquatic Organism Study for the *Koa* Timber Commercial Forestry Operation South Hilo District, County of Hawai'i

Prepared for:

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EXECUTIVE SUMMARY

The Hawaii Biological Survey (HBS) of the Bishop Museum conducted aquatic biological surveys as part of an environmental impact statement for the proposed *Koa* Timber Commercial Forestry Operations project. Selective commercial helicopter logging of *koa* (*Acacia koa*) is proposed for 13,129 acres of Conservation District land in the South Hilo District of the Big Island. These surveys specifically were conducted to assess native and introduced aquatic organisms, and particularly to determine if sensitive, rare, or Candidate Threatened or Endangered Species would be impacted by the proposed selective commercial harvest of *koa*. The objectives of this assessment was to 1) describe baseline distribution of native and introduced fish, crustaceans, mollusk, aquatic insect species, in the proposed project area, and 2) assess potential environmental impacts on native aquatic species from the commercial harvest of *koa* in Conservation District land.

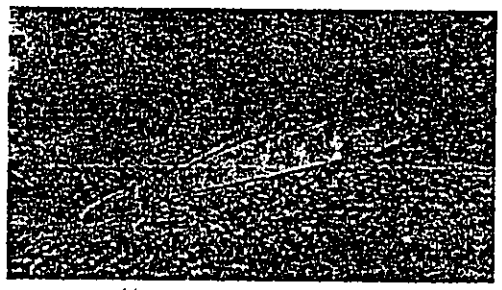
Six major streams flowing within the project area surveyed from south to north included Honoli'i, Pāhoehoe, Kapue, Hanawī, Kawainui, and Wai'a'ama Streams. The lowest and highest elevations accessible by helicopter in the project area for each major stream were surveyed. Streams within the study area were sampled along an altitudinal gradient. Elevations ranged from a low of 1760 ft on lower Honoli'i, to mid-elevations of 2300 ft at Hanawī Stream, to the upper reaches of Kapue (2900 ft) and Honoli'i Streams (3300 ft). The wide range of elevations eyaluated during this survey allowed a thorough sample of the entire range of aquatic habitats available found within the proposed project area.

Overall, native aquatic animal species predominated in aquatic habitats sampled within the proposed project area, indicating one of the most pristine aquatic ecosystems remaining in the Hawaiian Islands. A total of 61 species of aquatic macrofauna were collected in the six streams examined during this study, with forty-nine native aquatic species (mostly insects) and 11 introduced species were found. For all stations combined, 82% of the aquatic taxa found during this study were native (either endemic or indigenous) species and 18% were introduced. Fish species composition in the six streams examined in the study area consisted of one species, the native *'o'opu 'alamo'o* or *'o'opu hi'ukole* (*Lentipes concolor*) being found in Honoli'i, Pāhoehoe, Kapue, and Hanawī Streams. A major finding of this study was the rediscovery of one population of native aquatic insect that was presumed extinct, the long-legged fly *Sigmatineurum omega*. Despite numerous attempts to find this species in streams around Hilo, it had not been collected since 1971.

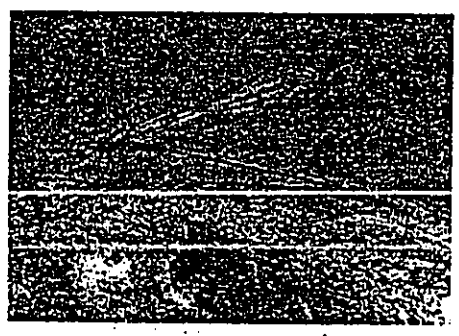
Every effort needs to be made to reduce invasive species from gaining increased access to areas where *koa* is selectively helicopter logged. All used logging equipment (e.g., chainsaws, ropes, etc.) brought in from the mainland should be steam-cleaned or disinfected and sterilized prior to use to eliminate any hitchhiking invasive species, especially ants, which can destroy the invertebrate ecosystem in only a few years. Any

helicopters brought in from the mainland should have their skids sterilized or disinfected prior to use in a Hawai'i *koa* forest. If invasive species start to become established in these small open areas, then weed control of some kind will be required, and these areas need to be immediately replanted with *koa* and/or *'ōhi'a* seedlings. Net beneficial effects to the native ecosystem would accrue if strawberry guava is cleared and replanted with *koa* seedlings in the lower elevations of the project area.

The major concern from an aquatic ecosystem perspective would be that weed control needs to be strong in the patches were *koa* is logged. This would ensure strawberry guava does not replace the mature *koa* that has just been logged. Aquatic biota would be adversely impacted if invasive weed species become established because they are not adapted to heavily sedimented water conditions. To ensure buffer zones are maintained and that invasive species do not gain a foothold in areas where *koa* is selectively logged, it is recommended that forest regeneration is monitored for the life of the project by a botanist or forester with experience in native Hawaiian rainforest ecosystems. It is also recommended that aquatic habitats and aquatic biota be monitored for the life of the project to ensure logging does not increase rates of sedimentation that would adversely impact native aquatic biota.



'O'opu hi'ukole (Lentipes concolor)

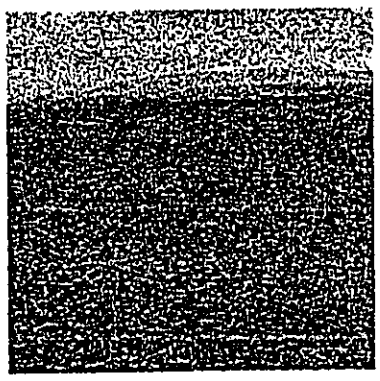


Pinao'ula (Megalagrion blackburni)

INTRODUCTION

The Hawaii Biological Survey (HBS) of the Bishop Museum conducted aquatic biological surveys as part of an environmental impact statement for the proposed *Koa* Timber Commercial Forestry Operations project. Selective commercial helicopter logging of *koa* (*Acacia koa*) is proposed for 13,129 acres of Conservation District land in the South Hilo District of the Big Island, and HBS surveyed aquatic biota in the six major streams and adjacent wetlands in the proposed project area. These surveys were conducted specifically to assess native and introduced aquatic organisms, and particularly to determine if sensitive, rare, or Candidate, Threatened or Endangered Species would be impacted by the proposed selective commercial harvest of *koa*. The objectives of this assessment were to 1) describe baseline distribution of native and introduced fish, crustaceans, mollusks, and aquatic insect species, in the proposed project area; and 2) assess potential environmental impacts on native aquatic species from the commercial harvest of *koa* in Conservation District land.

STUDY AREA

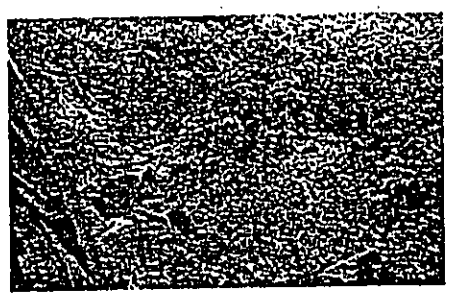


The project site is located ten miles northwest of Hilo on the southeastern flanks of Mauna Kea, and ranges in elevation from approximately 1400 to 3400 ft (Figure 1). The 13,129-acre project area lies within the eastern slopes of Mauna Kea, near Hilo, in the wettest region of the Big Island, with yearly annual rainfalls ranging from 200–240 inches (Juvik and Juvik 1998). The study area has few major landscape features other than the various stream canyons that are incised to as deep as several hundred feet in the lower sections. Otherwise, it consists of an almost featureless, gradually upsloping, and heavily forested area in the upper bounds of the study area. The one exception is the prominent Ka'uku pu'u or cinder cone (1964 ft) found at the extreme northeastern property boundary, adjacent to the lowest reaches of Wai'a'ama Stream. Streams draining this region of Mauna Kea generally flow in a west to east direction with permanent flow often appearing below the 4500 ft level. The higher sections of streams draining Mauna Kea (> 4500 ft), such as those found in Hakalau National Wildlife Refuge, often have permanent pools but flow only during periods of heavy rain.

The general topography of the project area is one of heavily forested, gradually sloping hills with no exposed rock faces or cliffs, except along the stream corridors. The upper portions of the study area are dominated by a mixed *koa* (*Acacia koa*) and *'ōhi'a lehua* (*Metrosideros polymorpha*) forest, with a thick understory of *uluhe* fern (*Dicranopteris linearis*) and a wide variety of other native plants. Starting around

the 2800 ft level, the forest becomes stunted with smaller trees in places, accompanied by a zone of more open *uluhe* fern bogs. Although introduced plants such as strawberry guava (*Psidium cattleianum*) were found in the highest reaches of our survey (3400 ft), they were relatively uncommon in the upper boundaries. Strawberry guava appeared to be the worst invasive plant in the area, forming an almost dominant monoculture in some lower portions of the study site below 2000 ft elevation. The forested areas composed of invasive species such as *Eucalyptus* or strawberry guava appeared to have little capacity to retain topsoil, and also were heavily disturbed by pigs. A general observation of siltier, warmer side tributaries flowing through either strawberry guava or *Eucalyptus* and entering the larger streams was observed in all of the lower reaches of the study area.

Within the proposed project area, all the major named streams on the U.S. Geological Survey (USGS) topographic quad maps were sampled. Some streams found in our current study area in the South Hilo District have names identical to streams found in Waipi'o Valley or elsewhere on Hawai'i Island, but obviously have no hydrological connection. The six major streams flowing within the project area surveyed from south to north included Honoli'i, Pāhoehoe, Kapue, Hanawī, Kawainui, and Wai'a'ama Streams. The lowest and highest elevations accessible by helicopter in the project area for each major stream were surveyed, with the exceptions of Kawainui and Hanawī Streams. Streams within the study area were sampled along an altitudinal gradient. Elevations ranged from a low of 1760 ft on lower Honoli'i, to mid-elevations of 2300 ft at Hanawī Stream, to the upper reaches of Kapue (2900 ft) and Honoli'i Streams (3300 ft). The wide range of elevations evaluated during our survey allowed us to thoroughly sample the entire range of available aquatic habitats found within the proposed project area.



Because of their small size, feasible helicopter landing zones (LZ) for both Kawainui and Hanawī Streams could only be located in their mid-to-upper reaches, and only one safe LZ for each of these streams was found within the project area. Sampling within a specific stream study site occurred within the confines of upstream and downstream waterfalls that were usually large enough to preclude further progress along the streambed.

A description and GPS coordinates (using Old Hawaiian datum) for the sampling stations are given below. GPS coordinates correspond to helicopter landing zones in the streambed at each site.

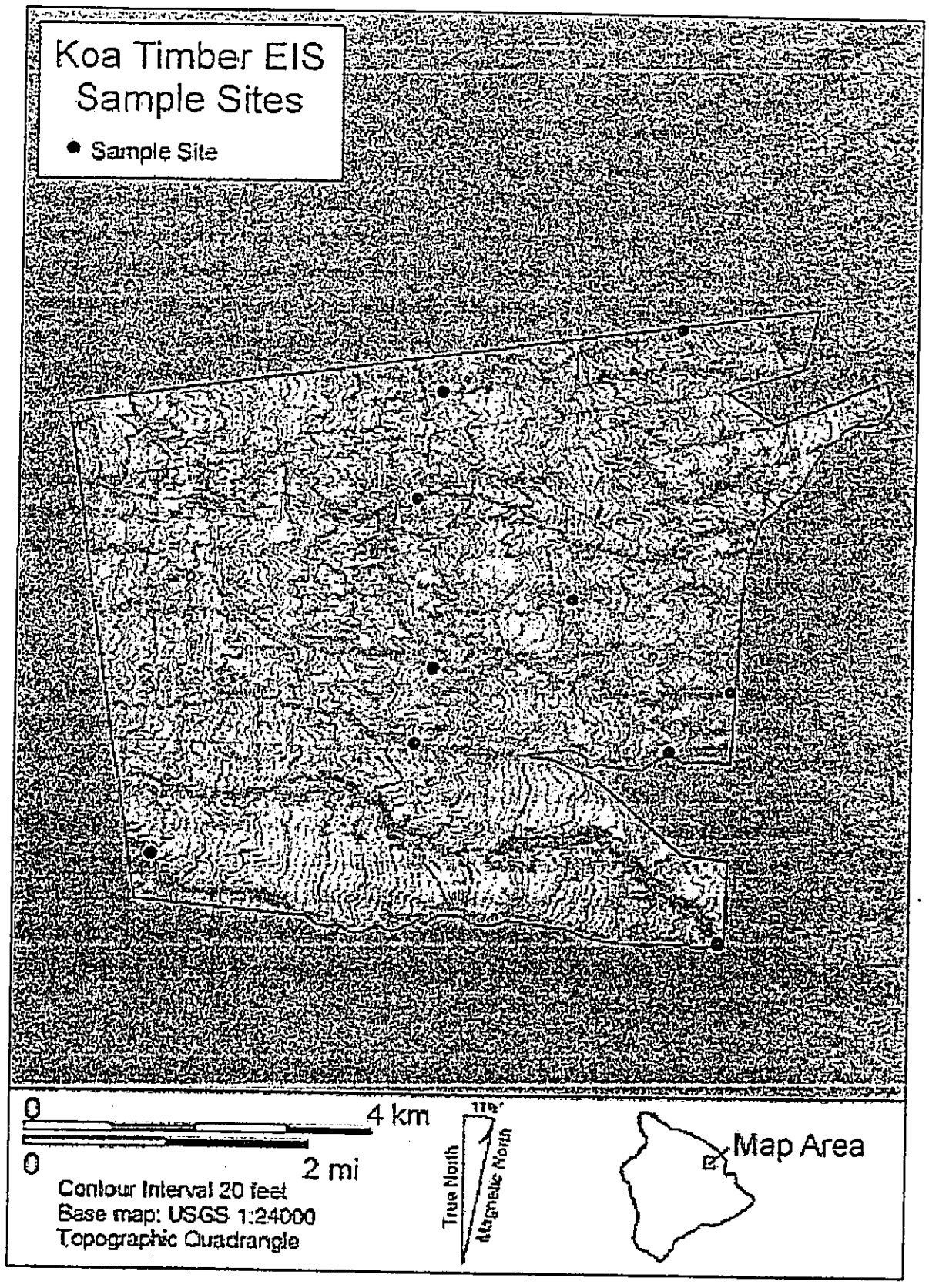


Figure 1. Study area and sampling stations for the *Koa* Timber surveys.

Station Descriptions and GPS Coordinates

Lower Honoli'i Stream – 1760 ft (19°46.388'N, 155°09.927'W)

Honoli'i Stream in this area is downstream of the confluence with Pōhakupa'a Stream, and this area was the largest stream examined during this study. Approximately 0.25 mi upstream a large waterfall at least 50 ft high impeded upstream progress, while the moderately sloping, incised canyon at this station ranged from 100-150 ft deep. A small tributary draining the strawberry guava monoculture and emptying into Honoli'i Stream was noticeably dirtier and siltier than the main stream channel. The raised banks of the stream here were often 10-15 ft above the low baseflow channel, and often contained standing water habitats because of the many seeps and springs flowing from the sides of the canyon in the area. The stream substrate seemed somewhat scoured from the recent high flows, but not as much as in upper Honoli'i, where little or no algae were observed on the rocks.

Large, deep (> 20 ft) pools were intermixed between riffles and cascades. During snorkeling observations only a slight layer of silt was observed on algae covering the rocks. The streambanks were lined with strawberry guava, *uluhe*, and *māmaki* (*Pipturus albidus*), with some remnant *koa* found higher above the stream canyon. Water temperature at this station was 61 F, pH was 8.0.

Upper Honoli'i Stream – 3300 ft (19°46.593'N, 155°13.477'W)

Located at a major branching area for upper Honoli'i Stream, this station allowed for sampling of both the south and north branches of Honoli'i. The helicopter LZ was located in small clearing approximately 250 yds upstream from the confluence of these two major branches. Our campsite was located near the north branch, where light trapping at night as well as daytime sampling took place. The water clarity at this station was very high, with > 25 ft visibility in the deepest pools. Much of the stream channel here was a scoured, bedrock channel, but the stream here was also lined with large (2-6 ft) boulders and had a moderate gradient punctuated by high waterfalls both up and downstream of the confluence. The north tributary had a bare bedrock channel with little sign of algae on the rocks, apparently the high flows of the previous week had scoured this tributary. In contrast, the south branch above the confluence had a slightly smaller (ca. 1/3 less) estimated flow than the north branch.

The highly invasive gorse (*Ulex europaeus*) was found around and below the confluence of the two major forks of Upper Honoli'i Stream, but only in the open areas along the stream channel. Apparently gorse seeds have washed down from higher elevation areas where this noxious plant is firmly established, but was only found along the stream corridor and had not yet penetrated the native forest.

Upper Honoli'i Stream contrasted from the other streams examined in this study because of the heavy scouring that occurred during heavy flows in the week prior to these surveys. The near complete lack of algae on the rocks on the north tributary and fresh rock piles that had been re-arranged by the high flows were evidence of these recent high flows. Because it drains a much larger land area, Honoli'i Stream has greater peak flows when compared to the smaller watersheds examined such as Kawainui Stream. Nighttime MV light trapping also occurred on the banks of the upper Honoli'i Stream, near the helicopter LZ area. Water temperature at this station was 60 F, pH was 6.5. This was the lowest pH recorded during these surveys.

Lower Pāhoehoe Stream – 2000 ft (19°47.213'N, 155°10.561'W)

Lower Pāhoehoe Stream at this elevation was large and contained significant flow and deep pools in the reaches we surveyed. A strawberry guava zone was evident at this elevation, with dense growths found along the riparian zone and up the canyon walls. Downstream of the LZ and starting at the top of the canyon rim a landslide of strawberry guava approximately 30 ft in diameter had fallen to near the stream channel. Seeps were found in abundance at this station, with many found elevated above the streambed on the canyon walls. The seeps also fed the elevated side-pools along the raised rock shelf or ledge common that was located above the stream channel. Other than strawberry guava, riparian vegetation consisted of tree ferns, *koa*, and *'ōhi'a*.

The water was very clear at this station, and the bottom of an estimated 30 ft pool at the base of large waterfalls near the helicopter LZ was easily observed while snorkeling. The stream at this site contained a good mixture of aquatic habitats, with ample riffle and run habitat. A thick algal growth on rocks in both fast-water velocity runs and riffles indicated this section of stream had not had a devastating scouring flow in some time, in contrast with the upper Honoli'i Stream. Water temperature at this station was 60 F, pH was 7.5-7.6.

Upper Pāhoehoe Stream – 2700 ft (19°47.375'N, 155°10.561'W)

Pāhoehoe Stream in this area flows through a mostly pristine *koa* and *'ōhi'a* forest, with many deep (> 20 ft) pools interspersed between a mostly lava bedrock channel. In contrast to most of the other sites, upper Pāhoehoe Stream had several smaller tributaries and streamlets where it was possible to hike upstream. These small streamlets offered habitats different than those found in the much larger main channel of the stream, and we sampled these areas for aquatic invertebrates as well. Near the helicopter LZ area, the stream branched for about 50 yds forming a small, raised island of *koa*. Only a few strawberry guava were found in the forest around the stream zone, and the native forest here was almost entirely intact.

Numerous slick, flat-rock lava ledges were found in the streambed, and stairstep ledges formed by pāhoehoe lava were formed as the stream changed in elevation. Large pools stream pools were found at the base of some of these cascades and waterfalls, and were estimated to be 20 ft deep and as large as 50 x 60 ft in dimension. The streambed was mostly bedrock, with areas occasional large and small boulders in riffles. Water temperature at this station was 58 F, pH was 7.3-7.4.

Lower Kapue Stream – 1900 ft (19°47.703'N, 155°09.712'W)

The helicopter LZ was located on a fairly level rock area, just above one of the tallest (> 100 ft) waterfalls observed in the study area, near the boundary with Conservation District land. Lower Kapue Stream also had the only diversion that we observed in the study area. This large diversion appeared to currently be working and was diverting a substantial amount of stream flow but it was unknown where the diversion terminated. Around the diversion was also the only location where the introduced aquatic plant watercress (*Nasturtium microphyllum*) was found.

Several large, pond-like habitats were found upstream of the diversion and they appeared to be overflow ponds that directed water into the diversion. Large pond habitats were not observed elsewhere in the study area, and these side-channel ponds were potential habitat for the very rare endemic *Megalagrion pacificum* damselfly. Upstream, and on the same side of the stream as the diversion, a small tributary flows through a dense stand of strawberry guava that was heavily disturbed by feral pigs. There was a noticeable increase in silt on the rocks in this tributary, and water clarity was lower. The surrounding forest still had large amounts of *koa*, *'ōhi'a* and *uluhe*, although strawberry guava had completely encroached in the small tributary immediately upstream of the diversion.

Stream substrate consisted of small amounts of large and small boulders, but was mainly lava bedrock. In places the lava bedrock formed chutes, and large piles of rocks were found in the bottom of the pools formed below the chutes. Cloud cover and light rain during our time at this site may have precluded capture of some native damselfly species here, particularly *M. pacificum*. Water temperature was noticeably warmer at this station and was 64 F, pH was 7.9.

Upper Kapue Stream – 2700 ft (19°47.993'N, 155°12.691'W)

The area surrounding the stream consists of a diverse old growth *'ōhi'a* and *koa* forest, with the *koa* standing taller than the *'ōhi'a*. Interspersed and found within the forest canopy were other native plants such as *Clermontia parviflorum and Trematolobelia grandiflorum*, although feral pigs have eaten most of the ground-dwelling *T. grandiflorum* in this area, and it was only observed growing out of *'ōhi'a* trunks. *Koa* trees were also actually growing within the streambed itself. Nighttime light trapping was conducted on the stream banks adjacent to Kapue Stream, near the campsite and helicopter LZ.

The stream flowed over slick red lava bedrock with almost no substrate, and only a limited amount of loose substrate. Many of the rock ledges adjacent to the stream channel contained standing water, and were also ideal aquatic habitats for insects. Upper Kapue Stream appeared to have a more stable flow than upper Honoli'i Stream because the stream substrate was not as scoured, but the smaller fist-sized rocks were clean, indicating some scouring had occurred during the recent high storm flows. However, growths of algae and mosses were found in areas around the mainstream channel indicating scouring was not severe. Around the camp area there were many deep (> 9 ft) pools formed by cascades and riffles.

Downstream of the camp and LZ the stream channel spread out into a low gradient wide, nearly flat area causing the stream to spread out into a wide, thin laminar flow, with few deep pools. The channel was estimated to be over 150 ft wide in places, with little riffle habitat and no substrate, only bedrock. This continued for nearly 0.5 miles until a large 80 ft impassable waterfalls is encountered. Water temperature at this station and was 60 F, pH was 6.9.

Hanawī Stream – 2300 ft (19°48.268'N, 155°10.817'W)

Hanawī Stream in this area is small, and composed of lava chutes with relatively little substrate except where rocks are flushed into the bottom of pools during high flows. The forest surrounding the stream was almost entirely native *koa*, 'ōhi'a, and *uluhe* fern. Because this is such a short watershed, helicopter access was very limited both up and downstream of this area, and there were few landing zones once past the planted rows of *Eucalyptus* sp. marking the Conservation District boundary line. Also, because of the small size of the Hanawī watershed, there were no observable scouring effects from the recent storm, and luxuriant growths of algae covered the stream bottom. The section of Hanawī Stream sampled contained a sloping but traversable long bedrock cascade, perhaps 40-50 ft high. Approximately 0.25 mi downstream of the sloping cascade near the helicopter LZ impassable falls were encountered. Water temperature at this station and was 61 F, pH was 7.7.

Kawainui Stream – 2700 ft (19°48.832'N, 155°10.992'W)

Kawainui Stream was also one of the smaller watersheds, with limited helicopter landing zones. An overnight camp and nighttime light trapping of aquatic insects occurred along the stream banks here, with the camp located on a rocky shelf 75 ft downstream from the boggy helicopter LZ that was located near the stream channel. Upstream was a series of riffles and stairstep cascades approximately 8-10 ft high, with a small channel only 2-3 ft wide in the shallow run and riffle areas. The steam at this location was generally

too small for snorkeling, with the exception of one very large pool upstream. Flowing through a bedrock channel, this area also had some cobble substrate in contrast to many of the other stream areas examined in the study area that were mostly lacking substrate.

Feral pig activity (e.g., rototilled soil) was also greater here than at the other high elevation stations, with pigs observed crossing the stream during the middle of the day. Water temperature at this station and was 58 F, pH was 7.3.

Lower Wai'a'ama Stream – 1950 ft (19°49.936'N, 155°10.385'W)

In the otherwise relatively featureless 13,129-acre project area, this study site occurred near one of the few landmarks, the Ka'uku pu'u (cinder cone), which can be seen from downtown Hilo, approximately 10 miles away. The lowest reaches of Wai'a'ama Stream are located at the extreme northeastern boundary of Conservation District land, and the lower reaches of Wai'a'ama Stream flow around the base of Ka'uku pu'u. In contrast to the higher elevation study site of Wai'a'ama Stream, the stream in this area flowed through a large *Eucalyptus* plantation, and dense strawberry guava was observable around the observable riparian zone. Upstream of the LZ the riparian vegetation turns into guava and *uluhe*, with some older remnant *koa* and *'ōhi'a*, however, no young *koa* recruits were observed. Feral pig activity and resultant damage to the surviving native forest was extremely high at this station.

The stream channel here is large and incised into an approximate 50 ft deep canyon, and comparable only to the lower Honoli'i, with deep pools (> 30 ft) connected by long riffles and runs. The *Eucalyptus* appear to have negative effects on water quality, because a > 1 inch thick layer of silt was observed on the stream substrate. Additionally, a small tributary flowing through the *Eucalyptus* (at the LZ) and over the rock wall of the canyon to the mainstream was noticeably more silty. The wetted area of the falls on this small rock wall tributary also had a noticeably thick silt layer. This silt layer provided further evidence of the negative impacts of introduced plants, including strawberry guava, on water quality. Elevated sidewater pocket water habitats were observed above the stream channel, mostly downstream of the LZ, and these elevated habitats appeared to be fed by the emergent seeps and springs issuing from the canyon walls. Water temperature at this station and was 61 F, pH was 7.3.

Upper Wai'a'ama Stream – 2640 ft (19°49.510'N, 155°11.750'W)

The main stream channel was hardly incised, and at this station was only 10-15 ft below a nearly impenetrable *koa*, *'ōhi'a*, and *uluhe* fern forest. As the elevation increased, Wai'a'ama Stream became smaller and consisted of stairstep, narrow cascades and a series of narrow lava chutes with excellent water clarity. Stream gradient was moderate, with a series of 10-30 ft high cascades that were mostly passable

because of their gradual nature. Although the stream was small in this area, pools as deep as 8-10 ft were common at the base of each cascade.

Stream flow appeared to be quite stable at this station, as the recent rains appear to have caused no scouring of algae or mosses from the mainly bedrock lava chutes. Many of the rock potholes above the main stream channel here were full of water from either the recent rains or high stream flow, and were also full of aquatic insect life. At 56 F, the coldest water temperatures during this study were found here, while pH was measured at 7.0.

METHODS

Field work for this study was conducted by staff from the Hawaii Biological Survey from 6-15 February 2002. Sampling took place during a period of low baseflow, clear stream conditions, and mostly dry and sunny weather. Occasional light misty rain occurred only near the end of fieldwork (14 February); however, this rain was not enough to cause the streams to noticeably increase in flow or effect water clarity. Habitat conditions for native aquatic organisms were evaluated at each sampling station. Altitude was determined by using a combination of USGS topographic quadrangle maps, helicopter altimeter, and a hand-held altimeter. Stream names were taken from USGS topographic quadrangles.

Aquatic Insect Sampling

Aquatic insect sampling methodology followed Englund *et al.* (2000) and Englund and Preston (1999). Collections of both immature and adult specimens were conducted with MV (mercury vapor) light traps at three streams: Honoli'i, Kapue, and Kawainui. Malaise traps, yellow pan traps, aerial nets, dip nets, selective fogging of aquatic habitats with pyrethrins, and benthic kick and Surber samples were all used to collect larval and mature stages of aquatic insects. Immature aquatic insects were also collected from rocks found in riffles by using a toothbrush and fine-point tweezers to extricate larvae from algae covering the rocks and into a yellow pan. Visual observations for aquatic insects, especially of larger taxa such as Odonata (dragonflies and damselflies) were also conducted as we hiked along the streambed. Although sampling effort was focused on habitat suitable for native insects: splash zones around riffles and cascades and wet rock faces associated with springs and seeps, waterfalls, and wetland areas near and along the stream corridor, all aquatic habitats were sampled.

General collecting was conducted in prime native aquatic insect habitats with numerous aerial net sweeps taken around riffle splash-zones, cascades, seeps, and waterfall areas. Repeated benthic sampling was

conducted at each sampling station by one person holding an aquatic dip net while another person disturbed rocks upstream of the net. Benthic sampling also included collecting individual rocks and using a toothbrush to gently sweep immature aquatic insects and other aquatic invertebrates off from the stream rocks. Nighttime surveys using light traps powered by a portable generator were located on the riverbank and employed to comprehensively collect aquatic insects that are only active nocturnally. These areas were sampled using an MV (mercury vapor) light shining on a white sheet, and night sampling started before dark at 1730 hrs and continued to at least 2230 hours, during a moonless night. Arthropods attracted to the sheet were collected for later identification. All insect specimens were stored in 75% ethanol and subsequently transported to the Bishop Museum Entomology laboratory for curation and identification. Voucher specimens are currently housed in the Bishop Museum collection.

Fish, Crustacean, and Amphibian Sampling

Fish and crustacean underwater sampling conformed to Hawaii Division of Aquatic Resources (HDAR) native fish sampling guidelines (Baker and Foster 1992). However, because this study was focused more on examining biodiversity rather than being a long-term monitoring study, point counts were not used to determine native fish densities. Fish densities were generally low and limited the usefulness of point counts, thus snorkel transects (as recommended by Baker and Foster 1992) were more appropriate for this study.

Snorkeling at least 300-400 yds of stream channel and more when possible at each sampling station allowed a thorough inventory to be conducted for all aquatic macrofauna found at each study site. Snorkeling also allowed us to find cryptic species that would not have been observed if above-water observation was the only method used to assess streams, e.g., the native gobiid *Lentipes concolor* and aquatic species such as native diving beetles and dragonfly larvae were found during snorkeling, and would not have been found if only above-water observations were conducted. Because of low fish densities, transect snorkeling was used to assess fish and crustacean species composition throughout the study area. This involved snorkeling through an entire habitat or large section of stream and visually assessing species composition and estimating relative densities of fish and crustaceans. Amphibian sampling consisted of both above water and underwater visual observations, and was presence or absence with areas of particularly high densities noted.

Mollusk Survey Methods

The purpose of the mollusk survey was to develop an inventory of aquatic mollusk species present in the study area and to assess the status of the aquatic mollusk fauna found within study area streams. At each survey site searches were made in the water by visual inspection from the bank, by wading, and by snorkeling. Hīhīwai sampling also conformed with HDAR sampling guidelines (Baker and Foster 1992), although none were observed in the study site. All mollusk species that were observed were collected, and collected specimens were returned to the Bishop Museum for sorting and identification by reference to the

extensive Hawaiian and Pacific collections already held at the Museum, and by reference to pertinent literature also available at the Museum. Live specimens were preserved in 75% ethanol (ethyl alcohol).

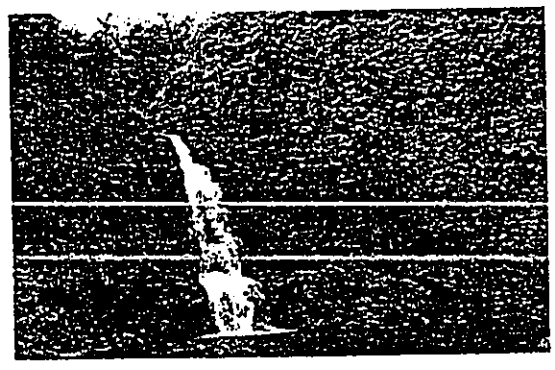
RESULTS AND DISCUSSION

Overall, native aquatic animal species predominated in aquatic habitats sampled within the proposed project area, indicating one of the most pristine aquatic ecosystems remaining in the Hawaiian Islands. A total of 61 species of aquatic macrofauna were collected in the six streams examined during this study (Table 1), and a complete list of species including their geographic origin can be found in Tables 2 and 3. In the study area forty-nine native aquatic species (mostly insects) and 11 introduced species were found (Table 1). For all stations combined, 82% of the aquatic taxa found during this study were native (either endemic or indigenous) species and 18% were introduced (Table 1).

Table 1. Summary of the native or nonindigenous status and total number (percent) of aquatic species found in all reaches combined in six streams assessed for the *Koa* Timber commercial logging EIS, South Hilo District, Hawai'i Island.

Geographic Status	All Aquatic Species	Amphibians	Fish	Mollusks	Aquatic Insects	Crustaceans	Oligochaete
Introduced	11 (18%)	1 (100%)	0 (0%)	1 (100%)	8 (14%)	0 (0%)	1 (100%)
Native	50 (82%)	-	1 (100%)	0 (0%)	48 (86%)	1 (100%)	0 (0%)
Total	61	1	1	1	56	1	1

Aquatic insects were by far the most species-rich group found in the study area, with 56 species collected (Table 1), and numerically were also the most abundant group. Figure 2 represents the total number of species found for each major aquatic taxa observed in study area streams. The native or nonindigenous status of arthropods was ascertained from Nishida (2002). Nonindigenous aquatic species have been brought into Hawai'i both accidentally and intentionally, and now comprise a major portion of aquatic biota found in many Hawaiian streams.



Falls at Honoli'i Stream, 1760 ft. elevation

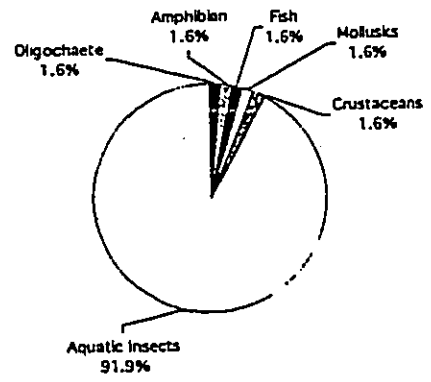


Figure 2. Percent composition of number of species of introduced and native aquatic macrofauna taxa found in six streams in the proposed *koa* timber logging area, South Hilo District, Hawai'i Island, February 2002.

Amphibians

The alien bullfrog (*Rana catesbeiana*) was the only species of amphibian observed within the project area, and was found in five of the six streams examined (Tables 2 and 3). High tadpole densities were found in certain areas such as lower Kapue Stream, with many observed in stream pools found near the irrigation diversion. The stomach contents of one bullfrog were examined in upper Kapue Stream, and an adult Hawaiian damselfly (*Megalagrion blackburni*) was found, along with the elytra of several terrestrial beetles. The impacts of bullfrogs on native aquatic biota, however, have not been quantified. Both and adults and tadpoles were found in the uppermost elevations of the project area, to 2900 ft in upper Kapue Stream. It was surprising to find tadpoles at such a high elevation, but it is also possible that bullfrogs have been coming down into the forest from the cattle ponds located above the Conservation District boundaries. While not observed in the upper stations at Honoli'i and Pāhoehoe Streams, it is likely that bullfrogs will eventually inhabit all the upper elevation stream areas because the adults appear to be going around the many waterfalls by dispersing through the surrounding rainforest and coming back to the stream to breed.

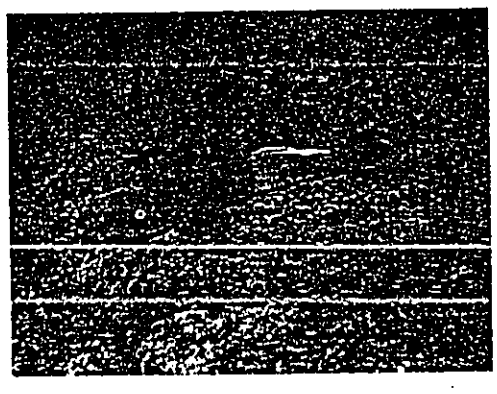
Fish

Fish species composition in the six streams examined in the study area consisted of one species, the native *'o'opu 'alamo'o* or *'o'opu hi'ukole* (*Lentipes concolor*) (Tables 2 and 3) being found in Honoli'i, Pāhoehoe, Kapue, and Hanawī Streams. As is the case with all native Hawaiian stream animals, the habitat requirements of *L. concolor* consist of clear, excellent water quality, and an unbroken stream connection to the ocean (Yamamoto and Tagawa 2000), all of which were found in the study area. Finding only one species of fish might initially seem to indicate the study area is poor for native fish species; however, the opposite is actually true. The presence of this fish species indicates that the entire watershed within the project area continues to function as a healthy ecosystem. *Lentipes concolor* is sensitive to ecological

disturbance (Yamamoto and Tagawa 2000) such as stream dewatering and siltation, and its presence indicates a healthy and functioning Hawaiian rainforest. The complete absence of alien fish species in the study area also indicates the aquatic habitats found here are some of the highest quality remaining in the State of Hawaii.

Lentipes concolor was commonly found in four of the six study streams, ranging from a low elevation of 1760 ft in Honoli'i to 2300 ft in Hanawī Stream. Although *L. concolor* has been found in streams above the town of Waimea, Hawai'i Island to elevations of nearly 3000 ft (D. Kuamo'o, HDAR, pers. comm.), the finding of this species as high as 2300 ft in the study area was significant. This is because streams draining the Waimea region are much lower gradient and lack the numerous large waterfalls that are present in all the streams we examined during the current study. Thus, it is a much greater physical challenge for the fish to ascend the numerous waterfalls within the study area.

Lentipes concolor populations were observed to have subtle but observable differences between streams. For example, of the estimated 20 individuals observed both in deep pools and shallow runs in Hanawī Stream, all were large adults, with lengths ranging from 3.5 – 5.5 inches, and with females generally smaller and males being very large. Small or recently recruited fish were not observed in Hanawī Stream, which contrasts with the much lower elevation station of lower Honoli'i Stream (1760 ft), where *L. concolor* as small as 1.25 inches were observed. It is possible that recruitment into the higher areas of Hanawī Stream is difficult because of the many falls that need to be ascended, and this may account for the current lack of recent recruits. *Lentipes concolor* were also common in lower Kapue Stream, with the base of each plunge pool having 1 to 5 fish (3-5 inches long), and some individuals also observed in shallow runs. One smaller, relatively recent recruit (2 inches long) individual was also observed in lower Kapue Stream. Lower Pāhoehoe Stream (2000 ft elevation) contained a significant *L. concolor* population, with as many as one fish observed every 10 ft during snorkeling transects in runs.



Lentipes concolor

Table 2. Results of Hawaii Biological Survey, Bishop Museum surveys of aquatic species in Honoli'i, Pāhoehoe, and Kapue Streams, South Hilo District, Hawai'i Island.

Taxon	Honoli'i Stream 1760 ft	Honoli'i Stream 3200 ft	Pāhoehoe 2000 ft	Pāhoehoe 2700 ft	Kapue 1900 ft	Kapue 2900 ft	Geographic Status
Amphibians							
Rana catesbeiana	X		X		X	X	Introduced
Fish							
Lentipes concolor	X		X		X		Endemic
Mollusks							
Physidae sp.					X		Introduced
Crustaceans							
Atyoida bisulcata	X				X		Endemic
Oligochaeta (semi-aquatic worms)							
Megascolecidae							
Amynthas diffringens		X					Introduced
Aquatic Insects							
Anisoptera (Dragonflies)							
Aeschnidae							
Anax strenuus	X	X	X	X	X	X	Endemic
Libellulidae							
Pantala flavescens	X		X		X		Indigenous
Zygoptera (Damselflies)							
Coenagrionidae							
Enallagma civile					X		Introduced
Ischnura posita					X		Introduced
Megalagrion blackburni	X	X	X	X	X	X	Endemic
Megalagrion calliphya	X	X	X	X	X	X	Endemic
Megalagrion hawaiiense	X	X	X			X	Endemic
Heteroptera (True Bugs)							
Mesoveliidae							
Mesovelia amoena							Introduced
Saldidae							
Saldula exulans	X	X	X	X	X	X	Endemic
Saldula procellaris	X	X		X	X		Endemic
Saldula oahuensis	X						Endemic
Veliidae							
Microvelia vagans	X	X	X	X	X	X	Endemic
Coleoptera (Beetles)							
Carabidae							
Bembidion cf. *ignicola*		X				X	Endemic
Dytisicidae							
Rhantus pacificus		X		X			Endemic
Diptera (Flies, gnats)							
Canacidae							
Procanace acuminata					X	X	Endemic
Procanace bifurcata					X		Endemic

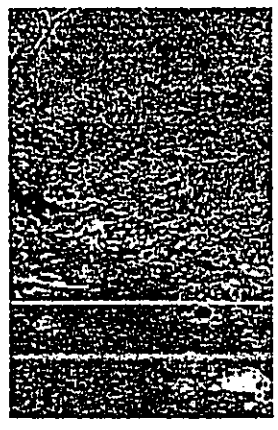
Table 2 (cont.). Results of Hawaii Biological Survey, Bishop Museum surveys of aquatic species in Honoli'i, Pāhoehoe, and Kapue Streams, South Hilo District, Hawai'i Island.

Taxon	Honoli'i Stream 1760 ft	Honoli'i Stream 3200 ft	Pāhoehoe 2000 ft	Pāhoehoe 2700 ft	Kapue 1900 ft	Kapue 2900 ft	Geographic Status
Procanace confusa	X				X	X	Endemic
Procanace constricta					X		Endemic
Procanace new sp.	X	X		X	X		Endemic
Ceratopogonidae							
Dasyhelea hawaiiensis		X		X		X	Endemic
Dasyhelea sp. not *hawaiiensis*						X	Endemic
Forcipomyia hardyi		X	X			X	Endemic
Forcipomyia sp.	X						Endemic
Chironomidae							
Chironomus prob. *hawaiiensis*		X					Endemic
Cricotopus bicinctus	X	X	X	X	X	X	Introduced
Orthocladius sp.					X		Endemic
Orthocladius prob. *grimshawi*		X			X	X	
Pseudosmittia paraconjuncta	X		X		X	X	Endemic
Telmatogeton torrenticola	X				X		Endemic
Dolichopodidae							
Campsionemus modicus							Endemic
Campsicnemus tibialis	X	X		X		X	Endemic
Eurynogaster new sp.		X		X		X	Endemic
Paraliancalus metallicus							Endemic
Sigmatineurum omega							Endemic
Ephydridae							
Hydrellia tritici						X	Introduced
Scatella amnica							Endemic
Scatella cillipes	X				X	X	Endemic
Scatella clavipes	X	X			X	X	Endemic
Scatella hawaiiensis							Endemic
Scatella oahuense	X		X		X		Endemic
Scatella warreni		X			X	X	Endemic
Scatella williamsi	X				X	X	Endemic
Psychodidae							
Psychoda sp.	X						Endemic
Trichomyia hawaiiensis							Endemic
Tipulidae							
Limonia hawaiiensis	X	X	X	X		X	Endemic
Limonia jacoba	X	X	X		X	X	Endemic
Limonia kauaiensis	X	X				X	
Limonia nigropolita	X						Endemic
Limonia stygipennis		X					Endemic
Limonia swezeyi	X	X		X			Endemic
Limonia sp.	X				X		Endemic

Table 2 (cont.). Results of Hawaii Biological Survey, Bishop Museum surveys of aquatic species in Honoli'i, Pāhoehoe, and Kapue Streams, South Hilo District, Hawai'i Island.

Taxon	Honoli'i Stream 1760 ft	Honoli'i Stream 3200 ft	Pāhoehoe 2000 ft	Pāhoehoe 2700 ft	Kapue 1900 ft	Kapue 2900 ft	Geographic Status
Trichoptera (Caddisflies)							
Hydropsychidae							
Cheumatopsyche pettiti	X				X		Introduced
Hydroptilidae							
Hydroptila potosina	X						Introduced
Lepidoptera (Aquatic Moths)							
Hyposmocoma sp. 1	X	X	X	X	X	X	Endemic

Elevated aquatic habitats found above streambed in Honoli'i Stream, 1760 ft elevation.



Pristine aquatic habitats, Honoli'i Stream, 3300 ft elevation

Table 3. Results of Hawaii Biological Survey, Bishop Museum surveys of aquatic species in Hanawī, Kawainui, and Wai'a'ama Streams, South Hilo District, Hawai'i Island.

Taxon	Hanawī Stream 2300 ft	Kawainui Stream 2700 ft	Wai'a'ama Stream 1950 ft	Wai'a'ama Stream 2640 ft	Geographic Status
Amphibians					
Rana catesbeiana	X		X		Introduced
Fish					
Lentipes concolor	X				Endemic
Mollusks					
Physidae sp.				X	Introduced
Crustaceans					
Atyoida bisulcata			X		Endemic
Oligochaeta (semi-aquatic worms)					
Megascolecidae					
Amynthas diffringens		X	X		Introduced
Aquatic Insects					
Anisoptera (Dragonflies)					
Aeschnidae					
Anax strenuus	X	X	X	X	Endemic
Libellulidae					
Pantala flavescens	X		X		Indigenous
Zygoptera (Damselflies)					
Coenagrionidae					
Enallagma civile					Introduced
Ischnura posita					Introduced
Megalagrion blackburni	X	X	X	X	Endemic
Megalagrion calliphya	X	X	X	X	Endemic
Megalagrion hawaiiense					Endemic
Heteroptera (True Bugs)					
Mesoveliidae					
Mesovelia amoena		X			Introduced
Saldidae					
Saldula exulans	X	X	X	X	Endemic
Saldula oahuense					Endemic
Saldula procellaris	X	X		X	Endemic
Veliidae					
Microvelia vagans	X	X	X	X	Endemic
Coleoptera (Beetles)					
Carabidae					
Bembidion cf. *ignicola*					Endemic
Dytisicidae					
Rhantus pacificus				X	Endemic
Diptera (Flies, gnats)					
Canacidae					
Procanace acuminata	X				Endemic
Procanace bifurcata					Endemic

Table 3 (cont.). Results of Hawaii Biological Survey, Bishop Museum surveys of aquatic species in Hanawī, Kawainui, and Wai'a'ama Streams, South Hilo District, Hawai'i Island.

Taxon	Hanawi Stream 2360 ft	Kawainui Stream 2700 ft	Wai'a'ama Stream 1950 ft	Wai'a'ama Stream 2640 ft	Geographic Status
Procanace confusa					Endemic
Procanace constricta					Endemic
Procanace new sp.			X	X	Endemic
Ceratopogonidae					
Dasyhelea hawaiiensis		X			Endemic
Dasyhelea sp. not *hawaiiensis*					Endemic
Forcipomyia hardyi		X	X	X	Endemic
Chironomidae					
Chironomus sp.			X		Endemic
Cricotopus bicinctus	X	X	X	X	Introduced
Orthocladius sp.	X	X			Endemic
Orthocladius prob. *grimshawi*	X	X	X		Endemic
Pseudosmittia paraconjuncta	X	X	X		Endemic
Telmatogeton torrenticola			X		Endemic
Culicidae					
Aedes albopictus			X		Introduced
Dolichopodidae					
Campsicnemus modicus	X				Endemic
Campsicnemus tibialis	X	X	X	X	Endemic
Eurynogaster new sp.	X				Endemic
Paraliancalus metallicus		X		X	Endemic
Sigmatineurum omega		X			Endemic
Ephydridae					
Hydrellia tritici			X		Introduced
Scatella cillipes	X	X	X		Endemic
Scatella clavipes	X	X	X		Endemic
Scatella hawaiiensis		X	X		Endemic
Scatella oahuense		X			Endemic
Scatella warreni	X				Endemic
Scatella williamsi	X	X	X		Endemic
Psychodidae					
Psychoda sp.		X			Endemic
Trichomyia hawaiiensis		X			Endemic
Tipulidae					
Gonomyia sp.					Endemic
Limonia hawaiiensis				X	Endemic
Limonia jacoba	X	X		X	Endemic
Limonia kauaiensis		X			Endemic
Limonia nigropolita					Endemic
Limonia stygipennis					Endemic
Limonia swezeyi		X			Endemic
Limonia sp.		X			Endemic

Table 3 (cont.). Results of Hawaii Biological Survey, Bishop Museum surveys of aquatic species in Hanawī, Kawainui, and Wai'a'ama Streams, South Hilo District, Hawai'i Island.

Taxon	Hanawī Stream 2300 ft	Kawainui Stream 2700 ft	Wai'a'ama Stream 1950 ft	Wai'a'ama Stream 2640 ft	Geographic Status
Trichoptera (Caddisflies)					
Hydropsychidae					
Cheumatopsyche pettiti	X			X	Introduced
Hydroptilidae					
Hydroptila potosina					Introduced
Lepidoptera (Aquatic Moths)					
Hyposmocoma sp. 1	X	X	X	X	Endemic

Crustaceans

One native species, the mountain dwelling freshwater shrimp or *'ōpae kuahiwi* (*Atyoida bisulcata*), was found within the study area and was abundant in Honoli'i, Kapue, and Wai'a'ama Streams (Tables 2 and 3). Because of their amphidromous nature, the mountainous *'ōpae kuahiwi* must pass through the stream mouth area at least two times to complete their life cycle. Their presence indicates an unbroken connection between the streams and the ocean. The shrimp were abundant in the three streams where they were present.

'Ōpae kuahiwi were in two of the four streams where the native fish *L. concolor* was present (Hanawī and Pāhoehoe were the two streams where these species were not found together). The absence of *'ōpae* from the streams containing *'o'opu* was especially puzzling, although the altitude of Hanawī Stream (2300 ft) where *L. concolor* was found was exceptionally high, especially considering the numerous waterfalls that must be ascended. Generally, the maximum elevational range of native *'ōpae kuahiwi* is far higher than that of native fish (see Englund and Polhemus 2001). Thus it would be expected that the two streams containing native fish would also contain *'ōpae kuahiwi*. For whatever reason, this was not the case, and the native fish exhibited a higher elevation distribution than *'ōpae kuahiwi* in these streams. Seasonality or some other unknown factors may be responsible for the observed distributions of native fish and shrimp. Native shrimp are often extremely abundant when present in the windward Hawai'i Island streams (e.g., upper Waipi'o Valley streams), and both numerous benthic samples and underwater surveys indicated that the shrimp were indeed not found in the two streams (Hanawī and Pāhoehoe) where *L. concolor* was common. However, it was not surprising to find *'ōpae kuahiwi* in a station of lower Wai'a'ama Stream lacking native stream fish, as finding native shrimp higher than the native stream fish is a more usual pattern.

Mollusks

The native freshwater mollusk fauna of the Hawaiian Islands includes very few species, most in the families Lymnaeidae and Neritidae (Cowie *et al.* 1995). However, a greater number of alien species has been introduced to the Islands (Cowie 1997, 1998) and these species now dominate the mollusk fauna of most freshwater ecosystems, especially those that have been modified for human use. Only one species of aquatic snail, an introduced species in the Physidae family, was collected during the survey, in lower Kapue Stream, near the area where watercress had been planted by the irrigation diversion. This physid species was very abundant on the rocks, watercress, and other aquatic vegetation at this station. As the only species of aquatic snail observed throughout the entire study area, it was no coincidence that this species was found near planted watercress and a major irrigation diversion. These findings are of interest because this indicates that the pristine streams sampled during this study are naturally devoid of both native and introduced aquatic snails. The limited range of the introduced physid species indicates that with the exception of the large neritid snail *hihiwai* (*Neritina granosa*), only found in the lower reaches of streams, aquatic snails are not native or found in streams draining Mauna Kea.

Aquatic Insects

No federally listed candidate aquatic insect species were observed in the study area. A total of 56 aquatic insect species representing 92% of the aquatic macrofauna were collected in the six streams within the study area. When all stations were combined, 86% were native and 14% were introduced aquatic insect species (Table 4). Generally, upper elevation stations contained a slightly greater proportion of native species than the lower elevations, with upper Honoli'i Stream (3200 ft) having the highest percentage of native species, while upper Kawainui Stream (2700 ft) had the greatest number of native species.

Table 4. Numbers of native and introduced aquatic insect species found in six streams assessed for the *Koa* Timber commercial logging EIS, South Hilo District, Hawai'i Island.

Station	Elevation	Number (%) Native spp.	Number (%) Introduced spp.	Total Aquatic Insect spp.
Honoli'i	1760 ft	27 (90%)	3 (10%)	30
Honoli'i	3200 ft	24 (96%)	1 (4%)	25
Pāhoehoe	2000 ft	13 (93%)	1 (7%)	14
Pāhoehoe	2700 ft	15 (93%)	1 (7%)	15
Kapue	1900 ft	24 (86%)	4 (14%)	28
Kapue	2900 ft	24 (92%)	2 (8%)	26
Hanawī	2300 ft	20 (91%)	2 (9%)	22
Kawainui	2700 ft	26 (93%)	2 (7%)	28
Wai'a'ama	1950 ft	18 (86%)	3 (14%)	21
Wai'a'ama	2640 ft	14 (88%)	2 (12%)	16
All Streams Combined:		48 (86%)	8 (14%)	56

A major finding of this study was the rediscovery of one population of native aquatic insect that was presumed extinct, the long-legged fly *Sigmatineurum omega*. Despite numerous attempts to find this species in streams around Hilo, it had not been collected since 1971 (Evenhuis and Polhemus 1994). Historically, this species had been collected from as low as 850 ft elevation (the "Boiling Pots" area) to 4220 ft elevation in the Wailuku River, with only five individuals collected prior to this study (Evenhuis and Polhemus 1994). *Sigmatineurum omega* is a large, metallic green fly in the family Dolichopodidae, and five individuals were found during the present study in Kawainui Stream. Adults were collected with sweep nets in the splash zones of cascades having a thick layer of green algae growing on the rock faces. Kawainui Stream was relatively small at the station sampled, and in places was only 2-3 ft wide, with a relatively stable flow through a bedrock channel. Despite apparently suitable habitat in nearby streams, *S. omega* was only collected at one station in one stream in the entire study area. The very low numbers and limited distribution of this species reflect its rarity, although very little is known about its biology other than adults (and presumably immatures) prefer splash-zone areas of cascades.

Two species of undescribed (new to science) aquatic flies were discovered during this study; new species in the genera *Eurynogaster* and *Procanace*. Species in the endemic genus *Eurynogaster* are only in found in undisturbed, high elevation habitats. Adults of the new *Eurynogaster* species were collected from 2300 ft elevation on Hanawī to 3200 ft in Honoli'i Stream, during aerial handnet sampling of large cascade and waterfall faces. The new *Procanace* sp. was found from a low of 1900 ft in Kapue Stream to upper Honoli'i Stream at 3200 ft elevation. Because these species have just been found during the present study, virtually nothing is known about their biology or life history, other than adults are found in splash-zones of cascades and waterfalls in relatively high elevation areas of pristine Hawai'i Island streams. Because the two new species have not been found during recent intensive surveys conducted by Hawaii Biological Survey staff in streams draining the Kohala volcano, it is likely they are restricted to upper elevation streams draining Mauna Kea.

Unlike aquatic vertebrates, most aquatic insects have narrow habitat tolerances meaning they can only live in certain sections of flowing water habitats, for example seeps, riffles, or cascade splash-zones. These narrow habitat preferences also have the effect aquatic insects being much more vulnerable to stream disturbances such as stream channelization, dewatering, and invasive species. Because aquatic insects are much less flexible in their habitat requirements than aquatic vertebrates, it then follows that insects provide an excellent tool for assessing the health of an aquatic ecosystem. The overwhelmingly high percentages of native species found during this present study indicate that aquatic habitats within the study area are some of the most untouched and pristine found within the Hawaiian archipelago. The study area compares as well as or better than other pristine aquatic habitats in Hawai'i that have been assessed by staff from the Hawaii

Biological Survey since 1990 (Englund 2001, Englund and Polhemus 2001, Englund *et al.* 2000, Englund and Preston 1999, Englund and Filbert 1997, Polhemus 1995). For example, Koai'e Stream (3700 ft elevation) in Kōke'e State Park, Kaua'i has the greatest number of native aquatic insects recorded from any stream in the Hawaiian archipelago, with 31 native and 8 introduced species of aquatic insects, for a total native percentage of 78% (Englund and Polhemus 2001, Englund *et al.* 2000). Streams sampled during the present study had lower numbers of total species than the exceptional Koai'e Stream, Kaua'i. A greater number of native species would be expected on a geologically older island such as Kaua'i, but all streams examined in the current study had higher percentages (as calculated by species numbers) of native aquatic insects (see Table 4) than the nearly pristine streams recently studied on Kaua'i (Englund and Polhemus 2001)

Five endemic aquatic insect species considered sensitive to environmental disturbance were found during this study: three species of damselfly (*Megalagrion blackburni, M. calliphya, M. hawaiiense*), the giant Hawaiian chironomid midge (*Telmatogeton torrenticola*), and the long-legged fly *Sigmatineurum omega*. All of these natives are highly sensitive to invasive species and environmental change, and none are found in disturbed environments. Although the three damselfly species remain common in undisturbed Hawai'i Island streams, *T. torrenticola* is becoming increasingly rare, and *S. omega* remains one of the rarest and most elusive of all aquatic insect species in the Hawaiian Islands. The presence of these species in both lower and upper elevation regions of the study area indicated aquatic habitats remain almost completely unimpacted (with a few notable exceptions) when compared to freshwater habitats found in closer proximity to the ocean. Although a limited number of small, silted tributaries flowed into larger streams in the lower study area (see Study Area), the overall waterflow contribution from these areas was insignificant and the impacts were not large enough to effect aquatic insects sensitive to siltation. For example, *Telmatogeton torrenticola* is one of the best indicators of water quality and water quantity of any aquatic species, and can only be found in clear flowing, unsilted stream habitats. Accordingly, this species was only found in the lower reaches of the largest streams in the study area: Honoli'i, Wai'a'ama, and Kapue Streams. *Telmatogeton torrenticola* was not found in the upper reaches of these streams, or the smaller side streams sampled because its larvae require crashing cascade and waterfall habitats (Benbow *et al.* 1997). It appeared that water volume in the uppermost reaches of the study area was not sufficient to support this species because streams draining Mauna Kea gain waterflow as elevation decreases. However, other species sensitive to disturbance such as the long-legged fly (previously believed extinct) *Sigmatineurum omega* were only found at high elevations within the study area, indicating the upper and lower portions of the study area supports invertebrate species sensitive to disturbance.

CONCLUSIONS

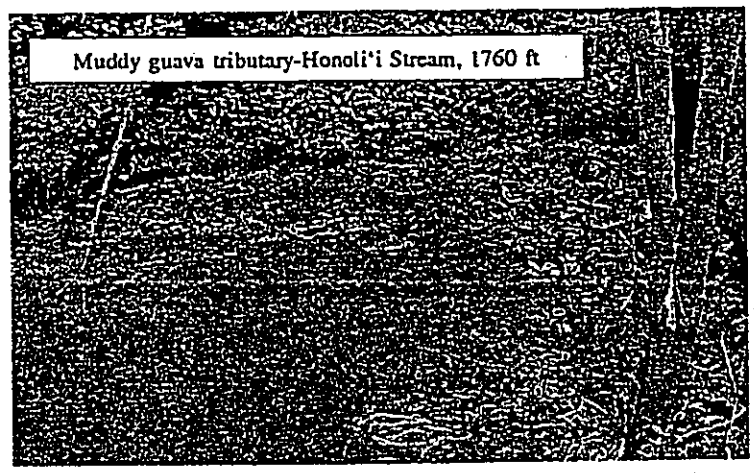
Overall Findings

The six major streams examined in this study included Honoli'i, Pāhoehoe, Kapue, Hanawī, Kawainui, and Wai'a'ama Streams, all located within the South Hilo District, Hawai'i Island. No Federally Threatened, Endangered, Candidate, or eminently threatened species of aquatic animals were found in or around the major stream ecosystems examined during the present study. Aquatic habitats within the proposed project area were found to be some of the most pristine remaining within the State of Hawai'i, and the lack of any major alien aquatic fauna within these habitats was unusual. The high percentages of native aquatic fauna found within the proposed project area, great densities of native aquatic species, and the high diversity of native taxa all indicate the aquatic habitats within the proposed area contain some of the best remaining examples of endemic native Hawaiian aquatic biodiversity within the archipelago.

Despite the high native aquatic biodiversity, some native invertebrates including important Hawaiian cultural food items such as the freshwater crustacean *'ōpae kuahiwi* are seriously threatened in this area by introduced ungulates such as feral pigs, and by introduced plants such as strawberry guava. Both feral pigs and strawberry guava threaten native aquatic habitats because they negatively impact water quality by increasing sediment inputs into streams, and can change a clear, cold mountain stream into turbid, warm habitats much less suitable for native fish, crustaceans, and aquatic insects and other native aquatic invertebrates.

The greatest threat from selective *koa* logging to native aquatic biota would be an increase in sediment input into streams flowing within the project area. Increased sedimentation resulting from this project could occur from two primary pathways: either through direct disturbance during the actual logging process, or from an increase in invasive species after the *koa* has been logged. Siltation or sediment input has been found to be the greatest single water pollutant in terms of ecological and economic impacts affecting streams in the United States (Waters 1995). Not only can silt impair fish reproductive and physiological processes, siltation also directly impacts fish food organisms such as aquatic insects and other invertebrates (Waters 1995). Small increases in sediment load can result in drastic changes in aquatic invertebrate species density and composition. Waters (1995) in his monograph on stream sediment stated that "...additions of anthropogenic sediment would result in loss of the best benthos habitat..." and consequently would lead to reductions in invertebrate populations and the fish that rely on these invertebrates for food.

Potential Impacts of Commercial *Koa* Harvest


Muddy guava tributary-Honoli'i Stream, 1760 ft

We observed that streamlets flowing through strawberry guava in the lower project areas were extremely silted. This silting is a result of a domino-effect of the alien invasive, strawberry guava (Staples 2001). Guava secretes an allelopathic chemical that kills off other plant species, and leaves a monoculture with no shrub or brush understory (Stone and Pratt 1994). Lacking this understory, there is nothing to hold the soil in place during heavy rains. The resultant soil erosion in these water drainages renders formerly clear streams cloudy (see picture above). Feral pigs increase the problem by spreading guava very efficiently through the feeding on fruits and spreading seeds through their fecal material (Kishinami 2001). They also increase soil disturbance in areas both with strawberry guava and in pristine areas by way of rooting up soil for food (usually tubers or roots).

A major concern from an aquatic ecosystem perspective would be that weed control needs to be effective in the patches were *koa* is logged. This would ensure strawberry guava does not replace the mature *koa* that has just been logged. Aquatic biota would be adversely impacted if invasive weed species become established because they are not adapted to heavily sedimented water conditions. To ensure buffer zones are maintained and that invasive species do not gain a foothold in areas where *koa* is selectively logged it is recommended that forest regeneration be monitored for the life of the project by a botanist or forester with experience in native Hawaiian rainforest ecosystems. It is also recommended that aquatic habitats and aquatic biota be monitored for the life of the project to ensure logging does not increase rates of sedimentation that would adversely impact native aquatic biota.

Logging areas lacking riparian buffer zones have higher suspended sediment levels and decreased fish and invertebrate densities (Waters 1995). A buffer zone is an area where *koa* logging does not occur, and this minimizes sediment impacts into the streambed that could harm native Hawaiian aquatic species. If a buffer zone were maintained, the physical act of selectively harvesting *koa* using helicopters at the rate of one tree per acre would have likely little or no impact on aquatic species. However, once logging is completed there is a strong potential that alien plant species will gain inroads into the native forest, especially in the upper project areas (> 2300 ft elevation). This is because by necessity the *uluhe* fern will be cleared for the loggers to gain access to the base of the *koa* trees, opening up this area to invasion by strawberry guava. It

should be noted that *uluhe* fern grows as high as 30 ft up a *koa* trunk, so the amount of *uluhe* clearing around the *koa* trees to be harvested will not be trivial.

Buffer strips are an old and reliable technique used to control excessive sediment input into a stream from forestry operations, and they operate by retaining and filtering sediment that would otherwise directly go into a stream (Waters 1995). Buffer strips leave an uncut zone of natural vegetation along the sides of streams where logging occurs (Waters 1995). Buffer zone measurements are the total width along a stream corridor starting from the edge of each side of a stream; e.g., a 70-foot buffer zone would be 35 feet of uncut forest on each side of the streambank, measured horizontally from the high-water mark or bank-full flow area (Platts et al. 1983) of each streambank.

It is recommended that a riparian buffer zone (an area where no timber harvest occurs) be maintained at least 75 feet away from the streambed (Waters 1995). However, Waters (1995) also mentioned other studies that showed the width of effective buffer strips was dependent on local conditions. Riparian buffer zone (or Streamside Management Zones-SMZs) recommendations by Hawaii DOFAW (1996) state that "SMZs should be designed on a case by case basis", and will be dependent on terrain, soil type, stream sensitivity, precipitation, and other factors.

DOFAW [see page 21] (1996) recommends a minimum width of 35 feet on each side of the stream, for a total buffer strip of 70 feet of protected stream width. The minimum riparian buffer zone recommended by DOFAW approximately equals the 75-foot total length recommended by Waters (1995), although partial harvesting, as allowed by the DOFAW (1996) guidelines, was not recommended by Waters (1995). However, it should be emphasized that the project area has a wide variety of soil types, wetlands, and deeply incised gorge areas. Thus, determining one overall buffer zone width for the entire project area is not possible, but will have to be done within each watershed and at each particular elevation and logging area. Determination of specific buffer zones will be dependent upon local conditions found along each stream, and will vary along a specific stream going from lower to higher elevations within the project area. Buffer zones will be need to be determined by a registered professional forester taking into account soil type, slope, wetlands, and other factors, but should be at minimum approximately 75 feet in total width.

Fortunately there is a program in Hawaii administered by the USDA Natural Resources Conservation Service that will actually pay private landowners to set aside buffer zones in and around streams in places such as the proposed *koa* logging area. A yearly rental rate will be paid to the private landowner by the USDA to maintain a buffer zone, this is called the Conservation Reserve Program (CRP). Details on this program are available at http://www.hi.nrcs.usda.gov/whip/whip.htm. This economic incentive provides further reasons for maintaining a no-cut buffer zone along the stream corridors within the project area.

Although DOFAW (1996) guidelines state that buffer zones (SMZs) are not "timber harvest 'keep out' zones" (page 20), they also state several sentences later that the "sensitivity of stream" should be a factor in establishing the width of SMZs. Because of the many sensitive and rare species of native aquatic animals found within the study area, we recommend against any timber harvesting within the riparian buffer zone. Additionally, the DOFAW (1996) guidelines that allow selective harvest within the buffer zone contrast with the findings of the scientific literature (see Belt et al. 1992; Waters 1995), and management plans for high quality streams in place for many states and provinces (Belt et al. 1992). According to Belt et al. (1992) timber harvest within the riparian buffer zone has the potential to affect water quality and fish habitat by removing forest canopy that reduces shading and raises water temperature. This adversely impacts fish food supply (i.e., invertebrates), and also alters the amount of large organic debris (LOD) that is important for fish habitat.

Mitigation of Impacts

Every effort needs to be made to reduce invasive species from gaining increased access to areas where *koa* is selectively helicopter logged. All used logging equipment (e.g., cages, chainsaws, ropes, etc.) brought in from the mainland should be steam-cleaned or disinfected and sterilized prior to use to eliminate any hitchhiking invasive species, especially ants, which can destroy the invertebrate ecosystem in only a few years. Any helicopters brought in from the mainland should have their skids sterilized or disinfected prior to use in a Hawai'i *koa* forest. If invasive species start to become established in the small open areas where *koa* is harvested, then weed control of some kind will be required, and these areas need to be immediately replanted with *koa* and/or *'ōhi'a* seedlings. Net beneficial effects to the native ecosystem would accrue if strawberry guava is cleared and replanted with *koa* seedlings in the lower elevations of the project area. Monitoring by foresters and biologists trained in Hawaiian ecosystems should be conducted to ensure control of alien species in areas where *koa* is selectively logged, and ensure no further degradation of the watershed.

Other potential mitigation measures could include an increase of feral pig hunting in the project area by providing access to local hunters. A successful model for increased local hunter participation that has reduced the impacts of feral pigs has been effectively used in Pelekunu Valley, Moloka'i by The Nature Conservancy of Hawai'i. Additionally, because of the extremely remote nature of the property, hunting may not always be possible or effective in all areas, and fencing may be required to exclude pigs from returning to areas where *koa* is being reforested. Fences are effective and would not need to be constantly monitored. Any needed monitoring could be conducted incidentally during the many helicopter flights required to transport *koa* logs throughout the project area. Federal agencies such as the USDA Natural Resources Conservation Service assist private landowners in habitat improvement projects such as feral ungulate fencing. Further information about this is available at http://www.hi.nrcs.usda.gov/whip/whip.htm.

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Appendix G

Archaeological Inventory Survey

Report 052-011001

ARCHAEOLOGICAL INVENTORY SURVEY

TMK: 3-2-9-005:002, 3-2-8-001:002, AND 3-2-7-001:001

LANDS OF HAKALAU NUI, MAKAHANALOA, KAWAINUI, ONOMEA, ALAKAHI, PĀPA'IKOU, MOKU'ŌNIKI, PU'UMOI, KALAOA, 'ALEMAI, AND PAUKA'A

SOUTH HILO DISTRICT

ISLAND OF HAWAI'I

Haun & Associates

Archaeological, Cultural, and Historical Resource Management Services
HCR 1 Box 4730, Keaau, Hawai'i 96749 Phone: 982-7755 Fax: 982-6343

ARCHAEOLOGICAL INVENTORY SURVEY

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SOUTH HILO DISTRICT

ISLAND OF HAWAI'I

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Prepared for:

Koa Timber, Inc.
c/o Mr. Roy Takemoto

January 2001

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SUMMARY

At the request of Mr. Roy Takemoto on behalf of Koa Timber, Inc., Haun & Associates conducted an archaeological inventory survey of TMK: 3-2-9-005:002, 3-2-8-001:002, and 3-2-7-001:001, a c. 16,267-acre area located in the Lands of Hakalau Nui, Makahanaloa, Onomea, Kawainui, Alakahi, 'Alemai, Pāpa'ikou, Kalaoa, Pu'umoi, Moku'ōniki, and Pauka'a; South Hilo District; Island of Hawai'i. The objective of the survey was to satisfy historic preservation regulatory review inventory requirements of the Department of Land and Natural Resources-State Historic Preservation Division (DLNR-SHPD), as contained within Hawai'i Administrative Rules, Title 13, DLNR, Subtitle 13, State Historic Preservation Division Rules.

There are few traditional or legendary references to the project area. Land Commission Award (LCA) claim testimonies indicate that by the early to mid-1800s traditional Hawaiian settlement and agriculture in the project area *ahupua'a* was situated 2.5 to 3.5 miles east of the project area, primarily below 500 ft elevation. The LCA testimonies document many residential structures and cultivated fields. Named crops consisted of coconuts, bananas, taro, and coffee. Other probable crops included breadfruit, *wauke*, sugar cane, and sweet potato. Canoe houses are mentioned in Pu'umoi and Pauka'a indicating access to the ocean and marine resources.

The Boundary Commission testimonies describe activities conducted in the project area including bird catching, canoe building, bullock hunting, and gathering of *olonā* and *pulu*. There is one reference to a probable shrine on the south bank of Waia'ama Stream opposite Pu'u Ka'uku, a short distance seaward of the project area. Trails and settlements for bird catchers and canoe makers are also described.

Historic use of the project area *ahupua'a* was dominated by sugar cane plantation agriculture beginning in the mid-1800s and continuing in some areas until the 1990s. Diversion structures in the Waia'ama, Kawainui, Kalaoa, Pahoehoe, and other stream drainages were constructed to feed flumes and ditches, which were used to transport wood and sugar cane. Oral historical research and interviews conducted for a cultural impact assessment of the proposed timber project provide information on 1800s to 1900s use of the project area, primarily for pig hunting and gathering food resources.

No traditional Hawaiian sites were identified during the survey. Archaeological evidence for such sites, primarily temporary camps and trails, would be minimal consisting of food remains and artifacts. Habitation structures were probably made entirely of perishable materials including wood and thatch because surface stones are rare. The combined factors of heavy rainfall, rapidly growing dense vegetation, and ground disturbance by pigs largely preclude the possibility of identifying such sites.

The archaeological survey identified one historic site, a water diversion feature and ditch (Site 22534) on an unnamed drainage in Pāpai'kou. The site is assessed as significant under DLNR-SHPD significance Criterion "d" and Criterion "c". The site has yielded information important for understanding historic land use. The site is a well-preserved example of plantation water system infrastructure probably dating to the late 1800s to early 1900s. The site is recommended for preservation. The specific plans for preservation of the site would be detailed in a Preservation Plan prepared for DLNR-SHPD review and approval.

Several portions of the project area retain the potential to contain prehistoric or historic cultural resources; however, such remains, except water diversion structures, probably would only be found during ground disturbing activity. These areas include Pu'u Ka'uku and the land within approximately 10 to 20 meters of the main streams. Historic records indicate the potential presence of old *kauhale*, temporary camps, and water diversion structures along Wa'awa'a Stream in Hakalau Nui, Waia'ama Stream in Makahanaloa, and Kawainui and Pahoehoe Streams in Pāpai'kou and Pauka'a. These areas should either be avoided for timber harvesting, or monitored by archaeologists during harvesting.

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INTRODUCTION

At the request of Mr. Roy Takemoto on behalf of Koa Timber, Inc., Haun & Associates conducted an archaeological inventory survey of a 16,267-acre parcel located in the Lands of Hakalau Nui, Makahanaloa, Kawainui, Onomea, Alakahi, Pāpai'kou, Moku'ōniki, Pu'umoi, Kalaoa, 'Alemai, and Pauka'a, South Hilo District, Island of Hawai'i (*Figure 1*). The objective of the survey was to satisfy historic preservation regulatory review inventory requirements of the Department of Land and Natural Resources-State Historic Preservation Division (DLNR-SHPD), as contained within Hawai'i Administrative Rules, Title 13, DLNR, Subtitle 13, State Historic Preservation Division Rules.

The planned use of the project area is long-term, sustainable harvesting of *koa* (*Acacia koa* Gray) timber. No roads are planned within the Conservation District lands, which occupy the majority of the project area. Harvesting would be accomplished using helicopters to log selected, primarily dead or dying *koa* trees. Milling operations will be situated within adjacent Agricultural District lands formerly used for sugar cane cultivation. The project goal is to practice timber harvesting in a manner that preserves important plant, animal, and water resources; maintains the character and habitat value of the forest; and promotes rapid regeneration of logged areas to their natural condition. A very long rotation of up to a century is proposed with only a small portion of the area being logged in any given decade. The inland limit of the proposed timber harvesting is between approximately 2,700 and 3,000 ft elevation. Above this, there are very few standing trees most of which have been long dead.

The archaeological inventory survey fieldwork was conducted December 11-28, 2000, and January 4-7, 2001. Described in this final report are the project scope of work, field methods, background information, survey findings, and significance assessments of the identified cultural resources with recommended treatments.

Scope Of Work

Based on DLNR-SHPD rules for inventory surveys and discussion with DLNR-SHPD staff, the following specific tasks were determined to constitute an appropriate scope of work for the project:

1. Conduct background review and research of existing archaeological and historical documentary literature relating to the project area and its immediate vicinity–including examination of Land Commission Awards, *ahupua'a* records, historic maps, archival materials, archaeological reports, and other historical sources;

2. Conduct pedestrian survey sample coverage of the project area;

3. Conduct detailed recording of all potentially significant sites including scale plan drawings, written descriptions, and photographs, as appropriate;

4. Conduct limited subsurface testing (manual excavation) at selected sites (a) to determine the presence or absence of potentially significant buried cultural deposits or features, and (b) to obtain suitable samples for radiocarbon age determination analyses;

5. Analyze background research and field data; and

6. Prepare and submit Final Report.

Project Area Description

The project area consists of a c. 16,267-acre area located in the Lands of Hakalau Nui, Makahanaloa, Kawainui, Onomea, Alakahi, Pāpai'kou, Moku'ōniki, Pu'umoi, Kalaoa, 'Alemai, and Pauka'a, South Hilo District, Island of Hawai'i (TMK: 3-2-9-05:02, 3-2-8-01:02, and 3-2-7-01:01). The project area

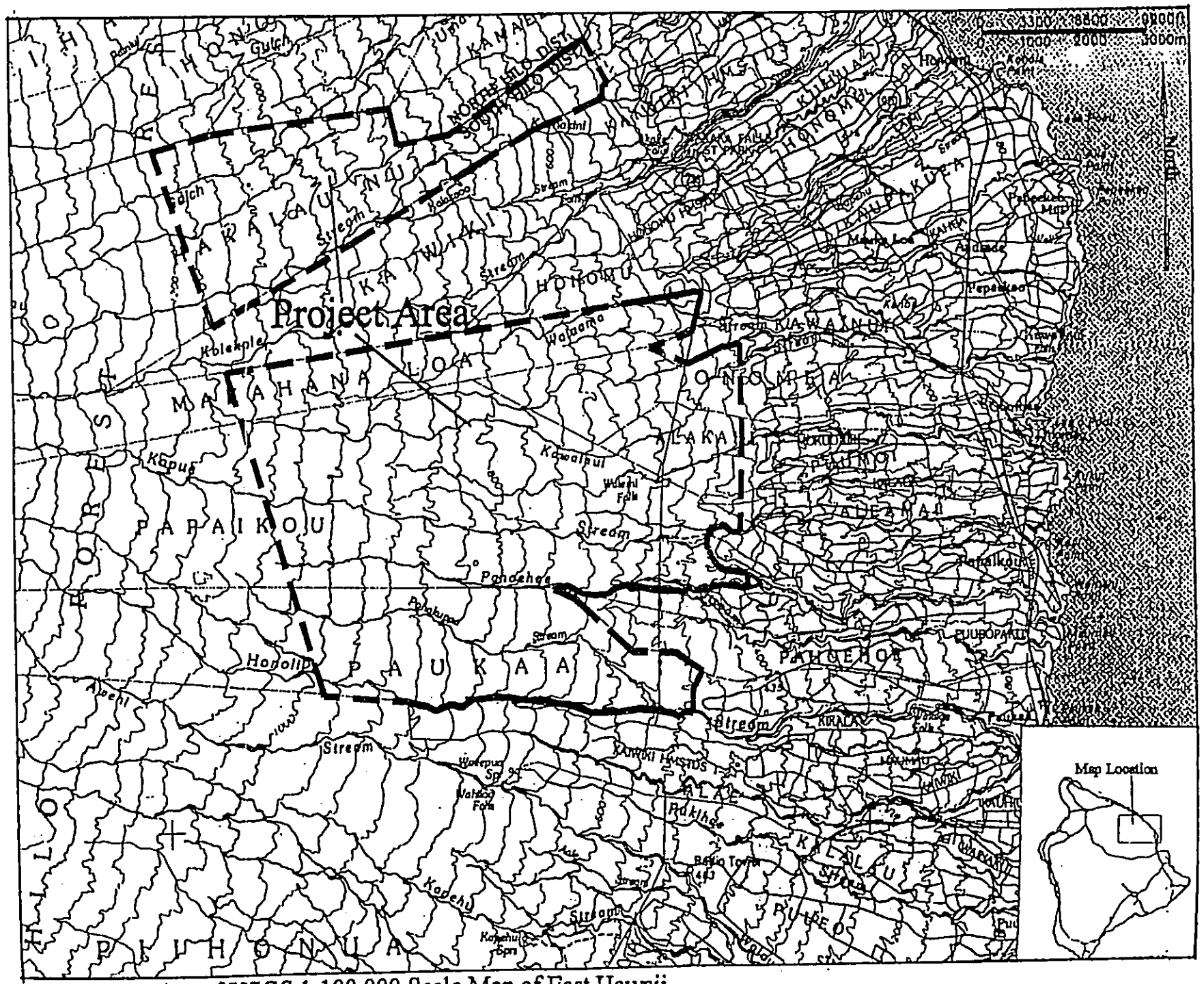

Figure 1 Portion of USGS 1:100,000 Scale Map of East Hawaii

is comprised of two parcels that are separated by the *ahupua'a* of Kaiwiki and Honomū (Hilo Forest Preserve lands). The northern parcel is located in the Land of Hakalau Nui. It is c. 3,112 acres (1,259 hectares) in area and extends from 1,500 to 3,700 ft (457 to 1,128 meters) elevation. It is bounded on the north by the North Hilo District boundary and the Lands of Umauma and Kamae'e, on the south by Kaiwiki, on the east by former sugar cane fields used for pasture, and on the west by the Hakalau Forest National Wildlife Refuge.

The southern portion of the project area is c. 13,155 acres (5,324 hectares) in area, and is located within the Lands of Makahanaloa, Kawainui, Onomea, Alakahi, Pāpai'kou, Moku'ōniki, Pu'umoi, Kalaoa, 'Alemai, and Pauka'a. It ranges in elevation from 1,400 to 3,650 ft (427 to 1,113 m). The area is bounded to the north by the Lands of Kaiwiki and Honomū, and to the south by the Lands of Kikala and Piihonua. The east boundary consists of former sugar cane fields used for pasture and the west boundary abuts the Hakalau Forest National Wildlife Refuge.

The project area is situated on the eastern slopes of Mauna Kea. The topography is comprised of gentle, rolling hills that slope towards the east. According to Wolfe and Morris (1996), the majority of the subject parcel consists of Holocene and Pleistocene lava flows that vary in age from 44,000 to 71,000 years old (*Figure 2*). The *makai* portions of the area are comprised of ancient Pleistocene flows and scattered scoria cones that date to between 200,000 and 250,000 years ago.

There are four major soil types within the project area (*Figure 3*). These soil categories are aligned in four bands that roughly parallel the coastline. A fifth soil type, not depicted on this map, is located within the numerous drainages. It is classified as Rough Broken Land, and is characterized by surface outcrops with little soil development (Sato et al. 1973:51).

The coastal areas *makai* of the project area are comprised of Hilo Silty Clay Loam soils (Sato et al. 1973:17). These include soils located on 0-10 %, 10-20 % and 20-35 % slopes, ranging in elevation from 0 to 1,000 ft. This soil series is characterized by well-drained silty clay loams that were formed in volcanic ash giving them a banded appearance. The soils are used for pasture, orchards, and truck crops.

The Kaiwiki Silty Clay Loam soil series is situated in a roughly parallel band *mauka* of the Hilo Series soil. This general soil type extends from c. 475 to 2,400 ft elevation, and is present in the seaward portion of the project area. This soil type is also comprised of well-drained silty clay loams formed in volcanic ash, and is commonly used for sugarcane cultivation and pasture (Sato et al. 1973: 23).

Akaka Series soils comprise the majority of the soils within the project area, originating at c. 1,250 ft elevation and continuing *mauka* of the project area to c. 4,500 ft. There are two general classifications within this series, Akaka Soils and Akaka Silty Clay Loam. An area of Akaka Soil is situated at the northeastern corner of the northern project area parcel. According to Sato et al., "These soils are in the rainforest above the sugarcane fields (1973:11). This soil is typified by shallow, swampy areas overlying pahoehoe bedrock.

The remaining portion of the project area consists of Akaka Silty Clay Loam soils. These soils are located on 0-10 and 10-20 % slopes, and are moderately well-drained (Sato et al. 1973:11). As with the Hilo and Kaiwiki soils, the Akaka Silty Clay Loams are formed in volcanic ash. Common uses for this soil series consist of woodland, wildlife habitat and watershed.

There are numerous stream drainages dissecting the project area. These include twelve named drainages and eight seasonal, unnamed streams. The named streams, from north to south, consist of the Honohina, Umauma, Wa'awa'a, Hakalau, Waia'ama, Kawainui, Hanawai, Ka'ie'ie, Kapue, Pahoehoe, Pōhakupa'a, and Honoli'i Streams (*Figure 4*). There are also several major, named waterfalls, and numerous smaller, unnamed ones (*Figure 5*). The named falls consist of Waiemi, Kapue and Pahoehoe Falls, all located within the Land of Pāpai'kou.

There are six vegetation zones, as defined by the Hawai'i Forest Bird Survey maps (*Figure 6*). The zones are all comprised of wet habitat species. The *makai* portion of the project area is dominated by Zone 146. This zone is characterized by an open canopy of approximately 10 m tall *koa* (*Acacia koa* Gray) and *'ohia* (*Metrosideros collina* Forst. Gray) trees, that cover 25-60% of the area, located at elevations ranging

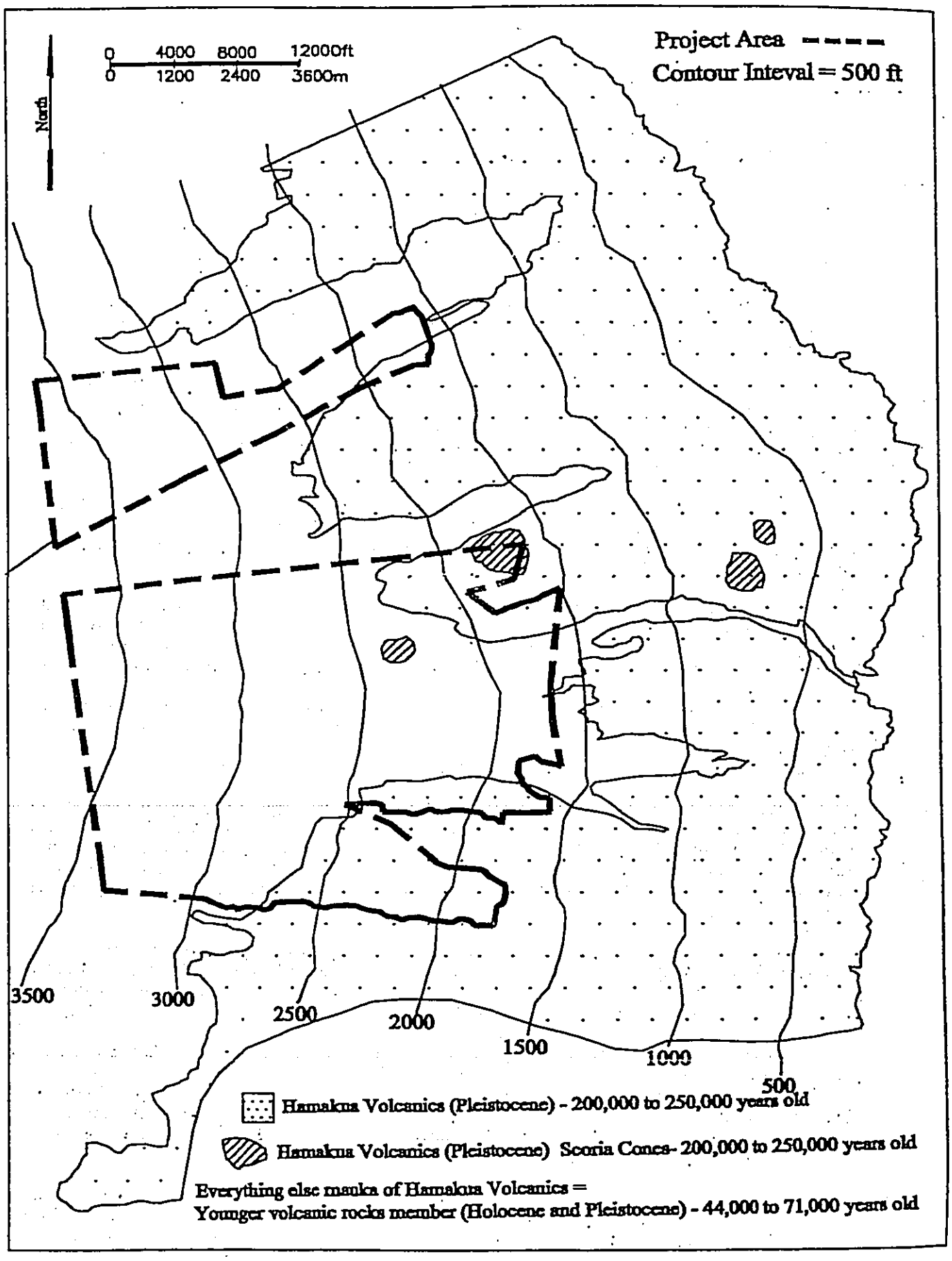

Figure 2. Distribution of Lava Flows (after Wolfe and Morris 1996)

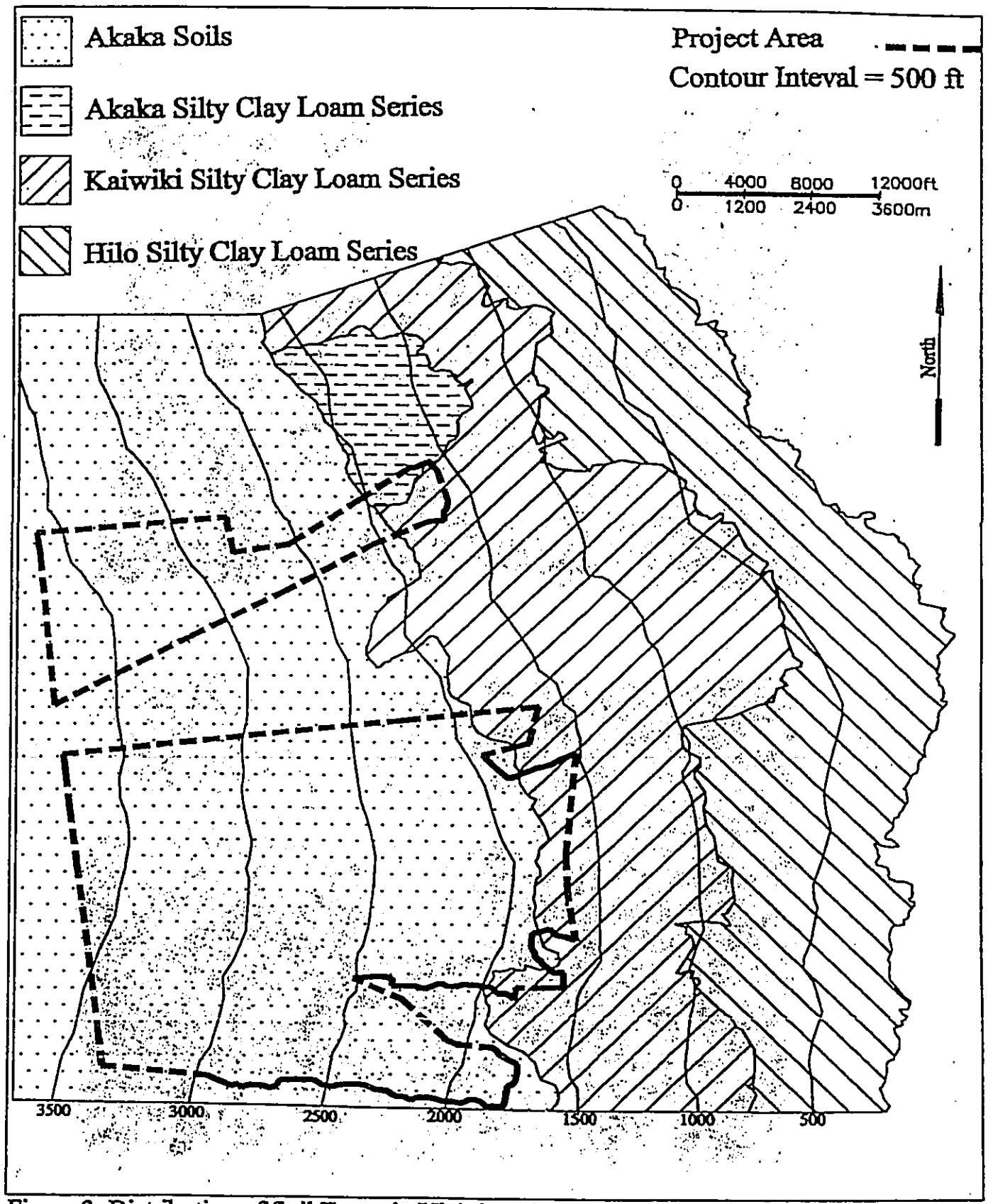

Figure 3. Distribution of Soil Types in Vicinity of Project Area (after Sato et al. 1973)

Figure 4. Waiaama Stream, View to South

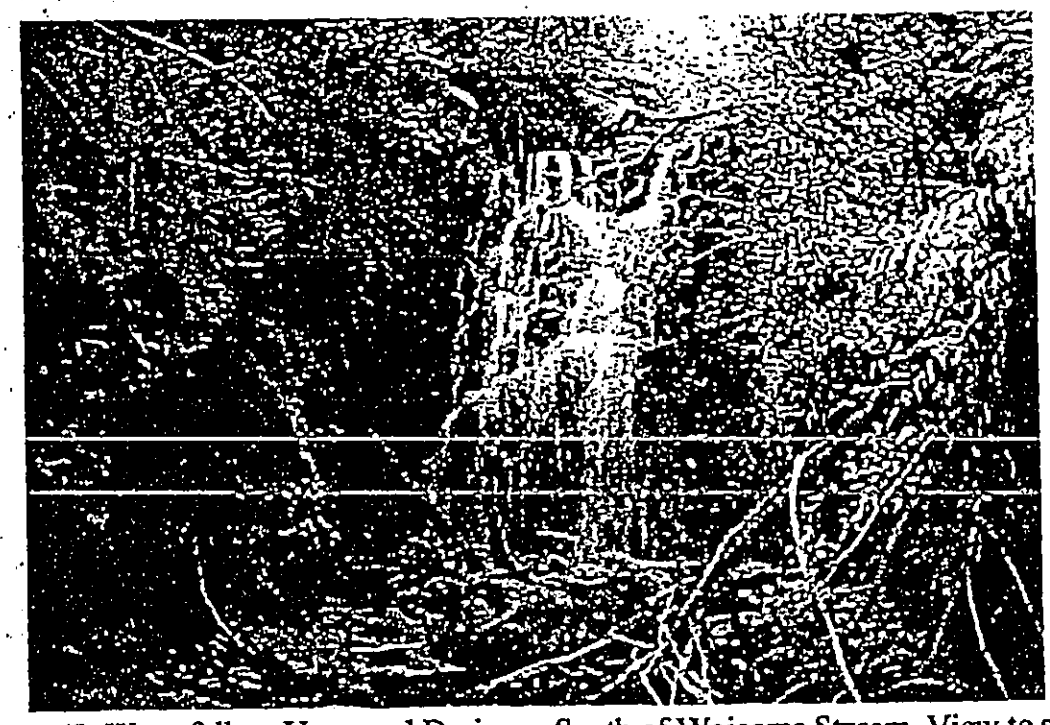

Figure 5. Waterfall on Unnamed Drainage South of Waiaama Stream, View to southwest

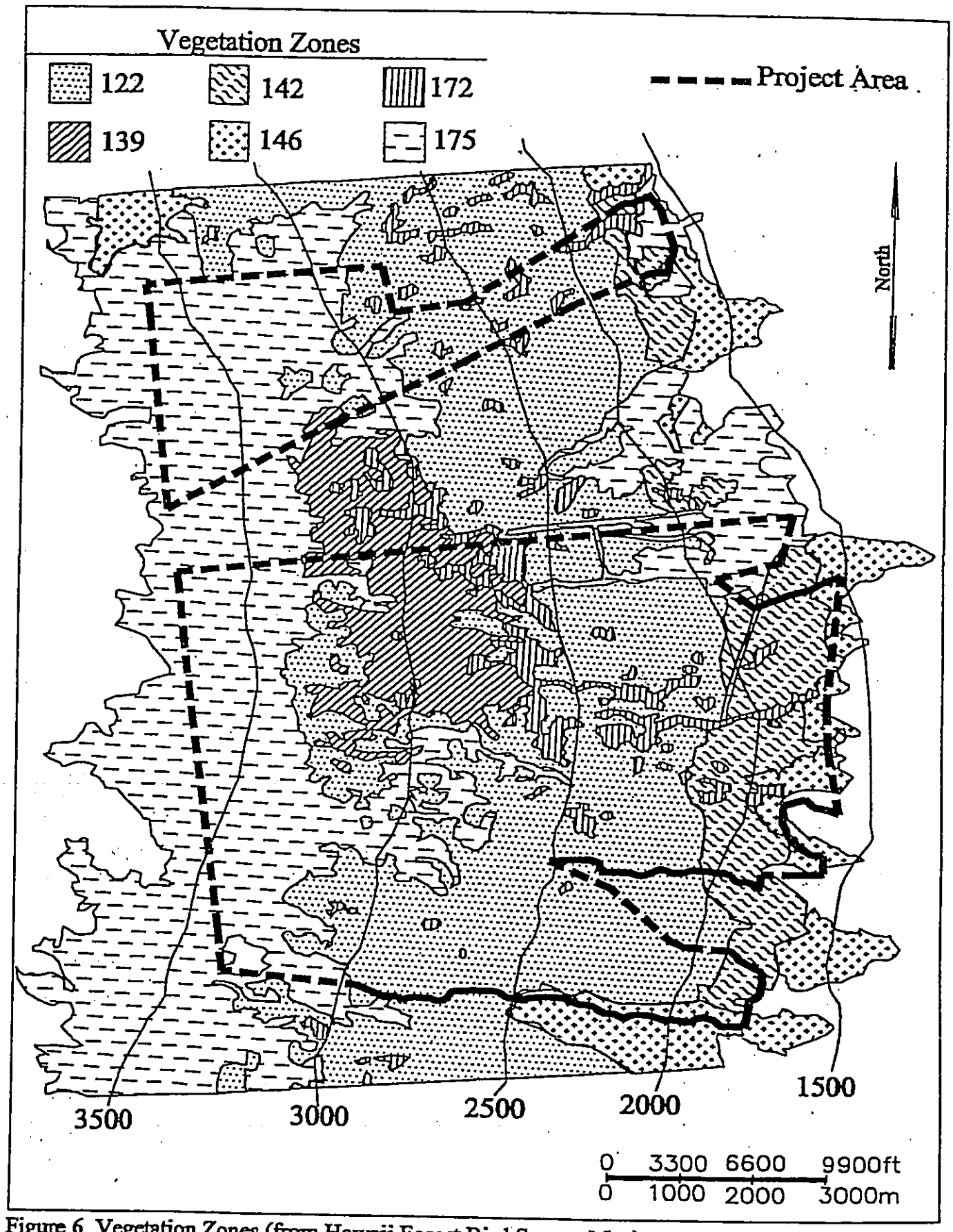

Figure 6. Vegetation Zones (from Hawaii Forest Bird Survey Map)

from 1,400 to 2,500 ft. One isolated area of this zone is also located at the c. 3,500 ft elevation. The understory is comprised predominately of dense strawberry guava (*Psidium cattleianum f. lucidum* Degener).

Zone 142 vegetation is also situated in the *makai* portions of the project area, at elevations ranging from c. 1,600 to 2,150 ft. This zone is similar to Zone 146 except scattered *hapu'u* ferns (*Cibotium* sp.), and *uluhe* (*Dicranopteris linearis* (Burm.) Underw.) are present within the understory.

The central portion of the project area is dominated by Zone 122 vegetation. This zone is present from c. 1,900 to 2,900 ft elevation, and is comprised of a closed canopy of *koa* and *ohia* trees that cover c. 60 % of the surface. Native tree ferns dominate the understory, with native shrubs also in evidence.

There are scattered pockets of Zone 172 vegetation situated in the central and *makai* portions of the project area. This vegetation zone consists of scattered *koa* and *ohia* trees that cover from 5 to 25% of the surface and vary in height from 5 to 10 m. The understory is comprised of native shrubs and ferns, along with introduced grasses. There are many standing dead or defoliated trees in these areas.

Zone 139 vegetation is situated in the north-central portion of the southern project parcel. This zone ranges in elevation from c. 2,600 to 3,300 ft, and is typified by c. 10 m tall *koa* and *ohia* in an open canopy that covers from 25 to 60 % of the surface. The understory is similar to that noted in Zone 172 and many standing dead or defoliated trees are also present.

The final vegetation zone within the project area is Zone 175, which is located primarily in the *mauka* portion of the project area at elevations ranging from 2,700 to 3,800 ft. Zone 175 is characterized by an open canopy of c. 10 m tall *ohia* trees, with an understory of matted native ferns and shrubs, along with introduced grass. Standing dead and defoliated trees are numerous in this area.

The historic cultivation of eucalyptus trees (*Eucalyptus spp.*) is apparent in several areas within the project area. These trees have been planted along *Ahupua`a* boundaries of Makahanaloa and a portion of the seaward boundary of the old forest reserve. Examples of the vegetation observed within the project area are illustrated in *Figures 7 and 8.*

Field Methods

The steep and dissected topography, dense vegetation, and saturated, muddy ground make the area nearly inaccessible. Much of the area is covered with matted ferns and brush making visual examination of the ground surface impossible without laborious removal of often more a one-meter thick layer of decomposing plant material beneath the existing vegetation. Background information indicated that probable site density would be extremely low and limited to temporary habitations and trails that probably would not leave any readily identifiable physical evidence. A survey sampling strategy was employed because 100% pedestrian coverage would be impracticable given the relative inaccessibility of the area and the very low potential for identifying archaeological remains.

The sample pedestrian survey coverage consisted of six *mauka-makai* transects that totaled approximately 18,655 m (11.6 miles) in overall length. The actual transect length was substantially greater because the routes were very circuitous winding around fallen trees, *uluhe* thickets, and steep terrain. The transects covered approximately 100 acres, representing a 0.6% sample of the project area.

Whenever possible transects crossed areas where the background research indicated the potential presence of trails or other sites. An altimeter was used to in conjunction with USGS maps of the area to determine positions in the field. Transects generally followed stream drainages or ridge crests. Transects typically began at the inland edge of former sugar cane fields and proceeded inland. Most transects followed pig trails and often faintly visible hunter's paths until further progress was limited by impracticably penetrable vegetation usually consisting of *uluhe* thickets two to three meters in height, excessively swampy terrain, or both. Transects were marked with pink flagging tape and their locations plotted on a scaled project area map.

DOCUMENT CAPTURED AS RECEIVED

Figure 7. Project Area Vegetation, View to South-Southeast

Figure 8. Project Area Vegetation, View to North

DOCUMENT CAPTURED AS RECEIVED

The single identified site was flagged with pink and blue flagging tape and its location plotted on a project area map. The site was recorded in detail, which consisted of preparing scaled plans maps, the completion of standardized site/feature forms and photographic documentation. No subsurface testing was undertaken.

ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

Historical Documentary Research

The project area is situated within a region called Hilo Pali-kū, or Hilo of the upright cliffs, an area that was arduous to traverse because of the steeply walled valleys and stream crossings (Maly, Appendix A in Walker and Rosendahl 1994). The project area includes portions of eleven traditional Hawaiian land units known as *ahupua'a*, which typically are pie-shaped land divisions extending from the ocean to the interior mountains providing access to the full range of the island's natural resources. The *ahupua'a* include the mid-elevation portions of Hakalau Nui, Makahanaloa, Pāpai'kou, and Pauka'a and the inland ends of the smaller *ahupua'a* of Kawainui, Onomea, Alakahi, Moku'ōniki, Pu'umoi, Kalaoa, and 'Alemai (*Figure 9*).

Originally, *ahupua'a* were probably centered on the main drainages and the boundaries typically followed readily identified natural features such as ridges and drainages. The presence of numerous other small *ahupua'a* along the coast undoubtedly is a result of fissioning of land units in the lower elevation areas where traditional agriculture and settlement were concentrated. Such fissioning would likely have occurred with the separation of the smaller *ili*-level subdivisions of an *ahupua'a*, which originally were parallel strips of land perpendicular to the shoreline with access to the full range of natural resources. The *ili* was an important late prehistoric-early historic land unit because of its association with the *'ohana* as the family land holding unit, an important social element in the traditional Hawaiian land use system.

There are few legendary or traditional Hawaiian references to the project area *ahupua'a*. Pāpai-'kou had a well-known surfing place (Ii 1995). A sacred bamboo grove called Homaika'ohe was said to have been planted by the god Kane in Makahanaloa (Emerson 1915). Knives for circumcision were made from the bamboo. A stream and rock in Pepe'ekeō were named for Kamapua'a, who tried to drown Maui's mother, Hina, there, but was unsuccessful (Pukui et al. 1976). One of the inciters of the Pahikaua War against Ka'ahumanu in the early 1830s, Ka'eo, husband of Kanaukapu, died at Puaka'a (Kamakau 1961).

King Kalakaua (1972) described the region between Hilo and Waipio as follows:

> In the time of Liloa [c. 1400s], and later, this plateau was thickly populated, and requiring no irrigation, was cultivated from the sea to the line of frost. A few kalo patches are still seen, and bananas grow, as of old, in secluded spots and along the banks of the ravines; but the broad acres are green with cane, and the whistle of the sugar cane-mill is heard above the roar of the surf...(1972:284).

One of the first western descriptions of the windward cost of Hawai'i Island comes from the naturalist Menzies, who was a member of Vancouver's expedition in 1793.

> The land we passed in the forenoon rose in a steep bank from the water side and from thence the country stretched back with an easy acclivity for about four or five miles, and was laid out into little fields, apparently well cultivated and interspersed with habitations of the natives. Beyond this the country became steeply rugged and woody, forming the mountains of great elevation (1920:51-52).

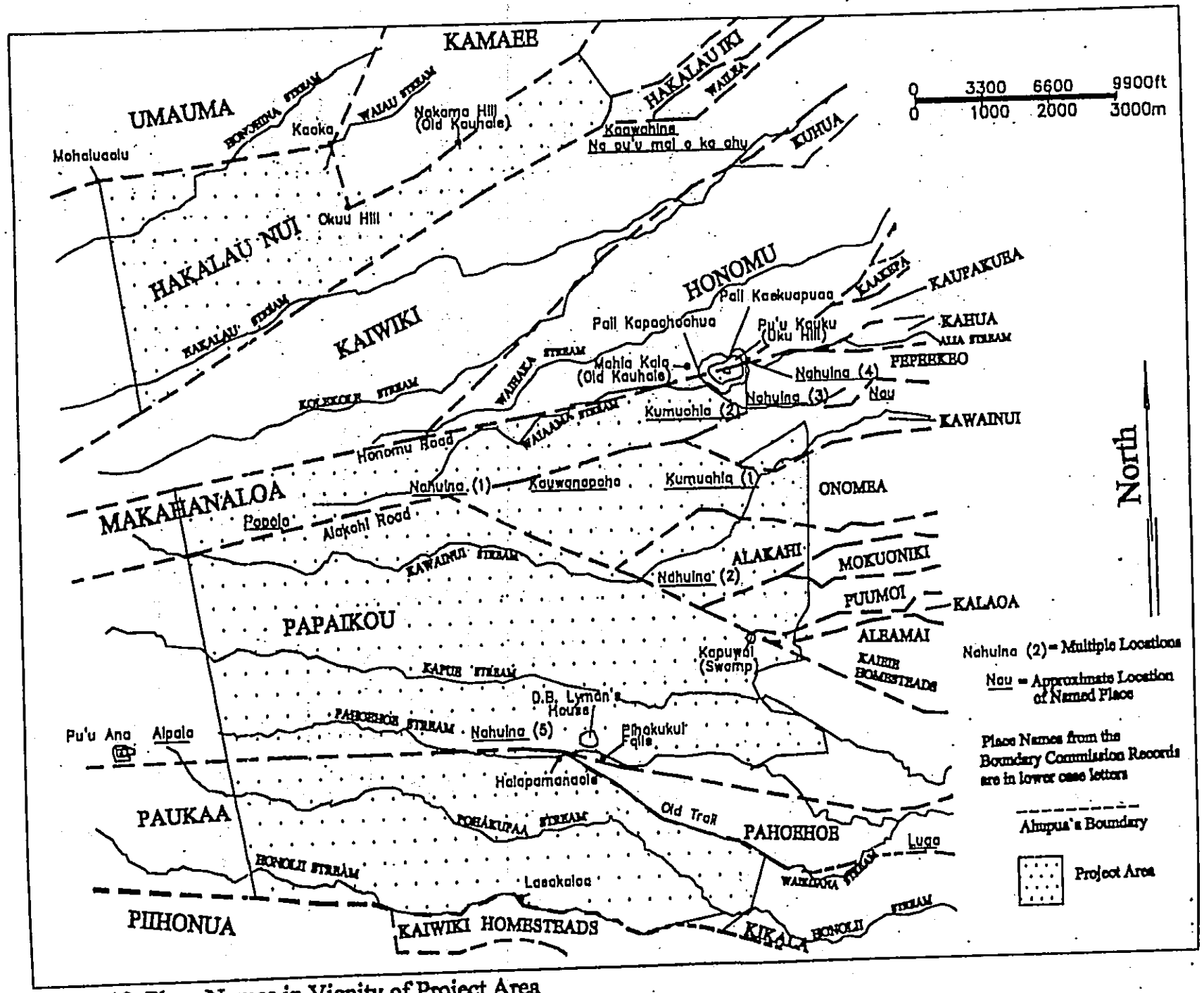

Figure 10. Place Names in Vicnity of Project Area

Puaa (k)-1882-80 year old *kama 'āina* of Kuhua, Kaiwiki and Wailea (Vol. B, pp. 457-458)
When young, he caught birds and made canoes on the above lands. Formerly lived at a village called Halekoloa along Kolekole Stream somewhere below Akaka Falls. Describes bird catching. At Māhoe, inland from the point where Kuhua is cut off by Honomu and Kaiwik, are big koa trees used for canoes. Mentions that once he went up on the mountain on Honohina to get hides; came down through "Puwai" (Pu'uwai Hill), where there was a big *koa* tree. He was told this is where Hakalau and Makahanaloa meet.

Kahau (k)-1882-born on Hakalau and raised on Kaiwiki (Vol. B, pp. 458-459)
He accompanied Brown during the survey of the Hakalau and Kaiwiki forests. Reports catching birds in forests of Kaiwiki. At Ki'ikapapa, Kaiwiki meets with Hakalau Nui and Wailea ends. Kaumuhāpu'u is the point where Hakalau joins Makahanaloa and Kolekole Gulch is the boundary at a waterfall.

Onomea-Certificate 175-2,579 acres-No native testimony given

Pu'umoi-Certificate 169-847.3 acres-No native testimony given

Pāhoehoe-Certificate 179 (replaced Cert. 37)-1,385 acres

Kanaeholo (k)-1874-*kama 'āina* of Pāhoehoe (Volume B, pp. 182-183)
States he was born at Hilo Palikū and moved to Pāhoehoe when he was young. Describes a place called Lua'a above the place ("Poapuaa") where the Pauka'a and Pāhoehoe roads meet. Lua'a is described as the "last of the old *kūlana kauhale* (village or settlement) on Pāhoehoe. 'Aipala is *makai* of Pu'u Ana ("the hill on Pauka'a) at the place where Pāhoehoe is cut off by Pauka'a and Pāpa'ikou. Describes catching birds and gathering *olonā* when he was very young. The boundary goes along the old road at Lua'a and ascends to "Waika ana", a water head, and runs up the ridge to Puaike Gulch, where it crosses the gulch and continues up the old trail to Ka'lā'auhaka and crosses Kupamanoa Gulch to Nahuina where the trail meets and goes on to Kaholoina, Pihakunui, Pihakuiiki, to Paina'ole to Wahinehoano, to 'Aipala *mauka*. From the sea to 'Aipala, a pāhoehoe gulch is the boundary for Pāhoehoe on the Hāmākua side.

Kamakamai (k)-1874-*kama 'āina* of Pāhoehoe (Volume B, p.183-184)
States he was born in Kona during the time of Kuiakawai and moved to Pāhoehoe at a very young age. Reports that he used to get canoes from the interior portion of Pāhoehoe as far *mauka* as Pihaku and Paiuaole.

Commissioner Rufus A. Lyman-1899-Boundary description (Vol. C, No.4, pp. 120-123)
Ancient trail mentioned along the interior northern boundary of Pāhoehoe. The trail crossed Pāhoehoe Stream above Pihakukui Falls. [Several discrepancies throughout as to the correct name of the falls, "a well-known point" where the ancient trail runs between Pāhoehoe and Pauka'a and crosses over the sream into Pāpa'ikou. Several spellings are given: Pihakukui, Pihakuiki, Piihakunui, Pihakunui.]

Pāpa'ikou-Certificate 165 (replaced Cert. 39)-14,000 acres.

Kapae (k)-1874-born at Hilo Palikū. (Vol. B, pp. 155-56)
States when he first came to Pāpa'ikou as *konohiki*, Henry Lyman surveyed the boundaries. Kukui is at the place where Kapoko ends. At this point, the boundary leaves the ravine (*"āwaawa"*) and goes toward Makahanaloa to Ka'ie'ie Gulch.

Pu'uhaula (k)-1874-born 1804 in Kona at the time of Peleleu and *kama'aina* of Pāpa'ikou (Vol. B, pp. 156-157)
Canoe makers told him the boundaries of P āpa'ikou. He describes a place he went to with Henry Lyman while surveying called Nahuina at the inland end of 'Aleamai where

Alakahi joins Pāpa'ikou. Canoe makers also knew where Nahuina was located. Reports that bird catchers used to go into the upland forest. The old water head for Pāpa'ikou Mill is called Waiakalae, on the 'Aleamai Stream. The old Alakahi road ran along the boundary between Makahanaloa and Pāpa'ikou up to Palanolelo.

Kuhipono (k)-1874-*Kama'āina* of Pāpa'ikou (Vol. B, pp. 157-159)

Father was a canoe maker and Kuhipono followed the same trade. Pi'ihau is an *ili* within Pāpa'ikou. Mentions the old trail up to Pāhoehoe Gulch that leads to Nahuina [conflict with Puumoi testimony]. Pāhoehoe ends a short distance above Pihaakunui Falls. Says that Pu'u Ana is on Pauka'a, with the boundary being on the north (Hāmākua) side of the hill in a ravine. Describes hunting cattle for hides on the mountain. Older *kama'āina* told him Pāpa'ikou extended through the woods to join Humu'la on the *pili* beyond the forest.

Pauka'a-Certificate 181-6,700 acres

Kalama (k)-1874-*Kama'āina* of Pauka'a (Vol. B, pp. 178-179)

Kalama states he was born at Pauka'a during the time when Aki built the pōwai of Hualilelile. He used to go with his father who was a canoe maker and bird catcher. The northern boundary begins at the coast in Kaleiiki Gulch. The boundary then follows Pōauwai Gulch to a place called Lua'a below a water head called Waikoana. Above Waikoana, was a new water head called Pōhakupa'a. Above Pōhakupa'a, he describes an old trail that led to a place called Hālapamana'ole where Pāhoehoe ends and Pauka'a and Pāpa'ikou unite *mauka* of Pu'uana Hill. Kalama states that D.B. Lyman had a house a short distance above Pihakunuia [Pihakukui]Falls at the inland end of Pāhoehoe.

Kauaeholo (k)-1874-*kam'āaina* of Pāhoehoe (Vol.B, pp. 179-180)

Kauaeholo heard about the boundaries of Pāhoehoe from old *kama'āina*. He describes a place called Lua'a above Poapua'a where the Pauka'a and Pāhoehoe roads meet. Mananui was below Poapua'a. Lua'a is described as the "last of the old *kūlana kauhale* [villages] on Pāhoehoe." 'Aipala is the place where Pāhoehoe is cut off by Pauka'a and Pāpa'ikou. 'Aipala is described as *makai* of Pu'uana. He describes catching birds and gathering *olonā* when he was very young.

Kamai (k)-1874-*kama'āina* of Pauk'a (Vol. B, p. 180)

Describes the hill, Pu'uana, as belonging to Pauka'a. A drainage below the hill is the boundary between Pauka'a and Pāpa'ikou. He describes an old trail following the boundary *makai* to the upper end of Pāhoehoe.

Kamakamai (k)-1874-*kama'āina* of Pāhoehoe (Vol. B, pp. 180-181)

He describes Lua'a 1st and 2nd as being situated above a place called Mananui and below Waikoana Gulch. Above Waikoana, he lists a succession of place names; Kepuki, Pauike, Kalā'auhaka (in the woods), Kupamānoa, Kaholoina (opposite Nahuina), Pihaku, and Paina'ole. Paina'ole was as far as he used to go for canoes. He said 'Aipala was the *mauka* corner of Pāhoehoe. He describes hunting cattle on the mountain and hearing that Pu'uana was on Pauka'a. He had always heard that the *makai* lands extended through the woods to Humu'ula..

Makahanaloa-Certificate 36-7,600 acres

Kahulanui (k)-1873-*kama'āina* of Kaupakuea (Vol.A, No. 1, pp. 182-183)

Kahulanui said he was born during the reign of Kamehameha I. He used to go up into the woods because he was formerly a canoe builder. His father was also a canoe builder and he once traveled inland with an old bird catcher named Kamanu from Kaiwiki. He describes a place called Nahuina on Alia Stream where Kaupakuea meets Makahanaloa. An old road (and ahupua'a boundary) extended from Nahuina to a pali called Ka'ekuapua'a on 'Uku Hill where "they used to let canoes down". The road continued mauka to Kapo'oho'ohua Pali on 'Uku Hill and then down to the foot of the hill to a place called Mahiakala, an old *kaubale*. Further inland he describes the Honomū Road along the bound-

ary between Makahanaloa and Honomu. He describes the upper-most portion of the forest between Makahanaloa and Hakalau and says that Kaukoa is where the tall *koa* trees end. Above Kaukoa, where Makahanaloa is cut off by Humu'ula, is Kapu'uakala (also, "Kapuakala"), a hill. Kapu'uakala is also the name of the water there. He describes Kapuakala as being "not entirely through the woods, but it is above the *koa* trees. There are a few scattering mamani [sic.] below the appendage of koa." The "mamani" (*māmane*) grows on Humu'ula.

Wahamu (k)-1873-Kawainui resident (Vol. A, No. 1, pp. 183-186)

Wahamu said he was born at Makahanaloa before the first missionaries arrived and he belongs to Makahanaloa and Pepekeo (Pepe'ekeo). At the time of his testimony he was residing in Kawainui. His father was a bird catcher on the lands of Makahanaloa and Pepekeo. He describes Nahuina as the inland end of Kahua. Above Nahuina, the Makahanaloa boundary follows an old road to 'Uku Hill and beyond to the Honomu Road. He describes hunting cattle far inland (above the project area) where Makahanaloa and Hakalau Nui join at Kolekole Gulch. He met bird catchers catching *mamo* at this place. Above here, in Hakalau, there are two "water ponds", similar in size, called Kapahunui and Kalepolepo. Above the woods, in Makahanaloa, is Palanolelo (also, Palauolelo), a water spring in a gulch. On the ridge above, there are houses (*kauhale*). There is a pile of stones on the *mauka* corner of Palanolelo, near a place called Kaloloa. Lā (La'a) (k), father of Hanauna from Humu'ula, said "the tall *koa* and 'ōhi'a were on *makai* lands, short *koa* and *mamani* [sic. *māmane*] on Humu'ula.

Wahamu describes the southern boundary between Pepekeo and Kula'imano as ending in Waiama Gulch above a small hill between two larger hills, named Pu'upulololu'u. The boundary between Pepekeo and Kawainui ends at a rock in the woods called Kukailimu, which used to be worshipped, on the south side of Waiaama Gulch opposite 'Uku Hill where Pepekeo ends. Between the upper end of Kula'imano and the rock, he describes three places (water heads) where water was taken out of the stream. At the *pōwai* of Waikū, the water was taken out to make a bullock pen. At Nā'ū, on Pepekeo, water was taken out for a sugar mill on Makahanaloa. Further inland at Waimana, where Kawainui Stream forks, water was taken out for irrigation by Onomea Plantation. Above Waimana, bird catchers lived at a place called Kumu'ōhi'a. He states that the woods began at Nā'ū where Makahanaloa cuts Pepekeo off.

J. Ili (k)-1873-Accompanied Henry M. Lyman on the survey of Makahanaloa (Vol. A, No. 1, pp. 185-186)

The *kama'āina* wtinessess who pointed out the boundaries were Kapoumo'oakea and Kamanu. 'Uku [Hill] is "where canoes were got out". Walked the boundary, past Nahuina, Kolekole Stream and, Pu'uwai Hill in Hakalau, and came out of the woods at Pukaiwaho "where small *koa, mamani* [sic.] and *pili* were growing. Here, lies the boundary between Humu'ula, Hakalau and Makahanaloa. A pile of stones was erected by the survey party here. From this stone pile, surveyed across to Palanalelo, an old *kauhale* and built another stone pile near the place where Pi'ihonua joins the south side of Palanalelo. Mentions that tall trees were on Makahanaloa and the small woods on Humu'ula. Also mentions a *loko wai* (pond) (didn't know name) near the Hakalau boundary [probably Kapahunui or Kalepolepo].

Kamalo (k)-1873-*Kama'āina* of Makahanaloa (Vol. A, No. 1, pp. 186)

States he was born on Punahoa during the time of Kanihonui and knows the mauka boundary of Makahanaloa. He was a bird catcher and lived on Pi'ihonua and "on the mountain". Says Palanalelo was the boundary of Makahanaloa and, Pi'ihonua and Kaloloa was on the other corner; Humu'ula bordered the *mauka* side. Above here, grew the "small *koa* and *mamani* [sic.]; *makai* of here grew the tall trees and *pili*. "The *koa* and *mamani* are on Humu'ula." There was a "dry time" about 1848 or 1849, when Leleiōhoku died, and there was water there in holes.

Kahue (k)-1873-*Kama'āina* of Humu'ula (Vol. A, No. 1, pp. 187-188)

States he was born at Humu'ula a little before the 'Ōku'u [1804]. His parents belonged to Humu'ula and had pointed out the boundaries of the lands joining Humu'ula. Makahanaloa and Humu'ula join at Kapahe'e at Hakalau. Pohopā'ele, an old village, was at a swampy place on Makahanaloa. Above the swamp was where Humu'ula people had their houses. States "below here Makahanaloa people took our feathers away; at Kapahe'e, Hakalau people took our ducks away. The boundary runs along Humu'ula to Waikaloa [Waikoloa?] at the point where Pāpa'ikou joins Makahanaloa and Humu'ula. He used to hunt wild cattle on the mountain with Kamalo (k) and Makahiki (k) from Ka'ū. He lived all over the mountain. Describes Kapahe'e as being in the Hakalau woods, but near Makahanaloa and estimates it is less than a mile from the upper edge of the woods. From Kapohokele [Kapohopā'ele?], it is less than a mile to the upper edge of the woods. Waikoloa, a circular water hole is less than a mile from the edge of the woods. Says there were holes in the tall woods of *'ōhi'a* and *koa*, but the *mamani* [sic.] did not grow near these holes. Kapuakala, in Humu'ula, is "out on the *pili*" and where they had their houses. The Humu'ula people were bird catchers and caught birds on 'ōhi'a trees. States Palanalelo is above the woods and Makahanaloa; Hakalau is near the woods and to Kapahe'e. Mamani [sic.] and *koa* grew at Palanalelo, where the water hole is located. Waipilopilo is where Sam Guess' old house was located. Kapuko Gulch/Stream is on "the boundary of Pauka'a and Pi'ihonua and is called Nukupahu, in the woods."

Nahale (k)-1873-Kama'āina of Makahanaloa/ Pepekeo (Pepe'ekeo) (Vol. A, No. 1, pp. 188-191)

Nahale was born during the last war of Kamehameha I, at the time when Namaka'eha died at Pi'ihonua. He was a bird catcher and learned his trade from older bird catchers. He states he always lived at Onomea until after Austin moved there. Then he moved to *Paihāloa (Paiha'aloa)*. He is a kama'āina and is familiar with the lands of Makahanaloa and Pepekeo. Walia Gulch, the boundary between Kahua and Makahanaloa, extends from the sea shore into the woods on the *makai* side of 'Uku Hill, at a swampy place (couldn't remember name) where Kaupakuea meets Makahanaloa. On the north side, Pepekeo and Makahanaloa run adjacent to each other, beginning from the shore to the point where Pepekeo ends in the woods. Mentions fishing rights extending out to sea. On the south side, Pepekeo is bounded by Kula'imano. Above of the Kula'imano water head (where Kula'imano ends and Kawainui joins Pepekeo) is a "large flat rock in the stream, covered with green moss such as grows in the sea". This place is called Pōhakupakaiea and the stream belongs to Pepekeo. Kukailimu is in the woods where Pepekeo and Kawainui end and the Makahanaloa boundary runs south, cutting off Kawainui. Waimana is where Kapuko Gulch empties into it. The 'ākōlea fern grows on the south side of Kapuko Gulch, in Onomea. He describes a place called Kumu'ōhi'a that was an old village on Onomea, inland from where Makahanaloa cuts Kawainui off. Further inland was a swampy place called Kauwanapoho where bird catchers and canoe makers lived. Further inland at the place where Makahanaloa and Papaikou meet and cut off Onomea is a place called Nahuina. Inland from Nahuina, the boundary between Papaikou and Makahanaloa follows an old road along Waimana Gulch. Popolo is a little above Nahuina. At Popolo, the water ends and the valley runs to the end of the tall woods. Humu'ula is where the grass, small trees and *mamani* [sic.] grow. Of Alakahi Road, Nahale says only the road belongs to Alakahi and not the land.

Hakalau Nui-Certificate 130-12,580 acres

Kanehoalani (k)-1873-*Kama'āina* of Kama'e'e (Vol. B, pp. 360-361)

Kanehoalani describes a hill called Nakama on Waawaa Gulch [also, Wāwa'a] where there was an old *kauhale* in *koa*. Not far from here the gulch turns north to a *pali* (cliff) called Kaoku [Ka'ōkū].

Kapou (k) *Kama'āina* of Hakalau (Vol. B, pp. 362-363)

Stated he was born at Hakalau, but lived at Wailea at the time he gave testimony. His father was the *luna* (overseer) of the bird catchers. At the time of the survey by Henry Lyman, he was *konohiki* of Hakalau Nui. Mentions a *pōauwai* (water head) called Wai-

baka in Hakalau Nui. Above this is the old trail leading to Ka'awahine, an old *kauhale* at the *mauka* corner of Hakalau Iki. Above this is Wailea and Nāpu'umai'a, where there are banana trees. From this point the old trail follows alongside Kaiwiki to Ka'ahakina Gulch. This is as far *mauka* as he knew.

Halaioo-1873-*Kama'āina* of Wailea (Vol. B, pp. 363-364)
Halaioo says the *mauka* corner of Hakalau Iki is at Na pu'u mai o ka Ahu. He says that Ka'awahine was *makai* of there. Further inland he describes banana trees (Nāpu'umai'a) and an old trail along the boundary between Wailea and Hakalau Nui.

The foregoing testimonies make thirteen references to bird catching, ten to canoe building, five to bullock hunting, and two to *olonā* gathering, all of which probably occurred in the project area. Five houses or settlements and five trails are described as being in, or adjacent to the project area. Kumu'ōhi'a, situated near the inland end of Kawainui, is described as an old village. Further inland was a place called Kauwanapoho where bird catchers and canoe makers lived. Mahiakala is described as an old *kauhale* situated inland from Pu'u Ka'uku. A house belonging to D.B. Lyman was situated above Pihakukui Falls near the inland tip of Pahoehoe. There was an old *kauhale* situated at Nakama in Hakalau Nui. Tomonari-Tuggle (1996) cites other Boundary Commission testimony indicating that there was a sixth settlement at Mohaluhalu where Hakalau Nui, Honohina, and Umauma meet.

An old trail followed the inland boundary between Pauka'a and Pahoehoe. Another old trail followed the boundary between Pahoehoe and Pāpai'kou to a stream crossing above Pihakukui Falls. The Alakahi Road followed the boundary between Makahanaloa and Pāpai'kou and the Honomū Road followed the boundary between Makahanaloa and Honomū. One probable shrine is mentioned. It is a rock that used to be worshipped on boundary between Pepe'ekeō and Kawainui on south side of Waia'ama Gulch opposite Pu'u Ka'uku where Pepe'ekeō ends.

Pulu gathering and two settlements are described above Akaka Falls in the inland portion of the adjacent *ahupua'a* of Honomū and Kaiwiki. Ula'ula Hale is described as a place where canoes were made, and Pukaonua was a canoe makers' settlement. Four other houses or settlements are described, two are inland of the project area above the forest line, and two are seaward of the project area.

In most instances, the testimonies suggest that the activities, trails, and settlements mentioned were no longer in use at the time the testimonies were given in the late 1800s. Trails and habitations are frequently described as "old" and the activities described as formerly practiced. Much of the information was second-hand having been passed down to the testifiers by their parents or teachers.

Place Names

The following place names were compiled from 19th and 20th century maps, Boundary Commission records, Land Commission Awards (LCA's), and historic documents. Hawaiian diacritical marks (*kahakō* or macron; *'okina* or glottal stop) were used wherever possible. In cases where the name meanings were uncertain (not documented from oral or historic sources) diacritical marks were not used because of the possibility of having more than one meaning. The standard guide used for all diacritical marks and meanings of names is *Place Names of Hawai'i* by Pukui, *et al.*, (1976) and the *Hawaiian Dictionary* (Pukui and Elbert 1986), unless otherwise noted.

'Aipala — Boundary Commission records describe 'Aipala as the place where Pāhoehoe is cut off by Pauka'a and Papa'ikou and indicates it is adjacent and inland from this cut-off place, but *makai* of Pu'u Ana (Vol. B:156-57, 179-80, 182-84).

The meaning of the word is uncertain. It could refer to eating the *pala* fern. *Pala* is an edible fern that was eaten especially during times of famine. The bases of the frond stems were baked in the *imu* and eaten. The mucilaginous water left over from slicing and soaking the raw stems was used medicinally. The fern was also used in *heiau* ceremonies. *Pala* can also refer to a variety of taro and sweet potato.

Alakahi	A land section and stream. According to the Waiki family, the last tenants of the old Hawaiian village of Kahali'i, the correct name for this stream is Kukilu (Pers. Comm., Luika Waiki Perreira to Ka'ohulani Mc Guire, 1995). *Lit.*, one way (Pukui, *et al.*, 1976:9).
'Aleamai	Land section. Listed in *Place Names*, but no literal meaning is given. Possibly a reference to the *hīnālea* fish.
Hakalau Nui	Land division, bay, gulch and stream and site of a former sugar mill. *Lit.*, big Hakalau. The word *hakalau* literally means many perches (Pukui, *et al.*, 1976:35).
Hālapamana'ole	A possible reference to a ridge an/or an obscure event that occurred there. *Lit.*, ridge without *mana*.
Hale Koloa	A former village along Kolekole Stream and below 'Akaka Falls (BC, Vol. B:457-58). *Lit*, house [of] Koloa.
Hōmaika'ohe	A sacred bamboo grove in Makahanaloa said to have been planted by the god Kāne. Bamboo knives for circumcision came from this grove (Emerson 1915:189; Pukui, *et al.*, 1976:139). *Lit.*, hand me the bamboo (Pukui, *et al.*, 1976:139).
Honoli'i	Cove, landing, stream, and gulch bordering Pauka'a on the Hilo side. Honoli'i gulch is the southern boundary for Pauka'a (C. J. Lyons: Reg. Map #570). Hi'iaka and Wahine'ōma'o swam across Honoli'i Stream as part of their many adventures in bringing Lohi'au to Pele (Emerson 1982: 60). A descriptive term for the land which means "little valley" (Pukui, *et al.*, 1976:49).
Ka'āpoko	Land area as shown on H. N. Lyman's Reg. Map #30. *Lit.*, the short stone (Pukui, *et al.*, 1976:61).
Ka'awahine	An old *kauhale* (settlement) along an old trail at the *mauka* end of Hakalau Iki (BC, Vol. B:360-61).
Ka'ekuapua'a	A *pali* (cliff) on 'Uku Hill (Ka'uku) where canoes were let down (BC, Vol A:182-83). *Lit.*, the rooting of [the] pig. *Fig.*, prow of a canoe (Pukui & Elbert 1986:40). A poetic reference to a canoe.
Ka'ie'ie	Land section and stream. *Lit.*, the *'ie'ie* vine. A reference to the *'ie'ie* vine, which was once abundant in the area. The aerial roots of the vine were used for weaving and the fruit of the *'ie'ie* was especially attractive to the native *mamo* bird. The plant itself is sacred to the hula goddess Laka and it is one of the plants used to decorate the *kuahu* or hula altar.
Kaiwiki	Land section. Boundary Commission records indicate the forests of Kaiwiki were frequented by bird catchers. *Lit.*, quick sea (Pukui, *et al.*, 1976:71).
Kalaoa	A land section said to be named for Kalaoa Pu'umoi, the sister of Kapalaoa. See "Pu'umoi" below. *Lit.*, the choker (as a stick for catching eels) (Pukui, *et al.*, 1976:75). *Kalaoa 'ai pō'ele'ele* is an *'ōlelo no'eau*, which means "Kalaoa eats in the night". This is a reference to the stinginess of the Kalaoa people who don't want to share their food (*Ibid.*:268).
Kaloloa	A place far inland on Makahanaloa, at the *mauka* corner of Palanolelo (Palauolelo). Spring (BC, Vol. A: 184).
Kānepu'u	An interior area above Pu'uwai Hill on Hakalau. Makahanaloa is "very near this place" (BC, Vol. A: 184).

Kapahe'e	An area far inland, on Hakalau, where the boundaries of Humu'ula and Makahanaloa meet. It is located in the woods near Makahanaloa, less than a mile from the "upper edge of the woods." A place where "Humu'ula people took our ducks away" (BC, Vol. A: 187).
Kapahunui	An inland pond above Waikaloa and Kapahu, comparable in size to Kalepolepo, another pond. Both ponds are on Hakalau (BC, Vol. A: 184).
Kapeke	A place above Kumu'ōhi'a (1), where the running water ends (BC, Vol. A: 189).
Kapo'oho'ohua	A *pali* (cliff) on Uku Hill (Vol. A: 182; see *Pu'u Ka'uku.*)
Kapue	A stream. The meaning is uncertain and the name has several connotations: 1) to huddle or sit crouched with cold; 2) *pue* refers to the feathers on the back of a bird, just above the tail feathers; 3) if spelled *kapu 'ē*, the meaning changes to "an unusual taboo".
Kapuko	A gulch and stream where the 'ākōlea fern grows on the Onomea side (BC, Vol. A: 189).
Kapuakala	A place "out on the *pili*" at Humu'ula, where houses were (BC, Vol. A: 187).
Kapuwai	A swamp. The name literally means "sacred water" with a secondary meaning as "wash tub". It is probably a descriptive name for the swamp.
Kauwanapoho	Described as a swampy place where bird catchers and canoe makers lived (BC, Vol. A:188-91). Meaning uncertain.
Kawainui	A land section, stream and falls. *Lit.*, the big water, in reference to the stream, which can come rushing down in torrents and make the road impassable at times.
Kīkala	Land section just outside of the project area in Pauka'a. *Lit.*, hip (Pukui, *et al.*, 1976:110).
Kolekole	A gulch and a stream which marked the boundary between Makahanaloa and Hakalau (BC, Vol. A: 184). *Lit.* scarred, raw (Pukui, *et al.*, 1976:116).
Kuhua	A forested area where Kuhua is cut off by Honomū and Kaiwiki. This area was used by bird catchers and canoe makers (Vol. B:457).
Kula'imano	An inland area in Pepe'ekeō where canoes were made. *Lit.*, push over many (a legendary man pushed his foes over a cliff as they came up) (Pukui, *et al.*, 1976:123). It is interesting to note that on H. N. Lyman's Reg. Map #30 and Reg. Map #1565 of Pepe'ekeō Plantation, the name is spelled "Kulaimanu".
Kumu'ōhi'a	A place above where Kawainui Stream forks in Onomea and where bird catchers lived (BC, Vol. A:183-86; 188-91). *Lit.*, *'ōhi'a* tree.
Laeakaloa	Land section in Pauka'a. Meaning uncertain. Could be a reference to the way the land comes down to a point on the *makai* end. *Lae* usually refers to promontories, capes and headlands usually located at the sea, but this is not always the case. An example would be *lae lā'au* which refers to "a forested point, whether at sea or inland" (Pukui, *et al.*, 1976:189).
Lua'a	Village and land area on Pāhoehoe. The word can be used to "pound poi till soft" or "to make poi and make ready food and conveniences for a feast (Fornander 1918-1919, VI:397). Boundary Commission records describe Lua'a as the "last of the old *kūlana kauhale* (village) on Pāhoehoe (Vol. B:182-83).

Makahanaloa	A cape and land division. There was a *leina* here which was a leaping-off place for spirits to enter the world of *pō* after death (Pukui, *et al.*, 1976:139). Hōmaika'ohe, the sacred bamboo grove was also located in Makahanaloa.
Moku'ōniki	A land section located between Pu'umoi and Alākahi. The name is most likely a reference to the physical land division itself. *'Ōniki* means "a pinch" or "a bit"; *moku* means "to be cut or severed" and is used as a descriptive term for "a severed portion of land" (Pukui, *et al.*, 1976:252,289).
Mohaluhalu	Site of an old *kauhale*. The point where Hakalau Nui, Honohina and Umauma join.
Nā Pu'u Mai O Ka Ahu	Located at the *mauka* corner of Hakalau Iki and above Ka'awahine (BC, Vol. B:360-61). Meaning not known.
Nahuina	Gulch, junctions in various locations (see *Figure 10*). Nahuina (1) is on Aliia [Alia, on modern maps] Stream where Kaupakuea joins Makahanaloa (BC, Vol. A: 182). Nahuina (2) is where "Makahanaloa and Pāpa'ikou join, and cut Onomea off" (BC, Vol. A: 180). Nahuina 3 is above Nā'ū and below Kumu 'Ōhi'a. Nahuina (4) is at the end of Kahua and Kaupakuea, along the old road to 'Uku Hill (BC, Vol. A: 183). Nahuina (5) is located along Pāhoehoe Stream, above Pihaakunui Falls (also known as Piha Kukui Falls) (Vol. B: 157-59). Nahuina Junction of Kaupakuea is the point where the boundary between Kahua and Makahanaloa turns away from Aliia Stream (BC, Vol. A: 182). *Lit.* the junctions (Pukui & Elbert 1986:87). A descriptive reference to the point of juncture where the land boundaries meet.
Nakama	A hill on Wa'awa'a Gulch in Hakalau Nui where there was an old *kauhale* (settlement) in *koa* (BC, Vol. B:360-61).
Nā'ū	A water head on Pepe'ekeo where water was taken out for a Makahanaloa sugar mill. The woods begin at Nā'ū (BC, Vol. A: 185). *Lit.* yellow (Pukui, *et al.*, 1986:164
'Ōku'u Hill	The older name was probably Pu'u 'Ōku'u. *Pu'u* means "hill". Given its location and elevation, the name likely refers to a "method of catching birds by gumming artificial *lehua* blossoms made of *'ie'ie* to a tree" (Pukui & Elbert 1986:282). Probably not a reference to the disease.
Onomea	A stream, bay, sea arch and site of an old Hawaiian village. The sea arch collapsed in 1958 (Macdonald and Abbott 1970). Listed in *Place Names* but no translation of the name is given.
Pāhoehoe	A land section and stream. The name is descriptive of a "smooth type of lava" (Pukui, *et al.*, 1976:49). Boundary Commission records indicate the interior forests of Pāhoehoe provided canoe makers with trees for canoes (Vol. B:183)
Paiha'aloa	Land section. Probably a descriptive reference to the tossing motion of the sea, like "a canoe in a rough sea" (Pukui, *et al.*, 1976:302). *Paiha'a* is a variant form of *paiāha'a*.
Palauolelo	A water spring in a gulch (*kahawai*) on Makahanaloa, above the woods. There was a "*kauhale ma luna kualapa*" (house(s) above on the ridge) (BC, Vol. A: 184). Frequently spelled "Palanolelo" in the BC records. Probably, Pālau'ōlelo (teller [of] tales). A pile of stones was said to be on the *mauka* corner of "Palanolelo", near Kaloloa (*Ibid.*). J. Ii indicates in his testimony that this pile of stones was put up by him and the *kama'āina* who accompanied H. M. Lyman on the survey of Makahanaloa (BC, Vol. A: 185-86).
Pauka'a	Meaning uncertain. Spelled as "Pouka'a" on H.N. Lyman's 1853 map (State Survey Office: Reg. Map #30) and probably an error.

Pepe'ekeō	A village, point and stream. A stream and rock are named for Kamapua'a, who unsuccessfully tried to drown Hina, Māui's mother here. Formerly spelled *Pepe'ekeō*, which means "the food crushed, as by warriors in battle" (Pukui, *et al.*, 1976:183).
Pihakukui	A falls mentioned in the Boundary Commission records (BC, Vol C, No. 4:120-23) which indicated that an ancient trail ran along the interior northern boundary of Pāhoehoe. The trail crossed Pāhoehoe Stream above the falls. D. B. Lyons' house was a short distance above the falls. *Lit.* full [of] kukui. Variant names for this same falls in the Boundary Commission records are Pihaakunui, and Pihaku'uiki/ike.
Pōhakupa'a	A stream which meets Honoli'i Stream at about 1850 ft. elevation. Not mentioned in *Place Names of Hawai'i*. A literal translation could be given as "foundation stone" or a stone that is solid and unmovable. Above Pōhakupa'a was an old trail which led to Hālapamana'ole where Pāhoehoe ends and Pauka'a and Pāpa'ikou join *mauka* of Pu'uana, a hill, at 3,800 ft elevation (BC, Vol. B:178-79).
Pohopā'ele	An old village on Makahanaloa, at a swampy place. Humu'ula people had their houses above here. Described as being a hollow (*poho*) on the top of a ridge (BC, Vol. A: 187, 190). Above Pōhakupa'a was an old trail that led to Hālapamana'ole where Pāhoehoe ends and Pauka'a and Pāpa'ikou join *mauka* of Pu'uana, a hill, at 3,800 ft elevation (BC, Vol. B: 178-79).
Popolo	A place located a short distance above Nahuina (2). "At this point, the valley runs *mauka* to the end of the tall woods" (BC, Vol. A: 189).
Pukaiwaho	A place at the upper edge of the forest (above the project area) where one comes "out of the woods... where small *koa*, *mamani* [sic.] and *pili* were growing; across of Palanolelo, the "old *kauhale*" or village. Marks the boundary between Humu'ula, Hakalau and Makahanaloa. A pile of stones was erected here by the informant and *kama 'āina* who accompanied him (BC, Vol. A: 186).
Pukaonua	Mentioned in Boundary Commission Records as a place further inland from 'Ula'ula where there was a canoe maker's settlement (Vol. B:457). Meaning of name is uncertain. It possibly is a misspelling.
Pu'u Ana	Located *mauka* of the project area in Pāpa'ikou on current USGS maps. Boundary Commission records describe the hill as belonging to Pauka'a (Vol. B:180). C. J. Lyons' Reg. Map #570 of 1879 (State Survey Office) concurs with this. Apparently, the boundaries have changed over the years. The name could be a reference to a cave on the hill, as the name implies.
Pu'u Ka'uku	Volcanic cone on the eastern slope of Mauna Kea from which two lava flows reached the sea; the southern one formed Pepe'ekeo Point. *Lit.*, the hill of the louse.
Pu'umoi	Land section. *Moi* refers to several things, a variety of taro and sweet potato, as well as a variety of fish. But, it is more likely a reference to Kalaoa Pu'umoi, sister of Kapalaoa who was the mother of the riddling expert, Kalapana. The land sections of Kalaoa and Pu'umoi are adjacent to each other. Not listed in *Place Names*.
Pu'uwai	A hill on Hakalau, in the woods ((BC, Vol. A: 184, 186).
'Ula'ula Hale	A inland place above 'Akaka Falls where canoes were made (Vol. B:457). *Lit.*, house [of] red; possibly a reference to the scarlet color of bird feathers.

Waikoloa	A pond or "round water hole not a mile from the edge of the woods" (BC, Vol. A: 187). *Lit.* duck water. This could also be a reference to *Waikōloa*, the name of a wind (Pukui, *et al.*, 1976:223). [Sometimes seen as Waikaloa in Boundary Commission records.]
Waikū	A water head (*pōwai*) where water was taken out to make a bullock pen (BC, Vol. A: 185).
Wailani	A place where bamboo grows on Kula'imano (BC, Vol. A: 189).
Waimaauau	A gulch said to be the boundary between Pepe'ekeo and Kula'imano at the shore (BC, Vol. A: 184). Spelled "Waimaauao" on USGS map (1994:Pāpa'ikou Quad).
Waimana	A water head above Nā'ū, where water was taken out for a sugar mill at Makahanaloa (BC, Vol. A: 185).
Walia	A gulch which marks the boundary between Kahua and Makahanaloa from the "sea shore into the woods on the *makai* side of 'Uku Hill, at a sort of swamp (name unknown), where Kaupakuea joins Makahanaloa (BC, Vol.

Nearly half of the above names are descriptive names of the physical environment or land features. Five of the names refer to legendary people and places such as the demi-gods Māui and Kamapua'a, while a little over a fourth of the names indicate land use by bird catchers and canoe makers. A few of the names also indicate plants that probably grew in the area. Information from the Boundary Commission records indicates that Hilo District forests were heavily utilized by both bird catchers and canoe makers. The heavily forested areas were a pristine environment and home to a number of Hawai'i's native birds such as the *'i'iwi*, the *mamo* and the *'ō'ō* and the 'amakihi. These birds provided colorful red, yellow, black and green feathers for royal symbols such as capes, *kahili* and *lei*. The forests also provided *koa* trees needed to build canoes and other supplies as well, such as *olonā* for snares and rope and *mamaki* for *kapa* cloth.

Land Commission Awards

The Waihona 'Aina database (2000b); which is a compilation of data from the Indices of Awards (Indices 1929), Native Register (NR n.d.), Native Testimony (NT n.d.), and Foreign Testimony (FT n.d.); lists 81 parcels claimed by 61 claimants within the *ahupua'a* of Alakahi, Kalaoa, Kawainui, Makahanaloa, Onomea, Pahoehoe, Pāpa'ikou, Pauka'a, Pueopaku, and Pu'umoi in the mid-1800s (*Table 1*). Sixty parcels were awarded to 53 claimants. *Figure 11* shows the location of awarded parcels based on the current tax maps. Nine parcels could not be located.

All except one of the largest awards are for entire *ahupua'a*. Aarona Kealiiahonui was awarded Pāpa'ikou, Hakalau Nui was awarded to Mikahela Kekauonohi, William Lunalilo received Makahanaloa, Pauka'a was awarded to Lota Kapuaiwa, Kanaulu was awarded Pu'umoi, and Victoria Kamamalu received Pahoehoe and Onomea. Kahikona was awarded one half of Pueopaku. All except one of remaining awarded claims are for *kuleana* parcels ranging from 0.17 to 4.97 acres in area with an average of 2.02 acres. LCA 8629, awarded to Kaapa in Kalaoa, consisted of two large *kuleana* parcels of 5.68 acres and 19.5 acres in area.

Nearly all of the *kuleana* awards are for parcels situated within one mile of the coast below 500 ft elevation. Land use described in the LCA claim testimony includes references to 97 houses in 56 claimed house lots, three canoe houses, over 80 cultivated fields, and a tanning establishment. Specifically mentioned crops consist of taro, coconuts, coffee, and bananas. The tanning establishment, 5,000 coffee trees, three acres of taro, and five houses were claimed by William McKenny (LCA 2256) in Kawainui 2, but were not awarded.

The majority of *kuleana* lands were received from the claimant's parents or ancestors (32 cases). Five were received from the *konohiki* and two each were given by Nihi in Pauka'a, Kuhio in Pāpa'ikou,

Table 1. Land Commission Award Claims

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Giver	Acreage	Royal Patent	Sources	Comment
1L	Olono	1	1			Pueopaku 2	N/D	house lot and 2 cultivated fields	Ravine	Kapua Stream	Ocean	Ravine	N/D	Kahona	3.29	6259	FT 50v5	Pueopaku 1 on Puna side
1O	Paaluhi	1	1			Pueopaku	Kukuionoi	house lot and 2 cultivated fields	Ili Piapau	Ohilohi	konohiki	Puapuaa	N/D	ancestors	2.17	5406	FT 52v5	
1P	Kakai	1	1			Pueopaku	Keakualawaia	2 house lots, coffee and kalo fields	field of Piipii	Ravine	Pahoehoe stream	Pahaola Stream	N/D	ancestors	1.05	6368	FT 52-53v5	Ravine divides ili of Kaulanamoa from Keakualawaia
118C	Kahaipule	1	0			Pueopaku	Piapau	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none		No 118 documents located, Kakaipule awarded LCA 4975
2256	Willam McKenny	2	0			Kawainui 2		5000 coffee trees, 5 houses, tanning establishment					1841	konohiki Akahi	0.00	none	FR 146v2, FT 57v5, NT 414v4, 667v4	
					1		Kaluanankele	house lot and cultivated field	konohiki	Kukuikoa	konohiki	konohiki						
					2		Haleolono	3 acres of taro	road	konohiki	konohiki/ Ili Haleolono	Ili Kapaku of Kawainui 1						
4528	Opunui	1	1			Paukaa	Kanaha	2 houses, 1 partially cultivated kihapai	road	Naniho's (Kaniho's) land	ocean	Paaoa's land	N/D	ancestors	1.02	4661	NR 682v8, FT 29v5, NT 429-430v4	
4548	Aheakalani	1	0			Paukaa	N/D	1 house, 2 cultivated kihapais	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 628v8, FT 30v5	
4569	Samuela	2	2			Onomea	N/D	coconut grove	N/D	N/D	N/D	N/D	N/D	N/D	1.00	7998	NR 85v8, FT 26v5, FT 30v5	2 apana awarded
4576	Inina	2	1			Papaikou	Wanui								1.68	4654	NR 683v8, FT 41v5, NT 482v4	
					1			1 house, 1 cultivated field	konohiki	Kanakaoka's land	road	Kapuhuaula's land	N/D	N/D				
					2			1 cultivated field	konohiki	Ahoki's land	idle land	Kapuhuaula's land	1839	Kuhio				
4595	Makuahine	2	1			Paukaa	Kahonulaula						N/D	konohiki	1.91	4659	NR 683v8, FT 31v5	unclear which lot awarded
					1			1 house lot	Kaupee's land	stream	stream	stream						
					2			1 house, 2 cultivated kihapais	konohiki	stream	konohiki	road						
4644	Palapala	1	0			Paukaa	Papaiki	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 385-386v8, FT 20v5, FT 54v5, NT 430v4	
4645	Paaoao	1	1			Paukaa	Papaiki	1 house lot (3 houses)	Keaka's land	Opunui's land	ocean	Kaniho's land	N/D	ancestors	0.68	4968	NR 685v8, FT 29v5, NT 430-431v4	
4646	Bauaie Pauaie	1	0			Pueopaku	Pehapau	1 cultivated field, 1 house lot	konohiki	stream	valley, konohiki	Kohuna's land, konohiki	Kam I Times	Kohuna	0.00	none	NR 685v8, FT 43v5, NT 486v4	
4648	Pahau	1	0			Papaikou	N/D	houses, kihapais	N/D	N/D	N/D	N/D	N/D	konohiki	0.00	none	NR 386v8, FT 54v5	
4650	Paukumoku	1	0			Papaikou	N/D	1 cultivated kihapai	N/D	N/D	N/D	N/D	N/D	konohiki	0.00	none	NR 386v8, FT 54v5	
4654	Pahua	2	1			Puumoi	Kaolehale						N/D	ancestors	0.17	4682	NR 685v8, FT 29v5, NT 430-431v4	unclear which lot awarded
					1			house lot with 4 houses, bananas, taro	Kalama's land	Pupuka's land	ocean	Kahiwa's land						
					2			cultivated field	konohiki	konohiki	konohiki	konohiki						

Table 1. Land Commission Award Claims (cont.)

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Giver	Acreage	Royal Patent	Sources	Comment
4661	Punaia	1	2			Pueopaku	Waipuka	2 house lots and 2 cultivated fields	konohiki	stream	Kaili's land	konohiki	N/D	ancestors	1.77	4665	NR 84v8, FT 51v5	2 apana awarded
4664	Punaia	1	1			Pueopaku	N/D		N/D	N/D	N/D	N/D	N/D	N/D	3.67	4868		All documents for this number are for Puana on Maui
4695	Lulana	1	1			Papaikou	Kapuakea/ Puahia	1 house lot, 2 cultivated kihapais	konohiki, idle land	stream	road, foot path	Kapuena's (Hewelewa's) land	1845	ancestors	2.25	4658	NR 686v8, FT 41v5, NT 481-482v4	
4703B	Kalua	1	1			Puumoi	Kauhihala 2	1 cultivated kihapai	Kahaha's (Kahaka's) Land	road	Kaukaamihai's (Kaukaenohai's) land	valley, ravine	N/D	ancestors	2.01	none	FT 36v5, NT 468v4	
4703D	Meheula	1	0			Puumoi	Kukuianiani	1 house lot, 2 cultivated kihapais	konohiki	Hue's land	Hoka's land	stream	1835	Hoka	0.00	none	NR 687-688v8, FT 35v5, NT 475v4	9 claimants
4703E	Kauhaomohai	1	0			Puumoi	Kauhihala	1 house, 1 cultivated field	Kaua's (Kaaua's) land	road	Olalau's land	valley, ravine	1838	Kalua	0.00	none	FT 36v5, NT 469-470v4	
4703F	Kulahilo	1	0			Puumoi	Lalioa	1 house lot, 1 partially cultivated kihapai	konohiki	stream	konohiki	stream	N/D	ancestors	0.00	none	FT 37v5, NT 471v4	
4703	Olalau	1	2			Puumoi	Kauhikala 1	house lot with 2 houses, 1 cultivated kihapai	Kahaenohai's land	mountain, street	Kalua's land	valley, ravine	N/D	Kalua	1.50	none	FT 36v5, NT 469v4	awarded two apana
4704B	Hue	1	1			Puumoi	Kikuianiani	2 houses, 1 partially cultivated kihapai	Mehaula's land	ravine, ditch	konohiki	Hoka's land	N/D	ancestors	1.70	7823	FT 35v5, NT 467v4	
4709B	Kahale	2	1			Puumoi	Hauaioi						N/D	ancestors	0.61	none	FT 36-37v5, NT 470v4	unclear which parcel was awarded
					1			cultivated field	Kaoiuloa's	cemetery	konohiki	stream						
					2			8 houses, 2 canoe houses, 18 coconut trees	pali	stream	ocean	cemetery						
4732	Makuihelani	1	1			Pueopaku 2	Kahoeulo	1 house lot and 1 kihapai	road	stream	Makua's land	pali	N/D	Parents	4.46	4663	NR 688v8, FT 30v5	
4733	Mahae	1	0			Pueopaku	N/D		N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 84v8, FT 57v5	Awarded under LCA 4773
4734	Mahi	1	1			Pueopaku 1	Kaukaumoa	2 house lots, 2 partially cultivated kihapais	konhiki, idle land	Pueopaku 1st	valley, ravine	valley, ravine	N/D	ancestors	1.50	4673	NR 689v8, FT 34-35v5, NT 474v4	
4735	Maa	1	1			Paukaa	Wahi	1 house lot (2-3 houses) 3 cultivated kihapais	Kalama's land	Kuaana's (Kuheana's) land	Paahua's (Kapahua's) land	Kahiwa's land	1847	Nihi	1.04	4683	NR 689v8, FT 19-20v5, NT 428-429v4	
4773	Mahuai	1	1			Pueopaku 1	N/D	1 house lot, 3 fields	ravine	ravine	ocean	Pahoehoe stream	N/D	ancestors	3.00	7404	NR 84v8, FT 44v5, FT 57v5	other claimant - daughter/heir, north ravine divides Pueopaku 1 and 2
4776	Naehu	1	1			Pahoehoe	Kukuinaiolo	2 house lots, 2 cultivated kihapais	konohiki	valley, ravine	school	road, mountain	Kam I Times	ancestors	0.73	4718	NR 690v8, FT 34v5, NT 473v4	
4781	Nakuapuu	1	1			Pueopaku	Hina	2 house lots, 1 cultivated kihapai	konohiki	konohiki	konohiki	konohiki	1833	Kaikona/ Kahekona	1.42	4679	NR 690-691v8, FT 42v5, NT 485v4	
4783	Nakai	1	1			Papaikou	Pihau	1 house lot, 1 partially cultivated kihapai	Kanahoukaki's land	stream	Puapaa's land	road	Kam I Times	ancestors	4.46	6683	NR 691v8, FT 33v5, NT 458v4	
4784	Nuki	1	1			Paukaa	Halekane	2 houses, 1 cultivated kihapai	Kameanui's land	konohiki	road	stream	N/D	Nihi	2.47	4852	NR 691v8, FT 31v5, NT 461v4	
4897	Kiolakia	1	0			Alakahi	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 334v4	

Table 1. Land Commission Award Claims (cont.)

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Given	Acreage	Royal Patent	Sources	Comment
4968	Kuheana	3	2			Paukaa	Alahale						Kam I Times	ancestors	4.97	4690	NR 693v8, FT 19v5, NT 478v4	Awarded 2 apana
					1			2 houses, 3 cultivated kihapai	konohiki	konohiki	road	road						
					2			1 cultivated kihapai	konohiki	stream	stream	stream						
					3			canoe house	konohiki	konohiki	konohiki	konohiki						
4969	Kalama	1	1			Paukaa	Kapoho	2 cultivated kihapai	Haopu's land (idle land)	konohiki (idle land)	Maa and Kamokuahua's (Nahakuahua's) land	stream	Kam I Times	ancestors	1.88	4689	NR 693-694v8, FT 20v5, NT 449-450v4	
4970	Kohuna	1	1			Puaopaku	Makahiloia	1 house lot, 2 cultivated kihapai	road	stream	ocean, stream	konohiki	1834	Kahikona Poiaole	2.42	4635	NR 694v8, FT 30v4, NT 466v4	other claimant - Samuela (father)
4972B	Kahiwa	1	1			Paukaa	Kalaekapola	2-4 houses, 1 cultivated kihapai	Maa's land	Paahua's (Kapahuaa's) land	ocean	river	1842	Ahaakaleai	2.07	5032	NR 694-695v8, FT 19v5, NT 428v4	Awarded 2 apana
4975	Kukaipula	1	1			Puaopaku	Piapau	1 house lot, 1 cultivated kihapai	konohiki	stream	ravine, valley	Kohuna's land	Kam I times	konohiki	0.35	4672	NR 686v8, FT 43v5, NT 485-486v4	
4976	Kuhipono	1	1			Papaikou	Piihau	2 houses, 1 cultivated kihapai	konohiki	road	Kashi's land	stream	Kam I times	ancestors	2.66	4662	NR 695v8, FT 32v5, NT 464v4	
4977	Kahoenakahi	1	1			Papaikou	Piihau	3 houses, 1 partially cultivated kihapai	konohiki	Mokihana 2	ocean	Kahiwi's land	Kam I Times	ancestors	3.86	4694	NR 695v8, FT 33v5, NT 460v4	
4978	Kanakaokai	1	0			Papaikou	Piihau	1 house, 1 partially cultivated kihapai	road	stream	ocean	Mauia's land (stream)	Kam I Times	ancestors	0.00	none	NR 695v8, FT 33v5, NT 459-460v4	
4979	Kenahu, wahine	1	1			Papaikou	Piihau	2 houses, 1 cultivated kihapai	Kahipa's (Kahupa's) and Kahua's (Kahua'i) land	stream	road	road	Kam I Times	ancestors	2.65	4680	NR 695-696v8, FT 32v5, NT 454-465v4	
4991	Kukaua	1	1			Papaikou	Piihau	2 houses, partially cultivated moo	Kaili's (Kashi's) land	road	Kamaka's (Kamaha's) land	stream	Kam I Times	ancestors	0.68	4685	NR 696-697v8, FT 31v5, NT 462v4	
4992	Kashi	1	1			Papaikou	Piihau	2-3 houses, 2 cultivated kihapais	Kuhipono's (Kameenui's) Land	Pahoehoe (road)	Kahalu'a land	stream	Kam I Times	ancestors	0.62	6745	NR 697v8, FT 31v5, NT 461-462v4	
4993	John B. Kekua	1	1			Papaikou	Piihau	2 houses, 1 partially cultivated kihapai	Waikoloa's (Waikalo'i) Land	stream	Kuikaua'i's land	road	Kam I Times	ancestors	1.97	5407	NR 697v8, FT 31-32v5, NT 463v4	
5008	Kaumiumi	2	3			Puumoi	Makuhoonaki, Kakuhole						Kam I Times	ancestors	1.38	none	NR 700-701v8, FT 40v5, NT 480v4	awarded 3 apana; no data on third parcel
					1			1 field, 1 house	Kalamahina's land	konohiki	Hua's land	konohiki						
					2			3 fields, 1 house	konohiki	konohiki	konohiki	stream						
5052B	Kahahaikeakaahi	1	1			Papaikou	Piihau	1 house, 1 cultivated kihapai	konohiki	stream	Haleili's land	road	Kam I Times	ancestors	1.47	7260	NR 699v8, FT 33v5, NT 458v4	
5096	Kapuhau'a	2	1			Papaikou	Mokupuni								1.50	4684	NR 699v8, FT 41v5, NT 483v4	unclear which parcel awarded
					1			1 house lot, 2 cultivated kihapais	konohiki	Inaina's land	road	stream	N/D	N/D				
					2			1 house lot, 2 cultivated kihapais	konohiki	Inaina's land	konohiki	konohiki	1839	Kuhio				
5097	Kaha	1	0			Papaikou	Piihau	houses, cultivation	N/D	N/D	N/D	N/D	N/D	ancestors	0.00	none	NR 387v8, FT 54v5	
5098	Kekiikeakahi	1	1			Puaopaku	Papakolea	2 houses, 1 cultivated kihapai	Mahi's land	valley, ravine	road	pali	1829	Ana Kaeo	2.35	4688	NR 699v8, FT 42v5, NT 483-484v4	

Table 1. Land Commission Award Claims (cont.)

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Giver	Acreage	Royal Patent	Sources	Comment
5103	Kamaka	1	1			Papaikou	Piihau	2 houses, 1 partially cultivated kihapai	Kuikaua's land	road	path	stream	Kam I Times	ancestors	3.16	6681	NR 699-700v8, FT 33v5, NT 458v4	
5111	Kaniho	3	1			Paukaa		1 house lot, 2 cultivated kihapais					Kam I Times	ancestors	2.19	4660	NR 701v8, FT 20v5, NT 429v4	unclear which parcel awarded
					1		Papaikou	1 house, 1 field	Palapala's land	Pascoe's land	ocean	valley						
					2		Makaliilii	1 partially cultivated field	road	konohiki	konohiki	Government land						
5210	Kahepa	1	1			Papaikou	Piihau	1 house, 1 partially cultivated kihapai	konohiki (idle land)	stream	Kekua's land	road	N/D	ancestors	1.28	4681	NR 701v8, FT 20v5, NT 429v4	
6247H	Kanuulu	1	1	4		Puumoi	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	Kam. III	847.30	7999	NR 270-271v5, NT 355v10	Awarded entire ahupua'a, award also includes lands on Oahu and Maui
7673	N. Kuhio	1	0			Papaikou	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 430v5	claimed one half of Papaikou
7713	Victoria Kamamalu	2	2	19		Onomea	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	2579.00	8117	NR 440-444v5, 569v5, FT 408-411v3, 538-539v3,	Awarded entire ahupua'a, award also includes lands on Oahu, Molokai, and Kauai
						Pahoehoe	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	1385.00	6860		Awarded entire ahupua'a
7715H	Lota Kapuaiwa	13+	1	12+		Paukaa	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	6200.00	8335	NR 434v3, NR 444-445v5, NT 244v10.	Awarded entire ahupua'a, award also includes lands on Oahu and Maui
7753	Kahikona	1	1			Puueopaku	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	58.65	7716	NR 669v8, FT 215v10	1/2 of Puueopaku ahupua'a
8559	William Lunalilo	1	1	30+		Makahanaloa	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	7600.00	7192	FT 551v3, 82v16, NT 450v10, 82v16,	Awarded entire ahupua'a
8629	Kaapa	2	2	1		Kalaoa		N/D					N/D	N/D		3542	NT 704v8, FT 80v5, 92v5, NT 408v4	
					1		Uhumalu		konohiki	konohiki	konohiki	stream/ Aleamai			19.52			Apana 1
					2		Kuluou		konohiki	stream/ Puumoi	konohiki	konohiki			5.68			Apana 2
8884	Kawaakialoa	1	1			Kalaoa	Waikii	house lot, cultivated field	road	Di Alaalaa	konohiki	konohiki	N/D	N/D	1.21	none	NR 705v8, NT 474v4	
10164	Moku	1	1			Puumoi	Mokuhoonaki	1 cultivated kihapai	Kua's (Hua's) land	stream	konohiki	konohiki	N/D	ancestors	0.37	none	NR 708v8, FT 37v5, NT 475-476v4	claimed entire ili
11045	Barenaba	1	0			Puumoi	N/D	ocean access	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 708v8, FT 39v5, NT 480v4	land said to be formerly part of Alakahi
11215H	Aarona Keaiiahonui	1	1	7+		Papaikou	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	14000.00	none	NR 362-363v4	Awarded entire ahupuaa, also awarded lands on Oahu and Kauai
11216H	Mikahala Kekauonohi	1	1	27		Hakalau Nui	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	12590.00	7541	NT 334v10	Awarded entire ahupua'a

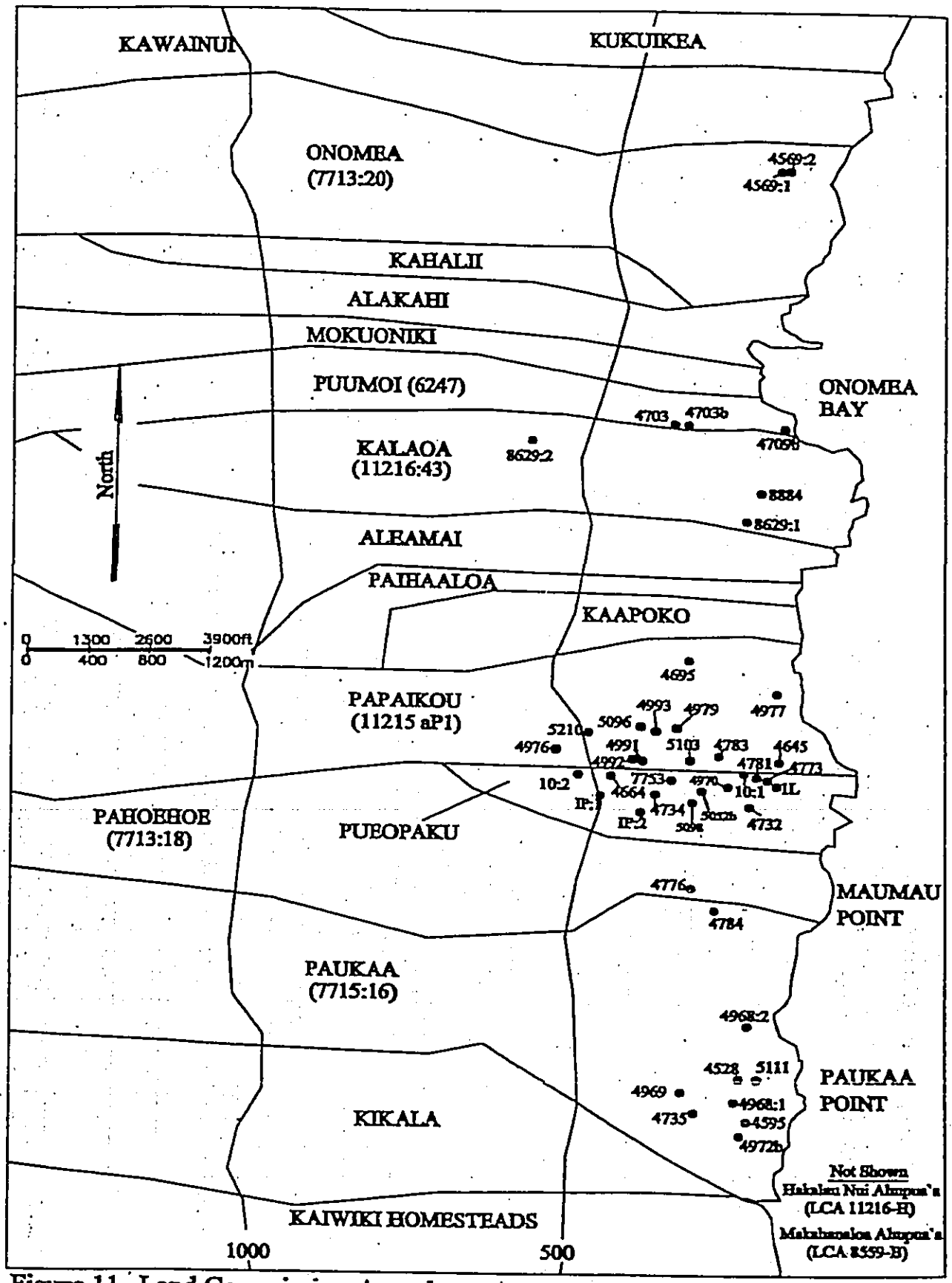

Figure 11. Land Commission Awards

Kalau in Pu'umoi, and Kahekona in Pueopaku, suggesting they may have been *konohiki*. The *konohiki*, Akahi, is named as the donor of the lands claimed by William McKenny in Kawainui. Seventeen claimed lands were transferred to the claimants during the time of Kamehameha I. The remaining lands, which have conveyance information, were transferred between 1829 and 1847.

The LCA testimonies usually mention the *ili* land unit where the claimed parcel is located. Seven *ili* are mentioned in Pu'umoi as follows: Kauhi hala (3 claims), Mokuhooniki (2), Kukuianiani (2), Hauaioi, Kaolehale, Lalkoa, and Kalahole. Kauhihala was probably situated along the northern *ahupua'a* based on the location of the awarded parcels. The other *ili* could not be geographically located. Nine *ili*, Kahomilo, Kaulanamoa, Hina, Keakualawaia, Kukuionoi, Pehapau, Piapau (2 claims), Waipuka, and Papakolea; are described in Pueopaku. Eight *ili*, Alahale, Halekane, Kahonulaula, Kalaekapola, Kanaha, Kapoho, Papaiki (2 claims) and Wehi; are mentioned in Pauka'a. Named *ili* in Pāpa'ikou consist of Kapuakea, Puahia, Mokupuni, Piihau (12 claims) and Wanui. Only one *ili*, Waikii, is mention for Kalaoa.

Mid-1800s to Present

Subsequent historic use of the project area *ahupua'a* was dominated by sugar cane plantation agriculture beginning in the mid-1800s and continuing in some areas until the 1990s. The majority of plantation activity was situated seaward of the project area where fields where located. Plantation worker camps were scattered over the countryside connected by roads to the plantation villages at the sugar mills at Pāpa'ikou, Pepe'ekeō, Honomu, and Hakalau. A railroad system connected the mills to the port at Hilo. Plantation-related activities, which extended into the lower portion of the project area, included the construction of water distribution systems and timber harvesting for lumber and firewood.

Much of the following summarizes historical information presented by Tomanari-Tuggle (1996) in her cultural resource overview of the Hakalau Forest National Wildlife Refuge. The development of sugar plantations and the associated labor requirements lead to an increase in population. The forests were cut to expand cultivation and supply wood for residential and industrial purposes. *Figure 12*, an 1853 map of a portion of Hilo District by the surveyor Lyman, shows the forest line at between approximately 900 ft and 1,000 ft elevation. By 1904, the sugar cane fields extended inland to between 1,500 and 1,600 ft elevation, which is near the inland limit today. The plantations began using flumes in the 1860s. The flumes were a combination of wooden troughs and ditches that were fed by diversion structures built on streams.

Tomonari-Tuggle (1996) quotes an 1868 description of flumes constructed by the sugar plantations to transport logs and sugar cane:

> The flumes now extend up into the forests and immense quantities of wood are brought down...The flume on the Onomea Plantation [Pauka'a and Pāpa'ikou], we were informed, answered to bring down seventy-five cords of wood in a single day...The Hitchcock brothers have a flume on their ranch [Pāpa'ikou] which is used alone for the transport of wood and timber. Their flume is three and a half miles long (1996:19).

By 1911, some Hawai'i Island plantations were required to import firewood because the costs for transporting wood from the increasing distant upland forests were becoming prohibitive. There were increasing concerns about the forest and water supply in the late 1800s to early 1900s. In 1905, the Hilo Forest Reserve was established. The reserve comprised 110,000 acres between the Hamakua District boundary and the 1881 lava flow above Hilo. The Territorial Bureau of Forestry began reforestation efforts by planting exotic trees including Sugi pine (*Cryptomeria joponica*) pine trees (*Pinus* spp.), and eucalyptus (*Eucalyptus* spp.).

Figure 13 is a portion of Wall's 1922 map of the Hilo Forest Reserve. The map shows the Onomea, Pepe'ekeō, and Honomu Sugar Companies occupying the lands below the forest reserve boundary. The map also shows the subdivision of mid-elevation lands into smaller homestead lots in Kaiwiki, Honomu, and on the south side of Pauka'a. *Figure 14* is a portion of a 1923 map of Hawai'i Consolidated Railway lines. The map shows a railroad paralleling the coast from Hilo to the Paauilo Mill. The Pāpa'ikou, Pepe'ekeo, Honomu, and Hakalau Sugar Mills are situated along the coast.

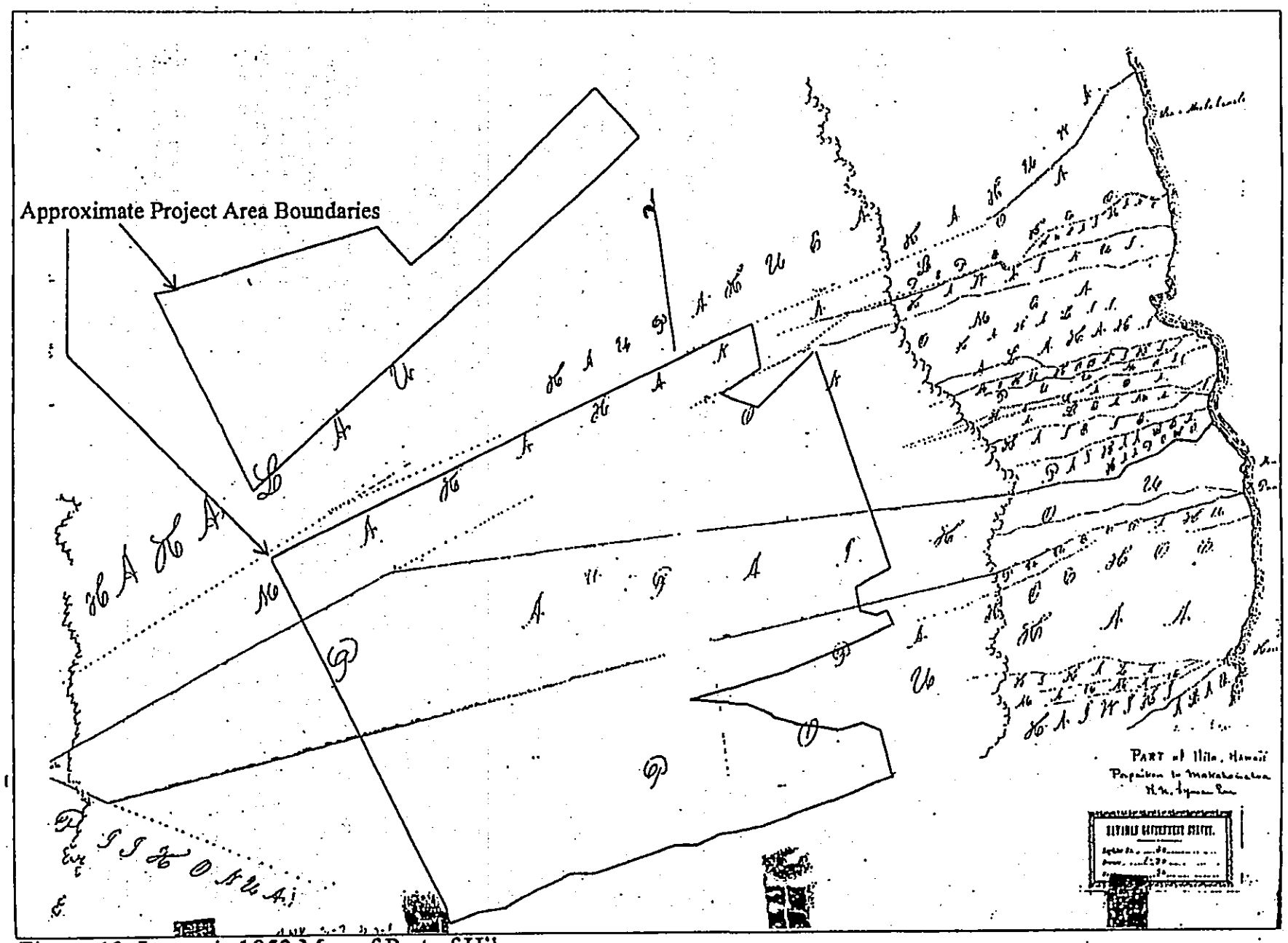

Figure 12. Lyman's 1853 Map of Part of Hilo

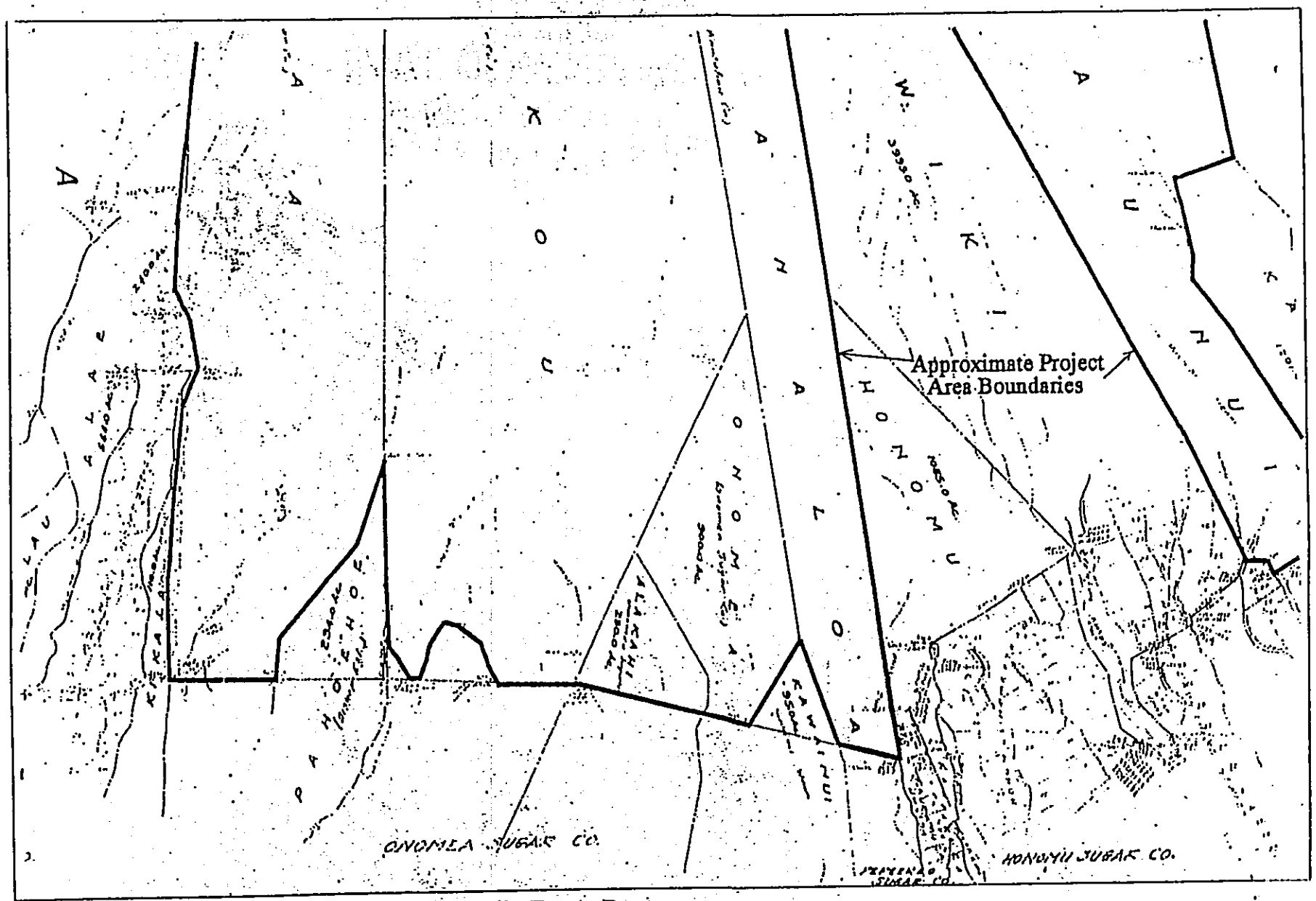

Figure 13. Portion of Wall's 1922 Map of Hilo Forest Reserve

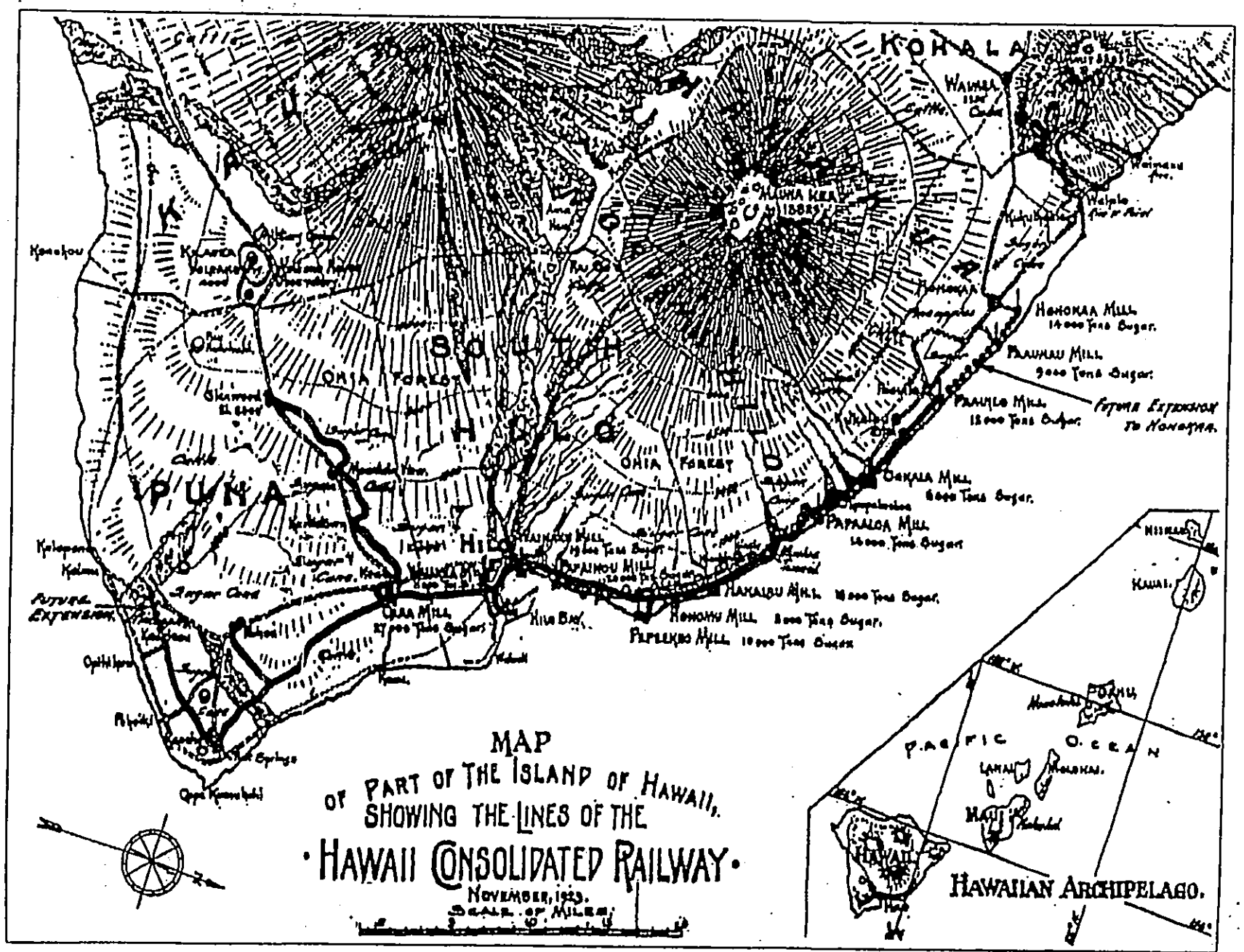

Figure 14. 1923 Map of Hawaii Consolidated Railway

Figure 15 is a portion of a 1931 Pepe'ekeō Sugar Company map of Makahanaloa that depicts several facilities in or adjacent to the project area. Pepe'ekeō Sugar Company water heads are situated on Waiaama Stream on the south side of Pu'u Ka'uku and on a branch of Kawainui Stream just north of the inland tip of Kawainui Ahupua'a. A "camp site" is shown immediately south of the latter "old" water head. A third water head feeding a ditch belonging to the Onomea Sugar Company is situated further down the same branch of Kawainui Stream. The water head beside Pu'u Ka'uku feeds a flume that flows along the contour around the hill to a point on the east side where it feeds a flume running seaward. A dashed line, potentially representing a road or trail extends between the two Pepe'ekeō water heads and the campsite.

Oral historical research and interviews were conducted for a cultural impact assessment of the proposed timber project (McGuire 2000). The research indicates that Hawaiian families in the area have hunted pigs in the project area since the 1800s and the hunting continues today. Area residents descended from Portuguese plantation workers who began arriving in the 1880s have hunted pigs in the project area for at least three generations. In addition to hunting pigs, fern shoots and watercress were gathered and freshwater shrimp and snails collected from the streams.

Previous Archaeological Research

A search of the DLNR-SHPD archaeological report database and other sources identified 19 archaeological projects in North and South Hilo Districts between the Wailuku River and Hamakua District. *Figure 16* shows the project locations and *Table 2* summarizes the projects. Not included in the figure or table are the studies by Stokes (Stokes and Dye 1991), which focused on major sites, primarily *heiau* throughout Hawai'i Island, a survey of east Hawai'i by Hudson (1932), and the general, primarily archival, study of McEldowney (1979). Two studies by Rosendahl (1990) and Carter (1990) were not available for review. Both studies were surveys of small areas in the upper portion of the Hakalau Forest NWR and the surveys did not locate any sites (Tomonari-Tuggle 1996). None of the previous studies included the current project area.

Stokes (Stokes and Dye 1991), relying primarily on the earlier reports by of Thrum, listed seven *heiau* for the area; however, all except one were destroyed at the time of Stokes fieldwork in 1906. Mamala or Ha'akoa Heiau overlooking Laupahoehoe village was the only intact site at the time of Stokes' survey. The destroyed *heiau* consist of Kinailoa and Kanoa in Pu'ueo Ahupua'a, Kahinihini'ula Heiau in Punahoa, Kiniakua Heiau near Waikapu Spring, and four *heiau* (Moeapuhi, Kama'o, Lonopuha, and Papauleki'i) at Laupahoehoe. Kanoa Heiau was reported to be for human sacrifice. Kahinihini'ula and Kiniakua Heiau were reported to be small agricultural *heiau*.

Hudson (1932) relocated Ha'akoa Heiau finding it in fairly good condition. At Laupahoehoe Point, he identified the possible remains of Lonopuha Heiau and Papauleki'i Heiau, which Stokes reported as destroyed. Hudson identified taro terraces in Maulua Gulch and three platforms on the coast at Maulua Bay. Informants told Hudson that Pu'u Ka'uku in Makahanaloa was used as a signal station. The signals were sent at night with torches between Ka'uku and the summit of a hill above Green Lake near Kapoho in Puna. The informants said there were holes in the ground to hold the torches, but Hudson did not find them. Other informants reported burial caves at two locations along the sea cliffs in northern Hilo District.

The surveys in *Table 2* cover nearly 37,000 acres between sea level and 6,845 ft elevation; however, much of the area was not subjected to 100% pedestrian coverage. The surveys identified 20 sites with 31 features. The only traditional Hawaiian sites are five hearths excavated by Goodfellow (1991) and a possible burial platform identified by Kennedy (1992), all on the north bank of the Wailuku River. The only radiocarbon dates from the area are reported by Goodfellow (1991). The dates from subsurface hearths range from the 1400s to 1600s with one date post-dating the mid-1600s.

The absence of traditional sites is attributed to the massive ground disturbance of sugar cane cultivation and pasture development. Historic remains identified by the surveys consist of 18 sites with 26 features. The historic features primarily consist of surveyor's boundary markers, petroglyphs, cattle walls, habitations, and roads.

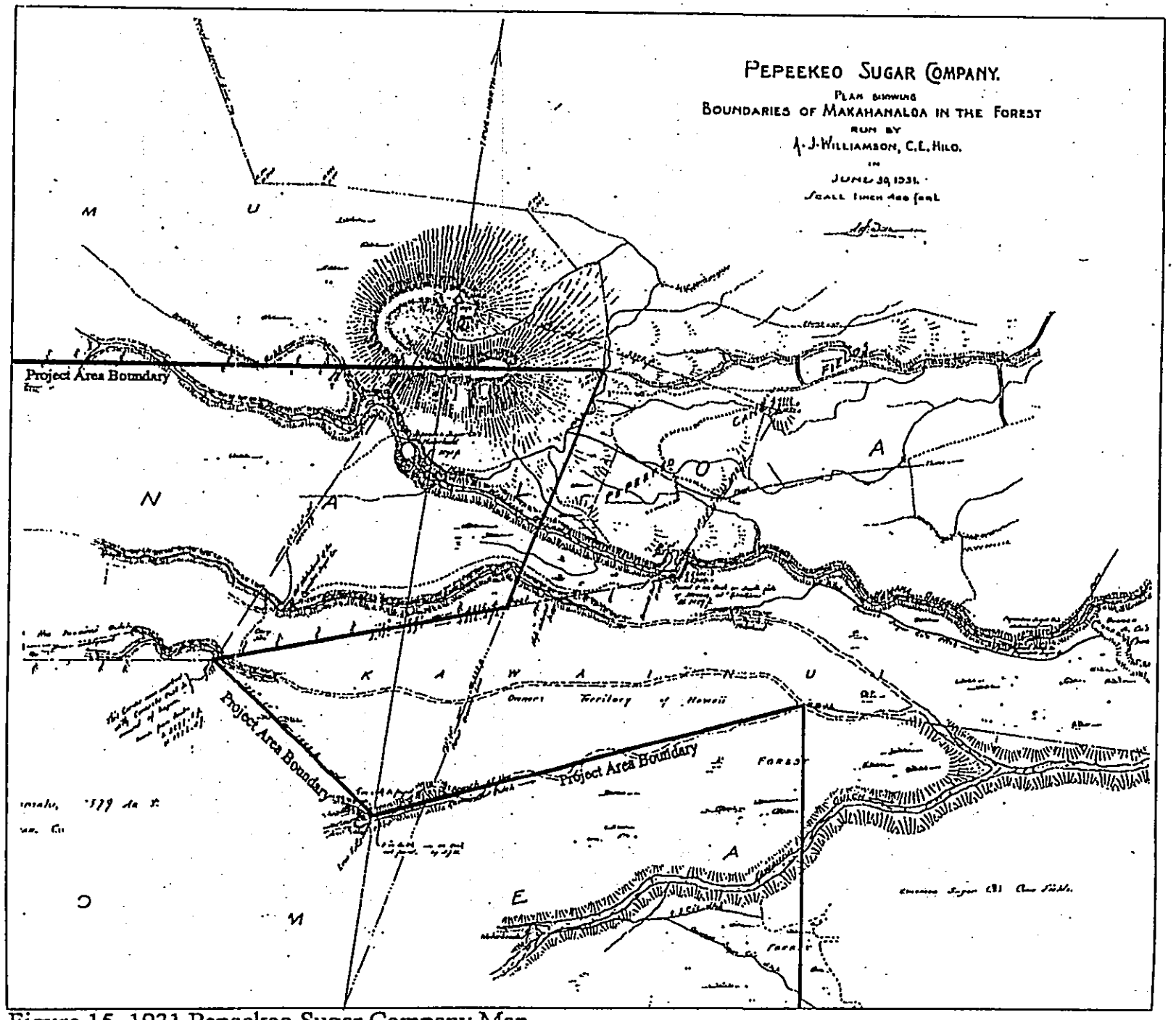

Figure 15. 1931 Pepeekeo Sugar Company Map

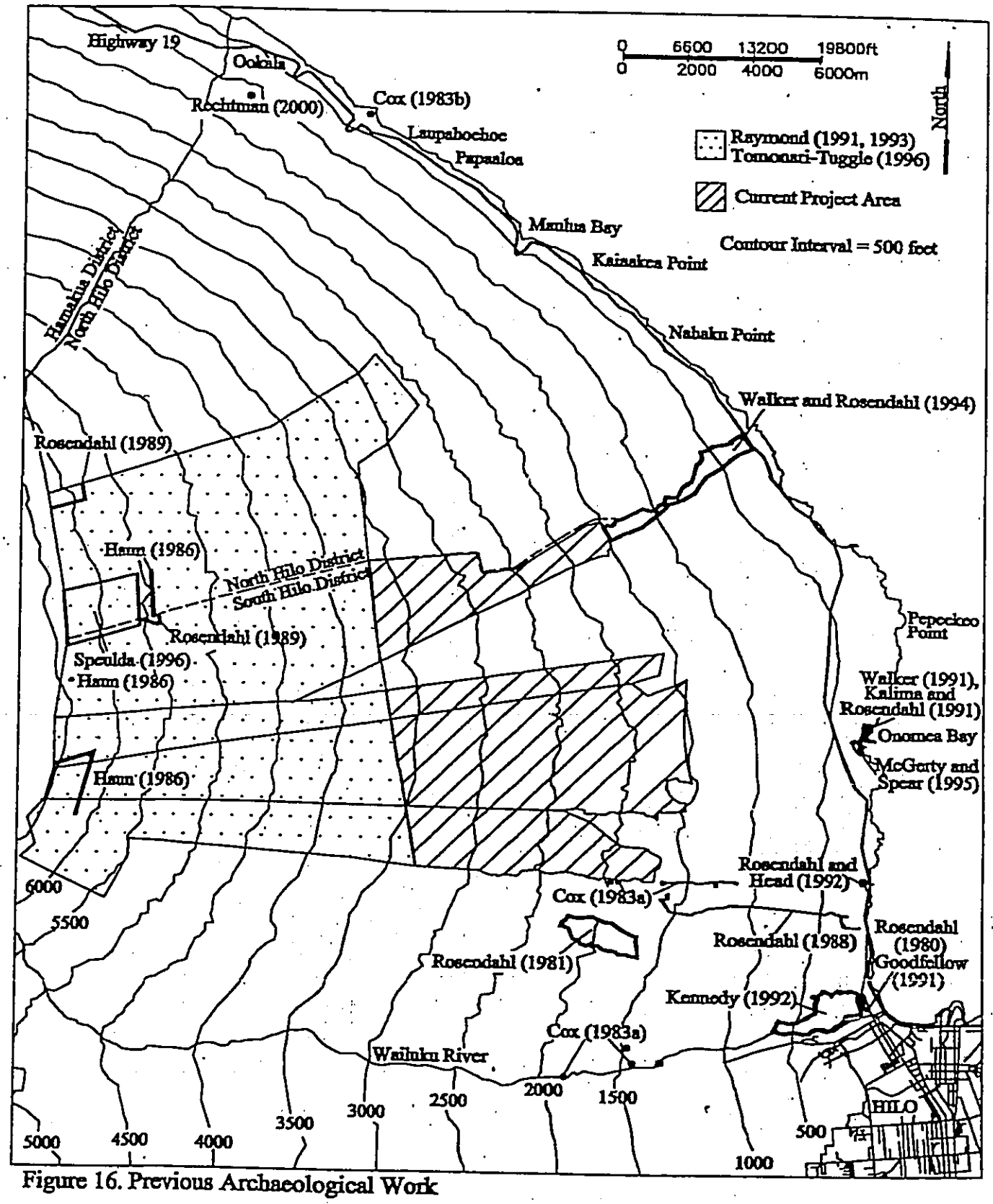

Figure 16. Previous Archaeological Work

Table 2. Summary of Previous Archaeological Work

Author	Date	Land	Study Type*	Elevation	Area (acres)	Historic Use	No of sites	No of Feas	Hab Feas	Ag Feas	Burial Feas	Cattle wall	Rock art	Historic fea
Cox	1983b	Laupahoehoe	RN	0-50	10	Landing area	1	1						
Walker/ Kalima and Rosendahl	1991, 1991	Onomea	FI/HR	0-220	40	Botanical garden	0							
McGerty and Speer	1995	Onomea	IN	0-220	17	Botanical garden	0							
Rosendahl/ Goodfellow	1980/ 1991	Puueo	RN/IN	10-50	1.73	?	3	8	5					3
Rosendahl, M.	1988	Kikala and Puakaa	RN	100-1530	5.5	Sugarcane	3	6				1		5
Rosendahl and Head	1992	Paukaa	FI	100-200	25	Sugarcane	0							
Kennedy	1992	Puueo	IN	131-918	482	Sugarcane	1	1			1			
Walker and Rosendahl	1994	Hakalau Nui	IN	200-1500	595	Sugarcane, Eucalyptus	0							
Rechtman	2000	Humuula	IN	1080	0.02	Sugarcane	0							
Cox	1983a	Various	RN	1200-1400	5	Sugarcane	0							
Rosendahl, P.	1981	Puueo	RN	1600-2200	300	?	0							
Raymond/ Tomonari-Tuggle	1991, 1993, 1996	Maulua Nui, Piha, Honohina, Hakalau Nui, Makahanaloa, Papalkou, Paukaa	IN/RN	2500-6500	33000	Ranching	9	12					1	11
Rosendahl	1989	Hakalau Nui, Maulua	IN	5480-6160	0.8	Ranching	0							
Speulda	1996	Honohina, Piia, Maulua	IN	5500-6500	1005	Pasture	4	4				1		3
Haun	1986	Honohina, Hakalau Nui, Makahana Loa, Papalkou, Paukaa	RN	5817-6845	2.5	Ranching	0							
				Total	35479.6		20	31	5	0	1	2	1	22

* RN=Reconnaissance Survey, FI=Field Inspection, HR=Historic Documentary Research, IN=Inventory Survey

McEldowney (1979) used site inventory and historic documentary evidence to develop a land use and settlement pattern model for the Hilo area that is applicable to the project area. The model consists of five elevationally-defined zones: Coastal Settlement, Upland Agricultural, Lower Forest, Rainforest, and Sub-Alpine or Montane. The Coastal Settlement Zone extended approximately 0.5 miles inland from the shoreline between sea level and 50 ft elevation. The zone was the most densely populated with both permanent and temporary habitations, high status chiefly residences, and *heiau*. Settlements were concentrated at Hilo Bay and sheltered bays and coves. Also present were gardens where breadfruit, coconut, *kukui*, banana, *wauke*, sugar cane, sweet potato, and wet and dryland taro were cultivated. The ocean provided fish and other marine resources. For the area north of the Wailuku River, the inland limit of this zone should be expanded to approximately one mile based on the distribution of LCA parcels.

The Upland Agricultural Zone was situated between approximately 50 ft and 1,500 ft elevation. Settlement in the zone consisted of scattered residences among economically beneficial trees and agricultural plots of dryland taro and bananas. Lava tubes were utilized for shelter. A pattern of shifting cultivation is believed to have converted the original forest cover to parkland of grass and scattered groves of trees. Wetland cultivation of taro occurred along streams.

The Lower Forest Zone ranged from 1,500 ft to 2,500 ft elevation. Timber and other forest resources such as medicinal plants, *olona*, and birds were gathered from the zone. Site types consisted of temporary habitations, trials, shrines, and minor agricultural features in forest clearings and along streams. For the area north of the Wailuku River, the seaward limit of this zone should be reduced to approximately 1,000 ft elevation based on the forest edge reported by Lyman (see *Figure 12*).

Sites in the Rainforest Zone (2,500-5,000 ft elevation) and Subalpine or Montane Zone (5,000-9,000 ft) were limited to trails and associated temporary habitations. These zones were used for intra-island travel and gathering of valued resources including hardwoods, birds, and stone for tool making.

SUMMARY OF LAND USE

The early 1900s surveys by Stokes and Hudson identified a few sites along the coast and reported the former presence of several *heiau*, none of which are in project area *ahupua'a*. Hudson's informants reported that Kauku Hill in Makahanaloa, partially within the project area, was used as a signal station. Subsequent studies elsewhere between the Wailuku River and the Hamakua District boundary did not identify any traditional Hawaiian sites except along the north bank of the Wailuku River near Hilo. The absence of sites in most of the previous studies is attributable to historic land modification primarily associated with sugar cane plantation agriculture.

McEldowney's (1979) settlement pattern model for the Hilo area is applicable to the project area. The project area lies within her Lower Forest Zone between 1,500 ft and 2,500 ft elevation, and the Rainforest Zone between 2,500 ft and 5,000 ft elevation. The Lower Forest Zone was the source for timber and other forest resources such as medicinal plants, *olona*, and birds. Predicted site types consist of temporary habitations, trials, shrines, and minor agricultural features in forest clearings and along streams. Sites in the Rainforest Zone are limited to trails and associated temporary habitations. This zone was used for intra-island travel and gathering of resources including hardwoods and birds.

The Boundary Commission testimonies describe activities conducted in the project area. Much of the information was passed down from the individuals who lived in the late 1700 to early 1800s. Activities included bird catching, canoe building, bullock hunting, and gathering of *olona* and *pulu*. Settlements for bird catchers and canoe makers are also described. The settlements were probably occupied on a temporary basis by individuals whose permanent residences were close to the coast. The residential structures in these settlements were likely constructed entirely of wood and thatch because the structures were temporary and surface stone is rare.

The trails described in the testimonies seem to have been primarily associated with the bird hunting and canoe building activity as opposed to transiting the upland forests to reach the upper edge of the

forests. Most of the testifiers had little or no knowledge of the uppermost *ahupua'a* boundaries. In general, the testimonies suggest that the activities, trails, and settlements described in the late 1800s were no longer in use. There is one reference to a probable shrine on the south bank of Waia'ama Stream opposite Pu'u Ka'uku, which is a short distance seaward of the project area.

The LCA data indicate that by the early to mid-1800s the primary traditional Hawaiian settlement and agriculture in the project area *ahupua'a* was situated 2.5 to 3.5 miles east of the project area, primarily below 500 ft elevation. The LCA testimonies document many residential structures and cultivated fields. Named crops consist of coconuts, bananas, taro, and coffee. Other probable crops include breadfruit, *wauke*, sugar cane, and sweet potato. Canoe houses are mentioned in Pu'umoi and Pauka'a indicating access to the ocean and marine resources.

Figure 17 is a map showing the *ahupua'a* in the region, awarded LCA parcels, and the seaward edge of the forest in 1853. The map shows that most of the smaller *ahupua'a* formerly included a portion of the upland forest within the *ahupua'a* boundaries. Settlement and agriculture were focused in the seaward portions of the *ahupua'a*. The inland extension of the forest to its present location at the seaward boundary of the project area was primarily due to timber cutting and field expansion by the sugar companies during the late 1800s and early 1900s.

Historic use of the project area *ahupua'a* was dominated by sugar cane plantation agriculture beginning in the mid-1800s and continuing in some areas until the 1990s. The majority of plantation activity was situated seaward of the project area where fields where located. Plantation worker camps were scattered over the countryside connected by roads to the plantation villages at the sugar mills at Pāpa'ikou, Pepe'ekeō, Honomu, and Hakalau. Plantation-related activities that extended into the lower portion of the project area included construction of water distribution systems, timber harvesting for lumber and firewood, and temporary camps.

Oral historical research indicates that the project area was used for pig hunting since the 1800s and this use continues today. Other 1900s activities in the project area include gathering fern shoots and collecting freshwater shrimp and snails from the streams.

PROJECT EXPECTATIONS

Based on previous archaeological work and historical documentary research, expected traditional Hawaiian site types potentially include temporary habitations, trails, and shrines. Expected historic features include water diversion structures, flumes, ditches, temporary camps, and roads or trails. McEldowney's (1979) model also predicts the potential presence of minor traditional agricultural features; however, these would be expected in the lower portion of the Lower Forest Zone. As indicated in Figure 17, the seaward edge of the forest in the mid-1800s was at approximately 1,000 ft elevation. Sugar cane cultivation and timber harvesting subsequently removed the forest up to approximately 1,500 ft to 1,600 ft elevation. If there were minor agricultural features in this area, then the features were probably destroyed by the cultivation with the possible exception of features in drainages that were not cultivated.

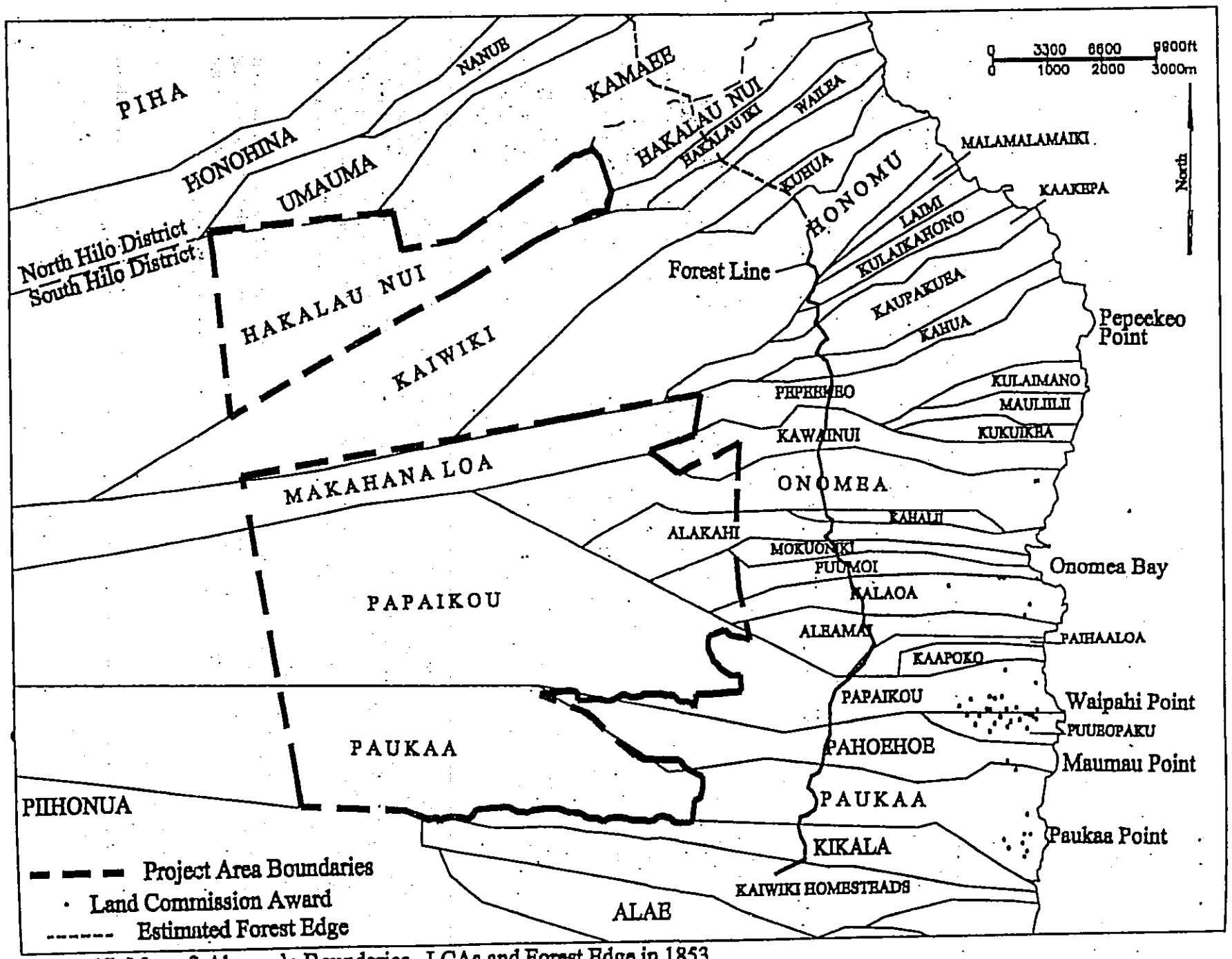

Figure 17. Map of Ahupua'a Boundaries, LCAs and Forest Edge in 1853

FINDINGS

The archaeological survey consisted of six *mauka-makai* transects (*Figure 18*). One site was identified during the survey, an historic water diversion dam (SIHP Site 22534) identified along Transect 4 in the southern project area parcel. The findings from each of the transects are discussed below.

Transect 1

Transect 1 was situated in the northern portion of the project area in the land of Hakalau Nui. This transect had an overall length of c. 1,975 m. It originated c. 120 m outside of the eastern project area boundary at c. 1,550 ft elevation in a grove of eucalyptus trees, south of Hakalau Stream. The transect extended up a narrow ridge to the west-southwest for c. 450 m through dense stands of strawberry guava and scattered eucalyptus and *koa* to approximately 1,500 ft elevation. A large swampy area was encountered at this point with vegetation consisting primarily of thick *uluhe* ferns, scattered *koa* trees, and *hapu'u* ferns. The transect angled through the swamp to the south for c. 350 m, turned to the west for c. 585 m, and exited the swamp at the c. 1,950 ft elevation. The transect extended an additional 470 m to the southwest, terminating at a dense thicket *uluhe* ferns. No archaeological sites were identified in Transect 1.

Transect 2

Transect 2 was a c. 3,745 m long transect situated in the southern project area parcel in the land of Makahanaloa. This transect was comprised of a main transect and two branch transects. Vegetation consisted of scattered eucalyptus, *koa*, and *ohia* trees with dense stands of *uluhe* and *hapu'u* ferns. The main transect originated outside of the eastern project area boundary at the end of a dirt road, at c. 1,600 ft elevation. It extended to the south for c. 90 m where it crossed Waia'ama Stream and continued on the south side of the stream for an additional 85 m. A pig hunter's trail was encountered at this point that extended to the west, roughly paralleling Waia'ama Stream. The main transect followed the pig hunter's trail with a branch transect (discussed below) continuing to the southwest. The main transect extended c. 820 m upslope along a narrow ridge top to the c. 1,800 ft elevation. The pig hunter's trail terminated at this point. The main transect continued to the west-northwest with the second branch transect extending to the west-southwest.

The main transect angled to the west-northwest for c. 580 m entering Waia'ama Stream at the c. 1,900 ft elevation. The transect extended upstream for c. 640 m, until an impassable waterfall was encountered at the c. 2,000 ft elevation. The transect exited the stream drainage at this point extending to the west-southwest for c. 235. The main portion of Transect 2 terminated at the c. 2,100 ft elevation at the edge of a dense stand of *uluhe*.

The first branch transect originated along the pig hunter's trail at the c. 1,700 ft elevation. This portion of Transect 2 was examined in an attempt to located an historic road situated along the southern boundary of Makahanaloa *ahupua`a*. The transect extended to the southwest from the main transect for c.175 m, crossing a small, unnamed drainage south of Waia'ama Stream. The transect then angled to the west for c. 645 m encountering the *ahupua`a* boundary at the 1,725 ft elevation. The area was carefully examined for any remnants of the road, but none were found. The first branch transect was terminated at this point.

The second branch transect originated at the c. 1,800 ft elevation, extending away from the main transect to the west-southwest for c. 235 m. The vegetation in this area was extremely thick, and numerous fallen logs were present. It angled to the northwest for c. 240 m and terminated in a dense stand of *uluhe* ferns at the c. 1,850 ft elevation. No archaeological sites were encountered on Transect 2.

Transect 3

Transect 3 was a c. 4,695 m long transect located in the southern project area parcel. It consisted of a main transect and two branch transects. The transect originated in the Land of Alakahi along the eastern project area boundary at the c. 1,600 ft elevation. It extended in a southwesterly direction for c. 1,550, roughly paralleling the southern banks of the Kawainui Stream. The old forest reserve boundary and current Conservation District boundary was crossed at approximately 1,900 ft elevation. A line of large euca-

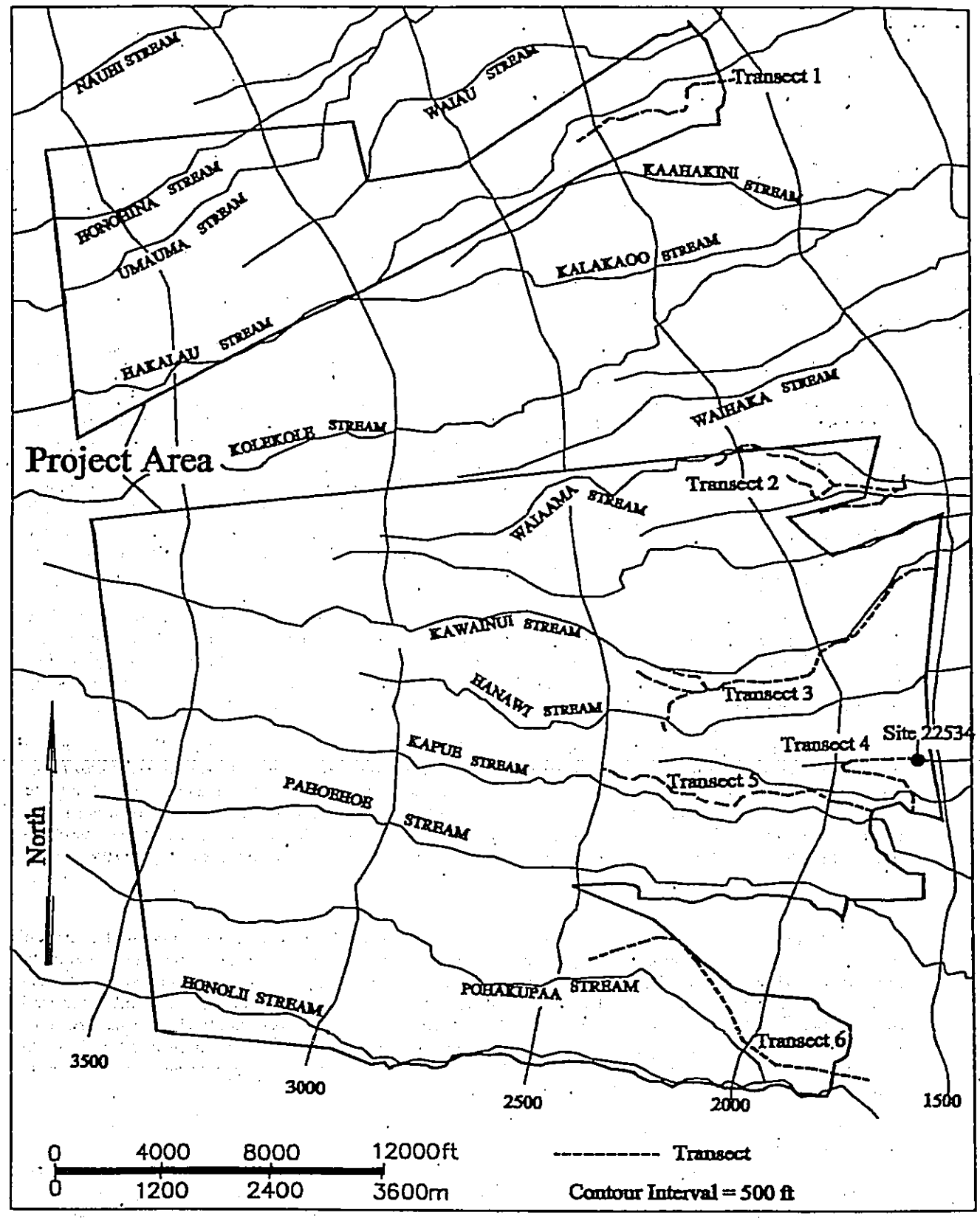

Figure 18. Project Area Map

lyptus trees follows the boundary line. At the c. 2,100 ft elevation, the transect entered the land of Papai'kou and angled to the south-southwest away from Kawainui Stream. The transect continued in this direction for c. 230 m and then angled to the west for an additional 1,050 m following sporadic pig trails. The first branch transect (discussed below) exited the main transect at the 2,250 ft elevation and the second branch trail began at 2,300 ft elevation. The main transect continued in a roughly westerly direction for c. 780 m terminating at the c. 2,400 ft elevation at a dense stand of *uluhe* ferns.

The first branch transect extended to the north-northwest away from the main transect a distance of c. 150 m where the transect entered Kawainui Stream and followed it upstream for c. 410 m where it terminated at waterfall surrounded by a dense *uluhe* fern thickets. The second branch transect followed a narrow pig trail extending to the southwest from the main transect for c. 205 m and then angled to south for an additional c. 320 m. This portion of the transect was terminated at an area of dense *uluhe* ferns at the c. 2,350 ft elevation. No archaeological sites were encountered on Transect 3.

Transect 4

Transect 4 was situated in the Land of Pāpa'ikou in the southern project area parcel. This sweep was undertaken to locate a flume in an unnamed drainage depicted on USGS maps of this area. Transect 4 had an overall length of c. 2,045 m. The transect originated at a barbed wire fence on the northern side of a pasture at c. 1,750 ft elevation. Vegetation in this area was comprised of extremely thick and intertwined strawberry guava. The transect extended to the north away from the fence for c. 205 m to a small, unnamed drainage. The transect angled to the west-northwest extending a distance of c. 820 m. At the c. 1,950 ft elevation, Transect 2 turned to the north for c. 60 m following a second, small unnamed stream drainage where the flume was supposed to be located. The flume was supposed to have been situated at the c. 1,700 ft elevation, so the sweep turned to the east, following the drainage. The drainage was densely vegetated with *uluhe* ferns. No evidence of the flume was found at the 1,700 ft elevation. The transect continued in a *makai* direction for c. 960 m exiting the project area at the c. 1,500 ft elevation.

A concrete dam (Site 22534) was encountered along the stream drainage near the eastern project area boundary (see *Figure 18*). Site 22534 consisted of a low concrete wall that extended across the stream in a east-northeast by west-southwest direction. The wall measures 9.7 m in length and 0.15 m in width. The top of the wall is level with water behind the dam. The wall is retained on the downstream side by mortared basalt boulders that range in size from 0.5 to 1.0 m in diameter (*Figures 19-21*).

There is an excavated earthen ditch located along the eastern side of the stream. Water diverted by the dam is entering the ditch. The ditch measures 0.75 m wide and 1.35 m deep. It extends to the east for c. 20 m and then angles to the north, paralleling the eastern project area boundary. There is a c. 0.4 m wide gap between the eastern end of the dam and the eastern bank of the stream. A small amount of water is bypassing the diversion ditch and continuing down the stream drainage. The nature and method of construction of this site suggests it was utilized historically to channel water away from the stream into the ditch.

Transect 5

Transect 5 was a c. 2,925 m long transect located in the southern project area parcel in the Land of Pāpa'ikou. The transect originated at a gate in a barbed wire fence along the eastern project area boundary at the c. 1,800 ft elevation. Transect 5 followed a well-marked pig hunter's trail that extended along a narrow ridge north of Kapue Stream and south of an unnamed drainage. Vegetation in this area was comprised of dense thickets of strawberry guava, scattered *koa* and *ohia* trees, and areas of thick *uluhe* ferns. The transect extended from the gate a distance of c. 2,925 m in a roughly westerly direction to the c. 2,500 ft elevation. It was terminated at this point which marked the end of the trail at the edge of an extremely dense stand of *uluhe* ferns. No archaeological sites were encountered.

Transect 6

Transect 6 was a 3,270 m long transect situated in the southern project area parcel. It originated outside of the survey area along the *mauka* side of a timber milling operation at c. 1,700 ft elevation. A network of recently bulldozed roads extends upslope from this point a distance of c. 410 m. These roads were followed to the eastern edge of the project area at the c. 1,800 ft elevation. A hunter's trail was en-

Figure 19. Site 22534, View to Northeast

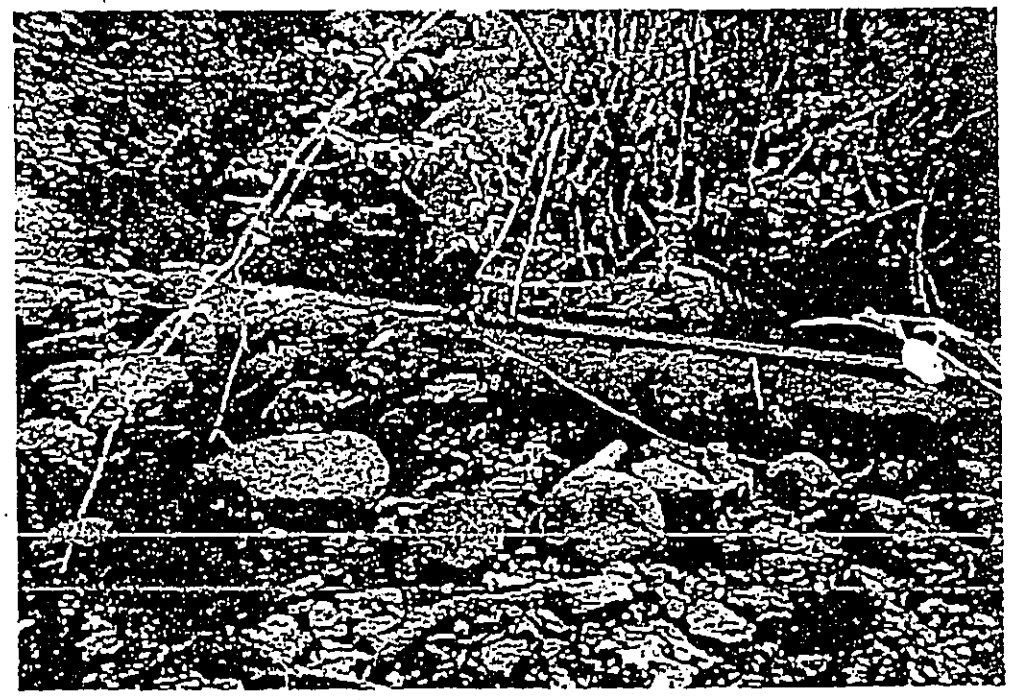

Figure 20. Site 22534, View to North

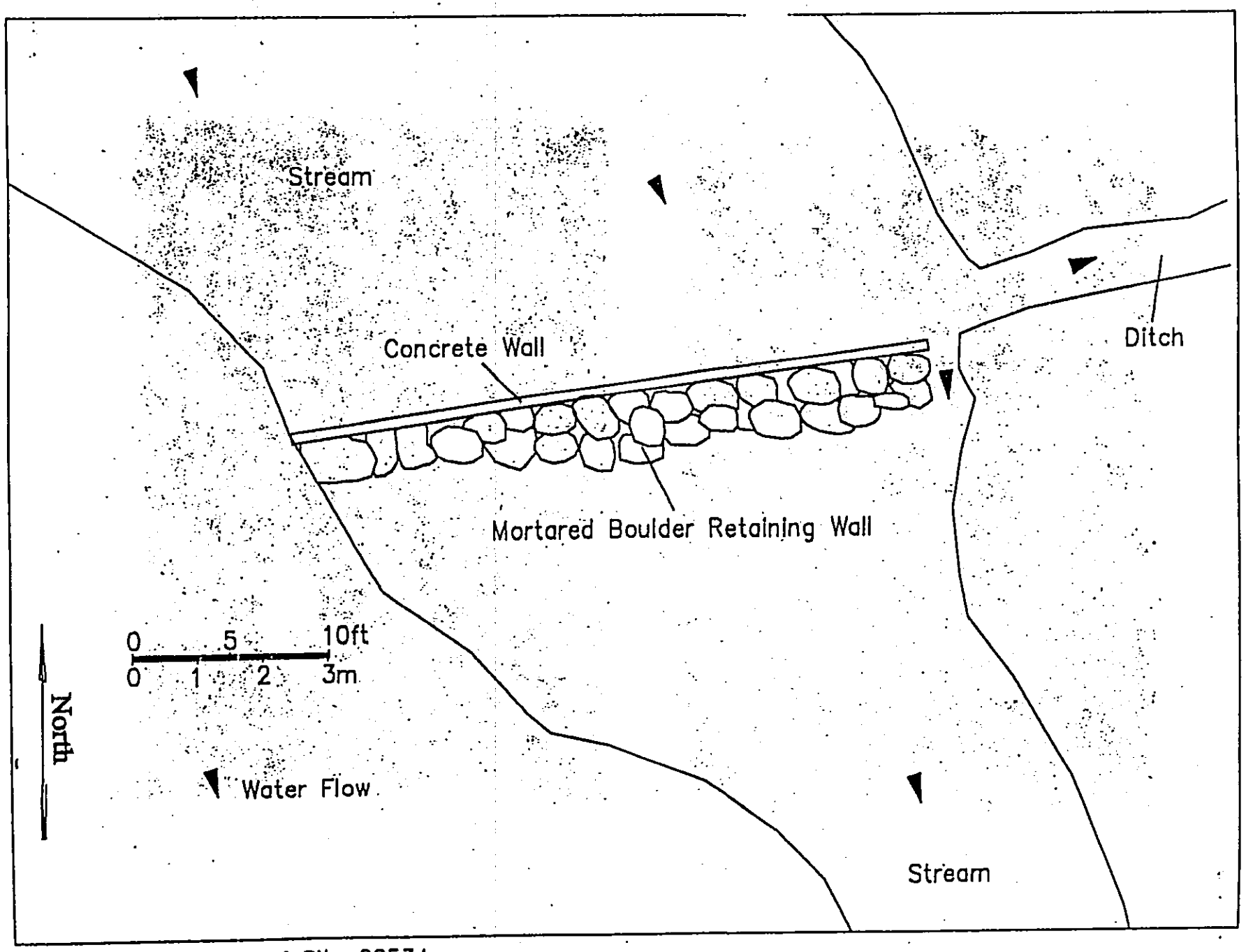

Figure 21. Plan Map of Site 22534

countered in this location that followed a narrow ridge top between Pohakupa'a Stream to the south and Pahoehoe Stream to the north. Transect 6 extended to the west c. 580 m and then angled to the north-northwest for c. 1,400 m. It then turned to the west-southwest for an additional c. 880 m terminating at the end of the trail in a dense thicket of *uluhe* ferns. Vegetation along Transect 6 was comprised predominately of strawberry guava, *koa* and *ohia* trees and *uluhe* ferns, with scattered eucalyptus trees near the *makai* end. No archaeological sites were encountered along Transect 6.

CONCLUSION

Discussion

The identified site, a water diversion structure and ditch (Site 22534), conforms to expected historic remains within the project area. No traditional Hawaiian sites were identified, but this is not unexpected because the area would have had a very low site density. Furthermore, archaeological evidence for such sites, primarily temporary camps and trails, would be minimal consisting of food remains and artifacts. Habitation structures were probably made entirely of perishable materials including wood and thatch because surface stones are rare. The combined factors of heavy rainfall, rapidly growing dense vegetation, and ground disturbance by pigs largely preclude the possibility of identifying such sites.

Historic records attest to the importance of the project area forests, which provided logs for canoes, feathers for chiefly regalia, and other valued plant resources. Cattle were hunted in the forest and above it. Trails and settlements for bird catchers and canoe builders are described in the records. Old *kauhale* and camps were formerly present along Wa'awa'a Stream in Hakalau Nui, Waia'ama Stream in Makahanaloa, and Kawainui and Pāhoehoe Streams in Pāpa'ikou and Pauka'a. Approximately one third of Pu'u Ka'uku, the most prominent hill in the area, lies within the project area. The hill was an important landmark. Trails and temporary settlements are described in the vicinity of the hill. Hudson (1932) reported that the hill was used for inter-district communication. A shrine on the south side of Waia'ama Stream was situated opposite Pu'u Ka'uku.

Historic documentary research conducted during the project provides a basis for modifying McEldowney's (1979) Hilo area land use and settlement pattern model for the region north of the Wailuku River. McEldowney's Coastal Settlement Zone extends approximately 0.5 miles inland between sea level and 50 ft elevation. Her Upland Agricultural Zone is between 50 ft and 1,500 ft elevation and the Lower Forest Zone ranges from 1,500 ft to 2,500 ft elevation.

Within Hilo District north of the Wailuku River, the Coastal Settlement Zone extended approximately one mile inland between sea level and 500 ft elevation based on the distribution of LCAs. The Upland Agricultural Zone extended from 500 ft to approximately 1,000 ft elevation where the Lower Forest Zone began based on the documented lower edge of the forest in 1853. McEldowney's inland limit of the Lower Forest Zone at 2,500 ft elevation appears to correspond well with the inland extent of most settlements named in the Boundary Commission testimonies.

The differences between the regions of Hilo District north and south of the Wailuku River are attributable to differences in topography, soils, and rainfall. North of the river the coastal sea cliffs average 100 ft in height and there is very little land below this elevation that was suitable for habitation or agriculture. The broad slopes above the cliffs are covered with a deep layer of soil and water sources are abundant permitting extensive use for residences and agriculture as observed by early western visitors. Zones of extremely high annual rainfall are reached a very short distance inland from the shoreline from the Wailuku River north to the Hilo District boundary. This rainfall pattern likely explains the lower seaward forest edge in the mid-1800s.

Significance Assessments and Recommended Treatments

Pursuant to DLNR-SHPD (1998) Chapter 275-6 (d), the initial significance assessments provided herein are not final until concurrence from the DLNR has been obtained. The site identified during the survey is assessed for significance based on the criteria outlined in the Rules Governing Procedures for Historic Preservation Review (DLNR-SHPD 1998:Chap 275). According to these rules, a site must possess integrity of location, design, setting, materials, workmanship, feeling, and association and shall meet one or more of the following criteria:

1. Criterion "a". Be associated with events that have made an important contribution to the broad patterns of our history;

2. Criterion "b". Be associated with the lives of persons important in our past;

3. Criterion "c". Embody the distinctive characteristics of a type, period, or method of construction; represent the work of a master; or possess high artistic value;

4. Criterion "d". Have yielded, or is likely to yield, information important for research on prehistory or history; and

5. Criterion "e". Have an important traditional cultural value to the native Hawaiian people or to another ethnic group of the state due to associations with traditional cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts—these associations being important to the group's history and cultural identity.

Based on the above criteria, Site 22534 is assessed as significant under DLNR-SHPD significance Criterion "d" and Criterion "c". The site has yielded information important for understanding historic land use. The site is a well-preserved example of plantation water system infrastructure probably dating to the late 1800s to early 1900s. The site is recommended for preservation. The specific plans for preservation of the site would be detailed in a Preservation Plan prepared for DLNR-SHPD review and approval.

Several portions of the project area retain the potential to contain prehistoric or historic cultural resources; however, such remains, except water diversion structures, probably would only be found during ground disturbing activity. These areas include Pu'u Ka'uku and the land within approximately 10 to 20 meters of the main streams. These areas should either be avoided for timber harvesting, or monitored by archaeologists during harvesting.

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Appendix H

Cultural Impact Assessment

Report 053-012801

CULTURAL IMPACT ASSESSMENT

TMK: 3-2-9-005:002, 3-2-8-001:002, AND 3-2-7-001:001

LANDS OF HAKALAU NUI, MAKAHANALOA, KAWAINUI, ONOMEA, ALAKAHI, PĀPA'IKOU, MOKU'ŌNIKI, PU'UMOI, KALAOA, 'ALEMAI, AND PAUKA'A

SOUTH HILO DISTRICT

ISLAND OF HAWAI'I

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CULTURAL IMPACT ASSESSMENT

TMK: 3-2-9-005:002, 3-2-8-001:002, AND 3-2-7-001:001

LANDS OF HAKALAU NUI, MAKAHANALOA, KAWAINUI, ONOMEA, ALAKAHI, PĀPA'IKOU, MOKU'ŌNIKI, PU'UMOI, KALAOA, 'ALEMAI, AND PAUKA'A

SOUTH HILO DISTRICT

ISLAND OF HAWAI'I

By:

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Prepared for:

Koa Timber, Inc.
c/o Mr. Roy Takemoto

January 2001

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SUMMARY

At the request of Mr. Roy Takemoto on behalf of Koa Timber Inc., Haun & Associates conducted a cultural impact assessment of TMK: 3-2-9-005:002, 3-2-8-001:002, and 3-2-7-001:001, a c. 16,267-acre area located in the Lands of Hakalau Nui, Makahanaloa, Onomea, Kawainui, Alakahi, ʻAlemai, Pāpaʻikou, Kalaoa, Puʻumoi, Mokuʻōniki, and Paukaʻa; South Hilo District; Island of Hawai'i. The objective of the assessment was to satisfy the cultural impact assessment guidelines of the Office of Environmental Quality Control (OEQC) Guidelines for Cultural Assessments and the Office of Hawaiian Affairs (OHA.

The study did not identify any traditional Hawaiian practices within the study area, although cultural practices were identified *makai* and outside of the area including *leinā* (jumping off point at Makahanaloa), Kāne stone, and *ʻaumakua* worship (feeding the sharks at Kahaliʻi). Today, the only people utilizing the project area are pig hunters who, along with hunting pig, occasionally gather fern shoots, fresh-water shrimp, *hīhīwai*, and prawns as an additional food resource. No one indicated they gathered these resources for cultural reasons or that they gathered them on a regular basis. The pig hunters all know each other and because they go out often, they know who uses the trails and the general area. None of them knew of anyone who accesses the area for cultural reasons.

Boundary Commission records from the 19th century indicate the project area was heavily used by Hawaiians for activities such as gathering *pulu*, *olonā*, and especially for bird hunting and canoe building. There would have been traditional cultural practices associated with these activities. None of these practices seem to have continued up to the present time in the project area. The lack of cultural practices is attributed to changes brought about by the sugar plantation industry that dominated agriculture and land use in the south Hilo District since the mid-19th century. The plantations encroached on and changed the lower forest boundary and provided Hawaiians with a non-traditional, cash-based way to subsist.

The forest undoubtedly contains a variety of plants that are used in Hawaiian cultural practices such as *ʻieʻie* used for weaving, *olonā* used for fishnets and capes, and *kukui* used for dying for fishnets and *tapa*. Such plants are associated with various native customs, practices, and beliefs. Although there is no evidence that native Hawaiians gathered plants from the area in recent history, if Hawaiian practioners come forth in the future, then access to the forest should be permitted for gathering related to cultural and religious practices.

Despite the lack of oral and documented references for Hawaiian traditions and practices, the study did document 20th century pig hunting practices, what hunters think about the forest environment, and the problems and issues they face as their hunting grounds seem to be shrinking because of concerns by the environmental community.

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INTRODUCTION

At the request of Koa Timber, Inc., Haun & Associates conducted a cultural impact assessment (CIA) of three parcels in TMK: 2-7-01:01, 2-8-01:02, 2-9-05:02, located in portions of the *ahupua'a* of Hakalau Nui, Makahanaloa, Onomea, Kawainui, Alakahi, 'Alemai, Pāpa'ikou, Kalaoa, Pu'umoi, Moku'ōniki, and Pauka'a; District of South Hilo, Island of Hawai'i (*Figure 1*). This report presents the results of the cultural impact assessment of the proposed Koa Timber Sustainable Forestry project.

This assessment is intended to be informational for the purpose of disclosing any cultural impacts the proposed development might have on native Hawaiian culture and to meet the cultural impact assessment requirements of the Office of Hawaiian Affairs (OHA) and the Office of Environmental and Quality Control (OEQC. The assessment aims to consider the effects the proposed sustainable forestry project may have on native Hawaiians as it pertains to their culture and their right to practice traditional customs and to utilize cultural resources within the study area.

The Hawai'i State Constitution, Article XII, Section 7 protects "all rights" of native Hawaiians that are customarily and traditionally exercised for subsistence, cultural and religious purposes". Most recently, H.B. No. 2895 was passed by the 20th Legislature, and approved by Governor Cayetano as Act 50 on April 26, 2000. The bill acknowledges

> "...the past failure to require native Hawaiian cultural impact assessments has resulted in the loss and destruction of many important cultural resources and has interfered with the exercise of native Hawaiian culture. The legislature further finds that due consideration of the the effects of human activities on native Hawaiian culture and the exercise thereof is necessary to ensure the continued existence, development, and exercise of native Hawaiian culture.

This bill mandates that "...environmental assessments or environmental impact statements should identify and address effects on Hawai'i's culture, and traditional and customary rights." This report will be included in the Environmental Assessment (EA) prepared by project planners.

Scope Of Work

Based on OEQC guidelines, the following specific tasks were determined to constitute an appropriate scope of work for the project:

1. Conduct background review and research of existing ethnographic, historical, anthropological, and sociological documentary literature relating to traditional cultural practices and resources in the project area and its immediate vicinity;

2. Identify and consult with individuals and organizations to identify knowledgeable individuals with expertise concerning the types of cultural resources, practices, and beliefs found in the vicinity of the project area;

3. Conduct formal ethnographic/oral historical interviews. All formal interviews were transcribed for inclusion in the CIA report. Interview transcripts were reviewed by the interviewees for accuracy and interviewee consent for transcript publication was be obtained subject to any requested constraints or limitations; and

4. Prepare and submit a CIA report in conformance with regulatory agency requirements for such reports. The CIA report includes: (a) a discussion of all methods and procedures used for data collection; (b) identification of identified cultural resources, practices, and beliefs within the vicinity of project area; (c) an assessment of the potential effects of the proposed project on any identified

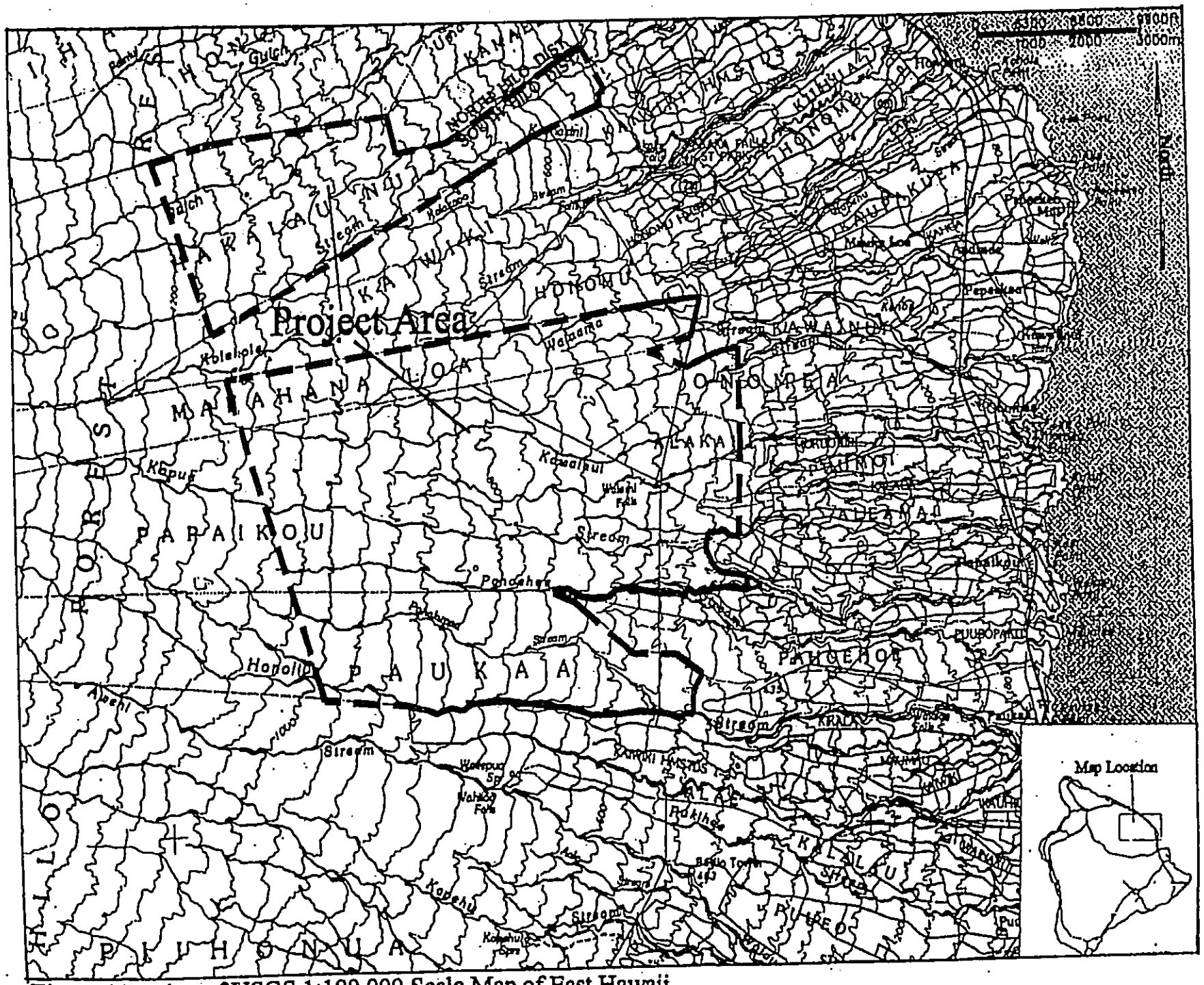

Figure 1 Portion of USGS 1:100,000 Scale Map of East Hawaii

resources, practices, and beliefs; and (d) recommendations for mitigating any potential adverse effects.

Project Background And Location

The project study area is located about ten miles north of Hilo above the towns of Pāpa'ikou, Pepe'ekeo, and Honomū between 1,400-3,600 ft elevation. The study area consists of three parcels (TMK: 2-7-01:01, 2-8-01:02, 2-9-05:02) totaling approximately 16,267 acres. The project site encompasses portions of the following *ahupua'a* in the South Hilo District, Island of Hawai'i: 'Aleamai, Pu'u Moi, Alakahi, Onomea, Pauka'a, Pāpa'ikou Makahanaloa, and Hakalau Nui, with the last four *ahupua'a* comprising the majority of the project site.

The project proposes to log *koa* trees (*Acacia koa*) in a sustainable manner while at the same time, maintain and preserve the surrounding forest habitat of plant, animal, bird, and water resources. Because most of the land is comprised of native forest, it is classified within the State Land Use Conservation District (CD) and a Conservation District Use Permit (Chapter 343 EA) is required. Much of the lands surrounding the project area comprise Hilo Forest Reserve and Hakalau Forest National Wildlife Refuge.

The project site is located on the windward side of the island on the eastern slopes of Mauna Kea. The topography of the study area is steep and dissected with dense vegetation of two principal types (a) Montane Wet Forest with a Montane Wet Sedgeland community at forest openings, and (b) Montane Rainforest. The dominant overstory composition is *koa-'ōhi'a* with scrub native trees subdominant and the dominant understory composition is native tree fern with native shrubs subdominant. At the lower forest boundary, the strawberry guava has invaded and replaced the sub-dominant understory and in some places it has replaced the subdominant overstory. If this problem remains unchecked, the invasion by an alien species will continue to pave the way for greater loss of the native forest.

Given its elevation (1,400 ft – 3,600 ft), the average annual rainfall is 196 - 236 inches. As a result, the soils and much of the terrain is constantly saturated creating pockets of muddy and boggy areas. The project area is a watershed for a twelve streams that bisect the project area.

Methodology

Historical documents, maps and reports were researched at the Hawai'i State Archives, Bernice Pauahi Bishop Museum, Hawai'i State Libraries, Hamilton Library and Map Collection at the University of Hawai'i at Mānoa, and the State Historic Preservation Division (SHPD) library. The Waihona 'Āina Database was utilized to extract Land Commission Awards and Boundary Commission records.

Hawaiian organizations, agencies, and community members were contacted in order to identify potentially knowledgeable individuals with cultural expertise and/or knowledge of the project area and the surrounding vicinity. Some of these organizations and agencies include the Office of Hawaiian Affairs, Alu Like, Inc., Hawaiian Civic Clubs, University of Hawai'i at Hilo - Hawaiian Studies Department, the Edith Kanaka'ole Foundation and Pig Hunters of Hawai'i (Hilo Club).

Based on communication with the above agencies and organizations, a joint, formal interview was conducted with two people from Pāpa'ikou who were familiar with the study area. The interview was taped and transcribed. Both informants had an opportunity to review the draft transcript and both informants willingly signed a written "Authorization for Release" form agreeing to release the interview for public record for historical documentation purposes. The informants also received an honorarium for their participation in the interview process. The interview transcript is included in its entirely and is appended to this report.

CUTURAL SETTING

Though geologically, Hawai'i is the youngest island, according to ancient Hawaiian chants, Hawai'i is the "*makahiapō*" or eldest child of Wākea Kahiko-Luamea (k) and Papahānaumoku (w) (Traditional Chant: *Mele a Pāku'i*). This is in reference to the fact that when sailing by canoe from the south, on approaching the island chain, Hawai'i is the first island to be seen.

The first settlers to Hawai'i were skilled voyagers, farmers and craftspeople that brought all the necessary knowledge and tools to begin re-establishing their culture in a new and unexplored environment. Settlement patterns for Hawai'i indicate early Hawaiian settlers tended to first inhabit the coastal areas and flat fertile lands nearby which could support fishing and agriculture (Kirch 1985:2). For this reason, much of the focus of Hawaiian archaeology has been on these coastal and near-coastal areas as opposed to the interior, upland regions.

However, as the culture evolved, the *kula* (open grasslands) and rugged interior forests were also utilized for acquisition of needed plant materials such as *olonā*, *mamaki*, *koa* and other native woods for canoes, weapons and tools, gathering herbs for medicine and hunting birds – both for food, as well as for feathers. As their religious beliefs dictated, cultural practitioners would have had upland sites and cultural features – *heiau* and/or small *kuahu* (altars) and *ko'a* (shrines), *lele* (sacrificial stand) and singular stones which may have been worshipped. Crafts people might have had storage caches here and there, or clues to evidence of human activity might still be present, i.e., tools, implements.

The Hawaiians' spiritual view of the world saw everything as animate and alive and something to be communicated with. They had a strong affinity to the physical and spiritual nature of their environment. They saw natural places as having *mana* because of the presence of the *akua* (gods). The plants and natural elements in nature were *kino lau* (physical manifestations) of the gods themselves. In this way, it was possible for the gods to reveal themselves to the people in the forms of clouds, rains, winds, plants and so on. Certain gods were prevalent in certain localities, which increased the *mana* of that place. For example, Pele's locality is Puna, Ka'u and Kona, while Kamapua'a's locality is Hilo, Hāmākua and Kohala (Pukui & Elbert 1965:386). Likewise, the Hawaiians considered the upland forest areas as having different stratums or environmental zones according to its uses.

Kuahiwi:	the summit and backbone of the mountain; sacred due to its elevation; sparse or no vegetation depending on elevation
Kualono:	the ridge and peaks that support the *kuahiwi*; the area near the mountain top; some vegetation
Kuamauna:	the rounded swell of the mountain; more vegetation than the *kualono*
Kuahea:	the area below the mountain side, and where the small trees grow; often a cold, misty zone
Wao nāhele:	the area where the larger trees and forest grow; the inland forest region
Waoma'ukele:	the rain belt and upland forest, and where the very large trees grow. The dominant canopy would be *koa* and *'ōhi'a*. Man only ventured into this area when a specific item was needed that could not be found at lower elevations. Going there was attended by much propitiation.
Wao akua:	the forest area below the *waoma'ukele* where the very large trees grow, and domain of the gods and spirits. This area would have more varieties of plant species than the *waoma'ukele*. Once again, going into this area would require sacrificial offerings and prayer.
Wao kanaka:	the inland area below the *wao akua* where people frequent and may occasionally live for temporary periods of time. This area would be heavily utilized to gather cultural resources such as *olonā* for cordage, birds for feathers, plant materials for medicines, dyes, leis; wood for tools, weapons, canoe accessories and the things one would need for everyday use.
Kula:	the grassy plains on slopes and open areas
Kahakai:	the seashore

The cultural zones within the project site are the *wao kanaka*, the *wao akua*, and the *waoma'ukele*.

Traditional Land Divisions

No one knows for sure when the system of dividing the islands into *moku* or major land units was first established. But, 'Umi a L'iloa is credited with starting this tradition. When 'Umi became king, he divided the island of Hawai'i into six major districts among the lesser chiefly lineages who help him in his rise to power.. His rationale for doing so was if they owed their political and social status to him they would remain loyal (Kame'eleihiwa 1992:53-54). When Kamehameha became king, he followed in the same tradition and kept the same divisions of Hilo, Hāmākua, Puna, Ka'ū, Kona and Kohala. The extent of the Hilo District is given in the *'ōlelo no'eau: Hilo, mai Mawae a ka pali o Maulua* (Hilo, from Mawae to Maulua Cliff) (Pukui 1983:O.N. #1004).

Within each major land unit (*moku*), further divisions were made: *ahupua'a*, *'ili*, *lele*, *mo'o*, and later, during the *Māhele*, *kuleana* or native tenant rights. The traditional understanding of *ahupua'a* is basically a pie-shaped piece of land extending from the ocean to the mountains. Ideally, each *ahupua'a* is self-sustaining and is comprised of all the major environmental zones. However, this was not necessarily the case and there was no hard fast rule that determined the size of an *ahupua'a*. Lands rich in resources might be portioned out in smaller pieces, while lands with lesser resources might be portioned out in larger pieces to make up for the lack of resources. *Figure* 2 shows how the present study area encompasses portions of eleven *ahupua'a* in the Hilo District. The figure also illustrates the shapes and size of the divisions.

Kamehameha consolidated the islands and the lands under one ruler. During, Liholiho's (Kamehameha II) rule, the larger lands were held by the chiefs and Liholiho received only what the chiefs were willing to give him (Kamakau 1961:256). This held true in the Hilo District until 1828 Boki, Governor of O'ahu, gave his lands to Kamehameha III, causing contention between the Hawai'i Island chiefs and Boki. Samuel Kamakau, the Hawaiian historian writes:

> They met a poor reception in Hilo, where the chiefs offered nothing more than cooked food. The custom of offering the King their lands was not followed. This prompted Boki to give the district of Hilo to the king to divide among his followers and thus uphold his dignity. When Ka'ahumanu and the other chiefs heard of Boki's actions, they suspected him of conspiracy. In response, they decreed that Boki and his wife Liliha were for their own debts, not to be a liability of the kingdom. (Kamakau 1961:284-285)

Kamehameha III then divided the lands of Hilo among the people (*Ibid.* 256).

Traditional And Legendary Associations

The District of Hilo was perhaps named after a famous Polynesian navigator and patron deity of navigation. Some also say he could control the winds by keeping them contained in his wind gourd (Gutmanis 1983:84, f.n. 204; Pukui & Elbert 1965:383). [Another tradition says that La'amaomao controlled the winds.]

There are several traditional proverbs that relate the Hilo District to physical characteristics of the land and the people. The common metaphor one usually associates with Hilo is rain and the red blossom of the lehua flower (O.N. #998, 1000, 1001). *Hilo palikū* refers to the tall cliffs that are always green because of the rain and mists (O.N. #1002). *Hilo, nahele paoa I ke 'ala* is a reference to the fragrance of the *hala* and the *lehua* which are abundant in the Hilo forest (O.N. #1005). There are several references to farming. *Hilo 'ai lū'au* refers to the storms that frequented Hilo, making it impossible to fish. The people were happy to eat the *lū'au* or taro greens they grew (O.N. #997). Hilo is also linked to the ancient chief Hanakahi who resided there (O.N. #999). From these, one can begin to develop an image of the Hilo District: the tall ocean cliffs, the mists, the heavy rains, the lush, green forests with *hala* and *lehua*.

The region of the project area is located in *Hilo Palikū*. The word *pali kū* (vertical cliff) also has a *kaona* or hidden reference to the priests of Lono who were also called the Order of Palikū (Malo 1951:159). Lono introduced farming techniques to the people and he is the patron of agriculture. He oversees the ac-

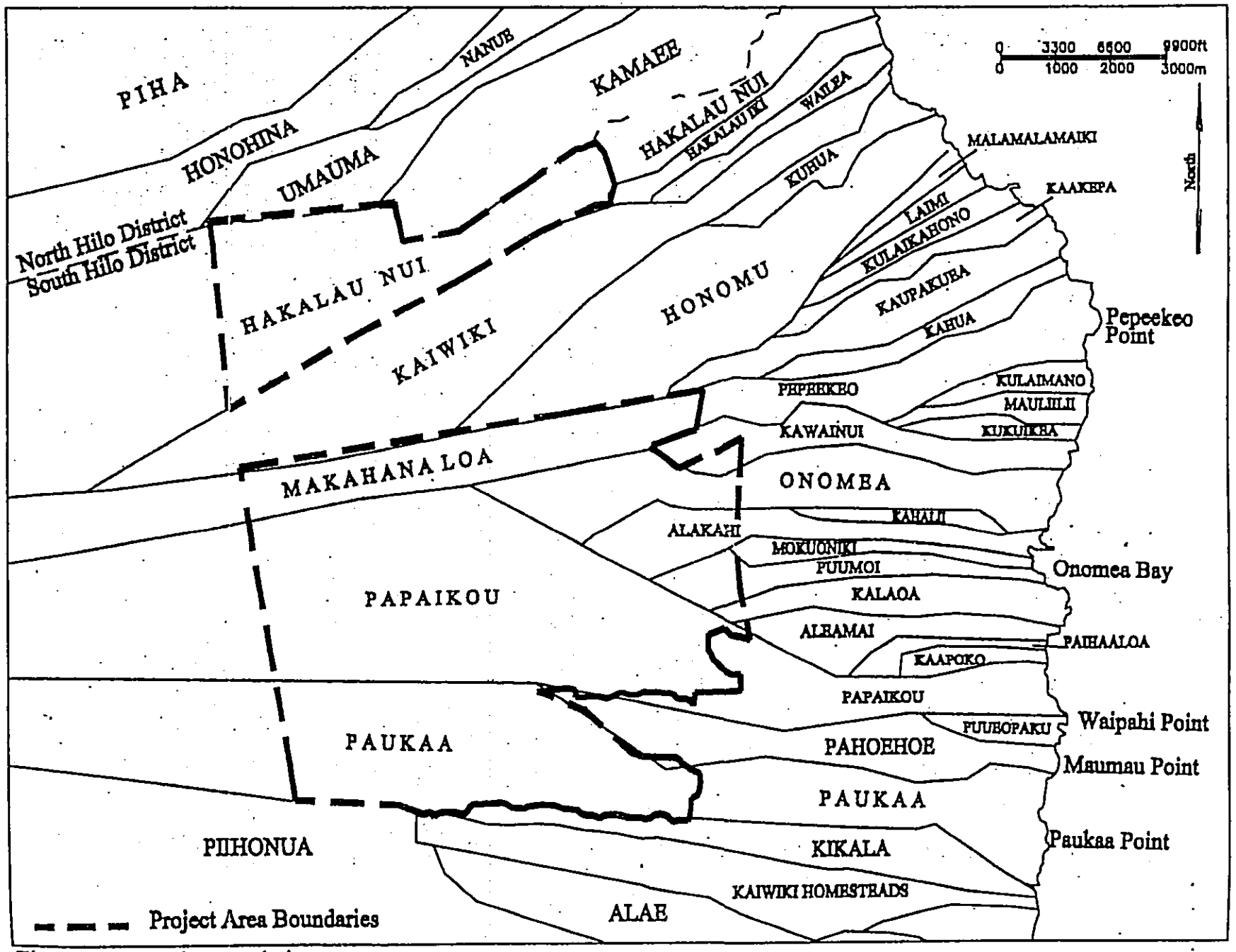

Figure 2. Ahupua'a Boundaries

tivities of the farmer, the fertility of the land, and his *kino lau* are the sweet potato, gourds, pigs, heavy rains and cloud forms (Gutmanis 1983:6). Lono is another dominant deity in the Hilo District. Stephen Desh wrote that Kamehameha I visited Hilo Palikū with Kekūhaupi'o, the famous warrior who taught Kamehameha the skills of *lua* and other fighting arts (Desha 2000:66).

The demi-god Kamapua'a is also another legendary association to Hilo. His rootings (*'eku*) created valleys and springs. His rival was Pele, the volcano goddess. He would tease Pele and entice her into a fiery rage. Then, he would use his many *kino lau* or plant forms to block her advances. Kamapua'a finally mates with Pele and claims Hilo as his territory. Some of Kamapua'a's plant forms are *kukui*, *'āma'uma'u*, *hala*, and *'uhaloa* (Pukui & Elbert 1965:386).

For an area so rich with flora and fauna, the South Hilo area north of the Wailuku River seems to be lacking in detailed and documented legendary associations in the form of *mo'olelo* or stories passed down from the ancestors. A study of Land Commission Awards during the *Māhele* indicates that coastal areas adjacent to the project area were indeed inhabited by native tenants. Throughout much of the project area, Boundary Commission records show even greater evidence of use of the forested areas by bird catchers and canoe makers. These crafts people would, no doubt, have had cultural traditions related to their highly specialized crafts and, therefore, traditions regarding legendary gods, people, sites and customs. However, the historical documentation that has survived has few and scant mentions of legends associated to the actual project area or mention of any sites in the project area.

The area of Pauka'a is mentioned briefly in Stephen Desha's retelling of the story of Keōuakū'ahu'ula (Keōua), chief of Ka'ū and Keawemauhili, chief of Hilo. The two chiefs fought against each other in a battle on the Hāmākua side of Hilo, somewhere between Wainaku and Pauka'a. During the battle, Keawemauhil met an unfortunate accidental death when, he was struck with a spear by his own warrior, Mo'o. Keōua got news of his rival's death while he was encamped a short distance away at Pauka'a. The story goes that Keōua quickly ran to the battlefield to claim Keawemauhili's body and to offer it up on the sacrificial *lele* at the *heiau*. Keōua's plans were circumvented by Keawemauhili's mother, who refused to turn over her son's body. She reasoned, "...do you not know that I am a sacred *ali'i*, and also this one here [referring to body of Keawemauhili] is within the *kapu* stakes, so that you are absolutely not able to seize the *kapu* body of my son who is of the highest *ali'i* blood." Meanwhile, Keawemauhili's chiefs were waiting outside to kill Keōua upon his exit. Keōua escaped death on that day only because Keawemauhili's mother gave him the feather helmet of Kalaninui'īamamao (Keawemauhili's father). Upon leaving the house with the helmet in hand, the other chiefs recognized the helmet of their *haku ali'i* (beloved chief) and Keōua was allowed to pass unharmed (Desha 2000: 269-271).

Hi'iaka and Wahine'ōma'o removed their clothes and held them above their heads as they swam across Honoli'i stream, the southern border for Pauka'a (Emerson 1915:60). Pauka'a is, once again, briefly mentioned in relation to the battle of Pahikaua, where certain chiefs plotted to kill Ka'ahumanu. Ka'eo, husband of Kanaukapu, was one the chiefs who instigated the war and the story relates that he had recently died at Pauka'a in Hilo (Kamakau 1961:301).

South Hilo has several traditional surfing spots, one of which is at Pāpa'ikou. It is described as, "a surf that rolls toward the mouth of the stream" ('Ī'i 1959:134). The name of the surf and any other specific details about it are not known.

Menehune were credited with building large fish ponds and *heiau* overnight. Though vague, there is a *menehune* tradition associated with Pepe'ekeo. A chief commanded his people to gather stones from the Pepe'ekeo area to build a *heiau*. When arriving at the site to continue their work, they were surprised to find the *heiau* was built overnight (Thrum 1907:117). John Stokes did a study on *Heiau of the Island of Hawai'i*, which was based on Thomas Thrums' work (1991:154-157). In his study, he documented only 12 *heiau* in the Hilo District and there is no mention of a *heiau* in Pepe'ekeo.

Traditional legends related to Onomea focus along the coast and the nearby village of Kahali'i. The "Twin Rocks" in the sea at the head of Onomea Bay were said to be two young lovers who gave their lives to stand guard and save the village from attacks by sea (Clark 1985:10). The ledge at Onomea Arch, which collapsed in 1956, was formed by the volcano goddess, Pele, when she became enraged by her rival Poli'ahu while *hōlua* sledding on a "sloping hillside south of Hāmākua" (Westervelt 1916:60-63). The

story of the "Living Waters of Kūkilu" explains why Kūkilu Stream, in Onomea Bay, never runs dry. Two Kahali'i residents who once showed kindness to a stranger were given specific instructions to carry out after his death. They were told to go up into the mountains and look for the head water of Kūkilu Stream. There, they were to tap the ground three times and return *mākai* to where the stranger's body was laid to rest near the shore. At this spot where the body lay, the couple was to tap the ground three more times. The stranger promised the couple they would never have to travel far to look for food and water and there would always be enough to share with others. The stream still flows to the sea today (Clark 1985:11).

The Hawaiian village of Kahali'i was also located near Onomea Bay, on a piece of land that juts out between Sharks Cove and Alakahi Bay. In the water close by, a *Kāne* stone is said to lie, where it was placed by the god Kāne (Kinney 1913:27). Luika Waiki Perreira was born at Kahali'i. Her grandparents told her, that during their time (turn of the century), about several hundred people still lived in the village. In earlier times, the village consisted of nearly a thousand people. Luika's father was the legendary Lono Waiki, whom many people in the south Hilo area know of because of his reputation for feeding the sharks at Sharks Cove. Her family was the last inhabitants of the village in 1957 when they moved out of the valley. Another interesting tidbit Luika related was that during the overthrow of Lili'uokalani (1893), some of her retainers came to Onomea to seek refuge, living in the area by the falls. Around mid-day people in the area would drop off *pū'olo* (bundles of food) for the Queen's retainers (Pers. Comm., 1995).

The cape of Makahanaloa is merely mentioned as a place name in a chant that references the coast and area between Leleiwi (in Keaukaha) and Makahanaloa (Emerson 1965:60-61). A famous warrior who fought for Kamehameha came from Makahanaloa. His name was Puniawa. He was skilled at hurling spears and he was the general of the Huelokū regiment (Desha 2000:66-68). In the epic story of Lā'ieikawai, 'Aiwohikupua landed at Makahanaloa and spent the night there. From Makahanaloa, the legendary paradise of Paliuli, in the Puna District, was seen (Kalākaua 1990:461). Though further details are not givin, it is likely that 'Aiwohikupua and his party spent the night near the landing place, as they sailed for Kea'au the next day.

In the story of Kekūhaupi'o, a tale is related of a battle at Hakalau between Kamehameha and Kahekili's warriors. While in training for war, Kamehameha and his warriors left Kohola and sailed to Hakalau. Stephen Desha writes:

> They sailed easily to land at Hakalau where Kamehameha and Kekūhaupi'o and their people were entertained by Chiefess Keakealani of Hilo; Princess Likoa; and Kahipa, the daughter of Chief Kānekoa of Hāmākua. She was living at Hakalau with her female *hoahānau* in those days. This visis by High Chief Kamehameha was a cause for joyous entertainment by these high chiefesses of Hilo and Hāmākua. The *ali'i 'ai kalana* of the Hilo districts in those days was Keawemauhili, a very high-ranking chief under the *mō'ī* Kalani'ōpu'u, the *ali'i 'ai moku*. Keawemauhili's status was held under his wife Ululani [Ululani-a-Moku] who possessed the *naha kapu*. She was the mother of Keaweokahikona and Kapi'olani.
>
> When Kamehameha arrived with his people at Hakalau, Kahāhāwai was staying in the upland forest of Hakalau, making a canoe for his lord, Kahekili of Maui. With him at that time was Kaihe, the "black [tattoo] of Kahekili," one of Kahekili's very great favorites, who was a famous warrior amongs Kahekili's men.
>
> The reason for the presence of this army of Kahekili in the upland forest of Hilo was the request by Kahekili to Keawemauhili, the Hilo chief, for permission for some of his people to sail to Hilo to make a canoe for him. The request was made at the time of the accords to end the war between Kalani'ōpu'u and Kahekili on Maui. It was a good time in the minds of both parties so Keawemauhili gave permission to this request by his high-born *hoahānau* of Maui. (Desha 2000:67)

The story goes on to relate that when Kahāhāwai heard Kamehameha and his warriors were at Hakalau, he became suspicious, thinking they might attack him in the forest, so he sent one of his men to spy on Kamehameha.. When Kamehameha heard rumors of a possible attack from the Maui warriors, he readied his Hunalele regiment, led by Kalawa of Kohala. The story continues:

> At this time also the Huelokū were readied. They were very skillful at hurling spears and at seizing them and they were led by Puniawa, a famous warrior of Makahanaloa, close to Hakalau...
>
> When those Maui warriors emerged from the *'ama'uma'u* ferns they were startled to meet the Hawai'i warriors. The stones from the slings of the Hunalele struck some of them, so that their bodies were left in the foreign land...
>
> Kamehameha's army was very skilled at hurling spears and in warding off or seizing the spears of the enemy They fought like hyenas, uttering their battle calls, and trampled the Maui people...
>
> ...It was said that this battle in the vicinity of Hakalau showed the strength of Kamehameha, which so terrified the Maui people, that they fell back, behind that "black" Kaihe.
>
> ...After the Maui people had fled into the forest of the Hilo districts, Kamehameha's people returned, and he conferred with his chiefs... (*Ibid.*:69-72.)

Kaihe was killed by Kekūhaupi'o in this battle. The story is interesting for several reasons. High-ranking chiefs resided at Hakalau. The fact that Maui people came here to make canoes implies it must have been an area reputed to have very large, tall *koa* trees to make the best canoes – especially a canoe fit for a high-ranking *ali'i* like Kahekili. It is not clear whether the bodies of the slain Maui warriors were later taken back to Maui or whether their bones were left to be exposed in the sun at Hakalau. The exact location of the battle is not known.

After the battle of Koapāpa'a in Hāmākua, Kamehameha sent one of his runners, Makoa, to spy on Keōua's fleeing troops. Upon Makoa's return that evening, he relates to Kamehameha that he has just returned from Hakalau where, "The *lama* [torches] are crowded from the *maulukua* (the upland forest) to the sea cliff" (*Ibid.* 283). This reply was in reference to the numbers of Keōua's army.

Previous Archaeological Research

A search of DLNR-HPD the archaeological report database and other sources identified 19 archaeological projects in North and South Hilo Districts between the Wailuku River and Humuula Ahupua'a. *Figure 3* shows the project locations and *Table 1* summarizes the projects. Not included in the figure or table are the studies by Stokes (Stokes and Dye 1991), which focused on major sites, primarily *heiau* throughout Hawaii Island, a survey of east Hawaii by Hudson (1932), and the general, primarily archival, study of McEldowney (1979). Two studies by Rosendahl (1990) and Carter (1990) were not available for review. Both studies were surveys of small areas in the upper portion of the Hakalau Forest NWR and the surveys did not locate any sites (Tomonari-Tuggle (1996). None of the previous studies included the current project area.

Stokes (Stokes and Dye 1991), relying primarily on the earlier observations of Thrum, listed seven *heiau* for the area; however, all except one were destroyed at the time of Stokes fieldwork in 1906. Mamala or Ha'akoa Heiau overlooking Laupahoehoe village was the only intact site at the time of Stokes' survey. The destroyed *heiau* consist of Kinailoa and Kanoa in Pu'ueo Ahupua'a, Kahinihini'ula Heiau in Punahoa, Kiniakua Heiau near Waikapu Spring, and four *heiau* (Moeapuhi, Kama'o, Lonopuha, and Papauleki'I) at Laupahoehoe. Kanoa Heiau was reported to be for human sacrifice. Kahinihini'ula and Kiniakua Heiau were reported to be small agricultural *heiau*.

Hudson (1932) relocated Ha'akoa Heiau finding it in fairly good condition. At Laupahoehoe Point, he identified the possible remains of Lonopuha Heiau and Papauleki'i Heiau, which Stokes reported as destroyed. Hudson identified taro terraces in Maulua Gulch and three platforms on the coast at Maulua Bay. Informants told Hudson that Kauku Hill in Makahanaloa was used as a signal station. The signals were sent at night with torches between Ka'uku and the summit of a hill above Green Lake near Kapoho in

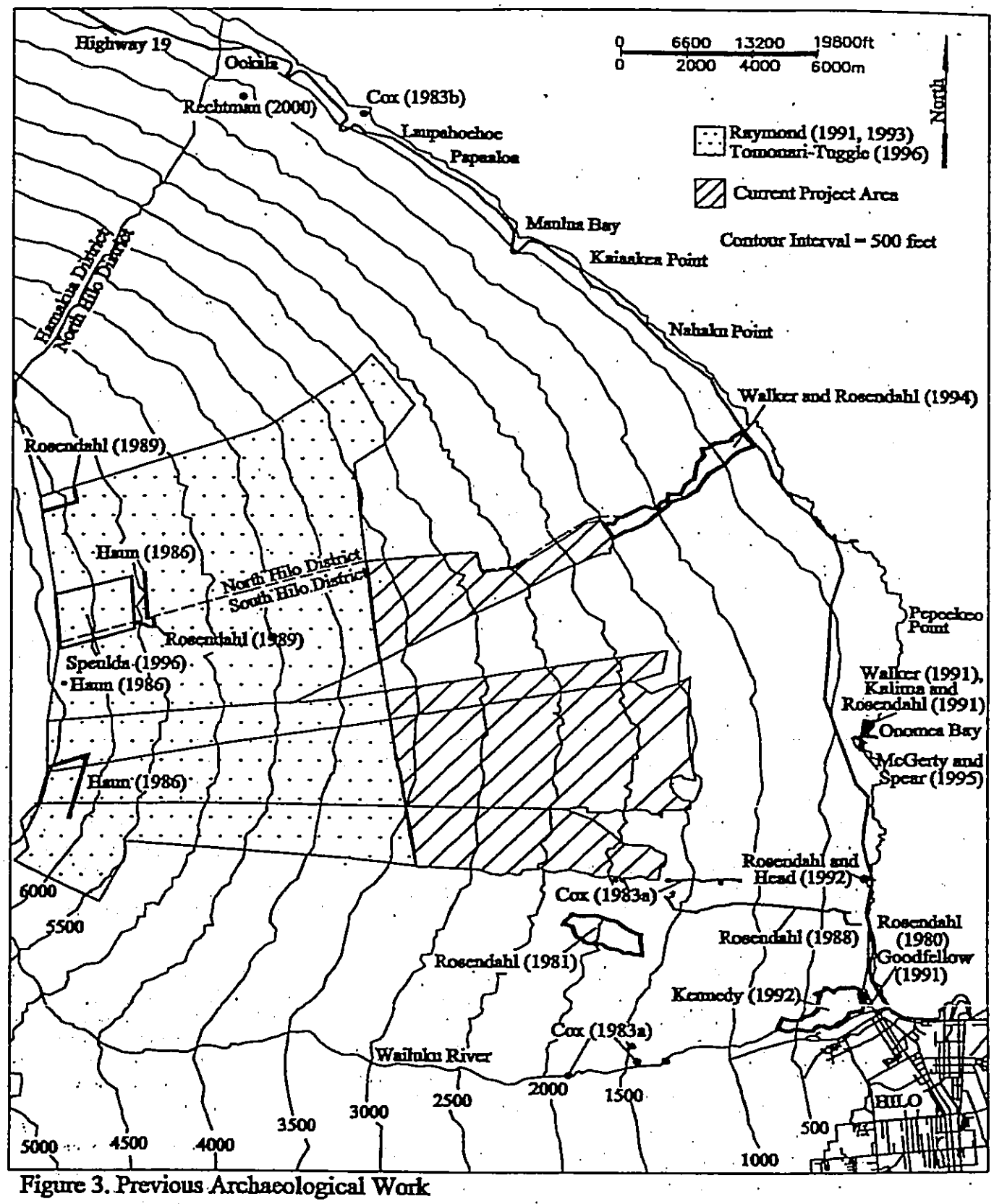

Figure 3. Previous Archaeological Work

Table 1. Summary of Previous Archaeological Work

Author	Date	Land	Study Type*	Elevation	Area (acres)	Historic Use	No of sites	No of Feas	Hab Feas	Ag Feas	Burial Feas	Cattle wall	Rock art	Historic fea
Cox	1983b	Laupahoehoe	RN	0-50	10	Landing area	1	1						
Walker/ Kallma and Rosendahl	1991, 1991	Onomea	FI/HR	0-220	40	Botanical garden	0							
McGerty and Spear	1995	Onomea	IN	0-220	17	Botanical garden	0							
Rosendahl/ Goodfellow	1980/ 1991	Puueo	RN/IN	10-50	1.73	?	3	8	5					3
Rosendahl, M.	1988	Kikala and Puakea	RN	100-1530	5.5	Sugarcane	3	6				1		5
Rosendahl and Head	1992	Paukea	FI	100-200	25	Sugarcane	0							
Kennedy	1992	Puueo	IN	131-918	482	Sugarcane	1	1			1			
Walker and Rosendahl	1994	Hakalau Nui	IN	200-1500	595	Sugarcane, Eucalyptus	0							
Rechtman	2000	Humuula	IN	1080	0.02	Sugarcane	0							
Cox	1983a	Various	RN	1200-1400	5	Sugarcane	0							
Rosendahl, P.	1981	Puueo	RN	1600-2200	300	?	0							
Raymond/ Tomonari-Tuggle	1991, 1993, 1996	Maulua Nui, Piha, Honohina, Hakalau Nui, Makahanaloa, Papaikou, Paukea	IN/RN	2500-6500	33000	Ranching	9	12					1	11
Rosendahl	1989	Hakalau Nui, Maulua	IN	5460-6160	0.8	Ranching	0							
Speakis	1996	Honohina, Piia, Maulua	IN	5500-6500	1005	Pasture	4	4				1		3
Haun	1988	Honohina, Hakalau Nui, Makahana Loa, Papaikou, Paukea	RN	5817-6845	2.5	Ranching	0							
				Total	35479.6		20	31	5	0	1	2	1	22

* RN=Reconnaissance Survey, FI=Field Inspection, HR=Historic Documentary Research, IN=Inventory Survey

Puna. The informants said there were holes in the ground to hold the torches, but Hudson did not find them. Other informants reported burial caves at two locations along the sea cliffs in Hilo District.

The surveys in *Table 2* cover nearly 37,000 acres between sea level and 6,845 ft elevation; however, much of the area was not subjected to 100% pedestrian coverage. The surveys identified 20 sites with 31 features. The only traditional Hawaiian sites are five hearths excavated by Goodfellow (1991) and a possible burial platform identified by Kennedy (1992), all on the north bank of the Wailuku River. The only radiocarbon dates from the area are reported by Goodfellow (1991). The dates from subsurface hearths range from the 1400s to 1600s with one date post-dating the mid-1600s.

The absence of traditional sites is attributed to the massive ground disturbance of sugar cane cultivation and pasture development. Historic remains identified by the surveys consist of 18 sites with 26 features. The historic features primarily consist of surveyor's boundary markers, petroglyphs, cattle walls, habitations, and roads.

McEldowney (1979) used site inventory and historic documentary evidence to develop a land use and settlement pattern model for the Hilo area that is probably applicable to the project area. The model consists of five elevationally-defined zones: Coastal Settlement, Upland Agricultural, Lower Forest, Rainforest, and Sub-Alpine or Montane. The Coastal Settlement Zone extended approximately 0.5 miles inland from the shoreline between sea level and 50 ft elevation. The zone was the most densely populated with both permanent and temporary habitations, high status chiefly residences, and *heiau*. Settlements were concentrated at Hilo Bay and sheltered bays and coves. Also present were where breadfruit, coconut, *kukui*, banana, *wauke*, sugar cane, sweet potato, and wet and dryland taro were cultivated. The ocean provided fish and other marine resources.

The Upland Agricultural Zone was situated between approximately 50 ft and 1,500 ft elevation. Settlement in the zone consisted of scattered residences among economically beneficial trees and agricultural plots of dryland taro and bananas. Lava tubes were utilized for shelter. A pattern of shifting cultivation is believed to have converted the original forest cover to parkland of grass and scatters groves of trees. Wetland cultivation of taro occurred along streams.

The Lower Forest Zone ranged from 1,500 ft to 2,500 ft elevation. Timber and other forest resources such as medicinal plants, *olona*, and birds were gathered from the zone. Site types consisted of temporary habitations, trials, shrines, and minor agricultural features in forest clearings and along streams. Sites in the Rainforest Zone (2,500-5,000 ft elevation) and Subalpine or Montane Zone (5,000-9,000 ft) were limited to trails and associated temporary habitations. These zones were used for intra-island travel and gathering of valued resources including hardwoods, birds, and stone for tool making.

Boundary Commission Records

Boundary Commission (BC) records dating to the late 1870s and 1880s (Waihona 'Aina 2000a) include testimony from native Hawaiians who were intimately familiar with the land. Most were elderly residents, or *kama'aina*, who visited the upland forests in search of birds, logs for canoes, and other forest resources. Much of the information was passed down from the individual's parents who lived in the late 1700s to early 1800s. The names of two testifiers, Kalama and Kuhipono, are the same as two individuals who were awarded *kuleana* parcels in the 1840s in Pauka'a and Pāpai'kou, respectively (see below). The accounts include references to old place names and activities in the project area.

Figure 4 depicts places named in the testimonies that are within or immediately adjacent to the project area. Frequently the testimonies are conflicting and inconsistent. Underlined place names are approximate, "best guess" locations. In two cases, the testimonies are conflicting and give more than one possible location for Kumu'ōhi'a (2 locations) and Nahuina (5) in Makahanaloa, Onomea, Pāpai'kou, and Alakahi. The boundary commission testimony for Pahoehoe indicates that Pahoehoe once extended further inland to a place called 'Aipala near a small hill called Pu'u Ana on Pauka'a. The upper portion of the *ahupua'a* was bounded by Pahoehoe Stream and Pāpai'kou to the north, and Pōhakupa'a Stream and Puaka'a to the south (BC 179 and 181). Despite the testimony, the Boundary Commission placed the inland bound

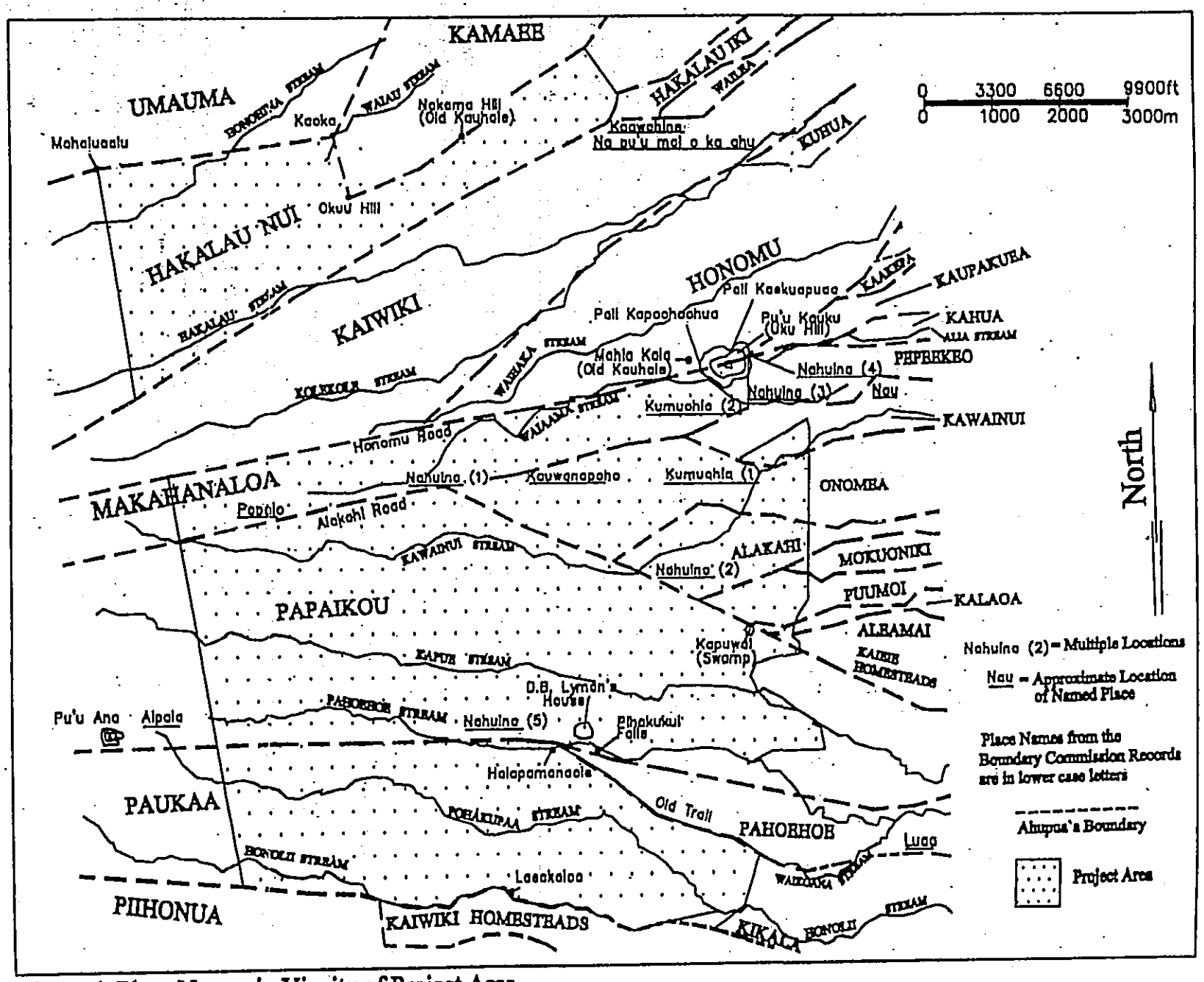

Figure 4. Place Names in Vicnity of Project Area

ary as shown on *Figure 4* because the boundaries of the adjacent lands had already been fixed by earlier surveys.

The following summarizes Boundary Commission (BC) records including testimony given between 1872 and 1882 that pertains to the project area. The summary is subdivided by *ahupua'a* listing the Boundary Commission Certificate Number and *ahupua'a* acreage. The testimony summaries include the testifiers name, year testimony was given, the testifier's connection with the land, and the BC citation. The sex of the witness is indicated by a (k) *kāne* for males and (w) *wahine* for females.

Kaiwiki and Wailea Ahupua'a-Certificate 140-no acreage given

Kalaeoo (k)-1882-States he is a *kama 'āina* of Wailea. (Vol. B, p. 456)
He heard that Kawahine (also, Kaʏawahine) is the area where Kaʏahakini Stream ends and where Hakalau Nui meets Wailea and Hakalau Iki ends. Not far above Wailea, Kaiwiki joins Hakalau Nui and they run adjacent to each other for a long distance. Haole (w), a widow who resides in Wailea, had a husband who was a canoe maker.

Pakele (k)-1882-Born and lived in Honomu (Vol. B, p. 457)
Describes living in forest above 'Akaka Falls at Kaholoina and gathering *pulu*. Inland was 'Ula'ula Hale where canoes were made. Further inland was a canoe makers' settlement called Pukaonua. Also describes bird catching with his parents in Kaiwiki and Honomū.

Puaa (k)-1882-80 year old *kama 'āina* of Kuhua, Kaiwiki and Wailea (Vol. B, pp. 457-458)
When young, he caught birds and made canoes on the above lands. Formerly lived at a village called Halekoloa along Kolekole Stream somewhere below Akaka Falls. Describes bird catching and At Māhoe, inland from the point where Kuhua is cut off by Honomu and Kaiwik, are big koa trees used for canoes. Mentions that once he went up on the mountain on Honohina to get hides; came down through "Puwai" (Pu'uwai Hill), where there was a big *koa* tree. He was told this is where Hakalau and Makahanaloa meet.

Kahau (k)-1882-born on Hakalau and raised on Kaiwiki (Vol. B, pp. 458-459)
He accompanied Brown during the survey of the Hakalau and Kaiwiki forests. Reports catching birds in forests of Kaiwiki. At Ki'ikapapa, Kaiwiki meets with Hakalau Nui and Wailea ends. Kaumuhāpu'u is the point where Hakalau joins Makahanaloa and Kolekole Gulch is the boundary at a waterfall.

Onomea-Certificate 175-2,579 acres-No native testimony given

Pu'umoi-Certificate 169-847.3 acres-No native testimony given

Pāhoehoe-Certificate 179 (replaced Cert. 37)-1,385 acres

Kanaeholo (k)-1874-*kama 'āina* of Pāhoehoe (Volume B, pp. 182-183)
States he was born at Hilo Palikū and moved to Pāhoehoe when he was young. Describes a place called Lua'a above the place ("Poapuaa") where the Pauka'a and Pāhoehoe roads meet. Lua'a is described as the "last of the old *kūlana kauhale* (village or settlement) on Pāhoehoe. 'Aipala is *makai* of Pu'u Ana ("the hill on Pauka'a) at the place where Pāhoehoe is cut off by Pauka'a and Pāpa'ikou. Describes catching birds and gathering *olonā* when he was very young. The boundary goes along the old road at Lua'a and ascends to "Waika ana", a water head, and runs up the ridge to Puaike Gulch, where it crosses the gulch and continues up the old trail to Ka'lā'auhaka and crosses Kupamanoa Gulch to Nahuina where the trail meets and goes on to Kaholoina, Pihakunui, Pihakuiki, to Paina'ole to Wahinehoano, to 'Aipala *mauka*. From the sea to 'Aipala, a pāhoehoe gulch is the boundary for Pāhoehoe on the Hāmākua side.

Kamakamai (k)-1874-*kama'āina* of Pāhoehoe (Volume B, p.183-184)

States he was born in Kona during the time of Kuiakawai and moved to Pāhoehoe at a very young age. Reports that he used to get canoes from the interior portion of Pāhoehoe as far *mauka* as Pihaku and Paiuaole.

Commissioner Rufus A. Lyman-1899-Boundary description (Vol. C, No.4, pp. 120-123)

Ancient trail mentioned along the interior northern boundary of Pāhoehoe. The trail crossed Pāhoehoe Stream above Pihakukui Falls. [Several discrepancies throughout as to the correct name of the falls, "a well-known point" where the ancient trail runs between Pāhoehoe and Pauka'a and crosses over the sream into Pāpa'ikou. Several spellings are given: Pihakukui, Pihakuiki, Piihakunui, Pihakunui.]

Pāpa'ikou-Certificate 165 (replaced Cert. 39)-14,000 acres

Kapae (k)-1874-born at Hilo Palikū. (Vol. B, pp. 155-56)

States when he first came to Pāpa'ikou as *konohiki*, Henry Lyman surveyed the boundaries. Kukui is at the place where Kapoko ends. At this point, the boundary leaves the ravine (*"awaawa"*) and goes toward Makahanaloa to Ka'ie'ie Gulch.

Pu'uhaula (k)-1874-born 1804 in Kona at the time of Peleleu and *kama'aina* of Pāpa'ikou (Vol. B, pp. 156-157)

Canoe makers told him the boundaries of P āpa'ikou. He describes a place he went to with Henry Lyman while surveying called Nahuina at the inland end of 'Aleamai where Alakahi joins Pāpa'ikou. Canoe makers also knew where Nahuina was located. Reports that bird catchers used to go into the upland forest. The old water head for Pāpa'ikou Mill is called Waiakalae, on the 'Aleamai Stream. The old Alakahi road ran along the boundary between Makahanaloa and Pāpa'ikou up to Palanolelo.

Kuhipono (k)-1874-*Kama'āina* of Pāpa'ikou (Vol. B, pp. 157-159)

Father was a canoe maker and Kuhipono followed the same trade. Pi'ihau is an *ili* within Pāpa'ikou. Mentions the old trail up to Pāhoehoe Gulch that leads to Nahuina [conflict with Puumoi testimony]. Pāhoehoe ends a short distance above Pihaakunui Falls. Says that Pu'u Ana is on Pauka'a, with the boundary being on the north (Hāmākua) side of the hill in a ravine. Describes hunting cattle for hides on the mountain. Older *kama'āina* told him Pāpa'ikou extended through the woods to join Humu'la on the *pili* beyond the forest.

Pauka'a-Certificate 181-6,700 acres

Kalam (k)-1874-*Kama'āina* of Pauka'a (Vol. B, pp. 178-179)

Kalama states he was born at Pauka'a during the time when Aki built the pōwai of Hualilelile. He used to go with his father who was a canoe maker and bird catcher. The northern boundary begins at the coast in Kaleiiki Gulch. The boundary then follows Pōauwai Gulch to a place called Lua'a below a water head called Waikoana. Above Waikoana, was a new water head called Pōhakupa'a. Above Pōhakupa'a, he describes an old trail that led to a place called Hālapamana'ole where Pāhoehoe ends and Pauka'a and Pāpa'ikou unite *mauka* of Pu'uana Hill. Kalama states that D.B. Lyman had a house a short distance above Pihakunuia Falls at the inland end of Pāhoehoe. [Pu'u Ana is situated at 3,800 ft elevation and Pihakunia Falls is at 2,200 ft elevation]

Kauaeholo (k)-1874-*kam'āaina* of Pāhoehoe (Vol.B, pp. 179-180)

Kauaeholo heard about the boundaries of Pāhoehoe from old *kama'āina*. He describes a place called Lua'a above Poapua'a where the Pauka'a and Pāhoehoe roads meet. Mananui was below Poapua'a. Lua'a is described as the "last of the old *kūlana kauhale* [villages] on Pāhoehoe." 'Aipala is the place where Pāhoehoe is cut off by Pauka'a and Pāpa'ikou. 'Aipala is described as *makai* of Pu'uana. He describes catching birds and gathering *olonā* when he was very young.

Kamai (k)-1874-*kama'āina* of Pauk'a (Vol. B, p. 180)

Describes the hill, Pu'uana, as belonging to Pauka'a. A drainage below the hill is the boundary between Pauka'a and Pāpa'ikou. He describes an old trail following the boundary *makai* to the upper end of Pāhoehoe.

Kamakamai (k)-1874-*kama'āina* of Pāhoehoe (Vol. B, pp. 180-181)

He describes Lua'a 1st and 2nd as being situated above a place called Mananui and below Waikoana Gulch. Above Waikoana, he lists a succession of place names; Kepuki, Pauike, Kalā'auhaka (in the woods), Kupamānoa, Kaholoina (opposite Nahuina), Pihaku, and Paina'ole. Paina'ole was as far as he used to go for canoes. He said 'Aipala was the *mauka* corner of Pāhoehoe. He describes hunting cattle on the mountain and hearing that Pu'uana was on Pauka'a. He had always heard that the *makai* lands extended through the woods to Humu'ula..

Makahanaloa-Certificate 36-7,600 acres

Kahulanui (k)-1873-*kama'āina* of Kaupakuea (Vol.A, No. 1, pp. 182-183)

Kahulanui said he was born during the reign of Kamehameha I. He used to go up into the woods because he was formerly a canoe builder. His father
was also a canoe builder and he once traveled inland with an old bird catcher named Kamanu from Kaiwiki. He describes a place called Nahuina on Alia Stream where Kaupakuea meets Makahanaloa. An old road (and ahupua'a boundary) extended from Nahuina to a pali called Ka'ekuapua'a on 'Uku Hill where "they used to let canoes down". The road continued mauka to Kapo'oho'ohua Pali on 'Uku Hill and then down to the foot of the hill to a place called Mahiakala, an old *kauhale*. Further inland he describes the Honomū Road along the boundary between Makahanaloa and Honomu.. He describes the upper-most portion of the forest between Makahanaloa and Hakalau and says that Kaukoa is where the tall *koa* trees end. Above Kaukoa, where Makahanaloa is cut off by Humu'ula, is Kapu'uakala (also, "Kapuakala"), a hill. Kapu'uakala is also the name of the water there. He describes Kapuakala as being "not entirely through the woods, but it is above the *koa* trees. There are a few scattering mamani [sic.] below the appendage of koa." The "mamani" (*māmane*) grows on Humu'ula.

Wahamu (k)-1873-Kawainui resident (Vol. A, No. 1, pp. 183-186)

Wahamu said he was born at Makahanaloa before the first missionaries arrived and he belongs to Makahanaloa and Pepekeo (Pepe'ekeo). At the time of his testimony he was residing in Kawainui. His father was a bird catcher on the lands of Makahanaloa and Pepekeo. He describes Nahuina as the inland end of Kahua. Above Nahuina, the Makahanaloa boundary follows an old road to 'Uku Hill and beyond to the Honomu Road. He describes hunting cattle far inland (above the project area) where Makahanaloa and Hakalau Nui join at Kolekole Gulch. He met bird catchers catching *mamo* at this place. Above here, in Hakalau, there are two "water ponds", similar in size, called Kapahunui and Kalepolepo. Above the woods, in Makahanaloa, is Palanolelo (also, Palauolelo), a water spring in a gulch. On the ridge above, there are houses (*kauhale*). There is a pile of stones on the *mauka* corner of Palanolelo, near a place called Kaloloa. Lā (La'a) (k), father of Hanauna from Humu'ula, said "the tall *koa* and 'ōhi'a were on *makai* lands, short *koa* and *mamani* [sic. *māmane*] on Humu'ula.

Wahamu describes the southern boundary between Pepekeo and Kula'imano as ending in Waiama Gulch above a small hill between two larger hills, named Pu'upulololu'u. The boundary between Pepekeo and Kawainui ends at a rock in the woods called Kukailimu, which used to be worshipped, on the south side of Waiama Gulch opposite 'Uku Hill where Pepekeo ends. Between the upper end of Kula'imano and the rock, he describes three places (water heads) where water was taken out of the stream. At the *pōwai* of Waikū, the water was taken out to make a bullock pen. At Nā'ū, on Pepekeo, water was taken out for a sugar mill on Makahanaloa. Further inland at Waimana, where Kawainui Stream forks, water was taken out for irrigation by Onomea Plantation. Above Waimana,

bird catchers lived at a place called Kumu'ōhi'a. He states that the woods began at Nā'ū where Makahanaloa cuts Pepekeo off.

J. Ili (k)-1873-Accompanied Henry M. Lyman on the survey of Makahanaloa (Vol. A, No. 1, pp. 85-186)

The *kama'āina* wtinessess who pointed out the boundaries were Kapoumo'oakea and Kamanu. 'Uku [Hill] is "where canoes were got out". Walked the boundary, past Nahuina, Kolekole Stream and, Pu'uwai Hill in Hakalau, and came out of the woods at Pukaiwaho "where small *koa, mamani* [sic.] and *pili* were growing. Here, lies the boundary between Humu'ula, Hakalau and Makahanaloa. A pile of stones was erected by the survey party here. From this stone pile, surveyed across to Palanalelo, an old *kauhale* and built another stone pile near the place where Pi'ihonua joins the south side of Palanalelo. Mentions that tall trees were on Makahanaloa and the small woods on Humu'ula. Also mentions a *loko wai* (pond) (didn't know name) near the Hakalau boundary [probably Kapahunui or Kalepolepo].

Kamalo (k)-1873-*Kama'āina* of Makahanaloa (Vol. A, No. 1, pp. 186)

States he was born on Punahoa during the time of Kanihonui and knows the mauka boundary of Makahanaloa. He was a bird catcher and lived on Pi'ihonua and "on the mountain". Says Palanalelo was the boundary of Makahanaloa and, Pi'ihonua and Kaloloa was on the other corner; Humu'ula bordered the *mauka side*. Above here, grew the "small *koa* and *mamani* [sic.]; *makai* of here grew the tall trees and *pili*. "The *koa* and *mamani* are on Humu'ula." There was a "dry time" about 1848 or 1849, when Leleiōhoku died, and there was water there in holes.

Kahue (k)-1873-*Kama'āina* of Humu'ula (Vol. A, No. 1, pp. 187-188)

States he was born at Humu'ula a little before the 'Ōku'u [1804]. His parents belonged to Humu'ula and had pointed out the boundaries of the lands joining Humu'ula. Makahanaloa and Humu'ula join at Kapahe'e at Hakalau. Pohopā'ele, an old village, was at a swampy place on Makahanaloa. Above the swamp was where Humu'ula people had their houses. States "below here Makahanaloa people took our feathers away; at Kapahe'e, Hakalau people took our ducks away. The boundary runs along Humu'ula to Waikaloa [Waikoloa?] at the point where Pāpa'ikou joins Makahanaloa and Humu'ula. He used to hunt wild cattle on the mountain with Kamalo (k) and Makahiki (k) from Ka'ū. He lived all over the mountain. Describes Kapahe'e as being in the Hakalau woods, but near Makahanaloa and estimates it is less than a mile from the upper edge of the woods. From Kapohokele [Kapohopā'ele?], it is less than a mile to the upper edge of the woods. Waikoloa, a circular water hole is less than a mile from the edge of the woods. Says there were holes in the tall woods of *'ōhi'a* and *koa*., but the *mamani* [sic.] did not grow near these holes. Kapuakala, in Humu'ula, is "out on the *pili*" and where they had their houses. The Humu'ula people were bird catchers and caught birds on 'ōhi'a trees. States Palanalelo is above the woods and Makahanaloa; Hakalau is near the woods and to Kapahe'e. Mamani [sic.] and *koa* grew at Palanalelo, where the water hole is located. Waipilopilo is where Sam Guess' old house was located. Kapuko Gulch/Stream is on "the boundary of Pauka'a and Pi'ihonua and is called Nukupahu, in the woods."

Nahale (k)-1873-Kama'āina of Makahanaloa/ Pepekeo (Pepe'ekeo) (Vol. A, No. 1, pp. 188-191)

Nahale was born during the last war of Kamehameha I, at the time when Namaka'eha died at Pi'ihonua. He was a bird catcher and learned his trade from older bird catchers. He states he always lived at Onomea until after Austin moved there. Then he moved to Paihāloa (Paiha'aloa). He is a kama'āina and is familiar with the lands of Makahanaloa and Pepekeo. Walia Gulch, the boundary between Kahua and Makahanaloa, extends from the sea shore into the woods on the *makai* side of 'Uku Hill, at a swampy place (couldn't remember name) where Kaupakuea meets Makahanaloa. On the north side, Pepekeo and Makahanaloa run adjacent to each other, beginning from the shore to the point where Pepekeo ends in the woods. Mentions fishing rights extending out to sea. On the south side, Pepekeo is bounded by Kula'imano. Above of the Kula'imano

water head (where Kula'imano ends and Kawainui joings Pepekeo) is a "large flat rock in the stream, covered with green moss such as grows in the sea". This place is called Pōhakupakaiea and the stream belongs to Pepekeo. Kukailimu is in the woods where Pepekeo and Kawainui end and the Makahanaloa boundary runs south, cutting off Kawainui. Waimana is where Kapuko Gulch empties into it. The 'ākōlea fern grows on the south side of Kapuko Gulch, in Onomea. He describes a place called Kumu'ōhi'a that was an old village on Onomea, inland from where Makahanaloa cuts Kawainui off. Further inland was a swampy place called Kauwanapoho where bird catchers and canoe makers lived. Further inland at the place where Makahanaloa and Papaikou meet and cut off Onomea is a place called Nahuina. Inland from Nahuina, the boundary between Papaikou and Makahanaloa follows an old road along Waimana Gulch. Popolo is a little above Nahuina. At Popolo, the water ends and the valley runs to the end of the tall woods. Humu'ula is where the grass, small trees and *mamani* [sic.] grow. Of Alakahi Road, Nahale says only the road belongs to Alakahi and not the land.

Hakalau Nui-Certificate 130-12,580 acres

Kanehoalani (k)-1873-*Kama'āina* of Kama'e'e (Vol. B, pp. 360-361)

Kanehoalani describes a hill called Nakama on Waawaa Gulch [also, Wāwa'a] where there was an old *kaubale* in *koa*. Not far from here the gulch turns north to a *pali* (cliff) called Kaoku [Ka'ōkū].

Kapou (k) *Kama'āina* of Hakalau (Vol. B, pp. 362-363)

Stated he was born at Hakalau, but lived at Wailea at the time he gave testimony. His father was the *luna* (overseer) of the bird catchers. At the time of the survey by Henry Lyman, he was *konohiki* of Hakalau Nui. Mentions a *pōauwai* (water head) called Waihaka in Hakalau Nui. Above this is the old trail leading to Ka'awahine, an old *kauhale* at the *mauka* corner of Hakalau Iki. Above this is Wailea and Nāpu'umai'a, where there are banana trees. From this point the old trail follows alongside Kaiwiki to Ka'ahakina Gulch. This is as far *mauka* as he knew.

Halaioo-1873-*Kama'āina* of Wailea (Vol. B, pp. 363-364)

Halaioo says the *mauka* corner of Hakalau Iki is at Na pu'u mai o ka Ahu. He says that Ka'awahine was *makai* of there. Further inland he describes banana trees (Nāpu'umai'a) and an old trail along the boundary between Wailea and Hakalau Nui.

The foregoing testimonies make thirteen references to bird catching, ten to canoe building, five to bullock hunting, and two to *olonā* gathering, all of which probably occurred in the project area. Five houses or settlements and five trails are described as being in, or adjacent to the project area. Kumu'ōhi'a, situated near the inland end of Kawainui, is described as an old village. Further inland was a place called Kauwanapoho where bird catchers and canoe makers lived. Mahiakala is described as an old *kauhale* situated inland from Pu'u Ka'uku. A house belonging to D.B. Lyman was situated above Pihakukui Falls near the inland tip of Pahoehoe. There was an old *kauhale* situated at Nakama in Hakalau Nui. Tomonari-Tuggle (1996) cites other Boundary Commission testimony indicating that there was a sixth settlement at Mohaluhalu where Hakalau Nui, Honohina, and Umauma meet.

An old trail followed the inland boundary between Pauka'a and Pahoehoe. Another old trail followed the boundary between Pahoehoe and Pāpai'kou to a stream crossing above Pihakukui Falls. The Alakahi Road followed the boundary between Makahanaloa and Pāpai'kou and the Honomū Road followed the boundary between Makahanaloa and Honomū. One probable shrine is mentioned. It is a rock that used to be worshipped on boundary between Pepe'ekeō and Kawainui on south side of Waia'ama Gulch opposite Pu'u Ka'uku where Pepe'ekeō ends.

Pulu gathering and two settlements are described above Akaka Falls in the inland portion of the adjacent *ahupua'a* of Honomū and Kaiwiki. Ula'ula Hale is described as a place where canoes were made

and Pukaonua was a canoe makers' settlement. Four other houses or settlements are described, two are inland of the project area above the forest line, and two are seaward of the project area.

In most instances, the testimonies suggest that the activities, trails, and settlements mentioned were no longer in use at the time the testimonies were given in the late 1800s. Trails and habitations are frequently described as "old" and the activities described as formerly practiced. Much of the information was second-hand having been passed down to the testifiers by their parents or teachers.

The Cultural Importance Of Place Names

'Aloha 'āina (love for the land) is a fundamental concept in Hawaiian culture. This is evident in the many *'ōlelo no'eau* (proverbs and sayings) such as *ka ua kani lehua o Hilo* (the lehua sounding rain of Hilo). Sayings can describe important events or emotional states, teach moral and cultural values, and contain names of places and people. Samuel Elbert, one of the compilers of the *Hawaiian Dictionary* and a co-author of *Place Names of Hawai'i*, noted that "...the largest proportion [of Hawaiian sayings] show *aloha 'āina*, 'love for the land and the people of the land...'" (Elbert *in* Kaeppler and Nimmo 1976:118). The *aloha 'āina* concept is also an example of the Hawaiian people's strong affinity to their natural environment which also ties in with their psychic and spiritual connection to their ancestors and, therefore, to the land where their ancestors are buried. This affinity or kinship to the environment is evident in the way they gave names to places, people and things.

Associated with the giving of place names is the concept of *wahi pana* (a place with a legend or story connected with the name). As with *aloha 'āina*, the idea of *wahi pana* is also a connection to the past and to the ancestors. The name of a place can provide intimate details about the people who lived there, the environment, cultural practices and historical events that took place. In the Hawaiian framework, a place was deemed important by the very fact that a name was even given to that particular place. Natural places can also be endowed with *mana* or spiritual power. This *mana* can be attributed to a place by a physical geologic feature of the landscape, the presence of *akua* (deities), natural phenomena such as cloud forms, continued use over time, the presence of cultural sites such as *heiau*, and by its spiritual and mythological significance such as *Kūlanihāko'i*, a pond in the sky which, when it overflows, materializes here on earth in the form of rain. On the subject of *wahi pana*, cultural practitioner and historian Edward Kanahele wrote:

> As a native Hawaiian, a place tells me who I am and who my extended family is.
> A place gives me my history, the history of my clan, and the history of my people.
> I am able to look at a place and tie in human events that affect me and my loved ones.
> A place gives me a feeling of stability and of belonging to my family, those living and dead.
> A place gives me a sense of well-being and of acceptance of all who have experience that place. (Kanahele *in* Van James 1995:6)

Because Hawaiian culture was an oral tradition, place names and their associated stories were an important way of remembering and marking these traditions, thus ensuring these stories would be passed on to future generations. As names were markers for events, over time some names were changed to indicate a more recent event or memory of a person who had meaning for the people living during that particular time period.

An example of how names evolve can be seen in the name "Kaweliweli", which refers to a trail in Onomea, South Hilo. It seems the traditional meaning of the name has been forgotten over the passage of time. However, one can look at the various possible literal meanings and make some conjectures about the name. The most common meaning of *weliweli* means "violent, dreadful, horrible, fearful". So, perhaps, a horrible event occurred here. However, the beauty and duality of the Hawaiian language is that the name can mean exactly the opposite or mean something totally different. Names can also have *kaona* or "hidden meanings" not readily apparent by its literal translation. Such is the case with *weliweli*. Secondary meanings are "revered, respectful, full of awe" and "numerous, immense" (Pukui & Elbert 1986:384). The danger in trying to assign literal meanings to place names is apparent. In an interview for this project with Antone Medeiros, he indicated Kaweliweli was the old Hawaiian name for an area and a trail frequented by pig hunters. Today, the younger generations refer to this trail as "Gardenia Trail" because gardenias once grew alongside the trail during their parents' time. Even though gardenias no longer grow there today, the

youth continue to use the name "Gardenia Trail" because this is the name they learned from their parents. One can see the importance of oral tradition knowledge in documenting and determining place name meanings.

As seen from the above, insight into traditional life-ways and land use practices can often be extracted from a study of place names in the vicinity. With this in mind, a list of annotated place names was compiled with derivations (where available). Insights from these place names are discussed further below.

The following place names were compiled from 19th and 20th century maps, boundary commission records, Land Commission Awards (LCA's) and historic documents (*Figure 2*). Hawaiian diacritical marks (*kahakō* or macron; *'okina* or glottal stop) were used wherever possible. However, in cases where the name meanings were uncertain (not documented from oral or historic sources) due to the possibility of having more than one meaning, diacritical marks were not used. The standard guide used for all diacritical marks and meanings of names is *Place Names of Hawai'i* by Pukui, *et al.*, (1976) and the *Hawaiian Dictionary* (1986), unless otherwise noted.

'Aipala — Boundary Commission records describe 'Aipala as the place where Pāhoehoe is cut off by Pauka'a and Pāpa'ikou and indicates it is adjacent and inland from this cut-off place, but *makai* of Pu'u Ana (Vol. B: 156-57, 179-80, 182-84).

The meaning of the word is uncertain. It could refer to eating the *pala* fern. *Pala* is an edible fern that was eaten especially during times of famine. The bases of the frond stems were baked in the *imu* and eaten. The mucilaginous water left over from slicing and soaking the raw stems was used medicinally. The fern was also used in *heiau* ceremonies. *Pala* can also refer to a variety of taro and sweet potato.

Alakahi — A land section and stream. According to the Waiki family, the last tenants of the old Hawaiian village of Kahali'i, the correct name for this stream is Kukilu (Pers. Comm., Luika Waiki Perreira to Ka'ohulani Mc Guire, 1995). *Lit.* one way (Pukui, *et al.*, 1976:9).

'Aleamai — A land section; listed in *Place Names*, but no literal meaning is given. A possible reference to the *hīnālea* fish.

Hakalau Nui — Land division, bay, gulch, stream, and site of a former sugar mill. *Lit.* big Hakalau. The word *hakalau* literally means many perches (Pukui, *et al.*, 1976:35).

Hālapamana'ole — A possible reference to a ridge an/or an obscure event that occurred there. *Lit.* ridge without *mana*.

Hale Koloa — A former village along Kolekole Stream and below 'Akaka Falls (BC, Vol. B: 457-58). *Lit.* house [of] Koloa.

Hōmaika'ohe — A sacred bamboo grove in Makahanaloa said to have been planted by the god Kāne. Bamboo knives for circumcision came from this grove (Emerson 1915:189; Pukui, *et al.*, 1976:139). *Lit.* hand me the bamboo (Pukui, *et al.*, 1976:139).

Honoli'i — A cove, landing, stream and gulch, bordering Pauka'a on the Hilo side. Honoli'i gulch is the southern boundary for Pauka'a (C. J. Lyons: Reg. Map #570). Hi'iaka and Wahine'ōma'o swam across Honoli'i Stream as part of their many adventures in bringing Lohi'au to Pele (Emerson 1982: 60). A descriptive term for the land meaning "little valley" (Pukui, *et al.*, 1976:49).

Ka'āpoko — A land area, shown on H. M. Lyman's Reg. Map #30. *Lit.* the short stone (Pukui, *et al.*, 1976:61).

Ka'awahine	An old *kauhale* (settlement) along an old trail at the *mauka* end of Hakalau Iki (BC, Vol. B: 360-61). (*Also*, Kāwahine.)
Ka'ekuapua'a	A *pali* (cliff) on 'Uku Hill (Ka'uku) where canoes were let down (BC, Vol A:182-83). *Lit.* the rooting of [the] pig. *Fig.* prow of a canoe (Pukui & Elbert 1986:40). A poetic reference to a canoe.
Ka'ie'ie	A land section and stream. *Lit.* the *'ie'ie* vine. A reference to the *'ie'ie* vine that was once abundant in the area. The aerial roots of the vine were used for weaving and the fruit of the *'ie'ie* was especially attractive to the native *mamo* bird. The plant itself is sacred to the hula goddess Laka and it is one of the plants used to decorate the *kuahu* or hula altar.
Kaiwiki	A land section. Boundary Commission records indicate the forests of Kaiwiki were frequented by bird catchers. *Lit.* quick sea (Pukui, *et al.*, 1976:71).
Kalaoa	A land section said to be named for Kalaoa Pu'umoi, the sister of Kapalaoa. See "Pu'umoi" below. *Lit.* the choker (as a stick for catching eels) (Pukui, *et al.*, 1976:75). *Kalaoa 'ai pō'ele'ele* is an *'ōlelo no'eau* which means "Kalaoa eats in the night". This is a reference to the stinginess of the Kalaoa people who don't want to share their food (*Ibid.* 268).
Kaloloa	A place far inland on Makahanaloa, at the *mauka* corner of Palanolelo (Palauolelo) Spring (BC, Vol. A: 184).
Kānepu'u	An interior area above Pu'uwai Hill on Hakalau. Makahanaloa is "very near this place" (BC, Vol. A: 184).
Kapāhe'e	An area far inland, on Hakalau, where the boundaries of Humu'ula and Makahanaloa meet. It is located in the woods near Makahanaloa, less than a mile from the "upper edge of the woods." A place where "Humu'ula people took our ducks away" (BC, Vol. A: 187).
Kapahunui	An inland pond above Waikaloa and Kapahu, comparable in size to Kalepolepo, another pond. Both ponds are on Hakalau (BC, Vol. A: 184).
Kapeke	A place above Kumu'ōhi'a, where the running water ends (BC, Vol. A: 189).
Kapo'oho'ohua	A *pali* (cliff) on Uku Hill ((Vol. A: 182 (See *Pu'u Ka'uku.*)
Kapue	A stream. The meaning is uncertain and the name has several connotations: 1) to huddle or sit crouched with cold; 2) *pue* refers to the feathers on the back of a bird, just above the tail feathers; 3) if spelled *kapu 'ē*, the meaning changes to "an unusual taboo".
Kapuko	A gulch and stream where the 'ākōlea fern grows on the Onomea side (BC, Vol. A: 189).
Kapuakala	A place "out on the *pili*" at Humu'ula, where houses were (BC, Vol. A: 187).
Kapuwai	A swamp.
Kauwanapoho	Described as a swampy place where bird catchers and canoe makers lived (BC, Vol. A: 189).
Kawainui	A land section, stream and falls. *Lit.* the big water, in reference to the stream which can come rushing down in torrents and make the road impassable at times.

Kīkala	A land section just outside of the project area in Pauka'a. *Lit.* hip (Pukui, *et al.*, 1976:110).
Kolekole	A gulch and a stream which marked the boundary between Makahanaloa and Hakalau (BC, Vol. A: 184). *Lit.* scarred, raw (Pukui, *et al.*, 1976:116).
Kuhua	A forested area where Kuhua is cut off by Honomū and Kaiwiki. This area was used by bird catchers and canoe makers (Vol. B: 457).
Kukailimu	"An old rock" in the Pepe'ekeo woods opposite 'Uku [Hill] that used to be worshipped. Also the boundary where Pepe'ekeo ends (BC, Vol. A: 185).
Kula'imano	An inland area in Pepe'ekeo where canoes were made. *Lit.* push over many (a legendary man pushed his foes over a clif as they came up) (Pukui, *et al.*, 1976:123). It is interesting to note that on H. M. Lyman's Reg. Map #30 and Reg. Map #1565 of Pepe'ekeo Plantation, the name is spelled "Kulaimanu". Also, a water head (BC, Vol. A: 189).
Kumu'ōhi'a	A village and place above where Kawainui Stream forks in Onomea and where bird catchers lived. (BC, Vol. A: 185; 189). *Lit. 'ōhi'a* tree.
Laeakaloa	A land section in Pauka'a. Meaning uncertain. Could be a reference to the way the land comes down to a point on the *makai* end. *Lae* usually refers to promontories, capes and headlands usually located at the sea, but this is not always the case. An example would be *lae lā'au* which refers to "a forested point, whether at sea or inland" (Pukui, *et al.*, 1976:189).
Lua'a	A village and land area on Pāhoehoe. The word can be used to "pound poi till soft" or "to make poi and make ready food and conveniences for a feast (Fornander 1918-1919, VI: 397). Boundary Commission records describe Lua'a as the "last of the old *kūlana kauhale* (village) on Pāhoehoe (BC, Vol. B: 182-83).
Mahiakala	Old *kauhale* (settlement), located at the foot of a Ka'uku Hill (BC, Vol. A: 182). Meaning uncertain. Possible spelling: Mahi'ākala. Could be a reference to an area or patch of the native 'ākala berry from which a pink dye was made from the juice. *Kala* is a variant form of *'ākala*; *mahi* means to cultivate.
Makahanaloa	A cape and land division. There was a *leina* here where there was a leaping-off place for spirits to enter the world of *pō* after death (Pukui, *et al.*, 1976:139). Hōmaika'ohe, the sacred bamboo grove was also located in Makahanaloa.
Mohaluhalu	Site of an old *kauhale*. The point where Hakalau Nui, Honohina and Umauma join.
Moku'ōniki	A land section located between Pu'umoi and Alakahi. The name is most likely a reference to the physical land division itself. *'Ōniki* means "a pinch" or "a bit"; *moku* means "to be cut or severed" and is used as a descriptive term for "a severed portion of land" (Pukui, *et al.*, 1976:252,289).
Nā Pu'u Mai O Ka Ahu	Located at the *mauka* corner of Hakalau Iki and above Ka'awahine (Also: Kawahine) (BC, Vol. B: 360-61). Meaning is uncertain.
Nahuina	Gulch, junctions in various locations. Nahuina (1) is on Aliia [Alia, on modern maps] Stream where Kaupakuea joins Makahanaloa (BC, Vol. A: 182). Nahuina (2) is where "Makahanaloa and Pāpa'ikou join, and cut Onomea off" (BC, Vol. A: 180). Nahuina 3 is above Nā'ū and below Kumu 'Ōhi'a. Nahuina (4) is at the end of Kahua and Kaupakuea, along the old road to 'Uku Hill (BC, Vol. A: 183). Nahuina (5) is located along Pāhoehoe Stream, above Pihaakunui Falls (also known as Piha Kukui Falls) (Vol. B: 157-59). Na-

huina Junction of Kaupakuea is the point where the boundary between Kahua and Makahanaloa turns away from Aliia Stream (BC, Vol. A: 182). *Lit.* the junctions (Pukui & Elbert 1986:87). A descriptive reference to the point of juncture where the land boundaries meet.

Nakama — A hill on Wa'awa'a Gulch in Hakalau Nui where there was an old *kauhale* (settlement) in *koa* (BC, Vol. B: 360-61).

Nā'ū — A water head on Pepe'ekeo where water was taken out for a Makahanaloa sugar mill. The woods begin at Nā'ū (BC, Vol. A: 185). *Lit.* yellow (Pukui, *et al.*, 1986:164

'Ōku'u Hill — The older name was probably Pu'u 'Ōku'u. *Pu'u* means "hill". Given its location and elevation, the name likely refers to a "method of catching birds by gumming artificial *lehua* blossoms made of *'ie'ie* to a tree" (Pukui & Elbert 1986:282). This is probably not a reference to the disease.

Onomea — A stream, bay, sea arch and site of an old Hawaiian village. The sea arch collapsed in 1958 (Macdonald and Abbott 199, 205). Listed in *Place Names* but no translation of the name is given.

Pāhoehoe — A land section and stream. The name is descriptive of a "smooth type of lava" (Pukui, *et al.*, 1976:49). Boundary Commission records indicate the interior forests of Pāhoehoe provided canoe makers with trees for canoes (Vol. B: 183)

Paiha'aloa — A land section. Probably a descriptive reference to the tossing motion of the sea, like "a canoe in a rough sea" (Pukui, *et al.*, 1976:302). *Paiha'a* is a variant form of *paiāha'a*. Also, *Paihāloa*.

Palauolelo — A water spring in a gulch (*kahawai*) on Makahanaloa, above the woods. There was a "*kauhale ma luna kualapā*" (house(s) above on the ridge) (BC, Vol. A: 184). Frequently spelled "Palanolelo" in the BC records. Probably, Pālau'ōlelo (teller [of] tales). A pile of stones was said to be on the *mauka* corner of "Palanolelo", near Kaloloa (*Ibid.*). J. Ili indicates in his testimony that this pile of stones was put up by him and the *kama'āina* who accompanied H. M. Lyman on the survey of Makahanaloa (BC, Vol. A: 185-86).

Pāpa'ikou — Landing and ancient surfing area. *Lit.* a hut or temporary shelter in a *kou* grove.

Pauka'a — Spelled as "Pouka'a" on H.M. Lyman's 1853 map (State Survey Office: Reg. Map #30) and probably an error. *Lit.* all taken, consumed (Pukui & Elbert 1986:320).

Pepe'ekeo — A village, point and stream. A stream and rock are named for Kamapua'a, who unsuccessfully tried to drown Hina, Māui's mother here. Formerly spelled *Pepe'ekeō*, which means "the food crushed, as by warriors in battle" (Pukui, *et al.*, 1976:183).

Pihakukui — A falls mentioned in the Boundary Commission records (BC, Vol C, No. 4:120-23) which indicated that an ancient trail ran along the interior northern boundary of Pāhoehoe. The trail crossed Pāhoehoe Stream above the falls. D. B. Lyons' house was a short distance above the falls. *Lit.* full [of] kukui. Variant names for this same falls in the Boundary Commission records are Pihaakunui, and Pihaku'uiki/ike.

Pōhakupa'a — A stream which meets Honoli'i Stream at about 1850 ft. elevation. Not mentioned in *Place Names of Hawai'i*. A literal translation could be given as "foundation stone" or a stone that is solid and unmovable.

Pōhakupakaiea — A large flat rock in the stream, covered with green moss, like the kind that grows in the sea. The stream belongs to Pepe'ekeo. Described as being a short distance above the

	Kula'imano water head and at the point where Kula'imano ends and Kawainui joins Pepe'ekeo (BC, Vol. A: 189).
Pohopā'ele	An old village on Makahanaloa, at a swampy place. Humu'ula people had their houses above here. Described as being a hollow (*poho*) on the top of a ridge (BC, Vol. A: 187, 190). Above Pōhakupa'a was an old trail that led to Hālapamana'ole where Pāhoehoe ends and Pauka'a and Pāpa'ikou join *mauka* of Pu'uana, a hill, at 3,800 ft elevation (BC, Vol. B: 178-79).
Popolo	A place located a short distance above Nahuina (2). "At this point, the valley runs *mauka* to the end of the tall woods" (BC, Vol. A: 189).
Pukaiwaho	A place at the upper edge of the forest (above the project area) where one comes "out of the woods... where small *koa, mamani* [sic.] and *pili* were growing; across of Palanolelo, the "old *kauhale*" or village. Marks the boundary between Humu'ula, Hakalau and Makahanaloa. A pile of stones was erected here by the informant and *kama 'āina* who accompanied him (BC, Vol. A: 186).
Pukaonua	Mentioned in Boundary Commission Records as a place further inland from 'Ula'ula where there was a canoe makers' settlement (Vol. B: 457). Meaning of name is uncertain. It possibly is a misspelling.
Pu'u Ana	Located *mauka* of the project area in Pāpa'ikou on current USGS maps. Boundary Commission records describe the hill as belonging to Pauka'a (BC, Vol. B: 180). C. J. Lyons' Reg. Map #570 of 1879 (State Survey Office) concurs with this. Apparently, the boundaries have changed over the years. The name could be a reference to a cave on the hill, as the name implies.
Pu'u Ka'uku	Volcanic cone on the eastern slope of Mauna Kea from which two lava flows reached the sea; the southern one formed Pepe'ekeo Point (Macdonald & Abbott 1970:303). Boundary Commission testimony says that ¾ of this hill belongs to Makahanaloa (BC, Vol. A: 183. *Lit.* the hill of the louse. In some Boundary Commission records and old maps, referred to as "Ka'uku" or just "'Uku Hill." (See *Ka'ekuapua'a.*)
Pu'umoi	A land section. *Moi* refers to several things, a variety of taro and sweet potato, as well as a variety of fish. But, it is more likely a reference to Kalaoa Pu'umoi, sister of Kapalaoa who was the mother of the riddling expert, Kalapana. The land sections of Kalaoa and Pu'moi are adjacent to each other. Not listed in *Place Names.*
Pu'uwai	A hill on Hakalau, in the woods ((BC, Vol. A: 184, 186).
'Ula'ula Hale	An inland place above 'Akaka Falls where canoes were made (BC, Vol. B: 457). *Lit.* house [of] red; possibly a reference to the scarlet color of bird feathers.
Waiama	A stream and gulch in Makahanaloa (BC, Vol. A: 183).
Waihaka	A stream and gulch in Honomū (BC, Vol. A: 183). One Boundary Commission testimony state that Waihaka Kahawai (stream, gulch) is a branch of the Waiama (*Ibid.*).
Waikoloa	A pond or "round water hole not a mile from the edge of the woods" (BC, Vol. A: 187). *Lit.* duck water. This could also be a reference to *Waikōloa*, the name of a wind (Pukui, *et al.*, 1976:223). [Sometimes seen as Waikaloa in Boundary Commission records.]
Waikū	A water head (*pōwai*) where water was taken out to make a bullock pen (BC, Vol. A: 185).
Wailani	A place where bamboo grows on Kula'imano (BC, Vol. A: 189).

Waimaauau	A gulch said to be the boundary between Pepe'ekeo and Kula'imano at the shore (BC, Vol. A: 184). Spelled "Waimaauao" on USGS map (1994:Pāpa'ikou Quad).
Waimana	A water head above Nā'ū, where water was taken out for a sugar mill at Makahanaloa (BC, Vol. A: 185).
Walia	A gulch which marks the boundary between Kahua and Makahanaloa from the "sea shore into the woods on the *makai* side of 'Uku Hill, at a sort of swamp (name unknown), where Kaupakuea joins Makahanaloa (BC, Vol. A: 188).

Nearly half of the above names are descriptive names of the physical environment or land features. Five of the names refer to legendary people and places such as the demi-gods Māui and Kamapua'a, while a little over a fourth of the names indicate land use by bird catchers and canoe makers. A few of the names also indicate plants that probably grew in the area. Information from the Boundary Commission records indicate the South Hilo forests, were heavily utilized by both bird catchers and canoe makers. No doubt the heavily forested areas were a pristine environment and home to a number of Hawai'i's native birds such as the *'i'iwi*, the *mamo* and the *'ō'ō* and the 'amakihi. These birds provided colorful red, yellow, black and green feathers for royal symbols such as capes, *kahili* and *lei*. The forests also provided *koa* trees needed to build canoes and other supplies as well, such as *olonā* for snares and rope and *mamaki* for *kapa* cloth. From a Hawaiian perspective, the fact that a place has a name indicates cultural use.

Bird Hunters And Canoe Makers

The Boundary Commission records indicate the primary users of the interior forest areas, from Pauka'a to Hakalau, were bird hunters and canoe makers. It is clear that bird hunters and canoe makers knew very well where the boundaries were located for each land division, especially in the areas they heavily utilized. Though for the most part, the boundaries were usually defined by gulches and streams (i.e., from stream to stream), anything could be a boundary marker: a lava flow, a pile of stones, a large *koa* tree in the middle of the forest marked with an "X" or a stone in the middle of a stream.

From the place names given in the records, it seems canoe makers accessed the lower forest areas, while bird hunters went much farther into the interior upland forest. (It should be remembered that the native forest once extended farther *makai* than it does today.) Some mention hiking out to the edge of the forest or even above the forest (*"pukaiwaho"*). Kapou, a witness for Hakalau Nui said, that his father, Kupouli, was the *luna* for the bird catchers when he was alive and he "used to go through the woods to the upper edge of the woods." Many witnesses indicate the different forest zones by the size and species of the trees (i.e., "Kaukoa is where the tall *koa* trees end" or "the tall *koa* and *'ōhi'a* were on *makai* lands, short *koa* and *mamani* [sic.] on Humu'ula").

At Ka'ekuapua'a, on Ka Uku Hill in Pepe'ekeo, "they used to let canoes down [the *pali*]" (Makahanaloa witness, Kahulanui). Getting a canoe down a pali was no small feat and it is another reason why canoe makers utilized the lower forest before going into the interior. After felling the tree, the log had to be hollowed out and shaped before it was taken to the shore. The following article explains how a canoe is let down the pali:

> Be very careful about calling to the men who are letting a canoe down by ropes tied to a tree, lest the rope slacken and the rope tied to the canoe will break. Many canoes have been lost...Some have never been recovered to this day and some have had their points rammed into the earth.
>
> This rope that is tied to the tree, smokes at the base of the tree like real smoke that rises from real fire. When it gets down to the slide, then the men who watch the course of the canoe (*pale-wa'a*) ride it like riding a race horse." (BPBM, HEN: Vol. 1:864)

As for bird hunting, here were two seasons of the year that were ideal: the Spring, from March-May, and late summer (August) into early fall (October). The seasons revolved around when the *lehua* blossoms bloomed and the *'ōhi'a 'ai* (mountain apple) were in fruit. N. B. Emerson wrote: "Wherever the *lehua* and certain other trees flourished and bloomed, there some, if not all of these birds, made paradise...the moist woodlands of Hilo were perhaps his favorite..." (1894:104)

Bird feathers were a status symbol and were most often used to adorn capes, helmets, *kahili* and *lei* for the *ali'i*. The brightly colored feathers were also used to pay taxes to the *ali'i* or were given as gifts to secure relationships and political ties. Kamakau relates the following incident about Kahekili [of Maui] asking for canoes from Hilo, "When Keawemauhili heard of the two messengers being sent to Kamehameha for canoes and failing to get them, he sent some double canoes together with feather capes and *'o'o* feathers as a gift of affection to Kahekili (Kamakau 1992:124). Keawemauhili was the *ali'i 'ai kalana* of the Hilo District during that time.

Other cultural uses mentioned in the Boundary Commission records were gathering *pulu* (*Cibotium* spp.) and *olonā* (*Touchardia latifolia*). Though several varieties of birds were hunted for feathes and food, the only specific bird name mentioned in the records was *mamo*. Where Makahanaloa and Hakalau Nui join at Kolekole Gulch, he [Wahanu] met bird catchers cacthing *mamo* at this place" (Makahanaloa witness, Wahamu). In the records, there are also frequent mentions of "hunting bullocks for hides".

The Māhele Of 1848

The changes to the traditional land tenure system and the effect of the *Māhele* has been well documented. The lands were divided among the King, the chiefs and the government. The *Māhele* did not actually convey any title to land. The chiefs and konohiki were required to present their claims to the Board of Land Commissions in order to receive awards for the lands quitclaimed to them by Kamehameha III. The title remained with the government until the award was issued (Chinen 1961:13). Due to a lack of surveyors in 1848, the lands were divided by name only, with the understanding that the ancient boundaries would hold until a survey of such lands could be made in the future. However, all lands were "subject to the rights of native tenants," (Laws of Hawai'i, 1848:22). Native tenants were the common people who lived and worked the land for their subsistence. Native tenants were also required to file claims to the Board of Commissioners to Quiet Land Titles for any *kuleana* lands they wanted to claim (*Kuleana* Act of 1850). *Kuleana* lands were the parcels they lived on and/or cultivated and improved. Claimants paid a filing fee and their claim was assigned a number (Land Commission Award/LCA). It was their duty to present two witnesses to testify in their behalf on the boundaries and to confirm they really did utilize the parcels they were claiming. The claim was theirs once the testimonies were approved and a Royal Patent Grant (RPG) was awarded.

Henry M. Lyman was one of the government surveyors at the time of the *Māhele*. His 1853 map of a "Part of Hilo" depicts the project area a few years after the *Māhele*. Notice how far down the lower forest boundary extended *makai* (toward the sea). A century later, the forest line will be at the edge of the project area (*Figure 5*).

The Waihona 'Āina database (2000b); which is a compilation of data from the Indices of Awards (Indices 1929), Native Register (NR n.d.), Native Testimony (NT n.d.), and Foreign Testimony (FT n.d.); lists 81 parcels claimed by 61 claimants within the *ahupua'a* of Alakahi, Kalaoa, Kawainui, Makahanaloa, Onomea, Pāhoehoe, Pāpa'ikou, Pauka'a, Pueopaku, and Pu'umoi the mid-1800s (*Table 2*). Sixty parcels were awarded to 53 claimants. *Figure 6* shows the location of awarded parcels based on the current tax maps. Nine parcels could not be located.

All except one of the largest awards are for entire *ahupua'a*. Aarona Keali'iahonui wais awarded Pāpa'ikou, Hakalau Nui was awarded to Mikahela Kekauōnohi, William Lunalilo received Makahanaloa, Pauka'a was awarded to Lota Kapuāiwa, Kanaulu was awarded Pu'umoi, and Victoria Kamāmalu received Pāhoehoe and Onomea. Kahikona was awarded one half of Pueopaku. All except one of the remaining awarded claims are for *kuleana* parcels ranging from 0.17 to 4.97 acres in area with an average of 2.02

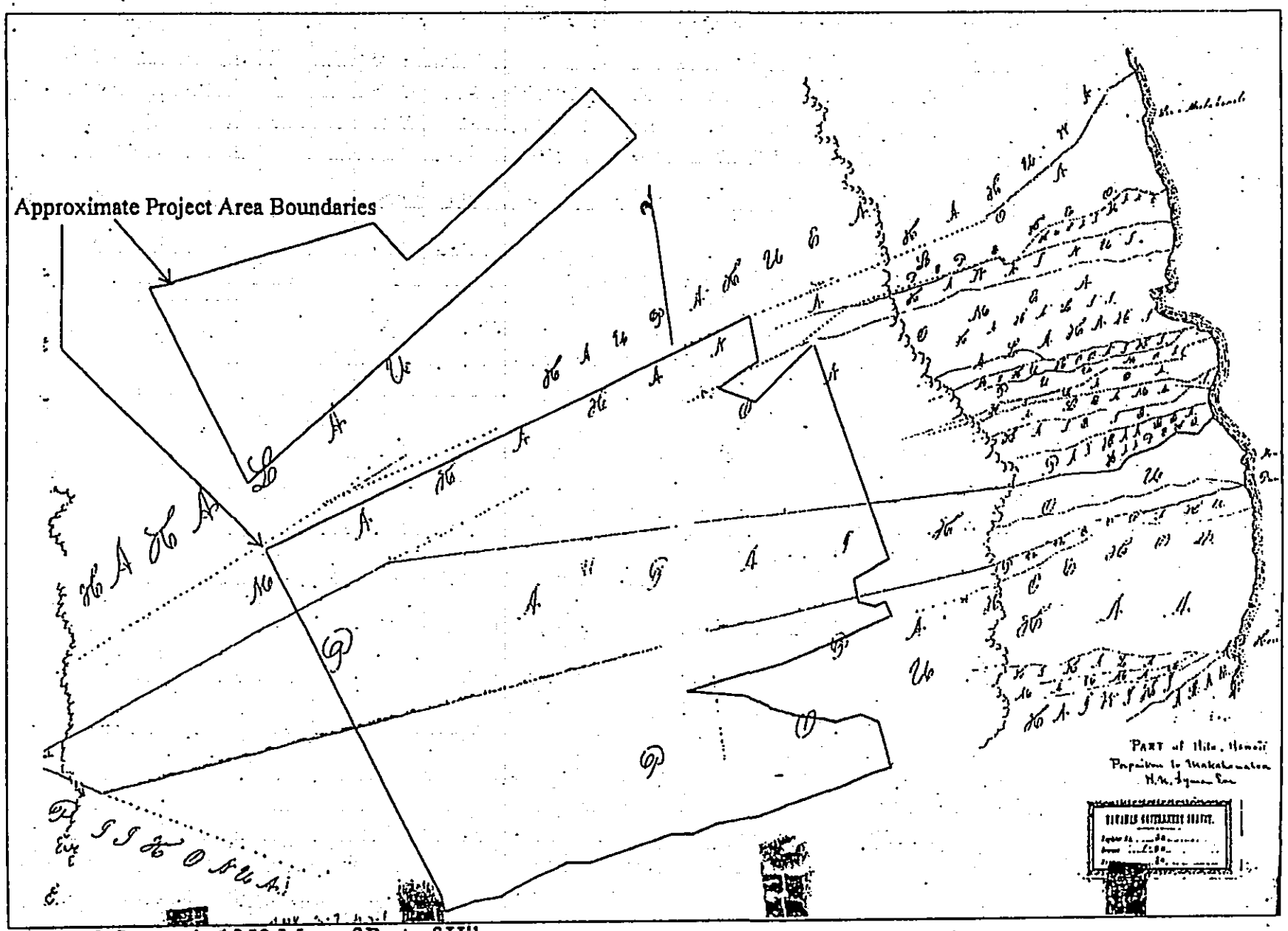

Figure 5. Lyman's 1853 Map of Part of Hilo

Table 2. Land Commission Award Claims

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Giver	Acreage	Royal Patent	Sources	Comment
1L	Olono	1	1			Pueopaku 2	N/D	house lot and 2 cultivated fields	Ravine	Kapua Stream	Ocean	Ravine	N/D	Kahona	3.29	6259	FT 50v5	Pueopaku 1 on Puna side
1O	Paahuhi	1	1			Pueopaku	Kukuionoi	house lot and 2 cultivated fields	Ili Piapau	Ohilohi	konohiki	Puapuaa	N/D	ancestors	2.17	5406	FT 52v5	
1P	Kakai	1	1			Pueopaku	Kaakualawaia	2 house lots, coffee and kalo fields	field of Piipii	Ravine	Pahoehoe stream	Pahaola Stream	N/D	ancestors	1.05	6368	FT 52-53v5	Ravine divides ili of Kaulanamoa from Kaakualawaia
118C	Kahaipule	1	0			Pueopaku	Piapau	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none		No 118 documents located, Kakaipule awarded LCA 4975
2256	William McKenny	2	0			Kawainui 2		5000 coffee trees, 5 houses, tanning establishment					1841	konohiki Akahi	0.00	none	FR 146v2, FT 57v5, NT 414v4, 667v4	
					1		Kahuanaikale	house lot and cultivated field	konohiki	Kukuikoa	konohiki	konohiki						
					2		Haleolono	3 acres of taro	road	konohiki	konohiki/ Ili Haleolono	Ili Kapaku of Kawainui 1						
4528	Opunui	1	1			Paukaa	Kanaha	2 houses, 1 partially cultivated kihapai	road	Naniho's (Kaniho's) land	ocean	Paoa's land	N/D	ancestors	1.02	4661	NR 682v8, FT 29v5, NT 429-430v4	
4548	Aheakalani	1	0			Paukaa	N/D	1 house, 2 cultivated kihapais	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 628v8, FT 30v5	
4569	Samuela	2	2			Onomea	N/D	coconut grove	N/D	N/D	N/D	N/D	N/D	N/D	1.00	7998	NR 85v8, FT 26v5, FT 30v5	2 apana awarded
4576	Inina	2	1			Papaikou	Wanui								1.68	4654	NR 683v8, FT 41v5, NT 482v4	
					1			1 house, 1 cultivated field	konohiki	Kanakaokai's land	road	Kapuhuaula's land	N/D	N/D				
					2			1 cultivated field	konohiki	Ahole's land	idle land	Kapuhuaula's land	1839	Kuhio				
4595	Makuahine	2	1			Paukaa	Kahonulaula						N/D	konohiki	1.91	4659	NR 683v8, FT 31v5	unclear which lot awarded
					1			1 house lot	Kaupee's land	stream	stream	stream						
					2			1 house, 2 cultivated kihapais	konohiki	stream	konohiki	road						
4644	Palapala	1	0			Paukaa	Papaiki	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 385-386v8, FT 20v5, FT 54v5, NT 430v4	
4645	Paeoso	1	1			Paukaa	Papaiki	1 house lot (3 houses)	Keaka's land	Opunui's land	ocean	Kaniho's land	N/D	ancestors	0.68	4968	NR 685v8, FT 29v5, NT 430-431v4	
4646	Bauaie Pauaie	1	0			Pueopaku	Pahapau	1 cultivated field, 1 house lot	konohiki	stream	valley, konohiki	Kohuna's land, konohiki	Kam I Times	Kohuna	0.00	none	NR 685v8, FT 43v5, NT 486v4	
4648	Pahau	1	0			Papaikou	N/D	houses, kihapais	N/D	N/D	N/D	N/D	N/D	konohiki	0.00	none	NR 386v8, FT 54v5	
4650	Paukumoku	1	0			Papaikou	N/D	1 cultivated kihapai	N/D	N/D	N/D	N/D	N/D	konohiki	0.00	none	NR 386v8, FT 54v5	
4654	Pahua	2	1			Puumoi	Kaolehale						N/D	ancestors	0.17	4682	NR 685v8, FT 29v5, NT 430-431v4	unclear which lot awarded
					1			house lot with 4 houses, bananas, taro	Kalama's land	Pupuka's land	ocean	Kahiwa's land						
					2			cultivated field	konohiki	konohiki	konohiki	konohiki						

Table 2. Land Commission Award Claims (cont.)

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Giver	Acreage	Royal Patent	Sources	Comment
4661	Punaia	1	2			Pueopaku	Waipuka	2 house lots and 2 cultivated fields	konohiki	stream	Kaili's land	konohiki	N/D	ancestors	1.77	4665	NR 88v8, FT 51v5	2 apana awarded
4664	Punaia	1	1			Pueopaku	N/D		N/D	N/D	N/D	N/D	N/D	N/D	3.67	4868		All documents for this number are for Puana on Maui
4695	Luiana	1	1			Papaikou	Kapuakea/ Puahia	1 house lot, 2 cultivated kihapais	konohiki, idis land	stream	road, foot path	Kapuana's (Hawelawa's) land	1845	ancestors	2.25	4658	NR 686v8, FT 41v5, NT 481-482v4	
4703B	Kalua	1	1			Puumoi	Kauhihala 2	1 cultivated kihapai	Kahaha's (Kahaku's) Land	road	Kauhaumihai's (Kauhaanohai's) land	valley, ravine	N/D	ancestors	2.01	none	FT 36v5, NT 468v4	
4703D	Meheula	1	0			Puumoi	Kukuianiani	1 house lot, 2 cultivated kihapais	konohiki	Hue's land	Hoka's land	stream	1835	Hoka	0.00	none	NR 687-688v8, FT 35v5, NT 475v4	9 claimants
4703E	Kaukeomohai	1	0			Puumoi	Kauhihala	1 house, 1 cultivated field	Kaua's (Kaaua's) land	road	Olalau's land	valley, ravine	1838	Kalua	0.00	none	FT 36v5, NT 469-470v4	
4703F	Kulahilo	1	0			Puumoi	Lalkoa	1 house lot, 1 partially cultivated kihapai	konohiki	stream	konohiki	stream	N/D	ancestors	0.00	none	FT 37v5, NT 471v4	
4703	Olalau	1	2			Puumoi	Kauhikala 1	house lot with 2 houses, 1 cultivated kihapai	Kaluamohai's land	mountain, street	Kalua's land	valley, ravine	N/D	Kalua	1.50	none	FT 36v5, NT 469v4	awarded two apana
4704B	Hue	1	1			Puumoi	Kikuianiani	2 houses, 1 partially cultivated kihapai	Meheula's land	ravine, ditch	konohiki	Heke's land	N/D	ancestors	1.70	7823	FT 35v5, NT 467v4	
4709B	Kahale	2	1			Puumoi	Hauaioi						N/D	ancestors	0.61	none	FT 36-37v5, NT 470v4	unclear which parcel was awarded
					1			cultivated field	Kaoiulloa's	cemetary	konohiki	stream						
					2			8 houses, 2 canoe houses, 18 coconut trees	pali	stream	ocean	cemetary						
4732	Makaihelaai	1	1			Pueopaku 2	Kahomilo	1 house lot and 1 kihapai	road	stream	Mahua's land	pali	N/D	Parents	4.46	4663	NR 688v8, FT 30v5	
4733	Mahua	1	0			Pueopaku	N/D		N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 88v8, FT 57v5	Awarded under LCA 4773
4734	Mahi	1	1			Pueopaku 1	Kaulenamoa	2 house lots, 2 partially cultivated kihapais	konhiki, idis land	Pueopaku 1st	valley, ravine	valley, ravine	N/D	ancestors	1.50	4673	NR 689v8, FT 34-35v5, NT 474v4	
4735	Maa	1	1			Paukaa	Wahi	1 house lot (2-3 houses) 3 cultivated kihapais	Kalama's land	Kuaana's (Kuhaana's) land	Paahua's (Kapahua's) land	Kahiwa's land	1847	Nihi	1.04	4683	NR 689v8, FT 19-20v5, NT 428-429v4	
4773	Mahua	1	1			Pueopaku 1	N/D	1 house lot, 3 fields	ravine	ravine	ocean	Pahoehoe stream	N/D	ancestors	3.00	7404	NR 88v8, FT 44v5, FT 57v5	other claimant - daughter/heir, north ravine divides Pueopaku 1 and 2
4776	Nashu	1	1			Pahoehoe	Kukuimaloko	2 house lots, 2 cultivated kihapais	konohiki	valley, ravine	school	road; mountain	Kam I Times	ancestors	0.75	4718	NR 690v8, FT 34v5, NT 473v4	
4781	Nakuapuu	1	1			Pueopaku	Hina	2 house lots, 1 cultivated kihapai	konohiki	konohiki	konohiki	konohiki	1833	Kaikona/ Kahakona	1.42	4679	NR 690-691v8, FT 42v5, NT 485v4	
4783	Nakai	1	1			Papaikou	Pihau	1 house lot, 1 partially cultivated kihapai	Kanihoukaaki's land	stream	Puapaa's land	road	Kam I Times	ancestors	4.46	6683	NR 691v8, FT 33v5, NT 458v4	
4784	Nuki	1	1			Paukaa	Halekane	2 houses, 1 cultivated kihapai	Kameanui's land	konohiki	road	stream	N/D	Nihi	2.47	4852	NR 691v8, FT 31v5, NT 461v4	
4897	Kiolakia	1	0			Alakahi	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 334v4	

Table 2. Land Commission Award Claims (cont.)

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4968	Kuheana	3	2			Paukaa	Alahale						Kam I Times	ancestors	4.97	4690	NR 693v8, FT 39v5, NT 478v4	Awarded 2 apana
					1			2 houses, 3 cultivated kihapai	konohiki	konohiki	road	road						
					2			1 cultivated kihapai	konohiki	stream	stream	stream						
					3			canoe house	konohiki	konohiki	konohiki	konohiki						
4969	Kalama	1	1			Paukaa	Kapoho	2 cultivated kihapais	Haopu'i land (idle land)	konohiki (idle land)	Maa and Kamokuahua's (Nahakuahua's) land	stream	Kam I Times	ancestors	1.88	4689	NR 693-694v8, FT 20v5, NT 449-450v4	
4970	Kohuna	1	1			Pueopaku	Makakiloia	1 house lot, 2 cultivated kihapais	road	stream	ocean, stream	konohiki	1834	Kahikona Polaole	2.42	4655	NR 694v8, FT 30v4, NT 466v4	other claimant - Samuela (father)
4972B	Kahiwa	1	1			Paukaa	Kalaekapola	2-4 houses, 1 cultivated kihapais	Maa's land	Paahua's (Kapahuaa's) land	ocean	river	1842	Ahaokalani	2.07	5032	NR 694-695v8, FT 19v5, NT 428v4	Awarded 2 apana
4975	Kukalpule	1	1			Pueopaku	Piapau	1 house lot, 1 cultivated kihapai	konohiki	stream	ravine, valley	Kohuna's land	Kam I times	konohiki	0.35	4672	NR 686v4, FT 43v5, NT 485-486v4	
4976	Kuhipono	1	1			Papaikou	Puhau	2 houses, 1 cultivated kihapai	konohiki	road	Keahi's land	stream	Kam I times	ancestors	2.66	4662	NR 695v8, FT 32v5, NT 464v4	
4977	Kahaanakahi	1	1			Papaikou	Puhau	3 houses, 1 partially cultivated kihapais	konohiki	Mokihana 2	ocean	Kahiwi's land	Kam I Times	ancestors	3.86	4694	NR 695v8, FT 33v5, NT 460v4	
4978	Kanakaoka	1	0			Papaikou	Puhau	1 house, 1 partially cultivated kihapai	road	stream	ocean	Maula's land (stream)	Kam I Times	ancestors	0.00	none	NR 695v8, FT 33v5, NT 459-460v4	
4979	Kanahu, wahine	1	1			Papaikou	Puhau	2 houses, 1 cultivated kihapai	Kahipa's (Kalupa's) and Kehua's (Kekua's) land	stream	road	road	Kam I Times	ancestors	2.65	4680	NR 695-696v8, FT 32v5, NT 454-463v4	
4991	Kuikaua	1	1			Papaikou	Puhau	2 houses, partially cultivated moo	Keali'i's (Keahi's) land	road	Kanaka's (Kanaha's) land	stream	Kam I Times	ancestors	0.68	4685	NR 696-697v8, FT 31v5, NT 462v4	
4992	Keahi	1	1			Papaikou	Puhau	2-3 houses, 2 cultivated kihapais	Kuhipono's (Kamoenui's) Land	Pahoehoe (road)	Kahala's land	stream	Kam I Times	ancestors	0.62	6745	NR 697v8, FT 31v5, NT 461-462v4	
4993	John B. Kakua	1	1			Papaikou	Puhau	2 houses, 1 partially cultivated kihapai	Waikoloa's (Waikalo's) Land	stream	Kuikaua's land	road	Kam I Times	ancestors	1.97	5407	NR 697v8, FT 31-32v5, NT 463v4	
5008	Kaumhumi	2	3			Puumoi	Mokuhooniki, Kahuahole						Kam I Times	ancestors	1.38	none	NR 700-701v8, FT 40v5, NT 480v4	awarded 3 apana; no data on third parcel
					1			1 field, 1 house	Kalamahina's land	konohiki	Hua's land	konohiki						
					2			3 fields, 1 house	konohiki	konohiki	konohiki	stream						
5052B	Kahehaikaikeahi	1	1			Papaikou	Puhau	1 house, 1 cultivated kihapai	konohiki	stream	Haleli's land	road	Kam I Times	ancestors	1.47	7260	NR 699v8, FT 33v5, NT 458v4	
5096	Kapuhaula	2	1			Papaikou	Mokupuni								1.50	4684	NR 699v8, FT 41v5, NT 483v4	unclear which parcel awarded
					1			1 house lot, 2 cultivated kihapais	konohiki	Inaina's land	road	stream	N/D	N/D				
					2			1 house lot, 2 cultivated kihapais	konohiki	Inaina's land	konohiki	konohiki	1839	Kuhlo				
5097	Kaha	1	0			Papaikou	Puhau	houses, cultivation	N/D	N/D	N/D	N/D	N/D	ancestors	0.00	none	NR 387v8, FT 54v5	
5098	Kalikelekahi	1	1			Pueopaku	Papaioloa	2 houses, 1 cultivated kihapai	Mahi's land	valley, ravine	road	pali	1829	Ana Kaeo	2.35	4688	NR 699v8, FT 42v5, NT 483-484v4	

Table 2. Land Commission Award Claims (cont.)

LCA	Claimant	Apana claimed	Apana awarded	Other Claims	Section No.	Ahupua'a	Ili	Land Use	Boundary Mauka	Boundary Hamakua	Boundary Makai	Boundary Puna	Date Rec'd	Giver	Acreage	Royal Patent	Sources	Comment
5103	Kamaka	1	1			Papaikou	Pihau	2 houses, 1 partially cultivated kihapai	Kuikaua's land	road	path	stream	Kam I Times	ancestors	3.16	6681	NR 699-700v8, FT 33v5, NT 45fv4	
5111	Kaniho	3	1			Pauka'a		1 houselot, 2 cultivated kihapai's					Kam I Times	ancestors	2.19	4660	NR 701v8, FT 20v5, NT 429v4	unclear which parcel awarded
					1		Papaikou	1 house, 1 field	Palapala's land	Paaoao's land	ocean	valley						
					2		Makaiaki	1 partially cultivated field	road	konohiki	konohiki	Government land						
5210	Kahepa	1	1			Papaikou	Pihau	1 house, 1 partially cultivated kihapai	konohiki (idle land)	stream	Kalua's land	road	N/D	ancestors	1.28	4681	NR 701v8, FT 20v5, NT 429v4	
6247H	Kanauka	1	1	4		Puumoi	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	Kam. III	847.00	7999	NR 270-271v5, NT 355v10	Awarded entire ahupua'a, award also includes lands on Oahu and Maui
7673	N. Kuhio	1	0			Papaikou	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 430v5	claimed one half of Papaikou
7713	Victoria Kamamalu	2	2	19		Onomea	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	2579.00	8117	NR 440-444v5, 569v5, FT 408-411v3, 538-539v3.	Awarded entire ahupua'a, award also includes lands on Oahu, Molokai, and Kauai
						Pahoehoe	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	1385.00	6860		Awarded entire ahupua'a
7715H	Lota Kapuaiwa	13+	1	12+		Pauka'a	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	6200.00	8335	NR 434v3, NR 444-445v5, NT 244v10	Awarded entire ahupua'a, award also includes lands on Oahu and Maui
7753	Kahikona	1	1			Puueopaku	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	58.65	7716	NR 669v8, FT 215v10	1/2 of Puueopaku ahupua'a
8559	William Lunalilo	1	1	30+		Makahanaloa	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	7600.00	7192	FT 551v3, 82v16, NT 450v10, 82v16.	Awarded entire ahupua'a
8629	Kaapa	2	2	1		Kalaoa		N/D					N/D	N/D		5542	NT 704v8, FT 80v5, 92v5, NT 408v4	
					1		Ulumalu		konohiki	konohiki	konohiki	stream/ Ajeamui			19.52			Apana 1
					2		Kuluou		konohiki	stream/ Puumoi	konohiki	konohiki			5.68			Apana 2
8884	Kaweakiaiea	1	1			Kalaoa	Waikii	house lot, cultivated field	road	Ili Alaalaa	konohiki	konohiki	N/D	N/D	1.21	none	NR 706v8, NT 474v4	
10164	Moku	1	1			Puumoi	Mokuhoonuki	1 cultivated kihapai	Kua's (Hua's) land	stream	konohiki	konohiki	N/D	ancestors	0.37	none	NR 708v8, FT 37v5, NT 475-476v4	claimed entire ili
11045	Barenaba	1	0			Puumoi	N/D	ocean access	N/D	N/D	N/D	N/D	N/D	N/D	0.00	none	NR 708v8, FT 39v5, NT 480v4	land said to be formerly part of Alakahi
11215H	Aarona Kaaliiahonui	1	1	7+		Papaikou	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	14000.00	none	NR 362-363v4	Awarded entire ahupuaa, also awarded lands on Oahu and Kauai
11216H	Mikahala Kekauonohi	1	1	27		Hakalau Nui	entire ahupua'a claimed	N/D	N/D	N/D	N/D	N/D	N/D	N/D	12580.00	7541	NT 334v10	Awarded entire ahupua'a

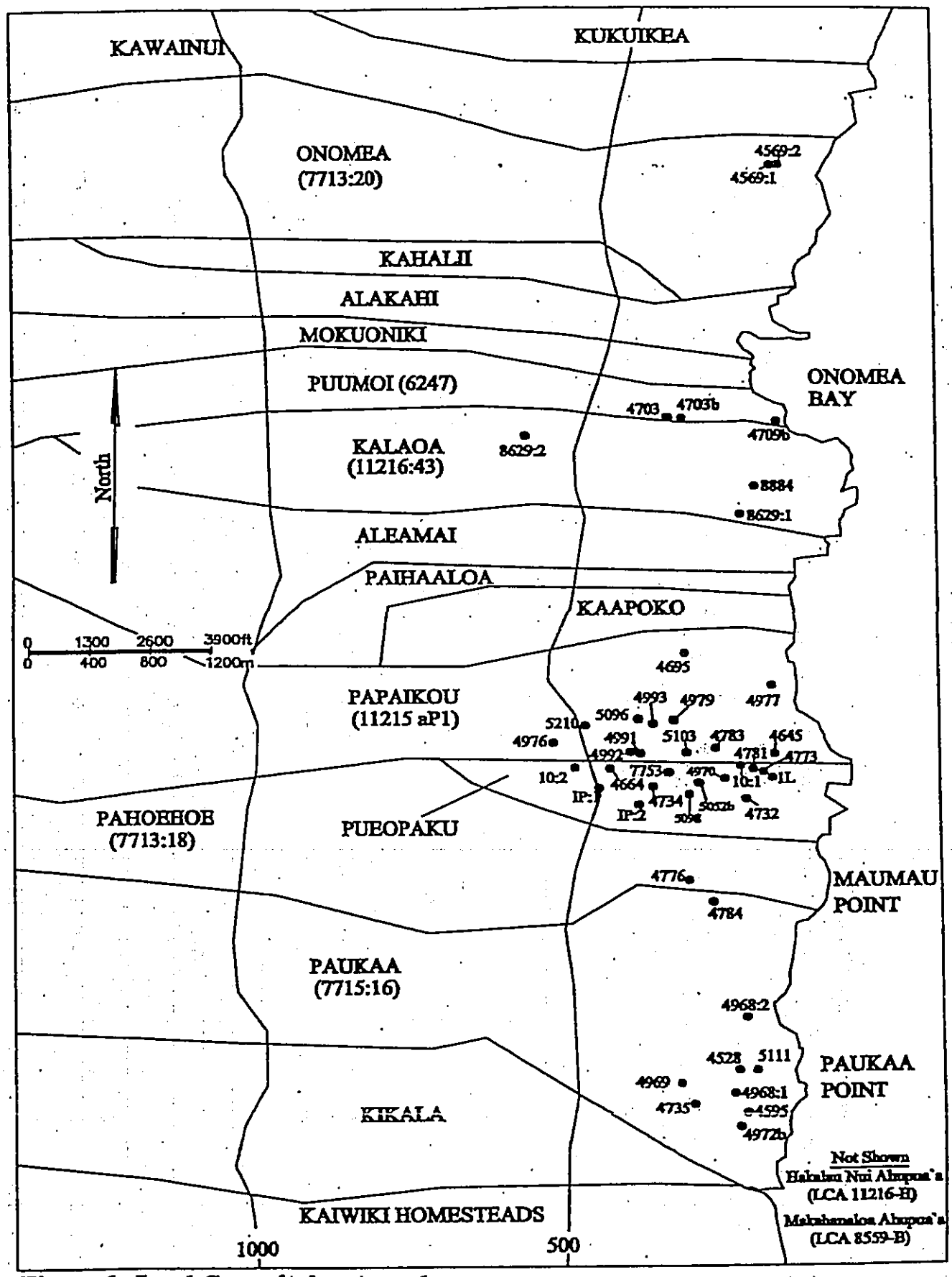

Figure 6. Land Commission Awards

acres. LCA 8629 awarded to Kaapa in Kalaoa consisted of two large *kuleana* parcels of 5.68 acres and 19.5 acres in area.

Nearly all of the *kuleana* awards are for parcels situated within one mile of the coast below 500 ft elevation. Land use described in the LCA claim testimony includes references to 97 houses in 56 claimed house lots, three canoe houses, over 80 cultivated fields, and a tanning establishment. Specifically mentioned crops consist of taro, coconuts, coffee, and bananas. The tanning establishment, 5,000 coffee trees, three acres of taro, and five houses were claimed by William McKenny (LCA 2256) in Kawainui 2, but were not awarded.

The majority of *kuleana* lands were received from the claimant's parents or ancestors (32 cases). Five were received from the *konohiki* and two each were given by Nihi in Pauka'a, Kuhio in Pāpa'ikou, Kalau in Pu'umoi, and Kahekona in Pueopaku, suggesting they may have been *konohiki*. The konohiki, Akahi, is named as the donor of the lands claimed by William McKenny in Kawainui. Seventeen claimed lands were transferred to the claimants during the time of Kamehameha I. The remaining lands, which have conveyance information, were transferred between 1829 and 1847.

The Early Historic Period

The focus of many of the early travelers to Hilo was the trek up to the volcano, which seems to have diverted attention away from the south Hilo coast, however there were a few early visitors who wrote about the overall area.

The first Western description for the south Hilo coast comes from William Ellis in 1823, an English missionary who toured the Island of Hawai'i. He walked the Puna coast to Hilo Bay, where he departed from Wailuku by canoe and sailed to Laupāhoehoe. Unfortunately, he did not actually hike through the South Hilo area, but he wrote down his impressions from the sea:

> The face of the country by which we sailed, was fertile and beautiful, and the population throughout considerable. The numerous plantations on the tops or sides of the deep ravine, of vallies [sic.], by which they were frequently interspersed, with the meandering streams running down them into the sea, presented altogether a most agreeable prospect. (1965:191)

In 1824, a group of Protestant American missionaries (Joseph and Martha Goodrich; Samuel and Nancy Ruggles) established the Hilo Mission Station. Soon, a flow of foreign vessels began making Hilo Bay a regular stop for repairs, supplies and outfitting (Kelly *et al.* 1981:49; McEldowney 1979:12; Benedetto 1982:32).

In 1825, Andrew Bloxam, a naturalist, came to Hawai'i on the ship, "Blonde". Bloxam was only 23 years of age at the time he with Lord Byron on the voyage. Lord Byron was returning the bodies of Liholiho (Kamehameha II) and his wife, Kamāmalu, who had died in London of measles. The ship landed at Hilo Bay on May 3rd and it gives another early description of the bay and the South Hilo area. He wrote in his journal about Hilo Bay:

> From this place [at sea] the outline of the land rose graduallyh to the northward uninterrupted by abrupt peaks or rocks until we lost it in the thick clouds of mist covering the hills in the neighborhood of Aheedo [Hilo]. Mauna Kaah [Mauna Kea] was completely obscured from our sight by the same cause.
>
> As we were desirous of reaching Aheedoo Bay...we ran along the coast towards it, keeping at a distance of about three or four miles from the shore, upon which we could distinguish the surf breaking with some violence. On some parts [of the coast] quantities of large scattered stones and pieces of rock and on others a low, black colored cliff of lava formed the boundary of the sea. We could distinguish several straw huts here and there, looking like so many haystacks with only one low entrance as a door and no window.

> Quantities of coconut, breadfruit and other trees, with here and there a green and verdant open space, met our eyes as we sailed onwards. On one spot we could clearly distinguish a very beautiful cascade of water, surrounded with crags and brushes, no doubt forming a very picturesque object when close to...The weather was so thick and cloudy upon the upper parts of the hill, that we could not during the whole day gain a sight of the snow clad summit of Mouna Kaah. (1925:20-21)

Bloxam gives a further brief description of the countryside:

> The country about Aheedoo appears much like a park in England, everything is green and verdant with numerous trees scattered about, and here and there a romantic waterfall, upon the whole we are delighted with its appearance. (*Ibid.* 22)

In 1840, Charles Wilkes and the United States Exploring Expedition arrived at Hilo Bay. The company stayed for 40 days. During that time, an expedition party spent 20 days mapping the summit crater of Moku'āweoweo Mauna Loa. They employed a large group of Hawaiians to carry equipment, food and supplies. Lack of decent clothing forced most of the Hawaiians to return before reaching the summit. The porters were replaced by volunteer sailors who boots quickly wore out on the lava and they became injured and lame (Kelley *et al.* 1981:55; Fitzpatrick 1986:91). The Wilkes Expedition impacted the native culture and introduced a "western, salary-based, non-subsistence economy". (Tomonari-Tuggle 1996:35).

In 1848, the formal dividing of lands (the 'Māhele) occurred. This event changed forever the traditional subsistence based life style of the native Hawaiians. As a result of the *Māhele*, the Hawaiian Government required the boundaries for land awards be surveyed. At the time, there was a shortage of surveyors and young men like C. J. Lyon (he was seventeen at the time) and H. M. Lyman, both missionary children, were employed by the government to conduct surveys (Fitzpatrick 1995:60). The Boundary Commission heard testimony from knowledgeable informants, both native and foreign. Within the project area, the majority of the informants were canoe makers, bird hunters and bullock hunters. One must remember that the division of lands occurred in 1848. But, often, it was several years later before the land was actually surveyed, during which time changes were occurring. In an 1851 letter, Lyons writes about the complexities of the *Māhele* as they were taking shape.

> If a man has walled in his yard since I have been here in the valley but before I come to survey it/i.e. if the survey is not purposely delayed; as he not a right to what is walled in. (Lyons *in* Fitzpatrick 1995:62)

Another complexity was how much land to award to Hawaiians who moved their patches from year to year to let the land lay fallow. He wrote:

> Some agents gave only the particular patches then under cultivation – stingy they- while others, too generous, gave from twenty to forty acres. The rule was to give what the natives improved. I multiplied the average cultivation by the number of years of fallow, or rest – three acres by three – and decided upon ten acres as a fair number, so the Hāmākua natives have an average of ten acres to the kuleana. It was of no use to wait for orders from headquarters, so I acted for myself, and was approved. (*Ibid.* 60)

At seventeen, Lyons was forced to make his own decisions rather than wait for a reply from the government.

By the late 1850's whaling was coming to an end and was being replaced by sugar. Along the south Hilo coast, plantations and mills began operating in: Paukaāa, Pāpa'ikou, Pepe'ekeo, Onomea, and Hakalau. The Pepe'ekeo Sugar Plantation acquired 7, 600 acres, part of which was in Makahanaloa. Only 445 acres were actually cultivated in cane and the rest was left in forest. Pāpa'ikou, Hitchcock and Co. had 11,000 acres which extended 15 miles inland of the coast. However, only 585 acres were in cane (Tomonari-Tuggle 1996:36). The sugar plantations encroached on the upland forests not only to expand their fields, but also to cut firewood to run the mills. Logging for wood was a practice that began when ships first arrived in Hawai'i and especially during the whaling period (Kuykendall (1968:308).

In 1873, Isabella Bird visited Hawai'i and her adventures were documented in letters she wrote to her sister in Scotland. She often stayed in Hilo, but she spent much of her time saying with the Austins who owned the Onomea Plantation. The plantation had opened ten years earlier, in1863, by Stafford L. Austin and E. H. Allen. Onomea Plantation had a reputation for being one of the best-equipped plantations along the south Hilo coast. In 1888, three smaller plantations consolidated to form Onomea Sugar Company. The three plantations were Pauka'a, Pāpa'ikou and Onomea (Hawai'i Sugar Planters Association Archives).

On one occasion, Isabella Bird traveled the south Hilo coast by horseback on a trip to Waip'o. And she commented on the horse trail leaving Hilo:

> The track crosses the deep, still Wailuku River on a wooden bridge, and then after winding up a steep hill, among native houses fantastically situated, hangs on the verge of the lofty precipices which descent perpendicularly to the sea, dips into tremendous gulches, loses itself in the bright fern-fringed torrents which have cleft their way down from the mountains, and at last emerges on the delicious height on which this house is built [home of the Austins]. (Bird1986: 110-111)

She continues her description of Onomea as she traveled along what is called the Onomea Scenic Route today and gives a general description of the view *mauka*.

> Onomea is 600 feet high, and every yard of the ascent from Hilo brings one into a fresher and purer air. One looks up the wooded, broken slopes to a wild volcanic wilderness and the snowy peaks of Mauna Kea on one side, and on the other down upon the calm blue Pacific, wrinkled by the sweet tradewind, till it blends in far-off loveliness with the still, blue, sky; and heavy surges break on the reefs, and fritter themselves away on the rocks, tossing their pure foam over *ti* and *lauhala* trees, and the exquisite gems a nd trailers which mantle the cliffs down to the water's edge. (*Ibid.* 111)

She describes the view *mauka* from Kaiwiki sugar plantation and speaks generally about the plantations in the Hilo District.

> ...the uplands slope away to the colossal Mauna Kea. The actual, dense, impenetrable forest does not begin for a mile and a half from the coast, and its broad dark belt, extending to a height of 4,000 feet, and beautifully broken, throws out into greater brightness the upward glades of grass and the fields of sugar-cane...
>
> The plantations in the Hilo district enjoy special advantages, for by turning some of the innumerable mountain streams into flumes the owners can bring a great part of their cane and all their wood for fuel down to the mills without other expense than the original cost of the woodwork. Mr. A. [Austin] has 100 mules, but the greater part of their work is ploughing and hauling the kegs of sugar down to the cove, where in favorable weather they are put on board of a schooner for Honolulu. This plantation employs 185 hands, native and Chinese an turns out 600 tons of sugar a year. (*Ibid.* 115-116)

Ms. Bird describes a fern-hunting trip in Onomea "on the margin of the forest".

> We rode in the *mauka* direction...till we reached the verge of the forest, where an old trail was nearly obliterated by a trailing matted grass four feet high, and thousands of woody ferns, which conceal streams, holes, and pitfalls. When further riding was impossible, we tethered our horses and proceeded on foot. We were then 1,500 feet above the sea by the aneroid barometer, and the increased coolness was perceptible...The forest would be quite impenetrable were it not for the remains of wood-hauling trails, which though grown up to the height of my shoulders, are still passable...There were some very fine tree-ferns (*Cibotium Chamissoi?*) two of which being accessible, we measured, and found them seventeen and twenty feet high, their fronds eight feet long, and their stems four teen ten inches in circumference three feet from the ground...The forest soon became completely impenetrable, the beautiful Gleichenia Hawaiiensis forming an impass-

> able network over all the undergrowth. And, indeed, without this it would have been risky to make further explorations, for often masses of wonderful matted vegetation sustained us temporarily over streams six or eight feet below. (*Ibid.* 124-128)

Ms. Bird also notes some of the native vegetation observed on her wanderings through south Hilo: bananas, *noni*, *koa*, *'ōhi'a*, *lauhala*, breadfruit, kukui and different varieties of ferns. Of all the early 19th century visitors, Isabella Bird gives one of the most colorful descriptions of the south Hilo coast and the forested areas where the lower portions of the project site impinges on.

The interview with Antone Medeiros revealed an interesting story about Pākē, a Chinese man who lived in the Pauka'a mountains, above where the present mill for the project site is today. He would peddle home-grown vegetable, wild water cress, fruits and other things to make survive in the woods. The man supposedly disappeared and it is rumored he died somewhere in the mountains. This would have been about the 1890's – turn of the century.

The Early 1900s To The Present

By the 1900's, changes to the native forests were occurring. Encroachment on the forest boundaries by large land owners, native bird extinction due to over hunting, forest fires, wild cattle and feral sheep, the introduction of non-native tree species – these all impacted the forested areas.

In the south Hilo district, the sugar industry controlled the majority of the flat fertile lands below the lower forest boundary. Over the years, the plantations had slowly begun encroaching on the native forests and the edge of the forests were pushed further *mauka*. From the 1860's, plantations used wooden flumes to divert water and transport wood and cane. An 1868 description gives one an idea of the quantities of wood used by the plantations in the south Hilo District and how over time this would greatly impact the forests.

> The flumes now extend up into the forests and immense quantities of wood are brought down...The flume on the Onomea Plantation [Pauka'a and Pāpa'ikou], we were informed, answered to bring down seventy-five cords of wood in a single day...The Hitchcock brothers have a flume on their ranch [Pāpa'ikou] which is used alone for the transportation of wood and lumber. Their flume is three and a half miles long. (Culliney *in* Tomonari-Tuggle 1996:19)

In addition to this, the need for firewood by the sugar mills caused further encroachment and depletion of the native forests. Following is a 1904 account:

> In southern Hāmākua and Hilo, in Hawai'i, a few of the mills are still consuming a large amount of native wood, and two or three, with surprising lack of foresight, are cutting away the timber which lies just above their plantations and upon which probably their water supply largely depends. (Hall 1904:20)

In 1905, the Hilo Forest Reserve was formed to protect 110,000 acres of the upper slopes of Mauna Kea and the water shed from which so many large land owners depended. About the same time, the Territorial Bureau of Forestry began reforestation projects using introduced tree species like eucalyptus (*Eucalyptus* spp.), Sugi pine (*Cryptomeria joponica*), and other s. It is likely that some of the eucalyptus trees in the project area were planted during this time. Also, portions of the eucalyptus in the project site was planted later in the 1930's by Onomea Sugar Company as an experiment to make charcoal (Antone Medeiros Interview). The project didn't pan out and the idea was abandoned. *Figure 7 is* a porion of Wall's 1922 "Map of the Hilo Forest Reserve. This map shows the Onomea, Pepe'ekeo, and Honomū Sugar Companies occupying the lands below the forest reserve boundary. The map also shows the subdivision of mid-elevation lands into smaller homestead lots in Kaiwiki, Honomū, and on the south side of Pauka'a.

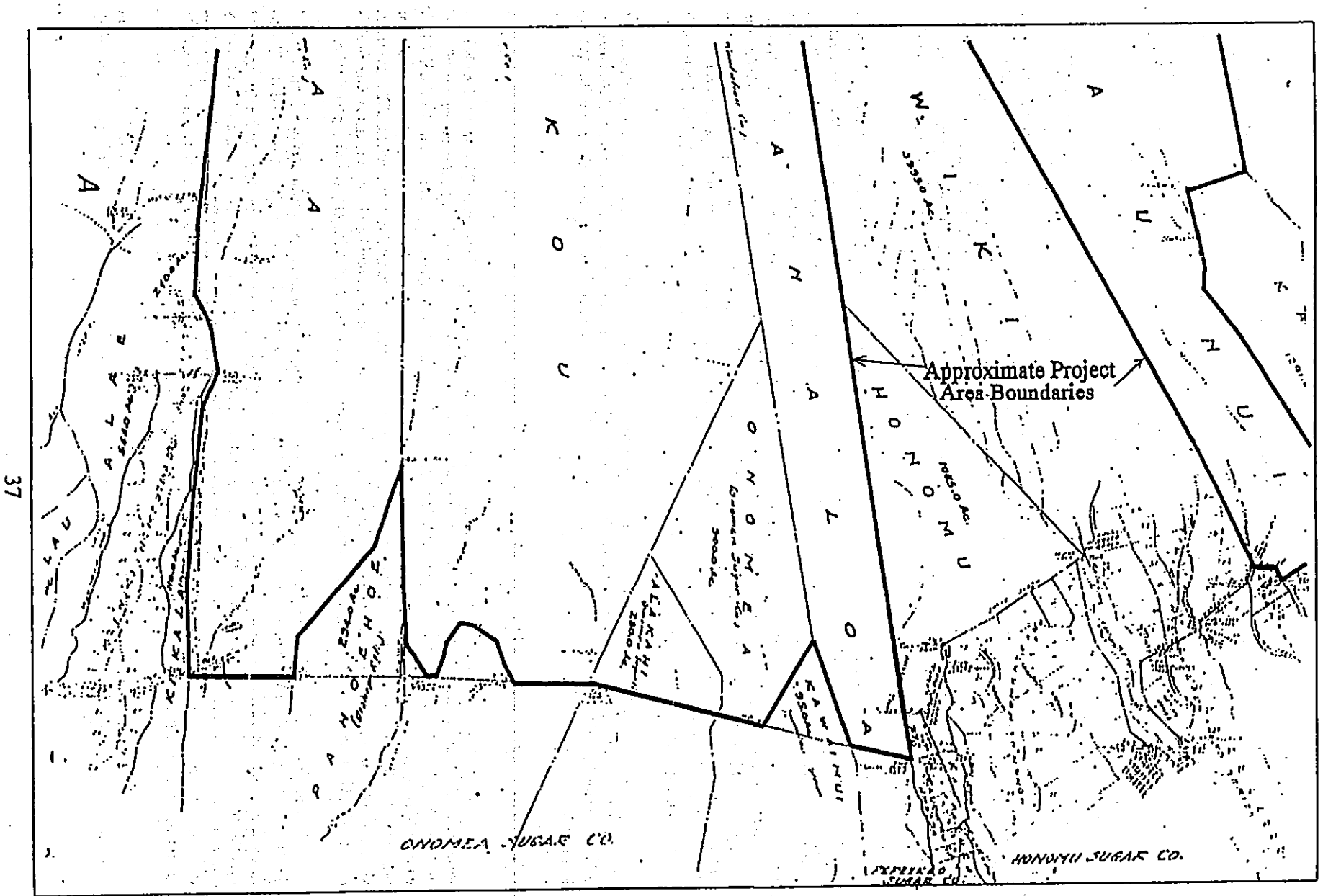

Figure 7. Portion of Wall's 1922 Map of Hilo Forest Reserve

A 1923 Hawai'i Consolidated Railway map shows the railway paralleling the coast from Hilo to the Pa'auilo Mill. The Pāpa'ikou, Pepe'ekeo,.Honomū, and Hakalau Sugar Mills are situated along the coast (*Figure 8*).

In the 1930's, the Civilian Conservtion Corps (CCC) was established by the federal government. The CCC took on projects like building fences as a means of animal control (feral sheep) and tree planting. A major fence line, 60-miles long, was contrasted around Mauna Kea (Bairos 1940). The CCC may have done additional tree plantings bordering the project area.

Pepe'ekeo Sugar Company leased lands in Makahanaloa, as well. A 1931 map of Makahanaloa depicts several facilities in or adjacent to the project area (*Figure 9*). The Company's waterheads are situated on Wai'a'ama Stream on the south side of Ka'uku Hill and on a branch of Kawainui Stream just north of the inland tip of Kawainui *Ahupua'a*. A "camp site" is shown immediately south of the latter "old" waterhead. A third waterhead feeding a ditch belongint to the Onomea Sugar Company is situated further down the same branch of Kawainui Stream. The waterhead beside Ka'uku Hill feeds a flume that flows along the contour around the hill to a point on the east side where it feeds a flume running seaward. A dashed line, potentially representing a road or trail extends between the two Pepe'ekeo waterheads and the campsite.

Pig hunting is a popular activity within the lower portions of the project area. Pig hunting has remained a tradition in some families for more than a few generations. One Hawaiian hunter, from Kaiwiki, stated his family has hunted in the area for at least seven generations (Pers. Comm., Race Ka'awa, 12/27/00). The Medeiros family (Antone Medeiros interview) represents five generations of hunting in the area. The hunters all have their own trails, though the commonly used ones are in Pauka'a, Pāpa'ikou, Pueopaku and Onomea. Another hunter, who grew up in Pu'u Moi, related that until the mid-1940's, his family hunted pigs with metal spears fashioned at home over the fire and anvil. It wasn't until 1946, when his uncle bought a rifle, that they made the transition to guns [dogs were used to trap the pigs first] (Pers. Comm., Sam Balgado, 1/4/01). For some families, besides being a sport, pig hunting supplies them with extra food, especially for parties and *lū 'au*.

In addition to pig hunting, the hunters also access the streams and a few other areas to gather food resources such as: *'ōpae* (shrimp), *hīhīwai* (*Neritina granosa*), prawns and *hō'i'oī* (*Diplazium [Athyrium]*), watercress and bamboo shoots and fruits. In times past, before they came endangered, they caught *'o'opu* in the streams, too.

Summary Of Land Use

No previous archaeological studies have been conducted in the project area. The early 1900s surveys by Stokes and Hudson identified a few sites along the coast and reported the former presence of several heiau, none of which are in project area *ahupua'a*. Hudson's informants reported that Kauku Hill in Makahanaloa, partially within the project area, was used as a signal station. Subsequent studies elsewhere between the Wailuku River and the Hamakua District boundary did not identify any traditional Hawaiian sites except along the north bank of the Wailuku River near Hilo. The absence of sites in most of the previous studies is attributable to historic land modification primarily associated with sugar cane plantations.

McEldowney's (1979) settlement pattern model for the Hilo area is applicable to the project area. The project area lies within her Lower Forest Zone between 1,500 ft and 2,500 ft elevation, and the Rainforest Zone between 2,500 ft and 5,000 ft elevation. The Lower Forest Zone was the source for timber and other forest resources such as medicinal plants, *olona*, and birds. Predicted site types consist of temporary habitations, trials, shrines, and minor agricultural features in forest clearings and along streams. Sites in the Rainforest Zone are limited to trails and associated temporary habitations. This zone was used for intra-island travel and gathering of resources including hardwoods and birds.

The LCA data indicate that by the early to mid-1800s the primary traditional Hawaiian settlement and agriculture in the project area *ahupua'a* was situated 2.5 to 3.5 miles east of the project area, primarily

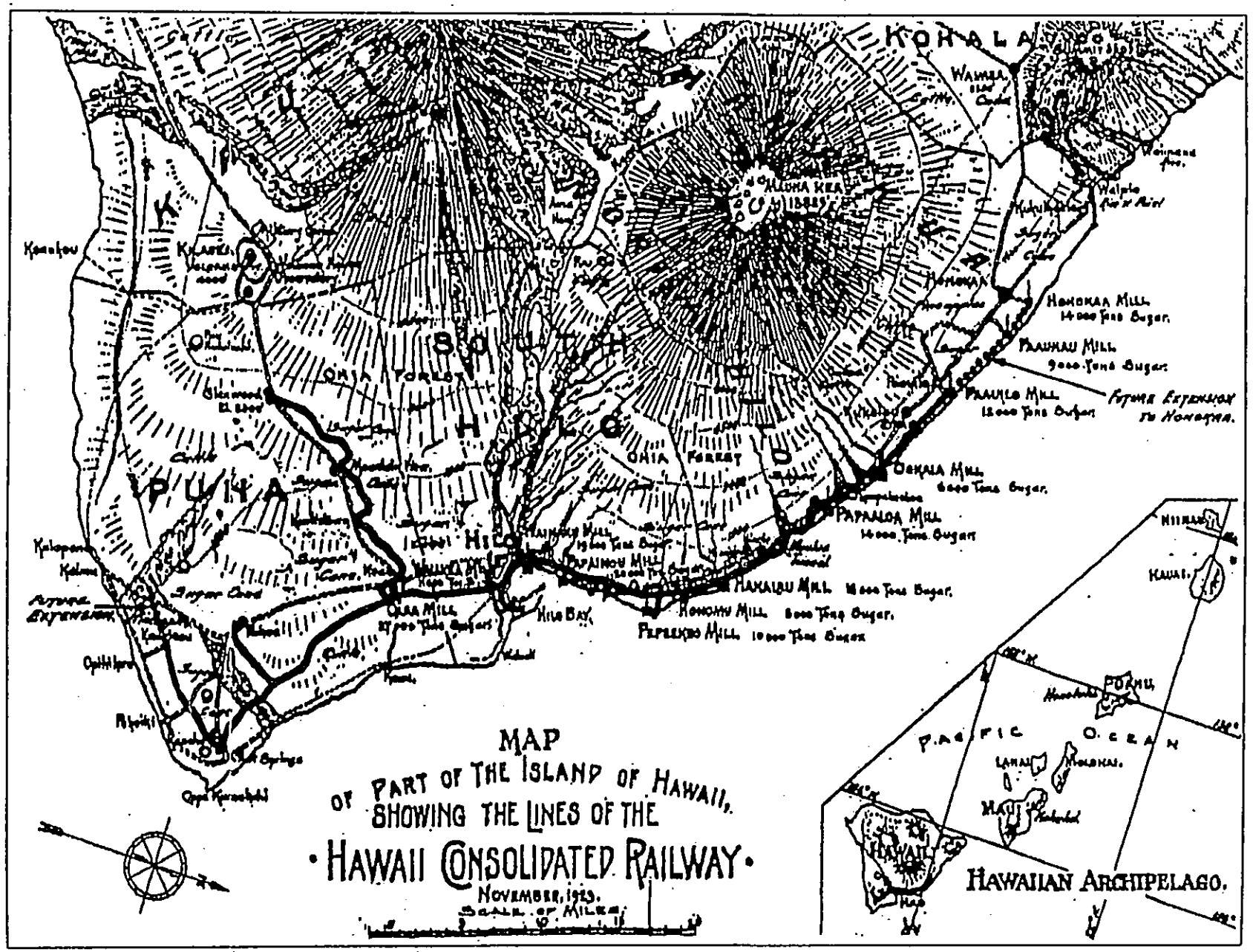

Figure 8. 1923 Map of Hawaii Consolidated Railway

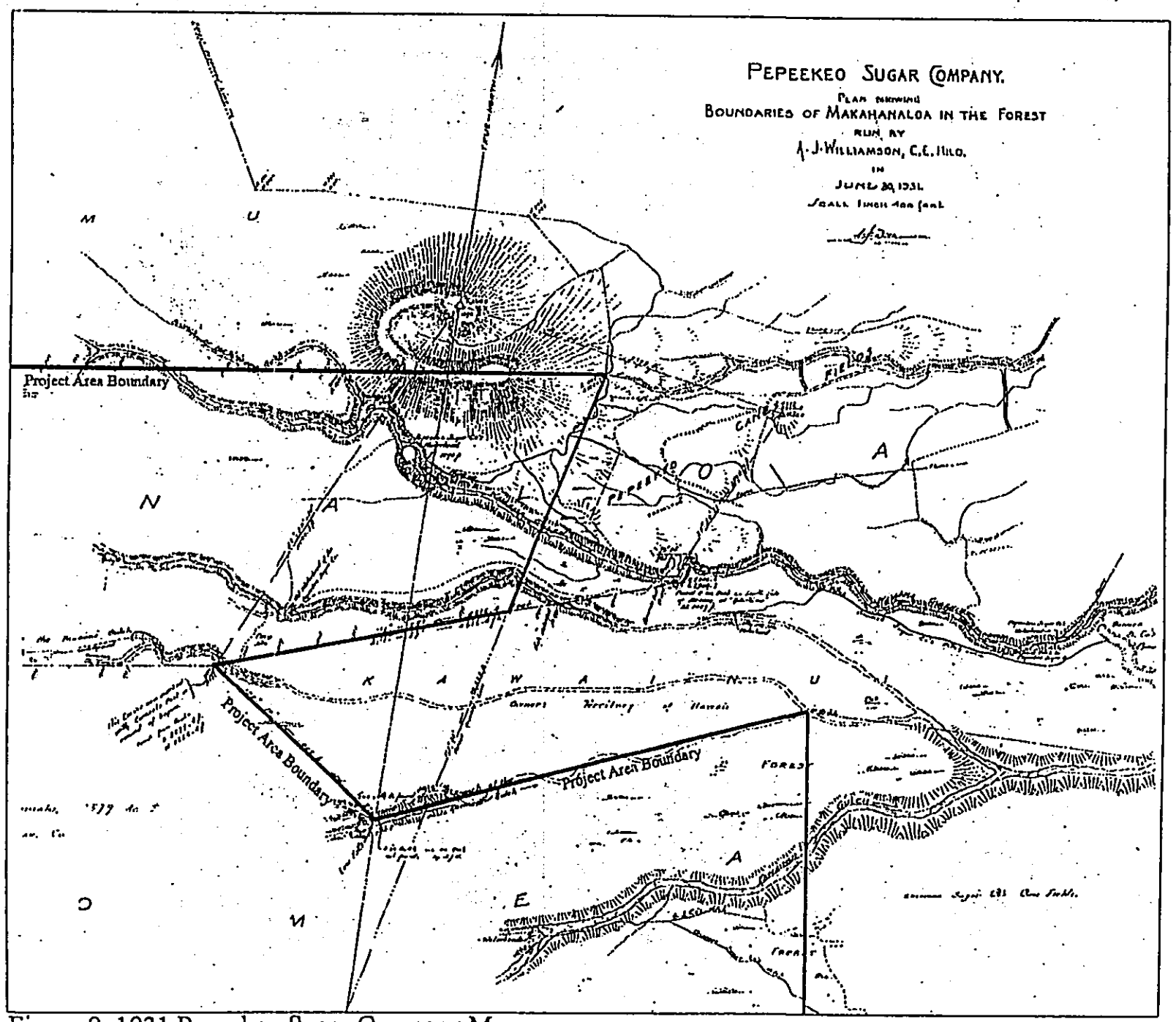

Figure 9. 1931 Pepeekeo Sugar Company Map

below 500 ft elevation. The LCA testimonies document many residential structures and cultivated fields. Named crops consist of coconuts, bananas, taro, and coffee. Other probable crops include breadfruit, *wauke*, sugar cane, and sweet potato. Canoe houses are mentioned in Pu'umoi and Pauka'a indicating access to the ocean and marine resources.

The Boundary Commission testimonies describe activities conducted in the project area including bird catching, canoe building, bullock hunting, and gathering of *olona* and *pulu*. Settlements for bird catchers and canoe makers are also described. The settlements were probably occupied on a temporary basis by individuals whose permanent residences were close to the coast. The residential structures in these settlement were likely constructed entirely of wood and thatch because the structures were temporary and surface stone is rare. The trails described in the testimonies seem to have been primarily associated with the bird hunting and canoe building activity as opposed to transiting the upland forests to reach the upper edge of the forests. Most of the testifiers had little or no knowledge of the uppermost *ahupua'a* boundaries. In general, the testimonies suggest that the activities, trails, and settlements described in the late 1800s were no longer in use. There is one reference to a probable shrine on the south bank of Waiama Stream opposite Uka Hill, which is a short distance seaward of the project area.

Historic use of the project area *ahupua'a* was dominated by sugar cane plantation agriculture beginning in the mid-1800s and continuing in some areas until the 1990s. The majority of planataion activity was situated seaward of the project area where fields where located. Plantation worker camps were scattered over the countryside connected by roads to the plantation villages at the sugar mills at Papaikou, Pepeekeo, Honomu, and Hakalau. A railroad system connected the mills to the port at Hilo. Plantation-related activities that extended into the lower portion of the project area included the construction of water distribution systems and timber harvesting for lumber and firewood. Diversion structures in the Waiama, Kawainui, Kalaoa, Pahoehoe, and other stream drainages were constructed to feed flumes and ditches, which were used to transport wood and sugar cane. An early 1900s map of Pepeekeo Sugar Company lands in Makhanaloa depicts a camp site in the project area that was probably used during construction of a diversion structure and flume.

Hunting has been a regular activity for many families along the south Hilo coast and there are some families with hunting traditions that go back to the early 1800's. After the introduction of guns, Hawaiians began using firearms to hunt birds and wild cattle in the project area. By the late 1800's pig hunting became another way to continue to practice a quasi-subsistence lifestyle. One still depended on a cash economy, but large families supplemented their diet and food supply by pig hunting; making sausage, smoked meat and salt pork. One family in particular took longer to adapt to modern hunting techniques. They hunted with home-made metal spears (and dogs) until the mid-1940's. Presently, the project area is predominantly utilized by pig hunters who have maintained their family traditions passed down to them. They hunt primarily for pig and on a much smaller level, gather food resources from mountain streams including i.e., fresh water shrimp, prawns, fern shoots, and other fruits and vegetables when they are in season.

INFORMANT INTERVIEWS

Two informants were identified as being knowledgeable about the project area based on their usage of the area for pig hunting and some gathering of plant and aquatic stream resources. It should be noted that both informants are not of Hawaiian descent, however, they have spent all of their lives hunting and hiking throughout the study area. This study was not able to identify any knowledgeable Hawaiians with cultural knowledge who would formally step forward to be interviewed. Many of the people in the Hawaiian community who were contacted had only limited knowledge related to their personal use, almost all of which occurred outside of the study area and near the shoreline. No doubt, the sugar plantation industry, which dominated the South Hilo area for over a century, impacted the Hawaiian cultural use and knowledge of the study area. Since the informants were related (father and son), a joint interview was conducted at the home of Antone Medeiros. Both informants belong to a hunting club – Pig Hunters of Hawai'i and Antone's oldest son, Thomas, was the previous club President. The Medeiros family represents five generations of hunters who have hunted in the vicinity of the project area for over 100 years. A brief sketch of each interview informant is included here.

Antone Medeiros was born at Paiha'aloa in 1921 and he has just turned 80 years of age. Mr. Medeiros is of Portuguese descent and currently resides at Pāpa'ikou where he has lived for most of his life. Antone's grandfather, Antone Medeiros Chiquita, immigrated to Hawai'i from Portugal sometime in the 1870's and took up employment with the Onomea Sugar Company where he worked until he retired. Antone's father, Marion Madeiros (the Chiquita was dropped) took up in his father's footsteps, as did Antone. Both of them were raised on the plantation and both worked for the plantation until retirement. Antone's father and grandfather both hunted in the upper forest areas of Pauka'a, Pāpa'ikou, Onomea and Pepe'ekeo. Antone remembers that he first began hunting (going out on his own without his father) in 1930, when he was nine years old. For his family, hunting has always been a regular activity that helped to supplement their subsistence and put food on the table. He says he went hunting at least once a week and always managed to return with a pig. Despite his age, Antone still hunts, though he says, he only goes out about twice a month because his feet hurt and it is difficult for him to walk three to four hours into the forest.

Norman Medeiros is forty-six years of age. He is the younger son of Antone Medeiros. Except for a short stint in the army, Norman grew up and lived in the Pāpa'ikou/Pauka'a area all of his life. Like his father, Norman is of Portuguese descent and he, too, was raised on the plantation. Norman attended Hilo High School, and after fulfilling his military obligations, he returned home to work for Maunakea Sugar Plantation, as a tractor operator, where he has been employed for the past 27 years. Norman also maintains a small ginger farm and raises cattle in addition to his full-time job at the plantation. He currently resides in Pauka'a with his family, just a stone's throw down the road from his father's house where he was raised. Following in the family tradition, Norman began hunting at a young age. He relates he first went hunting with his father at age five. Since Norman grew up in the area, he was very instrumental in providing names of people who might be knowledgeable about the study area.

A joint interview was conducted with Antone Medeiros (80 years old) and Norman Medeiros (46 yrears old). Mr. Medeiros was selected because of his age and expertise with trails in the project area. He, himself, has been hunting in the area since 1930. His father and grandfather also lived and hunted in the area when they were living. (He estimates his grandfather immigrated to Hawai'i from Portugal in the 1870's.) Raised on the plantation, he had an intimate knowledge of the lay of the land, the water heads, the trails and the upper forest in general. As a young boy, he hunted once a week on a regular basis. Though 80 years of age, Antone still hunts at least twice a month. The family has always hunted pig to supplement their diet. They often make sausage and smoked pork.

The Medeiros family uses four main trails for hunting. These trails are old trials built by the plantation and they lead up to the water heads for Pauka'a, Pāpa'ikou, Pueopaku and Kaweliweli (Onomea). Both Antone and Norman said they noticed a change in the pig population around the early 1980's. The pigs are not as numerous today as they were thirty or forty years ago. They were unwilling to offer any speculations for this taped interview. They have also noticed the grazing pattern of the pigs has changed. The pigs seem to travel over larger areas than they used to. Due to the drop in the pig population, they

now have to hike much further up the mountain to shoot a pig. In the past, they would only hike 1 ½-2 hours *mauka*. Now, they must hike 3 and usually 4 hours.

Antone had an interesting story about a Chinese man who used to live in Pauka'a, about a ½ hour walk above where the mill for the project site is located. It was rumored he had leprosy and he escaped to the mountains because he was afraid he would be sent to Kalaupapa. Pākē, as he was known, would come down from the mountains to peddle wild watercress, *liliko'i*, bamboo shoots and whatever else he could grow o make extra money. Supposedly he slept in a box (like a coffin) in case he died in his sleep. No one knows what happened to him and some people believe he died in the mountains. To those familiar with the area, it is known as Pākē Place, after this Chinese man.

Both Norman and Antone do not feel the pigs are detrimental to the environment. They believe it is important for the hunters to be educated about endangered plants and birds so they can take an active part in maintaining the environment they love and spend so much time in.

Antone has hunted throughout the project area for 70 years and his family has hunted in the same mountains for at least one hundred years. During this time, he has never seen or heard anything about Hawaiian legends, sites, walls or rock structures or artifacts in the areas he frequents. His son, Norman, concurred. However, he and Norman have noticed changes in the pig population and the forest growth.

CONCLUSION

The cultural impact assessment study did not identify any traditional Hawaiian practices within the study area, although cultural practices were identified *makai* and outside of the area including *leina* (jumping off point at Makahanaloa), Kāne stone, and *'aumakua* worship (feeding the sharks at Kahali'i). Today, the only people utilizing the project area are pig hunters who, along with hunting pig, occasionally gather fern shoots, fresh-water shrimp, *hīhīwai*, and prawns as an additional food resource. No one indicated they gathered these resources for cultural reasons or that they gathered them on a regular basis. The pig hunters all know each other and because they go out often, they know who uses the trails and the general area. None of them knew of anyone who accesses the area for cultural reasons.

Boundary Commission records from the 19th century indicate the project area was heavily used by Hawaiians for activities such as gathering *pulu*, *olonā*, and especially for bird hunting and canoe building. There would have been traditional cultural practices associated with these activities. None of these practices seem to have continued up to the present time in the project area. The lack of cultural practices is attributed to changes brought about by the sugar plantation industry that dominated agriculture and land use in the south Hilo District since the mid-19th century. The plantations encroached on and changed the lower forest boundary and provided Hawaiians with a non-traditional, cash-based way to subsist.

The forest undoubtedly contains a variety of plants that are used in Hawaiian cultural practices such as *'ie'ie* used for weaving, *olonā* used for fishnets and capes, and *kukui* used for dying for fishnets and *tapa*. Such plants are associated with various native customs, practices, and beliefs. Although there is no evidence that native Hawaiians gathered plants from the area in recent history, if Hawaiian practioners come forth in the future, then access to the forest should be permitted for gathering related to cultural and religious practices.

Despite the lack of oral and documented references for Hawaiian traditions and practices, the study did document 20th century pig hunting practices, what hunters think about the forest environment, and the problems and issues they face as their hunting grounds seem to be shrinking because of concerns by the environmental community.

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APPENDIX A: INTERVIEW TRANSCRIPT

INTRODUCTION

For this project a joint interview was done with two people, Antone Medeiros and Norman Medeiros. Haun & Associates would like to acknowledge their appreciation to both interviewees for allowing the interview to be taped and used in this report. A biographical sketch of both informants can be found in the "Introduction" section of this report.

The authors would like to remind the reader that the information shared in the interview is the opinion and view of the informants. Please respect the information they have so willingly shared by not using portions of the interviews out of context or quoting from the interviews without giving proper credit to the interviewees. These interviews may not be used in their entirety in any publications unless the written authorization of the interviewee is obtained.

INTERVIEW

Project: Sustainable Forestry for Koa Timber, Inc.
Interview with: Antone Medeiros (AM) and Norman Medeiros (NM)
Interviewed by: Ka'ohulani Mc Guire (KM) for Haun & Associates
Place of Interview, Pāpa'ikou, Hawai'i
Date: January 3, 2001

KM: Can you begin by stating for the record your birth name and birth date?

AM: Antone Medeiros. I don't have a middle name. I was born on January 26, 1921.

KM: And, where were you born?

AM: At Pahailoa [Paiha'aloa]. It's right by the road. I was born at my father's house.

KM: Can you tell me about your parents – their names and if they were born in Hawai'i?

AM: My father was from right here in the islands, Marion Medeiros. His mother was Emeila Ferreira Tavares from Paukā [Pauka'a].

KM: When did your family first come to Hawai'i?

AM: My father's father, Antone, he came from Portugal. His name was Antone Medeiros Chiquita. They used to carry Chiquita [as a last name] before.

KM: Do you remember hearing what year it was that your grandfather first came to Hawai'i?

AM: I don't know. My father went to World War I in 1914. I don't remember when he was born. I'd have to go look at the tombstone [9/16/1896]

KM: What did your grandfather do when he came to Hawai'i?

AM: He worked for the sugar plantation.

KM: Which sugar plantation?

AM: Onomea Sugar Company.

KM: How long did he work there?

AM: He retired from there. Same like my mother's father. He was a carpenter/supervisor at Paukā [Pauka'a] until they retired. They all worked there and they died there.

KM: Did your father also work for the plantation?

AM: Yes.

KM: So, you were raised on the plantation?

AM: Yes, on Onomea Sugar Company, where we started.

KM: How big was your family?

AM: We had four boys and four girls.

KM: Where did you go to school?

AM: Right down the road at Kalaniana'ole School [in Pāpa'ikou], until the eighth grade. Those were wonderful days.

KM: I understand you've been hunting in the area for many years. When did you begin hunting?

AM: I started hunting in 1930 [at the age of nine years]. *Just like when I took you when you were* small – seven or eight years old [speaking to his son, Norman].

NM: I was five years old.

AM: Yeah, I was young. Before that, I used to go with my father. But, when I first started to hunt by myself, it was 1930. My father hunted, his father hunted, we all hunted.

KM: So, probably from at least the late 1800's, your family hunted in this area?

AM: We all hunted – for food for the family because we had a big family.

KM: What did you hunt?

AM: Pig hunting.

KM: What areas did you use for pig hunting?

AM: Mostly from Paukā [Pauka'a] and up to Onomea, from river to river.

KM: How far up *mauka* would you hunt? Up to what elevation?

AM: I cannot tell you in elevation, but we would walk about four hours up. We walked four hours at least, about five or six miles up. I don't know what the elevation would be. Where the eucalyptus stay is about 1800 ft or so. I forget now.

KM: Do you remember hearing anything about the eucalyptus – about how old those trees are?

AM: We planted some with Mr. Bryan, at Mahaloa Mauka, up here. And, those are the same trees you see today. Mr. Bryan was our manager – the plantation manager.

KM: About what year was that?

AM: That's when I started working. I think that was about [19]38. They tried to experiment with [making] charcoal from the eucalyptus that wasn't too good.

KM: So, the eucalyptus is . . .

AM: Right on the plantation by where the sugar cane stay.

KM: Down here [pointing to map]?

AM: Yeah, right around there.

KM: Are there more eucalyptus trees further mauka?

AM: Just above that, and it goes up just about maybe a half-mile – not too far.

KM: And, you planted all of that, too?

AM: No. They had working people [laborers] do that. But, I used to go up there.

KM: So, those trees were already there or do you think the plantation planted them?

AM: Those first trees, the plantation planted them.

KM: What about above that?

AM: Above, no more. No eucalyptus. No more. Just *'ōhi'a, koa* and staghorn fern The plantation planted all that from here, from Mahaloa, and right up to Onomea. And, even Pepe'ekeo, get some there.

NM: Who used to go up to the ranch fence, Daddy? Remember, one time, they said they walked to the ranch fence?

AM: Oh, the one that went walk to the ranch fence was Mr. Bryan, the forestry guy. He walked from Pepe'ekeo. There's a rain gauge up there. He slept up there one night and then, he went up to the ranch fence.

KM: How far up is the ranch fence?

AM: The ranch fence is about 15 miles up, I think. It runs right across.

NM: That's the bird sanctuary.

AM: And, then it goes to Pihā and Laupāhoehoe.

KM: How often would you go hunting?

AM: Every week.

KM: Would you catch something every week?

AM: Pigs. Pigs, all over the place. That's what we would eat – sausage, smoked meat and like that. Pig, every day for the family. No can afford anything else. In those days, [we got paid] one dollar-a-day. Ten cents an hour in those days. So, everybody get hard time.

KM: Have you noticed any changes in the pig population over the years?

AM: To me, it changed pretty fast, from about 1980, it went down. We hear all kind of stories, but we cannot prove [it].

KM: What do you mean?

AM: Well, there's something else fishy that was going on. We hear, but we cannot prove.

KM: Can you tell me more about that?

AM: No, because I cannot prove. If I go to court, I gotta make sure my words was true.

KM: So, you're telling me the pig population declined dramatically around 1980?

AM: Yeah, declined.

NM: Declined plenty. Even in my time, I could see changes.

AM: The population, from the time I began hunting in 1930, went over 75% drop. Big loss!

KM: The environmentalists believe pigs are a problem. What do you think about that?

AM: No. There's not enough pigs to keep the forest clean. If the forest is clean, no more mosquitoes and the sunlight can get through and dry up the forest. Pigs were like ants in my father's time, and my time, when I was small. Pigs were just all over the place.

NM: That's why the forest was nice. It was nice because the pigs uproot everything. And, that itchy grass stuff, they dig all that itchy grass. New grass grow up and when they dig up the thing, new roots of *koa* pop up and grow, see?. If no more the pigs, even the *waiawī* – because the pigs are not eating the fruit, the seeds drop and it grows like mad. You cannot walk through now because there's so much *waiawī*

KM: So, you don't think the pigs are a problem for the environment?

AM: The environmentalists and the forestry people, they going tell you the pigs are a problem. But, the pigs not the problem.

NM: I get nothing against birds. I love birds. But, I think that birds cause more problems than pigs from carrying the seeds. Look at Pepe'ekeo. I don't know what type trees they get alongside the highway.

AM: Oh, right here by the road, that stuff somebody planted below that place and spreading on the power line road – those trees.

NM: The birds eat the beans and fly with 'em and drop 'em.

AM: I don't know why the pigs went drop so fast.

KM: Do you think it was because of disease or do you think it was more than that?

AM: I don't know. Even that other thing, it went go in National Park, too. I wish I could prove that one because man is doing something wrong. But, I cannot say what was going on. I only hear about it.

KM: So, there was a noticeable drop in the pig population in the '80's by about 75%?

AM: Yes. It dropped from my time [1930] by about 75%. Because in [19]82, when I retired, had plenty pigs yet. Not as much [as in 1930], but still had plenty yet, and then it started to decline.

KM: And, since 1982, the pigs declined even more?

AM: Yeah. From there, it went down fast. It went down fast after that – I don't, know when it happened.

NM: When the nineties came, it went real bad.

AM: Yeah, when the 90's came, then they started trapping pig and doing different business with pigs, too.

KM: When you were small, how did you hunt? Did you ever use traps?

AM: No, never traps. Only shoot with gun. Because going with the dogs, the dogs bark, you catch one pig and you bring 'em home. That's enough for the house already.

KM: How long would you be out before you got a pig?

AM: Oh, before I used to walk about hour-and-a-half to two hours and I catch one pig.

KM: And, in the1980's after the decline . . .

AM: In the [19] 80's already, sometimes we walk up about three hours. And, right now you gotta walk about, maybe, four hours. But, pigs are funny. They travel back and forth. Today, you might go and you're lucky, you get 'em here. Tomorrow, you go and they're about three or four miles up again. They move. And now, they're moving plenty. I don't know why the pigs are moving plenty.

KM: When you were small, they would stay in one area?

AM: They stay in one area. They graze around there, they eat the fruit and they come down through the banana place and eat bananas – they like the stumps and the *hāpu'u*. But, the only *hāpu'u* they eat is when the *hāpu'u* stump fall down. They don't go there and tear the *hāpu'u* up. They no tear, because that *hāpu'u* all growing nice. But, as soon as you look at the ones that fall down, you see that they're going for the core [of the *hāpu'u*]. They start eating all that core up. Otherwise, they no knock 'em down.

NM: Always, the tip of the *hāpu'u* grows.

AM: Yeah. When the *hāpu'u* falls down, the pig eat all this here and bum-bye get just the young guy [tip] of the one stay on the ground and this young guy [tip] starts shooting up.

KM: So, the pig doesn't actually eat the whole plant and kill it?

AM: No.

NM: To me, that's just like you planting one new one. So, that *hāpu'u* going grow nicer than the old one. Usually, when it falls, it's old. I never did see one pig eat all of the tip.

AM: But, I tell you the truth. It's rome my time and I look for our young generation coming up and look pig like this. That's a bad thing. Something I feel sorry about that because all our young boys like go hunt and hard to get the game. Where these young boys going hang around? In the corners, getting in trouble? Because I know, once when I was about middle-age, one of our judges asked me, "Tony, would you be interested if some young boys get in trouble, you take the real good behavior ones, go up with you in the forest?" I said, "Sure."

NM: And, when had plantation strike, they used to send you folks out, yeah?

KM: When was that?

AM: [19]46 strike. You see, if you keep the young out of mischief, they up there celebrating, you go through the forest and then you get stories to come back tell your friends, you get no more trouble growing up. Even birds. You gotta get birds for the people, too.

KM: You hunt birds, too?

AM: No. I no want birds. Every time I go "Boom", one pile of feathers, yeah. So, when I see the pig and I go "Boom", I get half bag of meat. So I can come home to my family.

NM: But, you know, seriously about hunting, like how my dad – even Mauna Kea, they went eradicate all the sheep. To me, in my days, when my dad took me, I used to look forward to hunt. In my mind, I never did think of going down the beach, drinking beer or, like now, these poor kids all with drugs. To me, half of these kids would be out of drugs if had lot of game on the mountain.

AM: When you talk about that, that's true. When you talk something like that, I took notice. Nobody out on the streets, nobody out fighting or making trouble with people. No more, because of the hunting. Just like they waiting for Sunday or they waiting for tomorrow . Everybody waiting for the day. Everybody go home, sleep early, and everybody no more problem.

KM: When you were going up, you would go hunting mostly on the week-end?

AM: Most time. Because I work everyday and I go on the Sunday. And, sometimes, I come home early and play ball, after 3 'o clock.

KM: And you would catch pig almost every time?

AM: Oh, never miss. Had one pig coming home or maybe two. But, you know, what we take is enough for our family, no? And, then we tie the dog up. When we get enough, we come home already.

KM: And, in those days, you had refrigerator?

AM: In those days, we used to preserve our meat – we make salt pork.

KM: In crocks?

AM: Yeah. We put the salt, put the pork on top, and put more salt. Either we smoke the meat or we make sausage. And, in those days, you no can preserve the stuff, because you had ice box and you put ice. You gotta wait 'til the ice man come and he put ice.

KM: Do you still hunt?

AM: I still hunt. Only this year, I kinda slowed down because my foot bothers me. I cannot walk four or five hours like before.

KM: How often do you go hunting nowadays?

AM: Right now, maybe twice a month.

NM: He's 80 years old and he still hunts.

KM: That's amazing!

NM: But, you know, when we get wild pork, no more all that fast growing – like when you buy the pork. You know, all grain fed and got chemicals inside. When you go in the forest, it's natural. That's why I think he's strong. I hope I can live 'til I'm 80.

KM: Do you still pack out your own pig?

AM: Yeah. I pack out [the pig]. Way back when I first started hunting, I brought home the bones, everything. But, at the end, I thought to myself, the big bones – we're not using them, so I bring

home only the nice ribs and whatever I bring home, we use all that. It made it easier. Why bring. all that big extra bone, if you not going use 'em. So, I just bring the good ribs and debone 'em.

KM: Were there any particular hunting trails that you used on a regular basis?

AM: Well, we get old trails from the plantation go up to the water heads. In those days, the plantation used to clean up all the trails nice up to the cement, the plantation water heads. I built the one up there. I took my pack mules and built the one up there.

KM: You built the trail or the water head?

NM: The water head.

AM: Yeah, the water head at Puepaku [Pu'u'eopaku]. I worked up there. I took all the cement and stone up there. From there, that's the first cement water head across this Puepaku [Pu'u'eopaku] area here, and then you go up this river about forty minutes more and that's the old first plantation water head, made of lumber. And, you can see the bolts in the stone yet, above that.

KM: How many water heads are there?

AM: Over here, Puepaku [Pu'u'eopaku] get two, Paukā [Pauka'a] get one, Mahaloa get one too. But, Mahaloa one, no was too good. They take 'em from the river side. And, then they get the other one at Onomea and – what do they call the trail on this side? Kaweliweli, they call that.

KM: Kaweliweli?

AM: Yeah. That's the old name my father used to tell us – Kaweliweli.

KM: And, you guys call it Gardenia Trail now? Why? Did it have gardenias growing over there?

AM: They call it Gardenia Trail because had gardenias growing on the trail.

KM: That's in Paukā'a?

AM: No. That's gonna be up Onomea.

NM: Onomea Ranch. You gotta go through the Onomea Ranch.

KM: Oh, Onomea Ranch, which is now Onomea Cattle Company?

NM: Yeah, exactly.

KM: So, Kaweliweli or Gardenia Trail was one trail you used and then there were the trails going up to the water heads?

AM: Up here at Puepaku [Pu'u'eopaku]. Before, gotta be all Hawaiian names

KM: So, as we're going towards Hāmākua, there's Pauka'a, then Puepaku [Pu'ueopaku] . . .

AM: That's the water head trail I took the cement and stone up. Then you come to Mahaloa

NM: That's Charcoal House side.

AM: Yeah, from Mahaloa, then it goes to Charcoal House and then get Kaweliweli or Gardenia Trail and then you go Onomea, where the ranch ends, up there there's a cement plantation water head.

KM: After Onomea, are there anymore?

AM: Up to Onomea is all I know. The other side is Pepekeo [Pepe'ekeo] already and I never did go there.

KM: You mentioned Charcoal House side.

AM: Oh, up Mahaloa.

KM: Do you know anything about that?

AM: That's the one where get the eucalyptus we planted in about '46 or '48 with Bryan. Bryan was the manager, the plantation manager.

KM: Why is it called Charcoal House?

AM: Charcoal House because we went build houses for make charcoal. So, we started charcoal with all that cement blocks, so we just call the name "Charcoal House".

KM: That was for the plantation?

AM: Yeah. So, you know, when you get a name of something you can say, "Just go up Charcoal House" and you know where to go, you get some kind of marking.

KM: So, they actually built a building?

AM: They had an old fertilizer house right there. And, right on the side there, they had all that cement for make the charcoal.

KM: Are they any remnants of the building left today?

AM: No more. Nobody living up there. All gone.

KM: No cement?

AM: I think only the cement from the Charcoal House. Maybe the cement is there yet.

KM: Were there any ovens or anything like that?

NM: When I was born, it was named that already.

AM: Yeah, that's an old name from before. Even this name Kaweliweli. Maybe they give the name themselves, but we just carry on from what our parents tell us. Because today, the young boys, they don't know Kaweliweli. They tell 'em just Gardenia Trail.

KM: Did you ever hear any stories about the area where you used to go hunting?

AM: Well, what I know, it was wetlands with *waiāwi* and staghorn fern growing with pigs and a few birds flying around here and there.

KM: Are you familiar with Hawaiian birds and what they look like?

AM: Well, as far as all the birds, I don't really know. I only know the few birds on the lower lands like the doves and mynah birds. But, the kind fancy birds, they get some . . .

NM: The yellow one, the *palila*.

AM: Yeah, the yellow one and one with white flying around. But, you know, we no pay attention. But, they're flying around.

KM: Have you noticed if there are less of those birds now than when you were little? Have you made any kind of correlations?

AM: No. I never bother the birds. I never worry. I was only worried about the pig.

NM: There probably were [more birds before].

AM: But, they were there.

NM: Just like *koa* trees.

AM: Yeah, I never pay attention. I never thought had so much *koa* like the way they talk now.

NM: Since they got the place up there, now you walk and you look and "Whoa, there one *koa* tree."

KM: And, before you never took notice of the *koa* trees?

AM: I never realized had *koa* trees.

KM: Do you know anything about a Chinese man that used to live in the mountains around here?

NM: *Pākē* Place, Dad.

AM: Oh, that's the Chinese place – *Pākē* Place.

KM: Where is *Pākē* Place?

AM: Paukā [Pauka'a].

KM: Is it in the project area?

AM: It's right up here, right on the plantation – we call that – but, now one new place there, you know, get that forest line from Onomea Sugar Company – the one go *Pākē* Trail before, no more. My Uncle Joe used to go up there.

NM: The *Pākē* Place?

AM: Yeah, the *Pākē* Place. I would say, just above where the sawmill is, you go up – you walk half an hour up, then the trail used to go there.

KM: From the sawmill in Pauka'a, where they're working now?

AM: Paukā [Pauka'a]

NM: Yeah.

KM: And, a half an hour walk up is *Pākē* Trail?

AM: You walk up and you get that trail there. I think supposed to still get one eucalyptus growing there in the boundary – a eucalyptus tree. Supposed to get one there.

KM: Just one?

AM: Only one tree. But, maybe now that tree went down with storms and all that. I never did go check. That's also where we get the old plantation pipe before, to take water for the water head for the plantation mill for bring down the cane.

KM: How did that trail get the name "*Pākē* Trail"?

AM: That [was] *Pākē* Trail because my mother's father and his father talked about this Chinese coming to Paukā [Pauka'a] bringing watercress and that yellow *lilikoi* [*liliko'i*] down, the poka, the yellow one. He'd bring it to sell and make a little money and then he go back live up there. Then, he had one mango tree. My father took me and then had the holes from the Chinese there. That's the only one I know.

KM: What do you mean by "holes"?

AM: Get holes for catch pigs – the pigs fall inside.

KM: Oh, a trap.

AM: Yeah, he trapped pigs.

KM: Is that mango tree still there?

AM: I never see 'em. The last time I went, no more.

NM: Yeah, we no could find 'em. Probably went rot.

KM: Now, is he the one that "disappeared" up there?

AM: We never seen him.

KM: So, do you think he died up there?

AM: Well, according to my father's story, this guy, Pākē, he get one little shed made and he get one little box. And, he sleep in that little box, in case he die.

NM: Like in one coffin.

AM: In case he die, he stay in one box already. I never even see lumber or anything. I try look around, but I never saw anything.

KM: So, you never saw where the shed was or anything?

AM: No. I never seen. Only I know the holes.

NM: Only the *Pākē* Trail one, yeah?

AM: Yeah, that's the only one.

NM: And, you can see little bit glass.

KM: Do you think that was from him?

NM: Yeah, that was him.

AM: That's him. Nobody else go up there.

NM: No, I think probably had two guys. Only one?

AM: I only know one.

NM: But, you find money too.

KM: How old? Any dates?

NM: I think 1896 and 1917 maybe.

KM: Really?

NM: Yeah. Ever y time you go, the pigs digging around so you find coins. He had some money hidden though.

KM: What kind of coins?

NM: American kind, silver dollars.

AM: I no like tell you where 'cause bum-bye you go up there dig and find the silver dollars. [Laughter]

KM: About what year was that when he was living up there?

AM: Well, I was . . .

KM: Before you were born?

AM: Before I was born. My father-in-law went war in 1914, that's the time the guys was up there.

NM: Or earlier, maybe.

KM: So, early 1900's and possibly late 1800's?

AM: Yeah. 'Cause that's the day when tuberculosis was a bad disease in Hawai'i. Every time you had tuberculosis, they take you and they lock you up. That's why he ran away up there.

KM: Oh, he had TB?

AM: Yeah. So, he couldn't go around everywhere or they would take him away. That's why they had the old Pūmaile Home [Pu'u Maile Hospital], down Keaukaha. All the guys with sick [TB], they'd put 'em down there. They took care of them down there. But, this guy ran away and made a living up there.

KM: Just by selling watercress and *liliko'i* and whatever he could sell?

AM: Yeah, just live on the land there. And then they pick all that fern and the *warabi* [*hō'i'o*] shoots – they eat all that.

KM: Did he have another name or did everyone just call him "*Pākē*"?

AM: No, only call him "*Pākē*".

NM: He probably had his garden. You can see the area where he probably had a garden.

AM: Yeah, because one place in back is all clear.

NM: You can see the mounds. Had some banana trees, too.

[At this point, Antone Medeiros asked to have the tape recorder turned off for about five minutes to discuss what he felt was a sensitive topic, regarding the decline of pigs in the forest over the years.]

KM: Do you know any other stories about the area where you used to go hunting or anything about anyone who used to live up there?

AM: No. That's the only guy I know. But, the rest, even from my father's time, nobody live up there. The water was plenty, but the land was too wet and damp.

KM: Did it rain a lot or was it just damp all the time?

AM: Damp all the time, because of the trees which keeps it shady and the staghorn fern. Unless you clear the area and you let the sun come in and dry the land, then you can work the land.

KM: So, about the only people that went up there were hunters?

AM: Yeah. Mostly hunters.

KM: No one else really went up there?

AM: No, nobody.

KM: What about catching *ʻōpae* in the streams?

AM: Well, *ʻōpae* now is going down fast [declining], too.

NM: We used to go. And, the old-timers used to go get *ʻōpae*.

AM: Oh, plenty. I used to get my patch up here. Pili Kalona and Sonny Kaukahi guys, when they come, they say, "Tony, I going catch *ʻōpae*." They go up there, they coming back with half bag rice full [of] *ʻōpae* already. Now, today I go – two years ago I went with Abraham to Paukā [Pauka'a], from nine 'o clock to one 'o clock, I only caught one hand-full like this. No more.

KM: How far up the stream would you go for *ʻōpae*?

AM: Above the forest line.

NM: About where Ed guys probably stay.

KM: Where the sawmill is?

AM: Yeah, where the sawmill is.

NM: The boundary. Yeah.

KM: So real close to the boundary?

AM: Yeah, a little ways up there.

KM: Because they wouldn't be much further up, right? They'd be more *makai*?

NM: Yeah, more down.

KM: What about *hīhīwai*, the fresh water *ʻopihi*?

AM: Oh, the *ʻopihi*. Before had plenty. But, now, I no see 'em. But, that was more down here – all up on the sugar cane lands. Had plenty. I used to go catch on the stones and pick 'em up.

NM: Yeah. Onomea, got plenty, too.

AM: The "river *wī*" we call 'em.

KM: Right. *WĪ*.

NM: That's good [tasty].

AM: Oh, had plenty before.

KM: How did you prepare it?

AM: Oh, we only just used to peel 'em out and . . .

NM: Boil 'em, yeah?

AM: Boil 'em.

NM: When you go night time, they stay all up on the rocks.

AM: And, then the river *'o'opu*.

NM: Yeah, the *'o'opu*. That, you no see already. Gone.

KM: How many different kinds of *'o'opu* did you see?

NM: To me, one was light brown and one was dark brown.

KM: How far *mauka* would the *'o'opu* be?

AM: Well, the *'o'opu* used to go up to where I had my pasture. Plenty there, yeah?

KM: How far up was that?

AM: No, right up here.

NM: Right where get the cane, the sugar cane line.

AM: The sugar cane boundary.

KM: So, the sugar cane boundary is about right here [looking at map], the white part..

AM: Yeah, all that right there. All the white there is supposed to be where we have sugar cane, huh?

KM: Yes.

AM: Yeah, all that through there.

NM: Those were the good old days. I remember one time with the pole, "Dad, dad! Stay stuck!" And I had one big *'o'opu* on 'em.

AM: When you like go up there, six or seven, you catch in no time.

NM: Yeah, plenty.

KM: What else did you catch or gather from the streams?

AM: Only just the *'o'opu, wī, 'ōpae, warabi*, and bamboo shoots.

KM: Do you know how the bamboo got there?

AM: The bamboo shoots got there from old Japanese, before, when they came from Japan. The plantation hired them and Japanese like to live all up, because that's the land they had from the planta-

tion to raise cane. So, they raise their cane, they build their house, they plant bamboo right in back. That's where all we had houses. So, they get bamboo shoots to eat too.

KM: But, that's in the sugar cane lands?

AM: Yeah, the sugar cane lands. All in sugar cane lands. Up in that forest, I no see nothing. Just like, nobody went up there living.

KM: So, you never heard your parents or grandparents talk about people going up there?

AM: No. Like me, from here, I walk from this Mahaloa, I go all the way, I come out Pepekeo [Pepe'ekeo], and then I come home. I cross all that part and I never see anything. Only what Puepaku [Pu'u'eopaku], when I told you guys must have had the '68 bronze plate on the waterfall and, above that, had the two palm trees in those days. That's the only two palm trees was up there growing.

KM: Where was that?

AM: Puepaku [Pu'u'eopaku] and go up. That's the one I walk up, me and my brother * hours . . .

KM: If you follow the stream?

AM: Yeah, you follow the stream. That thing was on the left and the two palms were *

KM: Was it a date palm or a royal palm or . . .

AM: No, like the regular kine palm. But , it was tall already. It was like this big [shows size with his hands].

KM: Do you mean it was a Hawaiian coconut tree?

AM: No. This was palm, not coconut. Coconut, I know.

NM: They found some, yeah? The palms up there.

KM: Did you say you used to pick warabi (*bō'ī'o*)?

AM: Oh, warabi, plenty.

KM: But, that was mostly on sugar cane lands?

AM: Yeah, mostly sugar cane lands. Not in the forest. The forest get, but not like down here. They grow better down here. I don't know why.

NM: Watercress grow good, though.

AM: Oh, yeah. Watercress, up there, nice.

KM: So, you used to go up there to get watercress?

AM: Where the Chinese guy stay.

NM: After they died, still had the watercress.

KM: Is there still watercress now?

AM: No. Anthony told me he went. The last big water, the big rainfall we had went just take everything down, even the ditch. Washed 'em all out. So, all gone.

KM: What about place names? Do you know any other place names, like Kaweliweli, that people don't use anymore?

AM: No.

KM: And trails?

AM: The trails was all old plantation trails. Those trails was made by the sugar company. The sugar people always used those trails, because it's easy to walk – all clean, yeah?

KM: In those days, when you worked for the plantation, did you have to ask permission to go in there to hunt or gather?

AM: No. Anytime, just get up in the morning and go. But, if you work, then you cannot go. You have to ask the boss. But, just any day when there's no more work, you just go right up into the rivers, pick *ʻōpae, ʻoʻopu* and everything. Start your car right now and go right up there now and get what you want. But, today, cannot. All fenced up, everything all closed.

KM: Thinking back to when you were little, how has the vegetation and the plants in the project area changed? Have you seen any changes?

AM: Well, the thing is changed now because we all get ranch lands now. So, everybody raising cattle.

NM: Yeah, the mountain.

AM: But, the mountain up there is terrible now with the *waiawī* and the itchy grass. Oh, that thing [the itchy grass] is just spreading. No more pigs, yeah? The thing just grow. The last time I went up there, oh, where I walk through, *hū*, the grass. Terrible!.

NM: Another five or ten years, this forest will be gone.

AM: Yeah. You cannot walk through with this grass. No more the pigs. And the *waiawī*, oh, that *waiawī* so much. And, where we used to go through, I could walk across. Now, oh, the *waiawī* is bending down and going all over.

NM: It's getting worse.

AM: Now, even when the dog bark right across, only right there, take you one hour for reach. Going around the *waiawī* and going under and over like that.

KM: Remember when you talked about the pigs moving around a lot? Within the project area, do you know if seem to concentrate in certain areas?

AM: Well, if they get their food, like when you get the guava season, the *waiawī* season . . .

KM: When there's fruit . . .

AM: And then, when get cane, they come down to the sugar cane, where they stay around and eat the cane. When they harvest the cane, then they go back up again.

KM: So, it's a seasonal thing evolving around when there's fruit and food for them to eat, that's when they come down?

AM: Yeah, they come down. They know.

KM: Do you recollect what time of the year they come down?

AM: Well, right now, what's supposed to be now is like [strawberry] guava, yeah, already?

NM: Just went pass, the *waiawī*.

AM: Just *pau*, the guava. So, now it's January.

NM: November, December, January.

AM: And, then now we get some *waiawī* yet again, no? *Waiawī*, the yellow one, is what I see.

KM: And in the summer time when it's drier down here, do they stay more *mauka*?

AM: Well, they go *mauka* because the land more wet, more swampy land. They go around and they dig the ground because they eat all the earthworms, too.

KM: So, Norman, do you know all the trails your dad went hunting on?

NM: No. Actually, my brother Tommy was the one more for hunt. I used to hunt, but my brother Tommy, he's older than me.

AM: Right now, funny you know. That trail is just like – the young guys go andif you no go for couple of months and then they go, they change the directions.

NM: They change the trails.

AM: But, I know. Like Paukā [Pauka'a], I know how to go up there. And Puepaku [Pu'u'eopaku], same thing – the one that goes up to the water head.

NM: That's why we like hunt with him. Just like he got something in his mind and he just know where for go. If you go by yourself, you end up in a thick place. He just know where for go. He know if you hit this stream and if you cross here, that's the main trail. No need compass, nothing. He knows this mountain like the back of his hand.

KM: All the times you've been hunting up there, did you ever see anything that looked Hawaiian – like stonewalls, rock mounds or any kind of Hawaiian artifacts?

AM: No. No more nothing. I never seen.

KM: You've never seen anything like poi pounders or pestals to grind medicines and herbs or any stone tools or implements?

AM: No. Because I walked right across and I walked all over. These plantation trails were used by a lot of people. I never seen nothing. The only thing I seen up by Puepaku [Pu'u'eopaku] River was that 1x3 [piece of board] that come from the ranch lands – from the forest up there and come down in the river. It was stuck on the bank with numbers on top, all painted white. It come from up in the ranch. It was some kind of marker. The water bring 'em down. That's all that I found.

KM: How long ago was that?

AM: Oh, in the 1950's.

KM: Norman, when you grew up, how often did you go hunting with your dad?

NM: Every week. That's why I said, I would put money down if they would bring animals back on this mountain, we'd take a lot of kids away from down the beach and drugs. They'd be up in the mountain [hunting].

AM: Yeah, Look at Tommy. Tommy, my son, took three boys with him last week – young kids.

NM: The only thing is now, if you take these young guys that never did hunt, you gotta walk so far and, sometimes, you no catch nothing.

AM: Then, they don't wanna go back.

NM: Exactly. Even Mauna Kea, I used to go with my dad. Oh, the hunting was so good – we used to hunt for sheep.

AM: They said the sheep was destroying the *māmane* trees. But, on the top of Mauna Kea, nothing grows. The *māmane* tree only grows from a certain elevation and downward. Those *māmane* trees, from the time I went, now it's looking a little better. The sheep used to eat some. But, it's a hard tree to grow. Somebody told me if the seed drop on the ground, it will not grow. I went up with you guys, yeah? With the Boy Scouts. We took seeds. We tried to plant seeds. The guys told me, it's not gonna grow you gotta put 'em in water or some kind of chemical and let 'em sprout before you plant 'em.

NM: Hard, the shell.

AM: It's just like the *koa*. If you no touch the ground, the *koa* no grow.

NM: As soon as you dozer 'em, hundreds come up., like up there. Nice, young kind.

AM: That's the one, when Mr. Campbell was our manager, look the place where he went bulldoze all that? Look the *koa* now, inside there.

NM: And, that was all sugar cane before. Now, get *koa*. Just like Maui. They're finding endangered plants inside all the sugar cane. The seeds buried under the ground. And, someplace else, they was cutting for build something and they went stop the job. And, no *koa* around for miles, and one *koa* went grow.

AM: Funny, yeah? There was *koa* there before.

NM: That's why I think – not because we hunt, but I think pigs get a lot to do with digging up the soil and helping the *koa* trees to grow.

KM: Do you have any idea how many people hunt in the project area? You all know each other, don't you? And, you know who hunts in which areas?

NM: Yeah. Like Michael Figueroa, he takes care of the hunting on the ranch side.

KM: I did talk to him.

NM: I know, get plenty young guys, now. New hunters. But, plenty hunters go, I'm surprised he only gave you a couple of names.

AM: Well, they get tired too. They go and no catch nothing, so they slack off from hunting.

KM: Are there any concerns that you or other hunters have about the project? Any fears or anything they're worried about because of the project?

NM: No. So long they work with the hunters and they've been doing that.

KM: How have they been doing that? In what way?

NM: They let us hunt. The only thing is like, in Paukā [Pauka'a], they get the sawmill there so we kinda limited on the hunting up there. He was nice enough for give me the hunting rights [Ed *].

Because I had the hunting rights for the plantation. If anybody used to hunt on that side, they would have to call me.

KM: What does it mean to have the "hunting rights"? You don't really own it.

NM: No.

KM: You have the key and people go through you?

NM: Yeah, they call. 'Cause for the plantation, it's so much trouble for them to take this guy's name down, and all that. They call me up and say, "Oh, can I go hunting this week-end?" Then, you look and see if anybody going be around and you let them hunt.

KM: You have the hunting rights for which area?

NM: Paukā [Pauka'a].

KM: And, Michael Figueroa has the hunting rights for Onomea Cattle Company?

NM: Yeah.

KM: Is there anyone else in between?

NM: No. Michael get the whole thing.

KM: So, just Michael and you.

AM: Michael got up there, because through Von Holt, from Kōhala.

NM: Actually, my brother Thomas was supposed to take half of the ranch area. But, he [Michael Figueroa] controls the key.

KM: So, Michael has the key?

NM: Yeah.

KM: But, does he allow people to go hunting?

AM: Yeah, they let. The only part is, a couple of years back, I went up there with Alan Winter. I tell Alan, "I like to hunt tomorrow." He tell me, "Okay." Then, I gotta go six 'o clock his house [to] go get the key. I go there and nobody home. So, I gotta come home, the boys waiting here for me for go. I went two times and I gave up.

NM: And, if you lose your dogs, you cannot go back the next day.

KM: Why?

NM: I don't know. Michael get that rule. So, some of the hunting dogs was found in Kona. Some guy stole 'em and sold 'em in Kona. Going get problems.

KM: He belongs to your hunting club, too?

NM: No.

KM: So, you don't think he has a good rapport with the hunters?

NM: To me, no. We get a lot of complaints that come back, but we cannot do nothing.

KM: You don't think you can talk to the owner, Alan Winters?

NM: Well, we no like – the first time we met, we was the first guys that met with Alan. Actually, we're supposed to, as a club it would be good if we could set up everything nicer than what it is now. Like, if you lose your dog, you're welcome to go the next day or the following day. You cannot take rifle and dogs the next day , so you cannot go hunt again. Just yesterday, I was talking to one guy and he said, "If I cannot go look for my dogs, I going cut all the locks and go up. But, then you create problems.

KM: But, on your side, if somebody loses their dog, they can go up and look for them?

NM: Oh, yeah. And, certain time when get young babies we try control the hunters. You no like destroy everything. Certain time of the season, when you get plenty young babies, we try and stop the hunters.

KM: Is there a certain time of year?

AM: Right now, it's baby season. The mother's get babies.

NM: Yeah. Summer time and right now. I get 'em real controlled on my side. The hunters respect me for that.

KM: Do you have a problem with poaching?

NM: Down in the mac nut, I get problems, like Del Monte.

AM: Yeah, the trees are close to your house, no?

NM: It's right close to my house. It's very dangerous. That's not one hunter. One hunter would have more respect. You get good and bad guys.

KM: Basically do all the hunters agree on the best ways to hunt and do they follow the same guidelines and respect them?

NM: We kind of follow the Forestry rules like, wearing orange vests, you can hunt only at certain times. You cannot hunt in the dark. You get one time limit for when you gotta be out of the forest.

KM: A half-hour before dusk and in the morning a half-hour after dawn?

NM: Yeah. Like my side, they gotta show me their safety-aid card. Some guys used to be mad at me.

KM: But, if somebody got hurt, you'd know what to do.

NM: That's why, I'd really like it if they [the environmentalist & Forestry people] would teach us about the plants, too. We're not against them. We would love it if they would show us things so we can be aware of the plants.

KM: Do you think the hunters would respect that?

NM: Oh yes.

AM: Oh, we talked a lot about how to protect the *palila* birds. That's why we support protecting the *palila* bird up on Mauna Kea. We spent time and money, whatever we can do.

NM: You know, you gotta have a balance. Now, it's more on their side. But, balance 'em. If get too much pigs, send more hunters in and bring the population down. That's how gotta be. There's a balance. And, that's how God made 'em. It's all gotta balance – sheep, pig, everything.

AM: You know, we no mind if you let us know and try show us about the plants so I no pass through there and I go chop 'em down. Just like, they don't want to pay attention to us.

NM: Even like our club, we're willing to sacrifice their day to do tissue culture for certain plants. Some guys, they're willing to sacrifice their anthurium farms and all to help tissue culture and us hunters go out and plant the endangered plants. Then, when get enough, you can take 'em off the list. Then, you take care the next plant. They make the pigs and sheep and goat look real bad. To me, that's the main source of food for the people that they're taking away.

AM: But, you know, if they say that the pig destroy the plants, my father's father was here, his father's father was here and the old people was here. And, the plants, they still find 'em today. Why are they there? If the pigs and goat were destroying them, they wouldn't be there. Why the plants is still growing.

NM: Just like Pōhakuloa. They fenced in such a big area.

KM: Are the hunters upset when they see this happening?

NM: Yes.

KM: Because, they're losing their territory.

NM: Big time. And, you really look like these people that study the main breeding ground for the pigs and they closing 'em up. To me, going come to the day when the hunters going be against the wall so much, going be one problem. When it comes down to feeding their family and they cannot get no pig, somebody going get it. Going be one problem in the future. As a club, we try keep everybody in line – line shooting signs on Saddle Raod – that's not one good hunter. We maintain – we put gates up in Kūlani. Up Saddle Road, we went help plant the silver sword. Our club go out and we pound all the posts and all of that. Rather than fencing the whole ten thousand acres, make small portions. We're willing to help, but they don't give us enough of a chance.

AM: We even go up nineteen miles [19-mile marker] for plant that silver sword. We went go up there and put one fence for protect the thing. That's what we like. Keep the pigs out and protect the plants.

KM: Did you do that in coordination with someone from the forestry?

NM: Yeah. It's like how I said. We like one balance. We no like act greedy and keep all the pigs or the goats or the sheep. But, balance where the people still get food and the plants still growing.

KM: In an average week, how many hunters usually go hunting in your area?

NM: Right now, cannot go hunt during the week, 'cause get the mills up there. The only time we can hunt is Saturday or Sunday or holidays. I would say, every week you going get somebody up there.

KM: One or two? Or five or six?

NM: No. Only one group. That's I let.

KM: What do you mean by one group? One name, but you can take three or four people with you?

NM: Exactly. Because if you going start letting two or three groups hunt, it's dangerous. It's a small area, Paukā [Pauka'a]. If I had an area like Michael's than it would be a different story.

KM: But, before they had the mill, people would go hunting during the week, too?

NM: Oh yeah.

AM: Every day.

NM: Every day you going get at least somebody going through.

KM: It seems that now people can't hunt as much.

AM: Run the game to slack the hunters.

NM: The thing is, if you can close the hunting and the pigs multiply, it's not bad. Like now, you'd think since we cannot hunt during the week would get lotta pig. It's worse. What's happening? We don't kno.

KM: Less pig and you have to walk farther up.

NM: We have no problem with them [the mill] up there, that's one sure thing.

AM: Yeah, they no bother. Even that boy that come from Honolulu, Ed , he's a nice guy.

NM: I get my cattle up there too, from the plantation. We work with each other. He get water from me. We all work with each other.

KM: I believe Alan Haun talked to you about trying to find that trail above where the mill is located.

NM: I think my brother found 'em. I gotta try ask Tommy. I think this past week-end he found 'em.

KM: Well, I think I've covered all my questions. Thank-you very much for talking story with me.

[End of interview]

Appendix I

Economic Impact

KOA TIMBER COMMERCIAL FORESTRY OPERATIONS: ECONOMIC IMPACTS

Prepared by

DECISION ANALYSTS HAWAI'I, INC.

December 2002

1. INTRODUCTION

Presented below is an assessment of the economic impacts of commercial harvesting and milling of *koa* trees (the Project) as proposed by Koa Timber, Inc. The analysis covers the operations of Koa Timber, related companies involved with harvesting the trees and milling the logs (including milling on the Big Island and on O'ahu), and companies that provide goods and services in support of these companies and their employees.

Following a description of the Project, the economic impacts addressed include: anticipated harvest, disposition of logs and lumber, sales, profits, employment, fine woodworkers who use *koa*, payroll, the increase in property values, and tax revenues to the State of Hawai'i and the County of Hawai'i.

Table 1 summarizes the economic activity based on recent operations. Without approval of the proposed project, harvesting and milling operations of Koa Timber and related companies will close down because the supply of *koa* trees will be insufficient to support viable operations. Thus, this table reflects the economic impacts of the proposed Project.

2. PROJECT DESCRIPTION[1,2]

a. Project Area and Location

The project site covers about 13,129 acres consisting of two parcels (TMK 3rd/2-7-01:01 and 2-8-01:02) located in the South Hilo District of the County of Hawai'i. The property is about 10 miles north of Hilo above the towns of Papa'ikou and Pepe'ekeo between the 1,400- and 3,600-foot elevations. It encompasses portions of the *ahupua'a* of Makahanaloa, Onomea, Alakahi, Papa'ikou and Pauka'a. The site is bordered by the state-owned Hilo Forest Reserve to the north and south, former sugarcane lands owned by Mauna Kea Agribusiness to the east, and the Hakalau National Wildlife Refuge to the west.

b. Land Ownership

Hawai'i Forest Preservation, LLC is the fee-simple owner of both parcels.

c. State Districting and Zoning

Over 11,600 acres of the Project site are within the State Conservation District and are zoned Open by the County, while about 1,500 acres are within the State Agriculture District and zoned A-20.

d. Project Objective

Koa Timber, Inc. proposes to harvest *koa* timber from the Project site in a manner that sustains the timber resource and minimizes impact on the native forest ecosystem. The Project objective is to profitably harvest the timber based on long-term viability as opposed to short-term financial gain. This objective favors management decisions that consider resource protection over market potential. Financial plans will depend on extensive information gathering and monitoring of the inventory. Towards this end, the Applicant will use a Global Positioning Systems (GPS) coupled with a Geographic Information System (GIS) to manage the inventory and to serve as the basis for a biological monitoring system.

e. Operations

Operational highlights are as follows:

— Harvesting Methods

Harvesting methods will minimize damage to felled *koa* trees as well as to surrounding trees. This will be accomplished using helicopters to remove the felled trees from the Conservation District to a cleared staging area on former sugarcane lands in the Agricultural District. At the staging area, the logs will be cut and loaded onto trucks for transport to a new mill at Pepe'ekeo or to Hilo Harbor for transport to an existing mill on O'ahu, depending upon final disposition of the lumber.

— Marketing Practices

Marketing will focus on obtaining the highest value for the harvested timber with minimal product waste. This will ensure that care will be exercised in felling and handling trees and will reduce the pressure for high-volume harvesting.

— Forest Management

To manage the *koa* timber resource and the native forest on a sustainable basis, Koa Timber plans to rotate its harvest on a ten-year cycle. The harvest will primarily take larger trees (circumference of 18 inches or greater). In locations that have a healthy native forest, harvesting will leave an all-aged stand of *koa* along with *ohia*, other native trees, and under-story vegetation. In locations invaded by strawberry guava or other invasive species, field crews will hand-apply herbicide to clear openings for the growth of seedlings and smaller trees. *Koa* will be replanted in areas where natural seeding is insufficient. Pigs will be controlled through hunting and snaring, as well as limited use of fencing

. Wildlife biologists will be retained to monitor the native wildlife populations, and will advise on measures to enhance the habitat (e.g., nesting areas, food species) and minimize harvesting impacts (e.g., avoid cutting during nesting season). Where a particular area may be exceptionally rich in or sensitive to endangered or threatened species, Koa Timber will seek alternatives that set aside the area as a reserve in return for tax or other benefits.

f. Services

Operations will require helicopter services to fly crews in and out of the forest, helicopter services to remove logs from the forest, and trucking services to transport logs.[2]

g. Project Schedule

Harvesting will commence upon receipt of necessary approvals.

3. ANNUAL HARVEST

Based on the Sustained Harvest Estimate and the Forest Management Plan, Koa Timber plans to harvest about 1 million board feet of *koa* per year, similar to the company's previous harvest levels.[3,4] Currently, Koa Timber provides over 95% of the State's production of *koa* lumber. Demand for *koa* wood is strong and is expected to increase over time.

Without approval of the Project, Koa Timber will be able to harvest only on the Agriculture portion of the property, which would severely curtail timber supply and jobs in future years.

4. DISPOSITION OF LOGS AND LUMBER

Currently, logs are partially milled in the open on agricultural land, then shipped to O'ahu for final milling into lumber. In the future, most of the logs for the Big Island and overseas markets will be milled at a new facility at the former sugarcane mill at Pepe'ekeo, while the remaining logs will be sent to an existing mill on O'ahu. The milling of logs within a covered structure at Pepe'ekeo will allow for a higher quality product compared to logs that are exposed to heavy rains.

Currently, about 10% of the supply of *koa* logs and lumber is sold on the Big Island, about 20% is sold on O'ahu and other islands, and about 70% is sold overseas (see Table 1). These percentages vary over time, depending upon demand.

5. ANNUAL SALES

Revenues are expected to average about $7.8 million per year for 1 million board feet of lumber (see Table 1). These figures are based on a price of about $7.80 per board foot of *koa* when averaged over all forms of the wood, including raw wood, veneer, molding, frames, flooring, etc.

Purchases of goods and services by Koa Timber, by related companies, and by employees of these companies results in an additional $5.6 million per year of sales (see Table 1). These indirect sales, which would be split mostly between the Big Island and O'ahu, are based on economic multipliers developed by the Hawai'i Department of Business, Economic Development and Tourism (DBEDT).[5]

Combined lumber sales and indirect sales will total about $13.4 million (see Table 1). As indicated in the table, about $1.1 million reflects consumption and about $12.3 million reflects intermediate sales. As discussed below, consumption and intermediate sales are taxed at different rates.

6. ANNUAL PROFITS

Profits for all affected companies—Koa Timber, related companies involved with harvesting and milling the *koa*, and companies providing goods and services to these companies and employees—are projected to average about $670,000 per year (see Table 1). Profits are estimated at 5% of Total Sales.

7. EMPLOYMENT

As indicated in Table 1, harvesting and milling employment is expected to provide about 28 jobs, about half of which would be on the Big Island and half

on O'ahu.[6] The projected job count includes a supervisor, managers, milling crews, a forester, groundsmen, and loggers.

Employment associated with the indirect sales will be about 21 jobs, based on economic multipliers developed by DBEDT.[5]

Direct plus indirect sales will total about 49 jobs, not including fine woodworkers who use *koa*.

8. FINE WOODWORKERS

The Hawai'i Forest Industry Association lists 85 companies involved with producing and selling fine wood products in Hawai'i, and lists 478 fine woodworkers: 248 are on the Big Island, 166 on O'ahu, 39 on Maui and Moloka'i, and 25 on Kaua'i.[7,8] An estimated 380 (80%) of these woodworkers use *koa* in their crafts.

9. ANNUAL PAYROLL

Payroll for all direct and indirect jobs is projected at $1.6 million per year, or an average of about $33,000 per job (see Table 1).[2,9] .

10. PROPERTY VALUE

The 13,129-acre project site is expected to increase in assessed value from about $2.1 million ($162 per acre) to about $3.3 million (about $250 per acre).[10, 11] The higher property value reflects government approval of sustainable forestry operations for that portion of the property within the Conservation District, and the resulting revenue and profits from these lands.

11. TAX REVENUES

Total tax revenues to the State of Hawai'i and the County of Hawai'i is projected to average about $263,000 per year (see Table 1). State tax revenues include excise taxes on consumption (taxed at 4%), excise tax on intermediate sales (taxed at 0.5%), corporate income tax (estimated at 6.4% of profits), and personal income tax (estimated at 5% of payroll). The County property tax is 1% of the assessed land value.

12. SUMMARY OF ECONOMIC IMPACTS

As summarized in Table 1, the Project will provide substantial economic benefits, including: about $12.3 million per year in direct and indirect economic

activity; about 49 direct and indirect jobs; payroll of about $1.6 million per year, and Hawai'i tax revenues of about $263,000 per year.

13. REFERENCES

[1] Wilson Okamoto & Associates, Inc. "Environmental Impact Preparation Notice, Koa Timber Commercial Forestry Operations." November 2001.

[2] Koa Timber, Inc.

[3] Atterbury Consultants, Inc. "Sustained Harvest Estimate." May 17, 2002.

[4] Atterbury Consultants, Inc. "Forest Management Plan." September 17, 2002.

[5] Hawai'i Department of Business, Economic Development and Tourism. *The Hawai'i Input-Output Study, 1992 Benchmark Report.* Honolulu, Hawai'i. December 1998.

[6] Based on estimates provided by Koa Timber, Inc.

[7] Hawai'i Forest Industry Association. "Resource Guide and Directory." September 2000.

[8] Hawai'i Forest Industry Association. Personal communication, January 18, 2002.

[9] Hawai'i Department of Business, Economic Development and Tourism. *The State of Hawai'i Data Book.* Honolulu, Hawai'i. Annual.

[10] Current assessed value provided by the County of Hawai'i.

[11] Projected assessed value estimated by Decision Analysts Hawai'i, Inc.

Table 1. Economic Impacts of Koa Timber and Related Operations

Item	Amount
Project Land Area	13,129 acres
Harvest	1,000,000 board feet per year
Disposition of Lumber	
Big Island	10%
Oahu and Other Islands	20%
Overseas	70%
Sales	
Lumber Sales ($7.80 per board foot)	$ 7,800,000 per year
Indirect Sales (72% of Lumber Sales)	$ 5,616,000 "
Total Sales	$ 13,416,000 per year
Consumption (70% of Payroll)	$ 1,131,158 "
Intermediate Sales (difference)	$ 12,284,842 "
Profit (5% of Total Sales)	$ 670,800 per year
Employment	
Harvesting, Milling and Forest Management	
Big Island	14 jobs
Oahu	14 "
Total Direct Jobs	28 jobs
Indirect Employment (75% of Total Direct Jobs)	21 "
Total Employment	49 jobs
Payroll	
Harvesting and Milling	
Big Island	$ 508,240 per year
Oahu	$ 561,700 "
Total Direct Payroll	$ 1,069,940 per year
Payroll, Indirect Jobs (at $26,000 per job)	$ 546,000 "
Total Payroll	$ 1,615,940 per year
Average per Job	$ 32,978 "
Property Value	$ 3,282,250
Per Acre	$ 250
Tax Revenue	
State of Hawaii	
Excise Tax on Consumption (4%)	$ 45,246 per year
Excise Tax on Intermediate Sales (0.5%)	$ 61,424 "
Corporate Income Tax (6.4% of Profits)	$ 42,931 "
Personal Income Tax (5% of Payroll)	$ 80,797 "
County of Hawaii	
Property Tax (1% of Property Value)	$ 32,823 "
Total Tax Revenues	$ 263,221 per year

Appendix J

Comments and Responses to the Draft Environmental Impact Statement

Harry Kim
Mayor

Patricia G. Engelhard
Director

Pamela N. Mizuno
Deputy Director

County of Hawai'i
DEPARTMENT OF PARKS AND RECREATION

101 Pauahi Street, Suite 6 • Hilo, Hawai'i 96720
(808) 961-8311 • Fax (808) 961-8411

February 20, 2003

Koa Timber, Inc.
91-188 Kalaeloa Boulevard
Kapolei, HI 96707

Attn: Kyle Dong - 988-1521

Re: Draft EIS for Koa Timber Commercial Forestry Operations
TMK: (3) 2-7-01:01 and 2-8-01:02

Dear Mr. Dong:

The proposed commercial forestry operations will have no adverse impact on any of our recreational sites or programs.

Thank you for the opportunity to review the DEIS.

Sincerely,

Pat Engelhard

Patricia Engelhard
Director

Cc DLNR
OEQC
PlanPacific, Inc.

Harry Kim
Mayor

Darryl J. Oliveira
Fire Chief

Desmond K. Wery
Deputy Fire Chief

County of Hawai'i
FIRE DEPARTMENT

25 Aupuni Street • Suite 103 • Hilo, Hawai'i 96720
(808) 961-8297 • Fax (808) 961-8296

January 30, 2003

Mr. Kyle Dong - 988-1521
Koa Timber, Inc.
91-188 Kalaeloa Boulevard
Kapolei, HI 96707

SUBJECT: DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
APPLICANT: KOA TIMBER, INC.
PROJECT: KOA TIMBER COMMERCIAL FORESTRY OPERATIONS
TAX MAP KEY: 3-2-7-01:01 AND 3-2-8-01:02

We have no comments to offer at this time regarding the above-referenced Draft Environmental Impact Statement (DEIS).

Sincerely,

DESMOND K. WERY
Deputy Fire Chief

RK:jdk

cc: State - Office of Environmental Quality Control
Dawn Hegger - State - DLNR Division of Land Management
Robin Foster - Plan Pacific, Inc.

Harry Kim
Mayor

Christopher J. Yuen
Director

Roy R. Takemoto
Deputy Director

County of Hawaii
PLANNING DEPARTMENT
101 Pauahi Street, Suite 3 • Hilo, Hawaii 96720-3043
(808) 961-8288 • Fax (808) 961-8742

February 21, 2003

Mr. Kyle Dong
Koa Timber, Inc.
91-188 Kalaeloa Blvd.
Kapolei, HI 96707

Dear Dong:

SUBJECT: Draft EIS for Timber Harvesting Project
TMK Nos. 2-7-01:01 and 2-8-01:02

The draft EIS corrects some of the shortcomings of the previous Environmental Assessment: the lack of actual fieldwork on birds and stream life, and the very limited botanical fieldwork. Please refer to our comments in the letter to Gilbert Coloma-Agaran, chair of the BLNR, dated April 16, 2001. These are now adequate. Our concerns about the sustainable level of harvest remain, however.

The stated goal of the project is "to develop a sustainable forestry." The "Sustained Harvest Estimate", Appendix "A" by Atterbury Consultants, Inc. (ACI): states: "The first step in developing a forest management plan is to organize a complete and accurate inventory." (Appendix "A", p. 12). It is clear from this report, however, that a complete and accurate inventory does not exist, and the report itself repeatedly emphasizes that it is only giving a rough estimate. The Jaakko Poyry inventory, referred to in the report, estimated 1695 board feet per acre; the ACI estimate, upon which the proposed harvesting level is based, is much higher: 2656 board feet per acre. This estimate in turn appears to be based upon a sample of only 163 trees. (Appendix "B" at p. 12). ACI states that "the volume estimates used in these stand tables are from the Scribner Log Rule. This is the standard log rule used in the western United States." The applicant should seek verification from experienced foresters that this yields a good estimate of the merchantable wood that can actually be obtained from a natural forest of koa.

The original EA stated that harvest would be limited to "dead and dying, or die-back trees," and the EA referred to a "100 year" rotation. The present EIS does not limit the

type of trees that can be cut, except that they will be 18 inches in diameter and over, and refers to a "ten year" rotation. ACI estimates there are 1552 board feet per acre in trees of this class, and the EIS mentions a harvest of 1000 board feet per acre, of 1000 acres/year, and that about 10,000 acres of the total of 13,000 acres would be harvested (the remainder would be in buffers for streams and the Hakalau National Wildlife Refuge.) Using these numbers, about 2/3 of the trees 18" in diameter and over would be harvested on the 10,000 acres in ten years.

ACI "conservatively" estimates growth at 100 board feet/acre/year, but the only data it presents is based upon growth recorded in sample plots elsewhere that had "even age ideal conditions", Appendix "A" at p. 8. Under these "ideal" conditions, 433 board feet/acre/year was achieved. These were koa forests with an average of 289 trees/acre, vs. 23 trees/acre in the Koa Timber property, and consisted entirely of trees in the younger, more rapidly growing period of life.

There is no longer any reference to Forest Stewardship Council certification, a positive feature of the previous EA. The proposed advisory council is a good idea, but a volunteer group cannot do the monitoring necessary for a project of this magnitude.

One very basic issue is that for the koa forest to properly regenerate, the seedlings need protection from weeds until they grow to a certain height, and then the trees must be thinned to become good timber trees in the future. This requires a long-term commitment that should be assured by a bond or other financial arrangement so that this does not become a project where the trees are harvested and the site is abandoned. There can be a substantial ecological benefit if koa is re-started in areas now dominated by strawberry guava, but this takes lots of hard work. There must also be third-party verification that the applicant is following through on its commitments.

The applicant had a previous koa harvesting project in the Honomalino area of South Kona in the mid-1990's. This project also began with a number of promises and representations about a long-term commitment to reforestation. The record of this project

should be carefully scrutinized to evaluate the ability of the applicant to carry through with a long-term commitment to a sustainable project.

Sincerely,

CHRISTOPHER J. YUEN
Planning Director

CJY:pak
W:\wp60\Chris\Koa Timber EIS comments.doc

cc: Honorable Harry Kim, Mayor
Mr. Peter Young, Chair – Board of Land and Natural Resources
PlanPacific, Inc.

Harry Kim
Mayor

Lawrence K. Mahuna
Police Chief

Harry S. Kubojiri
Deputy Police Chief

County of Hawaii
POLICE DEPARTMENT
349 Kapiolani Street • Hilo, Hawaii 96720-3998
(808) 935-3311 • Fax (808) 961-8369

January 15, 2003

Mr. Kyle Dong
Koa Timber, Inc.
91-188 Kalaeloa Boulevard
Kapolei, HI 96707

Dear Mr. Dong:

SUBJECT: ENVIRONMENTAL IMPACT STATEMENT FOR KOA TIMBER COMMERCIAL FORESTRY OPERATIONS

Staff has completed review of the EIS Preparation Notice dated November 2001, and the draft EIS for Koa Timber Commercial Forestry Operation dated December 2002, prepared by PlanPacific, Inc., as well as the correspondence dated December 11, 2002 from Mr. Robin Foster of PlanPacific.

After conferring with Mr. Foster regarding Koa Timber's current timber operations, and there being no adverse impact over the past year, staff has no objections or comments regarding this project.

Thank you for this opportunity to comment.

Sincerely,

LAWRENCE K. MAHUNA
POLICE CHIEF

RN

LINDA LINGLE
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF ACCOUNTING AND GENERAL SERVICES
P.O. BOX 119, HONOLULU, HAWAII 96810

RUSS K. SAITO
COMPTROLLER

KATHERINE M. THOMASON
DEPUTY COMPTROLLER

(P)1018.3

JAN 17 2003

MEMORANDUM

TO: The Honorable Eric Hirano, Acting Director
Department of Land and Natural Resources

ATTENTION: Ms. Dierdre S. Mamiya, Administrator
Land Division

FROM: Russ K. Saito
State Comptroller

SUBJECT: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations
South Hilo, Hawaii
TMK: (3) 2-7-01:01 and 2-8-01:02.

Thank you for the opportunity to review the subject project's Draft Environmental Impact Statement. The project does not directly impact any of the Department of Accounting and General Services' projects or existing facilities. Therefore, we have no comments to offer.

Should there be any questions, please have your staff call Mr. Bruce Bennett of the Public Works Division at 586-0491.

c: Ms. Genevieve Salmonson, OEQC
Ms. Dawn Heggar, DLNR Land Division, Planning Branch

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. Box 3378
HONOLULU, HAWAII 96801-3378

LORETTA J. FUDDY, A.C.S.W., M.P.H.
ACTING DIRECTOR OF HEALTH

In reply, please refer to:
File:

03-011B/epo

February 4, 2003

Ms. Dierdre S. Mamiya, Administrator
Department of Land and Natural Resources
Land Division
P.O. Box 621
Honolulu, Hawaii 96809

Dear Ms. Mamiya:

Subject: Additional Comments to Draft Environmental Impact Statement (DEIS) and Conservation District Use Application (CDUA)
Koa Timber Commercial Forestry Operations
South Hilo, Hawaii
TMK: 2-7-001:001 and 2-8-001:002
File No. HA-3066

In addition to our comments, previously sent to you on January 27, 2003 (see attached copy), please include our comments relating to the Total Maximum Load Program (TMDL) below:

Environmental Planning Office (EPO)

Water Body Status

This project is partially located in the Honolii Stream and Hilo Bay watersheds. Hilo Bay, including nearshore waters from Wainaku to Paukaa, is currently listed under section 303(d) of the Clean Water Act as a water body in which water quality is impaired by excessive nutrients and turbidity. Honolii Stream, which drains into these nearshore waters, is similarly listed. This impaired status requires that the Department of Health establish Total Maximum Daily Loads (TMDLs) suggesting how much the existing pollutant loads should be reduced in order to attain water quality standards in the stream and coastal waters.

Although these TMDLs are yet to be established and implemented, a first step in achieving TMDL objectives would be to prevent any project-related increases in pollutant loads. We expect that this would be accomplished through the proper application of suitable best management practices for pollutant load reduction and water quality improvement in all phases of the proposed project. When TMDLs are established for Honolii Stream and Hilo Bay, the

State will establish pollutant load allocations for the lands surrounding the water body and will develop an implementation plan to improve receiving water quality. One of the components of this implementation plan will be to reduce the polluted runoff entering the receiving waters from upslope property and activities. Thus we suggest that polluted runoff reduction be adopted as a Forestry Management Plan objective.

Water Body Protection and Improvement

Management practices that could help to achieve this objective, as discussed in the Draft Environmental Impact (DEIS), include Streamside Management Zones and no-harvest buffers (75' along all named perennial streams). Previous comments by the U.S. Fish and Wildlife Service suggested that the rationale used for designation of stream buffer areas and stream management areas should be described in detail, and the State of Hawaii Department of Business, Economic Development & Tourism previously suggested further discussion of Best Management Practices (BMPs) addressing potential erosion and soil damage.

Given these concerns and the conclusions in the DEIS that strawberry guava is positively associated with more disturbed areas (p. 23) and extremely silted streamlets (p. 32), we suggest that the Forest Management Plan (FMP) be revised to specify the BMPs employed for water quality protection (by minimizing soil erosion and soil damage) in various situations. It may be best to achieve this by developing and implementing a site-specific BMP plan (within the land management practices section of the FMP) that includes decision criteria for BMP selection and procedures for post-installation BMP maintenance. We suggest particular attention to:

- Maintaining a no-harvest buffer area along all perennial streams and tributaries, not just named streams;
- Establishing a decision rule/procedure for determining site-specific width of this zone;
- Describing the practices employed during the period between killing a patch of strawberry guava and the replanting and establishment of native vegetation, especially during and after mechanical removal of the killed guava (p. 11); Describing the practices employed in staging areas (pp. 15-16); and
- Describing the practices employed to reduce polluted runoff associated with private roads within the project Site and along the transportation route. Although the DEIS suggests that the planned quantity of truck traffic and use of public roads are practically identical to Koa Timber's current operations as it has been harvesting koa on the Agricultural district portion of the site (p. 44), it does not identify or discuss the current environmental impacts of this activity. We suggest that the Final EIS identify the ownership, length, surface, and condition (erodibility) of all roads to be used and explain how their potential function as sources and pathways for stream and coastal water sedimentation would be controlled.

Related Concerns

1. The DEIS refers to Koa Forest, Inc. (p. 1) and Koa Forests, Inc. (Appendix A, p. 3) as the owner of the project Site. Our search of the State of Hawaii Department of Commerce and Consumer Affairs, Business Registration Division "Online Business Name Search" at http://www.ehawaiigov.org/dcca/bizsearch/exe/bizsearch.cgi and a follow-up telephone call to the Division at 586-2727 failed to locate a registered business under either of these names. Thus we suggest that project Site land ownership be verified and reported in the Final EIS (FEIS).

2. The DEIS provides a list of seven (7) ahupua'a that are partially encompassed by the project Site and refers to Figures 1 and 2 for additional project Site information. However Figure 2 shows eleven (11) ahupua'a that include land within the project area boundaries. We suggest that all of the ahupua'a that include land within the project area boundaries be listed in the FEIS.

3. The DEIS reports an observation of a large, working, substantial diversion of Lower Kapue streamflow to unknown locations (Appendix F., p. 8). Our communication with the State of Hawaii Commission on Water Resource Management (Dean Uyeno at 587-0266) failed to verify any explicit registration of Kapue Stream water sources, declaration of Kapue Stream water uses, or record of stream diversion works permit for this diversion. Thus for informational purposes we suggest that the ownership and regulatory status of this diversion and the end use of the diverted water be reported in the FEIS.

4. Page 15 of the DEIS includes a statement that "Honoli'i Stream is known to suffer from excess sediment and bacteria...," yet "... there are no known water quality studies for project site streams ..." Thus we suggest that the FEIS document the source of this knowledge about excess sediment and bacteria. Please note that the Department of Health Clean Water Branch collected water quality data from two locations in Honolii Stream in 2000-2001 and again in 2002-2003 -- these data may be obtained by contacting Terry Teruya (586-4309).

5. We concur with Hawaii Biological Survey recommendation (Appendix F, p. 26) "... that aquatic habitats and aquatic biota be monitored for the life of the project to ensure logging does not increase rates of sedimentation that would adversely impact native aquatic biota." We suggest that such monitoring be identified as a component of the Forest Management Plan ("Forest Inventory – Soil Erosion and Water Quality Protection" and "Biological Monitoring" in Appendix B) and that the Department of Health, among others, be consulted in developing a suitable monitoring plan.

We encourage Koa Timber, Inc. to participate in the TMDL process and suggest that they consult with the Department of Health Clean Water Branch (Engineering Section) to discuss how water pollution control permitting may be linked with TMDL implementation.

If you have any questions about these comments or the Total Maximum Daily Load program, please contact David Penn at (808) 586-4337.

Sincerely,

June F. Harrigan-Lum

JUNE F. HARRIGAN-LUM, MANAGER
Environmental Planning Office

c: File

LINDA LINGLE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. Box 3378
HONOLULU, HAWAII 96801-3378

LORETTA J. FUDDY, A.C.S.W., M.P.H.
ACTING DIRECTOR OF HEALTH

In reply, please refer to:
File:

03-011/epo

January 27, 2003

Ms. Dierdre S. Mamiya, Administrator
Department of Land and Natural Resources
Land Division
P.O. Box 621
Honolulu, Hawaii 96809

Dear Ms. Mamiya:

Subject: Draft Environmental Impact Statement (DEIS) and
Conservation District Use Application (CDUA)
Koa Timber Commercial Forestry Operations
South Hilo, Hawaii
TMK: 2-7-001:001 and 2-8-001:002
File No. HA-3066

Thank you for the opportunity to review and comment on the subject proposal. The DEIS/CDUA was routed to the various branches of the Environmental Health Administration. We have the following comments.

Clean Air Branch (CAB)

All activities must comply with the provisions of Hawaii Administrative Rules Section 11-60.1-33 on 'Fugitive Dust. The contractor should provide adequate measures to control fugitive dust from any construction, operations, vehicular traffic, or other activities.

If you have any questions, please contact the CAB at (808) 586-4200.

Wastewater Branch (WWB)

A portable toilet system will be used to handle wastewater generated on site. All wastewater plans must conform to applicable provisions of the Department of Health's Administrative Rules, Chapter 11-62, "Wastewater Systems." We reserve the right to review the detailed wastewater plans for conformance to applicable rules.

If you have any questions, please contact the WWB at (808) 586-4294.

Sincerely,

June F. Harrigan-Lum

JUNE F. HARRIGAN-LUM, MANAGER
Environmental Planning Office

c: CAB
WWB

Division of Forestry & Wildlife

1151 Punchbowl Street, Rm. 325 • Honolulu, HI 96813 • (808) 587-0166 • Fax: (808) 587-0160

February 19, 2003

MEMORANDUM

TO: Dawn Hegger, Planner
Land Division

THRU: Dierdre S. Mamiya, Administrator
Land Division

FROM: Michael G. Buck, Administrator
Division of Forestry and Wildlife

SUBJECT: Request for Comments: CDUA No. HA-3066 Commercial Forestry Operations and Draft EIS by Kua Timber, Inc. South Hilo, Hawaii TMK: 3-2-7-01:01 and 3-2-8-01:02.

The Division of Forestry & Wildlife (DOFAW) has reviewed the subject document and provide the following comments for your consideration. DOFAW's previous comments dated January 14, 2002 remain relevant (see attached).

General comments: DOFAW has an obvious interest and responsibility to assure that harvesting koa in a native forest setting within the Conservation District is conducted in a responsible manner. The specific area proposed for harvesting is inaccessible, has intact native forests that provide habitat for endangered species, and is a valuable forested watershed. All of these factors add considerable challenges to the proposed sustainable forestry operations. While we recognize the gradual degradation of the forest from invasive weeds, a poorly run operation could cause even more damage by removing the forest canopy and allowing the weeds to spread at a faster rate. Yet, we believe that it is important to strive for management approaches where the value of koa harvested within a native forest could provide the means to support management actions to maintain forest health, control invasive species and promote native forest regeneration.

Although improved, we find the materials provided by the applicant still do not provide adequate detail to assess the professionalism and feasibility of the proposed operation. For example, much of the inventory data used to determine harvest levels are gross estimates and provide an insufficient base by which to conduct sustained harvest planning

for koa. It is even stated in the Appendix A that inventory data *"is only a rough estimate and cannot be supported statistically."* It is further stated that *"the first step in developing a forest management plan is to organize a complete and accurate forest inventory. Without an inventory, timberland owners can only make educated guesses as to the proper sustainable level. In addition, without a full and accurate inventory, even the current acreage is only a rough estimate."* We concur with these statements.

Basic requests detailed in DOFAW's initial comments (dated 1/14/2002) remain unanswered. DOFAW emphasized that Koa Timber, Inc. should implement a long-term monitoring program for weed monitoring and to support adherence to an approved timber harvesting plan/forest management plan. A specific proposal is needed in the forest management plan to identify a 5-year funding commitment for the monitoring of invasive weeds following harvesting in each area. The draft EIS lacks the detailed explanation needed to mitigate the control of invasive weeds, pig activity and preventing damage to bird, bat and insect habitat following harvesting. In addition, the proposed harvesting and site scarification period of January through March (which is the high rainfall season along Hamakua Coast) may increase soil erosion and complicate field operations. It is also the period when native forest birds are breeding and hawks are constructing their nests.

While the monitoring data can be costly to obtain, we find it difficult to support the approval of a harvesting permit over such a large, relatively undisturbed native forest area without adequate information. Other options to consider are a reduced scope of the proposed project area and allowing the applicant an opportunity to demonstrate the effectiveness of their plan over a 5-10 year trial period. If successful, the operator could request an amendment to expand their operation. Data from the ongoing harvesting regimes on agriculture lands could be used to support the efforts to their request on Conservation lands.

We also believe that the revised EIS should specifically describe the fiscal and legal instruments proposed to assure that a portion of the revenues derived from the harvest of koa will be reinvested in specific mitigation actions proposed.

Specific Comments:

- ACI estimated that 7.56 trees per acre (minimum 18 inches DBH) could be harvested over a 10-year cutting cycle. Based on the knowledge of many DOFAW staff members with decades of collective experience, we believe that it is highly

improbable that each acre of an extensively managed 10,000-acre forest could produce and yield 7.5 koa trees at 18 inches DBH every year in perpetuity. The proposed volume and revenue projections therefore do not appear to be accurate or sustainable.

- The "Stand Table Summary" presented in the forest management plan appears to be based on data obtained from DOFAW-monitored koa growth plots. The data appear to have been manipulated from their raw form with no corresponding explanation or discussion of assumptions. In most cases ACI's figures for koa growth parameters appear to be higher than our understanding of the true values from these plots. ACI states koa on these growth plots grow more than twice as fast as all-aged koa forests. No evidence or data are presented in support of this statement. While ACI recognizes several serious shortcomings of their analyses, they continue to employ speculative assumptions and data.

- Examples of detailed information that DOFAW needs to adequately evaluate the timber management component of the proposal include:

  - designated harvest units with maps showing the units
  - sequence (schedule) of which units will be cut
  - criteria for selection of cut trees
  - criteria for leave trees
  - how regeneration will be achieved and monitored
  - what stocking rate will be achieved
  - what species of native plants will be used for regeneration
  - specific methodology for invasive species control and monitoring

- The monitoring of invasive weeds, pig activity, koa regeneration, and native bird activity should be accomplished through the establishment and measurement of on-the-ground transects throughout the project area. Transects should be spaced at intervals that represent all forest types on the property in a statistically robust manner. Monitoring should be conducted at stations spaced at regular intervals along each transect. Data from the initial sampling of these transects should be used to determine the required time interval for subsequent transect re-measurements. Monitoring results and supporting documentation should be included with the proposed timber management plan.

In conclusion, the applicant's proposed concept for koa harvest and timber management is highly complex and challenging. Insufficient quantitative data and technical planning documentation are presented within the applicant's current proposal and Forest Management Plan to accurately assess whether this proposal is sound.

Please call DOFAW's review team (Mr. Jon Giffin, Hawaii Branch Manager (808) 974-4221, Mr. Roger Imoto, Hawaii Forestry Management Supervisor, (808) 974-4220, Mr. Michael Constantinides, Survey Forester, 587-4186), if you have further questions regarding the review of the draft EIS by Koa Timber, Inc. Thank you for the opportunity to comment on this project.

Cc: Jon Giffin, Hawaii DOFAW Branch
Roger Imoto, Hawaii DOFAW Branch
Michael Constantinides, Honolulu DOFAW Administration
Robin Foster, PlanPacific, Inc.

Attachment

Division of Forestry & Wildlife

1151 Punchbowl Street, Rm. 325 • Honolulu, HI 96813 • (808) 587-0166 • Fax: (808) 587-0160

January 14, 2002

MEMORANDUM

TO: Traver Carroll, Planner
Land Division

THRU: Harry Yada, Acting Administrator
Land Division

FROM: Michael G. Buck, Administrator
Division of Forestry and Wildlife

SUBJECT: CDUA HA-3066 Commercial Forestry Operations by Koa Timber, Inc.
South Hilo, Hawaii

We have reviewed the information provided for in this CDUA HA-3066 by Koa Timber, Inc. to do commercial forestry operations in South Hilo, Hawaii. The following are comments to help guide the applicant to what is needed in the EIS. DOFAW recommends that the applicant explain in detail the issues we are addressing here in the EISPN.

- DOFAW's previous comments to the draft EA are still pertinent and should be addressed in an EIS: One of the key issues that should be specifically addressed is the long-term monitoring program for both compliance of an approved harvesting plan and weed invasions. A specific proposal to identify adequate funds to control weeds after harvesting for a five-year time frame should be described.

- For the proposed harvest areas, there is a need to define minimum levels for both residual koa tree stocking (stems per acre) and residual koa basal area (square feet per acre). Trees marked for logging need to be based on specific criteria and defined in absolute quantitative terms. A detailed harvesting plan of each logging area is recommended. For example, it is important to develop maps of the harvesting units to support the estimated timber volume achieved per species. This will help DOFAW to understand the criteria and schedules used to select the trees for logging.

- If replanting will indeed attempt to restore the original diversity of the native forest in both species and structure, the target/desired species diversity and structure need to be quantified (in advance) for each vegetation zone/type in the proposed harvest area. Again, a detailed forest management plan for each logged area will need to be developed and approved. The key is a commitment to long-term monitoring of invasive weeds and time-frames following harvesting. The plan should address target species and densities for reforestation, and maintenance or monitoring of invasive plant and animal species.

- Helicopter use will need additional explaining in the harvesting plan. The applicant should describe the helicopter operation relating to the days or weeks skidding of logs will occur, and the schedule and frequency including the time of day that this system will be in operation.

DOFAW appreciates the opportunity to comment on this EISPN and will be looking forward to reviewing the completed EIS for this project.

C: Hawaii DOFAW Branch
Gilbert Coloma-Agaran, Chairperson DLNR

LINDA LINGLE
GOVERNOR

ANTHONY J.H. CHING
EXECUTIVE OFFICER

STATE OF HAWAII
DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM
LAND USE COMMISSION
P.O. Box 2359
Honolulu, HI 96804-2359
Telephone: 808-587-3822
Fax: 808-587-3827

January 22, 2003

Ms. Dierdre S. Mamiya, Administrator
Land Division
Department of Land and Natural Resources
P. O. Box 621
Honolulu, Hawaii 96809

Dear Ms. Mamiya:

Subject: DRAFT ENVIRONMENTAL IMPACT STATEMENT REVIEW
CONSERVATION DISTRICT USE APPLICATION (Board Permit HA-3066)
Applicant: Koa Timber, Inc.
TMK Nos: 2-7-001:001
2-8-001:002

We have reviewed the Draft Environmental Impact Statement ("DEIS") for the subject permit application to operate a tree farm and harvest timber at Makahanaloa, Onomea, Alakahi, Puu Moi, Aleamai, Papaikou, and Paukaa, South Hilo, Hawaii, and have the following comments:

1. We acknowledge that the proposed project area is within the State Land Use Conservation and Agricultural Districts, pursuant to Boundary Interpretation No. 01-19 issued on April 6, 2001.

2. Sections 1.3, Project Description; 2.8.1, Cultural Resources; and 2.8.2, Community and Public Involvement of the DEIS refers to an Advisory Committee which includes a community member that may have expertise on native Hawaiian culture. We recommend that the Final Environmental Impact Statement ("FEIS") provide more description of the role of the committee with respect to the proposed project (i.e. size, composition, meeting schedule, and how its input would affect or guide the project operations).

3. Section 1.3.2, Forest Management Plan, is unclear as to the nature and scope of the environmental resource training that the logging/harvest crews will utilize to address potential impacts to local fauna, avoid significant archaeological areas, and mitigate potential soil erosion. We recommend that the FEIS provide more discussion in this regard.

We appreciate the opportunity to review and comment on the DEIS for the subject applications.

Should you require clarification or further assistance in this matter, please contact Russell Kumabe of my staff at 587-3822.

Sincerely,

ANTHONY J. H. CHING
Executive Officer

LINDA
GOVERNOR

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
869 PUNCHBOWL STREET
HONOLULU, HAWAII 96813-5097

RODNEY K. HARAGA
DIRECTOR

Acting Deputy Director
GLENN M. OKIMOTO

IN REPLY REFER TO:

STP 8.0673

February 26, 2003

RECEIVED
FEB 28 2003
PLANNING DEPT.

TO: MR. PETER T. YOUNG, CHAIR
BOARD OF LAND AND NATURAL RESOURCES
DEPARTMENT OF LAND AND NATURAL RESOURCES

ATTN: DIERDRE S. MAMIYA, ADMINISTRATOR
LAND DIVISION

FROM: RODNEY K. HARAGA
DIRECTOR OF TRANSPORTATION

SUBJECT: KOA TIMBER FORESTRY OPERATIONS
DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
TMK: 3-2-7-01: 01 AND 3-2-8-01: 02

Thank you for your transmittal requesting our comments on the subject project.

The proposed Koa Timber operation will not significantly impact the State transportation facilities provided the number of truck trips remains at the existing level. However, the use of helicopters for harvesting operations will require the applicant to coordinate with our Airports Division for any required permits.

We appreciate the opportunity to provide comments.

LINDA LINGLE
GOVERNOR OF HAWAII

GENEVIEVE SALMONSON
DIRECTOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
[redacted]

February 20, 2003

Mr. Peter Young, Chair
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawai'i 96809

Dear Mr. Young:

Subject: Draft EIS for the Koa Timber Commercial Forestry Operations, Hawai'i

Thank you for the opportunity to review the subject document.

1. This is a large scale and long-term project with many unknowns and assumptions. Therefore, DLNR should continually monitor the operations of Koa Timber, Inc. The Land Board should review the CDUA permit on a regular basis to add or modify permit conditions to protect native ecosystems and conservation lands.

2. All perennial streams should be surveyed before the timber operations begin. The streams should be monitored during the operations and steps should be taken to maintain or improve the conditions of the streams.

3. The EIS should fully analyze the noise impacts of the helicopter operations on humans and animals. How much noise do the helicopters generate? Where are the noise sensitive human and animal communities in relationship to the helicopter's travel path?

Should you have any questions, please call Jeyan Thirugnanam at 586-4185.

Sincerely,

Genevieve Salmonson
Director

c: Plan Pacific, Koa Timber

PHONE (808) 594-1888

FAX (808) 594-1865

STATE OF HAWAI'I
OFFICE OF HAWAIIAN AFFAIRS
711 KAPIOLANI BOULEVARD, SUITE 600
HONOLULU, HAWAI'I 96813

HRD02/136C

January 28, 2003

Kyle Dong
Koa Timber, Inc.
91-188 Kalaeloa Blvd.
Kapolei, HI 96707

RE: Draft Environmental Impact Statement for the Koa Timber Commercial Forestry Operations, TMK (3)-2-7-01:01

Dear Mr. Dong,

OHA is receipt the draft environmental impact statement for the above referenced project. We offer the following comments.

Cultural Impacts

In our letter of December 18, 2003, OHA requested that the EIS assess the impact of the project on native plants used in cultural practices. We also requested that the EIS document any trails located in the area. However, as no Native Hawaiian cultural practices were found to exist in the area, neither of these requests could be fulfilled. However, the EIS does note that should Hawaiians who want to resume cultural practices in the area come forward, then "access to the forest should be permitted for gathering related to cultural and religious practices." We encourage the project proponents to work with Native Hawaiians who would like to resume gathering practices in the area to find mutually beneficial means of growing and harvesting koa and native under story plants.

Thank you for the opportunity to comment on this project. If you have further questions, please contact Pua Aiu, Policy Antilyst at 594-1931 or e-mail her at paiu@oha.org.

Sincerely,

Ernest Kimoto
Acting Director
Hawaiian Rights Division

UNIVERSITY OF HAWAI'I AT MANOA
Environmental Center

February 21, 2003
RE: 0731

Mr. Kyle Dong
Koa Timber, Inc.
91-188 Kalaeloa Blvd.
Kapolei, Hawaii 96707

Dear Mr. Dong:

Draft Environmental Impact Statement
Koa Timber Commercial Forestry Operations
South Hilo, Hawaii

Koa Timber, Inc., a Hawaii company, proposes to develop a sustainable forestry for koa in an existing rainforest area, most of which lies within the resource subzone of the State Conservation District. Using adaptive management, the Project will harvest timber in sustainable increments and take actions to enhance the growth and regeneration of koa and the rainforest ecosystem in ways that are consistent with native Hawaiian culture. To minimize impacts on the rainforest, the company will use helicopters to transport crews and cut trees. Forestry management will include: (1) cultivating the growth of koa trees and generation of seedlings; (2) controlling alien pest species, especially strawberry guava (by cutting and applying herbicide) and feral pigs (by hunting, trapping and exclosure fencing); and (3) developing a geographic information system-based forest inventory, with which to monitor forest growth.

The harvest of timber is planned to be carefully planned and carried out in a manner that protects endangered plants and animals. Lands will be set aside from harvest along stream-courses and the adjacent Hakalau Forest National Wildlife Refuge. Harvest activities will be limited to January through March, while milling at the company's Pepe'ekeo sawmill will continue at a slower pace year-round. Production is projected to remain at the company's current rate of 1.0 million board feet per year. About 10 to 12 truckloads of lumber will be delivered each week to Hilo Harbor for barge transport to Oahu.

The Environmental Center reviewed this document with the assistance of Kevin Polloi of the Environmental Center.

2500 Dole Street, Krauss Annex 19, Honolulu, Hawaii 96822-2313
Telephone: (808) 956-7361 • Facsimile: (808) 956-3980

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General Comments

The Environmental Center is pleased to see Koa Timber, Incorporated's initiative in cooperating with the recommendations from the various agencies. It is understandable that current biotic information is unavailable or difficult to acquire, however we recommend that Koa Timber, Inc. continue to collect and evaluate data to ensure that both the economic viability of the project as well as the natural ecosystem remain healthy and viable.

Periodic surveys of avifaunal populations should be performed to verify relative abundance of native and endangered species in view of the mature makeup of the koa forest itself as well as the project site's proximity to the Hakalau Forest National Wildlife Refuge and the Hilo Forest Reserve System.

New information that is collected should be continually used to evaluate and modify current activities if necessary.

Specific Comments

Section 2.12 Public Facilities, Utilities, and Services
Subsection 2.12.1 Water System

The document states that the "[A]pplicant will construct pond systems as necessary for irrigation" (p. 45). However, it fails to provide detail on the size of such pond systems and water source. If water is to be diverted from the streams, potential environmental impacts must be addressed.

Thank you for the opportunity to review this Draft EIS.

Sincerely,

Jacquelin M. Miller

Jacquelin Miller, Ph.D.
Associate Environmental Coordinator

Cc: OEQC
Dawn Hegger, DLNR
Robin Foster, PlanPacific, Inc.
James Moncur, WRRC
Kevin Polloi

Cooperative Extension Service
College of Tropical Agriculture and Human Resources
University of Hawai'i at Mānoa
United States Department of Agriculture Cooperating

February 11, 2003

Review of Draft Environmental Impact Assessment
For Koa Timber Commercial Forestry Operations

Kyle Dong - 988-1521
Koa Timber, Inc.
91-188 Kalaeloa Blvd.
Kapolei, HI 96707

Dawn Hegger
State of Hawaii
Department of Land and Natural Resources
Division of Land Management
PO Box 621
Honolulu, HI 96809

Robin Foster
PlanPacific, Inc.
345 Queen St. Suite 802
Honolulu, HI 96813

Genevieve Salmonson
Office of Environmental Quality Control
235 South Beretania St. Suite 702
Honolulu, HI 96813

Dear Mr. Dong,

I have reviewed the draft environmental assessment for the koa timber project. While I believe sustainable forestry including koa timber production is a good use of the land, the plan as it stands has so many difficulties that I believe it has little chance of success.

I will limit my discussion to the silvicultural aspects of the plan and leave the wildlife, botanical, water quality, cultural, and economic aspects to others to review.

The forest management plan does not seem to take into account the silvics of koa. Koa is an early-successional, sun-loving tree. It does not regenerate in shade and requires a disturbance on

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the ground and a gap in the forest canopy to regenerate. We don't know how big a gap koa requires, but koa seedlings growing into small gaps do not have enough light to thrive and are eventually crowded out by competing vegetation. There is a strong possibility that the logging methods described will not open up large enough gaps for koa to regenerate and grow to maturity.

The forest inventory showed that the forest has many diameter classes of koa. It cannot be assumed, as the plan does, that these represent different ages of koa trees, and that if the larger trees are harvested the smaller ones will grow to replace them. It is likely that the smaller diameter classes represent not young, healthy trees, but rather suppressed, sick trees which are gradually dying and will never grow larger. I have worked on an inventory project in the nearby Laupahoehoe forest reserve, and while we found young koa of many diameter classes growing there, clearly most were established at the same time, after logging in the 1970s. The smaller koa trees were being crowded out and there was almost no healthy regeneration in the forest.

In addition to harvesting the healthiest trees, a diameter-limit cut, as proposed, will also tend to harvest the trees with the best genetics. Over the long term, selectively harvesting the straightest and fastest growing trees will erode the gene pool of the koa and lead to a less productive and healthy forest.

The other major wild card in koa silviculture is how koa will compete with alien invasive weed species, particularly strawberry guava. The report states that almost all plots contained strawberry guava, and any treatment that releases or regenerates koa will also regenerate guava. Koa cannot hope to compete with strawberry guava. The herbicide glyphosate is not effective on strawberry guava and any herbicide which would be effective on strawberry guava would also kill koa regeneration. Even if guava were grubbed out of the soil, which I think would be prohibitively expensive, it would regenerate from seed.

All this is not to say that I think koa silviculture is impossible, but that to be successful a project will have to develop new techniques and monitor what works and what does not. Permanent plots should be set up in the forest to learn the growth rates of the smaller diameter koa trees in untogged forest. Plots should also be set up in logged areas to monitor regeneration. While koa seedlings will sprout up anywhere there is a seed bank if the soil is disturbed, the critical questions is how many of these will survive to maturity. Regeneration plots will need to be monitored for at least half the rotation age (i. e. for 15 to 20 years) to determine if regeneration is successful, although early indications from the first 5 years would be valuable. While 20 years may seem like a long time, young koa trees may flourish for 5 to 10 years and then stagnate or die. In the data on long-term growth plots presented in the draft assessment, it can be seen that plot 12 basically stopped growing after year 20 (page 8, appendix A). Long-term monitoring is essential to the success of the project. Growth of koa in the forest should be compared with growth of koa in other forests monitored in dozens of plots which have been set up by the Division of Foresfry and Wildlife, the USDA Forest Service, and the University of Hawaii.

Different strategies of weed control will also need to be tested and monitored. The plan would be strengthened by including information on what monitoring has been done and what has been learned from the logging operations that have already been undertaken on the agriculturally-zoned parts of the property.

The current plan calls for logging on 1000 acres per year and the entire property, exclusive of buffer zones, to be logged in 10 years. Results from monitoring work to be started after the first year will not be available until year 5, after half the forest has already been harvested. At this rate, most of the forest will be harvested before the owners know whether the cutting rates and regeneration are sustainable or not. It would be better to start on a much smaller area, or harvest an initial increment and then monitor results for several years before proceeding. Lastly, an educational program should be established in order to share the knowledge of koa silviculture gained in the project with other landowners who also are trying to do sustainable forestry.

Sincerely,

J. B. Friday, PhD, Certified Forester®
Extension Forester

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

In Reply Refer To:
PI-03-55

FEB 21 2003

Mr. Kyle Dong
Koa Timber, Inc.
91-188 Kalaeloa Boulevard
Kapolei, Hawai'i 96707

Subject: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations, South Hilo, Hawai'i; TMKs 3-2-7-01:01 and 3-2-8-01:02

Dear Mr. Dong:

The U.S. Fish and Wildlife Service (Service), including Hakalau Forest National Wildlife Refuge (NWR), has reviewed the subject Draft Environmental Impact Statement (DEIS) prepared by PlanPacific, Inc., in conjunction with an application by Koa Timber, Inc. (the applicant), to the Hawai'i Department of Land and Natural Resources (DLNR) for a Conservation District Use Permit. The proposed permit would authorize Koa Timber to conduct commercial forestry operations over approximately 13,129 acres of predominantly native forest owned by Koa Forest, Inc. We offer the following general comments in accordance with the Endangered Species Act (ESA) of 1973, as amended (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), and other authorities mandating Service concern for environmental resources. Specific comments addressing particular elements of the DEIS are provided in the enclosed addendum.

Overall, the Service remains concerned that logging will degrade old-growth native forest within a Conservation District adjacent to Hakalau Forest NWR. The project area serves as a buffer between the refuge and degraded agricultural lands along the coast. It currently provides valuable habitat for the endangered Hawaiian hawk 'io (*Buteo solitarius*), the endangered Hawaiian hoary bat 'ōpe'ape'a (*Lasiurus cinereus semotus*), at least one and potentially up to 15 endangered Hawaiian plants, and a rich biota of other native plants and animals. The current lack of human activity and resource extraction within the project area slows the invasion of alien plants and animals into the refuge. Although we recognize hunting contributes to rehabilitation of native forest by reducing numbers of feral animals, we are concerned that opening the project area to public hunting and commercial forestry will facilitate the invasion of invasive species via access trails and seeds transported by dogs, hunters, and work crews.

We are further concerned that, if DLNR decides to issue the permit, the applicant's Final Environmental Impact Statement (FEIS) and Forest Management Plan will set an example for other commercial logging permit applications in Conservation District native forests. We consider the applicant's DEIS an inadequate assessment of the potential impacts associated with the proposed timber harvest and mitigation activities. In particular, the DEIS lacks

comprehensive baseline surveys, harvest schedules, monitoring protocols, and decision-making criteria. The Service does not object in principle to an adaptive management approach in situations where lack of information precludes detailed long-term planning. Nonetheless, a project based on adaptive management must incorporate clear guidelines to ensure that goals and objectives are clearly stated and met. We note furthermore that the DEIS fails to provide most of the information we requested in our previous comments on the applicant's March 2001 Draft Environmental Assessment and November 2001 Environmental Impact Statement Preparation Notice (see Service letters dated April 23, 2001, and December 26, 2001). The Service recommends the applicant revise the DEIS to formally articulate an adaptive management approach, for which we provide suggestions in the enclosed addendum.

Regarding potential adverse impacts to federally listed threatened and endangered species, the DEIS generally describes intentions to avoid take and does not consider the need to obtain an incidental take permit under ESA section 10(a)(1)(B). The Service is unable to evaluate this approach due to the DEIS's lack of baseline surveys and protocols for conducting pre-harvest and monitoring surveys. Moreover, the DEIS does not provide adequate information to determine whether take of all listed species can be completely avoided; in particular, the DEIS lacks consideration of impacts to listed species resulting from modification of native forest habitat features. We recommend the DEIS be revised to incorporate the applicant's assurances that appropriate baseline, pre-harvest, and monitoring surveys will be conducted and coordinated with the Service. Where listed species occur, the applicant should coordinate the designation of suitable no-work protective areas with the Service, or delay harvesting until an incidental take permit with an approved habitat conservation plan is obtained.

Based on the issues described above, the Service recommends that DLNR not issue a Conservation District Use Permit for the proposed action until our comments are adequately addressed. If DLNR decides to issue the permit, we recommend the applicant be required to obtain an ESA section 10(a)(1)(B) incidental take permit for actions that may result in take of listed species or our written concurrence that timber harvesting in each tract is not likely to result in take of listed species, before the project is allowed to proceed.

We appreciate the opportunity to comment on the proposed DEIS. For further information, please contact Fish and Wildlife Biologist Jenness McBride at (808) 541-3441.

Sincerely,

for Paul Henson, Ph.D.
Field Supervisor

Enclosure

cc: Richard Wass, USFWS, Hakalau Forest NWR
Hawaii Office of Environmental Quality Control
Michael Buck, DLNR-DOFAW
Dawn Hegger, DLNR-DLM
Robin Foster, PlanPacific, Inc.

ADDENDUM
SPECIFIC COMMENTS ON DRAFT ENVIRONMENTAL IMPACT STATEMENT
KOA TIMBER COMMERCIAL FORESTRY OPERATIONS
Prepared by
U.S. Fish and Wildlife Service, Pacific Islands Fish and Wildlife Office
February 2003

ADAPTIVE MANAGEMENT

The applicant's Draft Environmental Impact Statement (DEIS) acknowledges that a sustainable harvest plan could not be prepared owing to lack of site-specific timber inventory and biological resources data. To compensate for such information gaps, an adaptive management strategy must contain the following elements: a statement of the project's long-term goals and objectives, including a description of the future forest condition expected from the proposed forestry and mitigation activities; a program for conducting baseline surveys, pre-harvest surveys, and periodic monitoring based on sound science, standard protocols, and measurable objectives; a timeline for initiation and completion of all expected activities; a procedure for evaluating the results of all implemented activities; and guidelines for readjusting proposed activities as necessary to meet the project's goals and objectives in response to new information or changed conditions. In particular, the effectiveness of mitigation activities should be evaluated each year and alternative measures identified if needed. The DEIS should be revised to present the overall adaptive management strategy in narrative form, with an activity timeline tabulated in an easily referenced format, for public review prior to approval of the Final Environmental Impact Statement (FEIS).

In developing the adaptive management strategy, the applicant should consider the benefits of determining adequate baselines for federally listed threatened and endangered species over the entire project area at the outset, rather than conducting surveys in each harvest tract prior to logging. Adequate project-wide information would allow development of an overall strategy to minimize and mitigate potential take of listed species. If unavoidable take is anticipated, the applicant should develop a habitat conservation plan and obtain an incidental take permit for all listed species likely to be affected, as provided for under section 10(a)(1)(B) of the Endangered Species Act (ESA). This approach would provide regulatory certainty to both the applicant and the Service that adverse impacts to threatened and endangered species will be properly addressed. Moreover, the incidental take permit and habitat conservation plan would allow harvesting operations to proceed without the delay of additional coordination with the Service. We would be glad to provide technical assistance to the applicant for developing a habitat conservation plan, which we believe also will facilitate long-term forest management planning.

The Service supports the applicant's intention to organize and consult with an Advisory Council for review and evaluation of ongoing forestry practices and ecosystem management techniques, forest inventory and biological monitoring data, and appropriate habitat improvement efforts. The adaptive management strategy incorporated in the FEIS should include explicit annual reporting requirements to the Advisory Council, as well as procedures for communicating the Advisory Council's recommendations to DLNR. We recommend that DLNR authorize the Advisory Council to monitor the project to ensure appropriate forestry and mitigation activities are implemented, through a Memorandum of Agreement or similar instrument signed by Koa Timber and the constituent members. In addition, the project's Forest Management Plan should be re-evaluated at 5-year intervals, and modified in consultation with the Advisory Council if the expected results of habitat mitigation measures or native forest regeneration activities appear ineffective. The FEIS also should include a procedure for dispute resolution if the applicant and Advisory Council disagree on any proposed activities, and provisions for DLNR to revoke the Conservation District Use Permit if so recommended by the Advisory Council.

PROJECT BENEFIT TO NATIVE FOREST RESTORATION

The DEIS contends the proposed mitigation and pro-active forestry management practices will control and potentially reverse on-going degradation of the project area's native forest. We agree a sustainable harvest and regeneration program could potentially help rehabilitate native forest ecosystems through active regeneration of native species and control of alien invasive mammals and plants. Because these activities constitute the major benefits of the proposed action over natural gap-phase replacement (i.e., no action), we believe the DEIS should provide assurances they will be adequately implemented, monitored, and mitigated. At the least, the DEIS should be revised to provide an evaluation of whether the project's expected increase in koa survival and growth will more than offset proposed harvest removals. As currently described, we are unable to evaluate either existing forest conditions or expected changes resulting from the harvesting and regeneration activities. For example, the DEIS includes no assurances that its proposed weed control program will be sufficiently implemented in response to canopy tree removals. We recommend the DEIS be revised to provide a scientifically-based projection of the future forest condition expected under both proposed and no-action conditions.

ENDANGERED SPECIES

Section 2.4.1 (Terrestrial Flora), DEIS pages 16-24, and Section 2.4.3 (Terrestrial Vertebrate Resources), DEIS pages 27-31: Based on minimal preliminary surveys, the DEIS documents only two Federally listed species within the project area: the endangered Hawaiian hawk (*Buteo solitarius*) and the endangered plant *Phyllostegia velutina*. In addition, the DEIS states that other endangered forest birds, colonially nesting seabirds, and the Hawaiian hoary bat (*Lasiurus cinereus semotus*) are likely to be present at least seasonally. The DEIS acknowledges its biological surveys are initial attempts and that further surveys are planned to detect the presence of listed species prior to harvesting or other management activities. We note that the DEIS's only adequate biological baseline survey, the Bishop Museum's aquatic organism study (DEIS Appendix F), reported the occurrence of two undescribed and one rediscovered native invertebrate species. We suspect further surveys are likely to document the presence of other listed species within the project area. According to the DEIS, forestry activities will be modified as necessary to avoid potential harm to listed species. The Service is unable to evaluate the acceptability of this approach from the information provided in the DEIS. We recommend the DEIS be revised to incorporate an adaptive management strategy based on an appropriate monitoring program that identifies survey protocols for each species likely to occur in the project area. The Conservation District Use Permit should be conditioned to require the applicant to

obtain an incidental take permit prior to implementation of any activities that may result in take of listed species.

Hawaiian Hawk (DEIS pages 28, 35, and 36): We concur that pre-harvest, audio-playback surveys during the nesting season should be conducted by a qualified ornithologist to determine if nesting hawks are present. We recommend these surveys be conducted during the March-through-September breeding season directly preceding scheduled logging operations. While we concur that no-harvest buffer zones around nest trees may reduce the likelihood of take, there is no documentation provided to assess the adequacy of a 300-foot buffer in preventing take. Therefore, an incidental take permit should be obtained prior to working in areas of occupied habitat. Post-harvest impacts to nesting hawks also should be monitored to determine the effectiveness of buffer zones around nest trees. All survey and monitoring reports should be provided to the Service.

Hawaiian Forest Birds and Colonially Nesting Seabirds (DEIS pages 27-29, 35, and 36): The DEIS acknowledges that the Hawai'i 'ākepa (*Loxops coccineus coccineus*), Hawai'i creeper (*Oreomystis mana*), and 'akiapōlā'au (*Hemignathus munroi*) may be present at certain times of year in koa and koa-'ōhi'a forest areas. We concur that audio-playback surveys and intensive searches should be conducted by a qualified ornithologist to detect the presence of endangered forest birds prior to logging. However, the DEIS should be revised to include implementation of specific minimization and mitigation measures if forest birds are detected. The DEIS also should include protocols for detecting the presence of breeding Newell's shearwaters (*Puffinus auricularis newelli*) in appropriate areas during the June-through-September nesting period prior to harvesting, as well as guidelines for protecting colonies from logging impacts. If listed forest birds or seabirds are detected during the surveys, the applicant should coordinate that information with the Service to determine if take can be avoided when the proposed activities are implemented, or if an incidental take permit should be obtained prior to implementation.

Hawaiian Hoary Bat (DEIS pages 29-31, 35, and 36): To avoid take of native bats, the DEIS states that no timber harvesting will occur during the June-through-August pup-rearing period. Although no bats have been documented on-site and no bat surveys have been conducted, the DEIS acknowledges bats are "probably at least seasonally present" due to reported observations on adjacent lands. The DEIS also notes that incomplete knowledge of the bat's life cycle and lack of adequate, feasible survey techniques complicate any assessment of potential take. Therefore, we recommend the DEIS be revised to incorporate specific survey protocols for detecting the presence of bats in potential harvest areas, and that the applicant coordinate survey methodology and results with the Service. Surveys should be conducted during the spring/summer prior to scheduled harvesting operations, using standardized methods and protocols (e.g., sonar detectors along appropriately designed sampling transects). If bats are detected during the surveys, the applicant should coordinate that information with the Service to determine if take can be avoided when the proposed activities are implemented, or if a incidental take permit should be obtained prior to implementation.

The Service supports seasonal restrictions on harvesting operations to minimize and likely avoid direct take of bats. Removal of potential roost trees outside the pup-rearing season, however,

also constitutes an additional adverse effect to the species that must be assessed. If bats are detected within an area, logging restrictions may be necessary until a habitat conservation plan to mitigate the loss of roosting habitat is approved and a Service incidental take permit is issued.

Hawaiian Plants (DEIS pages 16-24, 34, and 35): Preliminary surveys found only one individual of the endangered *Phyllostegia velutina* within the project area. The project area also includes part of the proposed critical habitat for the endangered *Clermontia peleana*. The Botanical Report prepared by Geometrician Associates lists 15 endangered plant species (including the two referred to above) known to occur in the vicinity of the project area (DEIS Appendix C, Table 2, page 8). The Botanical Report's field surveys covered 56 plots in potential koa harvest areas (sampling intensity not reported); other areas, including vegetation zones with native 'ōhi'a-uluhe cover, were not sampled. The DEIS acknowledges that "absence from the surveys does not indicate [endangered plants] are not present within the project area" (DEIS page 22), and that additional plant surveys will be conducted by qualified biologists during the planned timber cruise of the entire property and prior to logging. The Service supports the proposed preservation of a no-harvest buffer zone along the NWR boundary, which will include the proposed critical habitat area. We recommend that harvest areas be adequately surveyed for the presence of listed plants prior to logging, and all plant survey protocols and results be provided for review by the Advisory Council.

WETLAND AND RIPARIAN IMPACTS

Section 2.2 (Streams and Drainage Basins), DEIS pages 15-16: The DEIS states that State of Hawai'i Best Management Practices will be observed in maintaining no-harvest streamside management zones. The DEIS inconsistently identifies the minimum width for these zones as a 75-foot no-harvest buffer along all named perennial streams (DEIS pages 12 and 36) and as a 50-foot zone measured from a stream's high water mark (Forest Management Plan, DEIS Appendix B, page 8). According to Best Management Practices, the width of streamside management zones should be designed on a case-by-case basis depending on local conditions. We recommend the DEIS be revised to incorporate a comprehensive rationale for determining stream-specific, no-harvest zones based on such characteristics as slope, soil erodibility, and adjacent vegetative cover. Descriptions and maps of streamside management zones should be provided in annual reports and harvesting plans for review by the Advisory Council.

Section 2.4.1 (Terrestrial Flora), DEIS page 21: The DEIS describes the project area as a "complex mosaic of various-sized wetland and upland patches" for which a wetland delineation/determination would be impractical. This discussion is inadequate to address the potential impacts of the proposed logging activities. Wetlands, by whatever definition, function in a landscape context to retain water for groundwater recharge, slowly release surface water to moderate the effects of rainfall on streamflow, and retain sediments and nutrients from entering adjacent surface waters. Forested wetlands in Hawaii provide a specialized habitat type for a number of plant and animal species. The structure and function of forested wetlands throughout the project area should be preserved to the extent practicable, and a wetland mitigation plan should be prepared for unavoidable impacts identified in these areas.

structures along project area streams, which are not mapped or described. We recommend timber harvesting be avoided in such areas through designation of streamside management zones along the streams and diversion ditches. Preservation of the historical value of these features should include measures to correct adverse impacts to instream flow and native fish migration.

Section 2.12.1 (Water System), DEIS page 45: According to the DEIS, the applicant will construct pond systems as necessary for irrigation, and design them as habitat for native wetland birds. The Service does not support irrigation pond construction in native forest, even if the ponds may create habitat for native wetland birds. We recommend the DEIS be revised to include more information on the location, size, general features, water sources, and equipment needed to construct these ponds. Ponds should be limited to the minimum size needed to accomplish critical irrigation needs, and should be excavated in upland areas well away from wetlands and ephemeral stream drainages. We are particularly concerned that water not be diverted from natural stream environments to irrigation ponds, which could compound existing water withdrawal impacts in the project area. No new diversion structures should be constructed in stream channels; if ponds are constructed, only existing diversion structures should be used. Any modification to existing structures should be engineered to facilitate passage of migratory organisms and mitigate unavoidable impacts to stream environments. Also, because all resident native wetland birds are listed as endangered, the applicant should develop a plan to monitor any irrigation ponds that are constructed and coordinate with us on appropriate measures to avoid take of listed species resulting from operations at the ponds.

ADDITIONAL SPECIFIC COMMENTS

Section 1.3 (Project Description), DEIS page 2; Section 1.3.1 (Sustained Harvest Estimate), DEIS pages 3-6; and Section 1.3.2 (Forest Management Plan), DEIS pages 6-12: We recommend the DEIS define "sustainable" and "sustained" in regard to forest management and harvest estimates; these terms are not synonymous.

The applicant proposes to harvest only koa trees 18 inches DBH and larger (i.e., mature and dead/dying trees) in an apparently polycyclic shelterwood system involving a low-intensity harvest of selected big trees in a continuing series of 10-year cutting cycles. We caution that diameter-limit cutting often results in high-grading (i.e., removal of only the most commercially valuable trees to the detriment of the residual stand) by progressively removing fast-growing trees, unless some of these trees are purposefully retained to sustain an all-aged condition. The DEIS provides no objectives or guidelines for achieving and maintaining a full range of koa age classes, owing to a lack of site-specific inventory and stand table data. In addition, it is unclear from the minimal surveys conducted (for which neither sampling intensity nor sampling locations were described) if existing koa stands currently provide or can sustain even the expected light harvest of 1-6 koa trees per acre every 10 years, or maintain a forest density of an average 200 trees per acre. In fact, the sustained harvest estimate prepared for the project area by Atterbury Consultants, Inc. (DEIS Appendix A), states that the estimated harvest figures are "rough" and "cannot be supported statistically."

Section 2.4.4 (Stream Fauna), DEIS pages 31-32: The aquatic organism study prepared by the Bishop Museum's Hawai'i Biological Survey (DEIS Appendix F) concludes that "native aquatic animal species predominated in aquatic habitats sampled within the proposed project area, indicating one of the most pristine aquatic ecosystems remaining in the Hawaiian Islands." Project area streams evidenced a very high native aquatic diversity (approximately 82 percent of the aquatic taxa found), and the native fish *Lentipes concolor* was found in four of the six streams sampled. The Bishop Museum study also reports a "major finding" in the rediscovery of a population of the long-legged fly *Sigmatineurum omega*, a native aquatic insect that has not been collected since 1971 and was presumed extinct. Two species of undescribed aquatic flies of the genera *Eurynogaster* and *Procanace* also were discovered within project area streams. Overall, the survey recorded the presence of five endemic aquatic insect species (including *S. omega*) that are considered "sensitive to environmental disturbance." We recommend that designation of streamside management zones be closely coordinated with the Service and the Advisory Council, and that a comprehensive stream monitoring program be conducted to detect potential impacts to these sensitive aquatic species.

The Bishop Museum study also describes in detail 10 discrete sites on the six larger streams found in the project area. The Service recommends the FEIS assess the major topographical features and human-made points of diversion described in that study, with particular attention to any features that may act as complete or partial barriers to migration of aquatic organisms. Diversion structures that block migratory pathways should be evaluated and considered for removal as part of a comprehensive, ecosystem-based stream management program. Alternatively, modification of existing diversions to allow passage of migratory organisms could be part of a mitigation plan to reduce overall impacts to stream environments in the project area.

Section 2.4.5 (Impacts and Mitigation), DEIS pages 32-37: The DEIS identifies increased sediment input resulting from timber harvesting as the greatest threat to aquatic habitats and organisms, and proposes to monitor stream water quality. We concur that helicopter logging, absence of road construction, control of pigs and alien invasive plants, and regeneration of native forest minimizes sedimentation impacts to stream habitats. We recommend the DEIS be revised to fully describe a long-term monitoring program to assess any changes in water yield and water quality that may occur as a result of selective logging. The water quality monitoring program should identify sampling stations, parameters to be sampled, sampling design and intensity, and analytical methodology. Control samples should be regularly collected above, adjacent to, and downstream from harvested areas during the first year after harvesting and periodically afterwards. All water quality monitoring designs and reports should be provided for review by the Advisory Council.

Section 2.5 (Historical and Archeological Resources), DEIS pages 37-39: The DEIS discusses only one water diversion structure, historic site 22534. An Archeological Inventory Survey prepared by Haun and Associates (DEIS Appendix G) describes the site as a water diversion feature and ditch on an unnamed drainage in Pāpa'ikou, located near the project area's eastern boundary and probably outside the Conservation District. The DLNR State Historic Preservation Division has assessed this site as significant and recommends its preservation. The DEIS notes that historic records indicate the potential presence of other water diversion

We concur with Atterbury Consultants in calling for an adequate forest inventory and accurate estimates of a *sustainable* harvest before this project is allowed to proceed. The DEIS should be revised to specifically address how much residual koa will be retained in harvested stands, and identify the overall long-term planning horizon needed to achieve a full, self-maintaining age-class distribution for koa. Lacking this information, we are concerned that over time, the proposed harvesting plan will eliminate existing and potential old-growth koa components. Furthermore, too-frequent cutting could adversely impact wildlife habitat features dependent on large koa trees, such as invertebrate substrates and cavity-nesting sites (as noted in the Koa Timber Botanical Report, DEIS Appendix C).

Section 2.4.5 (Impacts and Mitigation), DEIS pages 32-37: The Service concurs that many of the DEIS's proposed mitigation measures would minimize adverse impacts of the proposed activities, and especially support the following: preservation of approximately 3,100 acres (about 23 percent of total project area) as no-harvest, conservation set-asides (including a 300-foot-wide buffer along the Hakalau Forest NWR boundary); preservation of streamside management zones and implementation of State of Hawai'i Best Management Practices for maintaining water quality; reduced-impact logging using helicopter transport; designation of no-harvest buffers around nest and roost trees; retention of dead/dying koa for native invertebrates and forest birds; eradication and/or control of invasive alien plants; and establishment of a long-term pig eradication and fencing program. The Service also welcomes Koa Timber's participation in the interagency/stakeholder Hawaiian Hoary Bat Research Cooperative, and we encourage Koa Timber to contribute expertise and funding towards suitable research within the project area.

We support the proposed preservation of a riparian wildlife corridor as a no-harvest control area, for example, along a stream where previously undescribed and newly rediscovered aquatic insect species have been documented (see DEIS Appendix F). We also suggest extending the proposed 300-foot-wide Hakalau Forest NWR buffer farther into Vegetation Zone 175 ('ōhi'a scrub and uluhe; see DEIS Table 2, page 20, and DEIS Figure 7). Many of this zone's relatively few koa trees are dead, and provide perch sites for Hawaiian hawks and substrates for native insects. The NWR's last recorded 'o'u (*Psittirostra psittacea)* occurrence was noted immediately adjacent to this portion of the project area. The NWR has not revisited the area to confirm the presence or absence of this rare and possibly extinct species since 1977. The threatened Newell's shearwater 'a'o (*Puffinus auricularis newelli*), also may possibly nest in this vegetation zone.

Section 2.9 (Economic Impacts), DEIS pages 42-44: The DEIS should be revised to contain a financial plan that addresses long-term projections of economic viability; schedules for harvest, regeneration, mitigation, and monitoring activities; the estimated percentage of standing inventory to be cut and regenerated each year; and costs associated with maintaining a continuous forest inventory system. We are concerned that the DEIS's economic projections seem to be based on optimistic expectations of the project area's currently unknown koa stocking rates. The adaptive management strategy incorporated in the FEIS should provide a contingency plan for continued funding of monitoring and mitigation requirements if timber harvest profits are lower than expected.

Section 2.13 (Secondary and Cumulative Impacts), DEIS page 46: The FEIS should address the proposed action's cumulative landscape impacts to native forest ecosystems. These impacts should be evaluated in context with other timber harvesting operations that are ongoing or planned for east Hawaii.

Section 3.6 (List of Required Permits and Approvals), DEIS page 52: The FEIS should include guidelines for requesting the Service's technical assistance, and applying for an incidental take permit, if baseline surveys or monitoring reports indicate potential harm to Federally listed threatened and endangered species.

Section 4 (Alternatives to the Proposed Action), DEIS page 53: See our April 21, 2001, letter for comments on comparing the intensity and frequency of forest disturbance (e.g., gap size and residual koa) that would result from selective harvest and no-action alternatives. The DEIS should be revised to include comparison of existing koa mortality rates with projected harvest rates (e.g., as expressed by percentages of total volume and/or area available).

Section 7 (Unresolved Issues), DEIS page 54: The DEIS acknowledges the lack of a long-term timber harvest schedule. We recommend the DEIS be revised to incorporate a formal adaptive management strategy, as discussed throughout this letter.

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Water Resources
677 Ala Moana Boulevard
Suite 415
Honolulu, Hawaii 96813

January 16, 2003

Mr. Kyle Dong, President
Koa Timber, Inc.
91-188 Kalaeloa Boulevard
Kapolei, Hawaii 96707

Dear Mr. Dong:

In response to your draft Environmental Impact Statement (EIS) for Koa timber commercial forestry operations in the South Hilo District, I offer the following comments:

1. The U.S. Geological Survey (USGS) operates a streamgaging station on Honolii Stream at an altitude of 1,540 feet, near the makai boundary of your project site. Streamflow data have been collected from 1967 to the present. Currently, data are telemetered every 4 hours and are available in real time on our web page (http://hi.water.usgs.gov). Data from this gage may be useful for assessing effects of your proposed operations on streamflow, if any.
2. The existing USGS streamgage on Honolii stream could be upgraded to a sediment and water-quality station. Water-quality data collected before and during timber operations could quantify any adverse effects of logging as well as beneficial effects of exotic species control. The USGS can work with state and county agencies to cooperatively fund and operate streamgages and water-quality stations.

Thank you for the opportunity to comment on your draft EIS. If you have any questions, please call Barry Hill at (808) 587-2407.

Sincerely,

Gordon Tribble
District Chief

CC: OEQC
DLNR Land Management Division
PlanPacific, Inc.

Hawai'i Forest Industry Association
Since 1989

Hawai'i Forest Industry Association
P. O. Box 10216 (808) 933-9411
Hilo, Hawai'i 96721 Fax (808) 933-9140
hawaii-forest.org hawaii.forest@verizon.net

20 February 2003

Mr. Kyle Dong
Koa Timber, Inc.
91-188 Kalaeloa Boulevard
Kapolei, HI 96707

RE: Draft Environmental Impact Statement, Koa Timber Commercial Forestry Operations

Dear Mr. Dong:

The Hawai'i Forest Industry Association (HFIA) is pleased to have had an opportunity to review the Draft Environmental Impact Statement (DEIS) for the commercial koa forestry operations proposed by Koa Timber, Inc. for 13,129 acres in the South Hilo District. Timber harvesting is an allowed use in the Resource subzone of a Conservation District.

The EIS process is intended to provide a mechanism to identify the impacts of a project and ways to mitigate those impacts, or to clarify why the project should not proceed. HFIA supports following the appropriate environmental assessment process, when required, on both public and private lands.

There is a statewide need for sustainably harvested koa. A well thought out, sustainable commercial koa forestry operation in the South Hilo forest could help meet this demand if it were carefully and properly implemented. As written, this DEIS does not give us confidence that this would happen. However, HFIA feels that the Koa Timber, Inc. project should be allowed to proceed after appropriate modifications in response to legitimate, scientifically sound concerns raised during the comment process. Observations and concerns generated by our association's review are noted below.

It is difficult from the information provided to accurately assess the positive and negative impacts, both economic and environmental, of this project. The amount of ecological and biological information is constrained by the size and complexity of the project area, which prevented complete sampling and data collection. However, it does appear that the data which were collected often came from the areas where koa harvesting would most likely occur.

The DEIS describes the economic benefit of this project as "substantial" (p.42.) Indeed, if the project does continue for a decade or more, it will be the largest single, ongoing koa operation in Hawai'i since Campbell-Burns ceased operations in the early 1980s. The proposed annual harvest of 1,000,000 board feet per year represents between 2.5 and 3 times the normal annual average koa harvest in Hawai'i in the years since Campbell-Burns.

Annual koa harvests since the early 1980s are estimated to have averaged approximately 400,000 board feet. The 1,000,000 board feet noted as a "lesser amount" compared to a sustained harvest of 1.5 million board feet annually (Section 1.31, p. 7), while apparently conservative, may not represent a realistic figure, given the concerns expressed regarding authoritative inventory data (Appendix A, "Sustained Harvest Estimate—2nd revision.")

This project can significantly increase the amount of koa on the market. However, the economic opportunity for existing Big Island woodworkers is likely to be small to moderate, since current use is probably well under 500 board feet per year for each woodworking business. While some woodworkers might easily be able to double or even triple the amount of koa they now use, most are sole proprietorships who are not going to be able to make order-of-magnitude changes.

The proposed helicopter harvesting technique, while admittedly potentially benign from the standpoint of minimizing soil erosion and damage to the residual stand and other plants, may not be the best choice for regeneration of koa. Koa is a light-demanding, early successor on highly disturbed sites. It does not regenerate or grow well in the shade of larger trees or other plants. Since helicopter logging creates minimal soil disturbances, the natural regeneration of koa in the harvested sites could be disappointing.

It is unclear from the DEIS how natural regeneration will be accomplished using soil scarification techniques (p.10). Will bucked logs be dragged or winched to scarify the soil? Will there be rototilling or discing using ATVs? The size of the clearings and how they will be made are important considerations in order to ensure regeneration, whether by natural or seeded means.

We are concerned that felling koa at 7.56 trees per acre each decade will not produce scarification over a sufficient area to ensure that a healthy stand of koa will regenerate naturally. Further, it is not certain that the limited amount of sunlight penetrating the remnant forest cover after selective harvesting will allow healthy growth of seeded koa, should natural regeneration fail.

The forest management plan documents koa trees in many diameter classes in the forest, although there is a lack of data regarding seedlings (trees less than 12 inches dbh), apparently due to lack of certain measurements which were not included in the Jaakko Poyry inventory data (Appendix A, p. 10). The management plan assumes that the smaller trees represent younger stock which will rapidly grow to merchantable size. Since koa is a fast-growing, early successional species, it is possible that the smaller trees on the property represent suppressed stock rather than young trees. If this is the case, a diameter limit cut as proposed will merely high-grade the merchantable timber out of the forest during the first rotation without leaving anything for future harvests. High-grading of this nature is not conducive to the development of a sustainable koa forest and native ecosystem.

It will take an enormous effort, both physical and financial, to keep the koa growth areas clear of aggressive plant species such as uluhe, strawberry guava, clidemia, tibouchina and setaria grass, all of which are acknowledged in the DEIS. A long-term commitment of resources is essential to ensure adequate koa regeneration.

Weed suppression strategies described in the DEIS may prove to be inadequate to counteract the prolonged, aggressive encroachment of weedy species. The project must be prepared for a decades-long, costly, weed control program. Properly used fertilizers and herbicides will be essential to the success of this project, while improper or excessive use must be avoided so as not to contribute to non point source pollution.

The DEIS notes that Koa Timber, Inc. will apply Best Management Practices (BMPs) and other appropriate mitigation methods to prevent adverse environmental impacts, such as erosion, sedimentation, and deterioration of water quality. The voluntary BMPs promulgated

by the Department of Land and Natural Resources have proven to be effective at preserving water quality when properly implemented. Adherence to the highest standards of operation should be the norm, not the exception, in a Conservation District.

If proper monitoring of koa growth and weed populations were implemented, this project would represent a valuable opportunity to analyze harvesting and reforestation data at an interesting and unique site. The information that might be obtained by a rigorous, well executed scientific program would be an invaluable addition to our knowledge of Hawaiian forest ecosystems, particularly if it is made available to the public in an appropriate and timely manner. However, there is no firm commitment to monitoring and evaluation in the plan. The suggested time scale has monitoring beginning only after the harvest has been initiated, and evaluation is to be undertaken at five years' time, after half the forest will be harvested.

As noted earlier, there is a statewide need for sustainably harvested koa. A good plan for sustainable forestry in the South Hilo forest could help meet this demand if it were implemented properly. The project as currently proposed does not provide the degree of assurance needed to be considered a truly sustainable supply of koa timber. If a satisfactory degree of assurance is not provided prior to the inception of the project, it is very possible that long-term ecological damage will occur in the Conservation District. It is HPIA's hope that the necessary assurances will be provided and the appropriately modified project will be allowed to proceed.

Aloha,

Andrea T. Gill
Executive Director

cc: Dawn Hegger, DLNR Division of Land Management
Robin Foster, PlanPacific, Inc.
Genevieve Salmonson, OEQC

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January 27, 2003

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Koa Timber, Inc.
91-188 Kalaeloa Blvd.
Kapolei, Hawai'I 96707
Contact: Kyle Dong 988-1521

RE: *Environmental Impact Statement for Koa Timber Commercial Forestry Operations*

Dear Koa Timber, Inc.:

This letter is written on behalf of Metropolitan Mortgage Company, and its subsidiaries, Old Standard Life Insurance Company and Summit Securities, Inc. (collectively, "Metropolitan") to submit comments on the record regarding the above referenced Environmental Impact Statement ("EIS"). Metropolitan is the mortgagor of the property, originally owned by Hawaii Forest Preservation, LLC ("HFP").

On page 13 of the EIS, the timetable states that, in April 2001, "Lender Metropolitan Mortgage assumes control of project, commissions additional forestry and biological studies." However, Metropolitan did not assume control of the project. Rather, Mr. Kyle Dong and Mr. Nekoba, as co-owners of HFP, were in control of the project. HFP, Mr. Dong and Mr. Nekoba participated in every stage of the project. Metropolitan only provided support and assistance to the owners, in developing the original Conservation District Use Application ("CDUA"), including assistance in obtaining the Jaako Poyry Consulting "Koa Forest Inventory" report. That report was provided by Metropolitan to Mr. Dong and Mr. Nekoba. Metropolitan did not receive a request for raw data or the GIS files related to that report. Had such a request been made, Metropolitan would have provided the data and files.

Sincerely,

Steven G. Jones

SGJ:myh

MTH_Koa_EIScomment_012103

SIERRA CLUB
FOUNDED 1892

February 10, 2003

MEMO TO:

Kyle Dong, Applicant
Koa Timber, Inc
91-188 Kalaeloa Blvd
Kapolei HI 96707

Department of Land & Natural Resources, Accepting Authority
Division of Land Management
Attn: Dawn Hegger
State of Hawaii
P. O. Box 621
Honolulu HI 96809

Office of Environmental Quality Control
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State Office Tower Suite 702
Honolulu, Hawaii 96813

PlanPacific Inc
Attn: Robin Foster
345 Queen St. Suite 802
Honolulu HI 96813

KOA TIMBER COMMERCIAL FORESTRY OPERATIONS

COMMENTS TO DRAFT EIS

The Sierra Club supports the concept of responsible stewardship of this unique resource at risk. We support active management to reduce the invasion of alien pests, both plant and animal, and the restoration of the habitat to support the native flora and fauna. However, we do not find that the proposed actions described in the Draft EIS support this objective. Nor does the Forest Management Plan appended to the Draft contain documentation that supports the efficacy of actions proposed. No financial resources are budgeted to address or mitigate for problems associated with logging. Queries raised by several parties in the scoping process were

Moku Loa Group, Hawai'i Chapter, P.O. Box 1137, Hilo, HI 96721

efforts. Water quality must be monitored and practices adjusted to avoid stream degradation. A knowledgeable biologist must be on site to evaluate presence of sensitive habitats and endangered species and take action to avoid harm. Community impacts such as helicopter noise should be assessed and abated. Green certification of the timber produced by a reputable agency would be desirable.

Of concern are the following proposed actions as outlined in the Draft EIS:

1.3.1 Sustained Harvest Estimate:

The sustained harvest estimate varies from 25 million to 78 million board feet (a very wide range!) The available data (un-sourced) contains significant errors in fact and in interpretation. No literature review is appended, there are no references to support the suppositions made by this consultant from Oregon, and we see no evidence that consultation with local foresters was used to make the estimates.

The sustained harvest estimate is based on flawed interpretation of data presented on page 14 of the Forest Management Plan, Appendix B. Figure 1 shows a range of diameter class in inches which indicates a number of trees 18" and larger, and somewhat smaller trees which may never reach the desired diameter of 18", but virtually no trees in the juvenile stage. It is wrong to confuse diameter with age, and the data indicates that a sustained harvest is unlikely, given the conditions presented. The applicant may extract all marketable trees within the first ten years, but could be unable to sustain substantial further harvest. An opening in the canopy may encourage sprouting of seedlings, but is no indicator of seedling success of the long run. The consultant did not have the raw data based on extensive helicopter fieldwork at the proposed site collected by the previous consultant, and instead based his estimates on a few observations and from incomplete data taken from even-aged planted stands in another forest with different substrate and climatic conditions.

1.3.2 Forest Management Plan

The primary objectives of the FMP are laudable, but the details for execution are scant.

Alien Species Control (1.3.2 Page 11)

Psidium cattleianum (Waiawi, strawberry guava)
The proposed actions regarding waiawi control do not reflect on the ground experience. The proposed actions simply will not work. We recommend consultation with Extension Specialist Phil Motooka, or utilization of practices recommended in the publication "Woody Plant Control for the Home, Pasture and Forest" available from the University of Hawaii at Manoa (enclosed). Foliar application of glyphosate (Round-up) by backpack sprayer will not be effective, and removal of rooted trees will result in further degradation of the site. Under wet, humid conditions such as those described for the site, herbicide applications must be timed with dry, windless weather. Spray drift from foliar application of herbicide can adversely affect adjacent native plants even under the best of conditions.

Feral pigs
What is improved access for hunters into a road-less area? How will access facilitate the stated goal of eradication, when the stated goal of the hunters interviewed (in Appendix

not addressed. References were not cited, and both the surveys and the literature review were inadequate to document assertions about yield and habitat restoration.

Summary of Project Concerns

The Sierra Club, Hawaii Chapter has reviewed the proposal for koa timber commercial forestry operations in the undeveloped forest in the South Hilo district of Hawaii Island on land in the Conservation Resource Subzone. The land adjoins the Hakalau Forest National Wildlife Refuge on the western boundary, and contains within its boundaries the state's highest quality pristine streams. Flora and fauna found in this native habitat are unique and rare. The parcels, which comprise a total of13,129 acres, are very wet (average 236 inches of rainfall annually), largely road-less, and accessible only by helicopter.

The land is degraded by invasive species including waiawi or strawberry guava. Spread by feral pigs, waiawi has become a dominant vegetation type in the lower reaches of the land, hindering regeneration of native trees, shrubs and ferns. The waiawi and pig disturbance lead to soil erosion and siltation of the streams. Cats, rats and pigs have led to the decline in vigor and fecundity of native birds. Ants, if introduced by harvesting operations could further disrupt the ecosystem.

We are disappointed that the Applicant did not secure the services of a Certified Forester with experience in Hawaii, who could provide a Forest Management Plan that addresses Best Management Practices for local conditions, who could correctly interpret data and literature about Acacia koa silviculture, and who understands the challenges inherent in management of invasive species.

Although nearly half of the forest contains few koa trees, (the lowest portion is overrun by invasive trees, and the portion above 3000' is dominated by uluhe fern and sedge) Koa Timber proposes extract mature koa trees from 10,000 acres of native rainforest in ten years. By harvesting 2,500 trees from 1,000 acres each year, or 100 trees on 10-13 acres per day during a three-month harvest period, they expect to remove one million board feet per year from the conservation subzone. Koa Timber has been harvesting the land in the agricultural district for about two years, but while document notes that koa seeds have sprouted in the area, it does not report any efforts to control alien pests trees, manage feral pigs, cats, or rats, or control erosion and siltation. Nor does it document any experiments to compare management strategies for restoration. Now the applicant proposes to move into the conservation subzone.

If this proposal were to go forward, and a Conservation District Use Application were to be formulated, we would repeat our request for the following conditions: a limited segment of the proposed area be utilized in the first biennium, so that the practices proposed can be analyzed by an independent group of forest professionals and biologists; best management practices (BMP) must be defined to adequately protect this fragile and little known area. We would request regular reports be filed with the Board of Land and Natural Resources, including the amount and condition of wood harvested, mitigation accomplished and results; and an elevation gradient, such that the lowest elevations be harvested and replanted first, and more fragile and less impacted upland areas be reserved until more is known about the success of mitigation

H) is to increase the numbers of animals? How far in a boggy, dense forest will a hunter drag a pig? Annual hunting by a club is not sufficient to manage 13,000 plus acres of road-less wilderness.
How will trapping be conducted? Will repeated visits by helicopter be implemented to remove trapped animals?
How much resource will be allocated to fencing and exclosures? How will fences be maintained, and how often will the area be visited to check on fence integrity?

Goats
The sustained harvest estimate (Appendix A) mentions goats as a problem. Is this true? How will goats be controlled?

Cats and rats
The biologists (in Appendix D) note that cat and rat predation are significant risk factors to the native birds and pollinators, but no mention of control of these animals is noted.

Ants
Biologists (in Appendix D) note that introduced ants could devastate native mini-wildlife. How ill ant introduction be avoided?

Land Management Practices : Site Disturbance and Stream Protection (1.3.2 Page 12)

Streams in the area are rated the highest quality in the state, and the habitats for native fauna as some of the most pristine in the state; an aquatic insect, long considered extinct, was rediscovered during the survey. However, only a 75' buffer zone is proposed along the stream edges, while a minimum of 100' is recommended in several state documents. Several of the proposed actions could harm the stream quality, including disturbance of soil, invasion of aliens into openings created in native forests, and establishment of new alien pests, both plant and animal, by equipment. Streams and riparian buffer zones provide opportunities to designate wildlife corridors from makai to mauka that protect habitat for both aquatic organisms, insects, birds, bats and other wildlife. These corridors should be wide and generously designated throughout the proposed project.

Where will the helicopter landing sites be located? The document is inconsistent about this, stating that the sites will be in the agricultural zone or the conservation zone in different places in the document. How large will the sites be, and how will they be constructed?
The proposal says the applicant will construct pond systems as necessary for irrigation. How will this be accomplished without a bulldozer? Why is irrigation needed in an area with 236" of annual rainfall? Is a reservoir being proposed to provide water for firefighting?

Helicopters are mentioned in relation to harvest during a three-month period, but helicopter support for management efforts to remove alien species, monitor forest health, compare seedling trials, vegetation restoration, stream protection from siltation and other activities are not mentioned.

The habits of the hoary bat are little known; the document proposes to avoid interfering with the animals during June to August, but operations proposed in the Forest Management Plan (page 12, Appendix B) are inconsistent with these recommendations. Will all helicopter operations cease during this period?

2.9 Economic Impact

The project proposes to employ 14 part-time workers on the Big Island, and an equal number on O'ahu. Payroll and taxes of the project are estimated, but no estimate is proposed for the costs of environmental inputs to restore habitat. Will helicopter support be funded year round for management efforts to remove alien species, monitor forest health, comparative seeding trials, vegetation restoration, stream protection from siltation and other activities? Is the absence of a budget an indication of the level of commitment to mitigation of known problems?

What capital costs are expected over the duration of this project, and how will these costs be funded? Will the applicant purchase a performance bond to pay for mitigation, should the project fail to carry out the environmental restoration and monitoring needed?

Since only Harvesting and Milling are listed as costs, (Appendix I) how does the applicant propose to finance all restoration efforts? The only mention of this issue is the sentence " Several iterations of the cash flow analysis may have to be done to align management operations with budget constraints." We would prefer to see a commitment to a specific percentage of the gross revenue devoted to restoration and monitoring for forest and stream health by qualified full time natural resource managers.

Other questions
The consultant states that governmental agencies were contacted to ascertain whether there are ancient Indian burial sites or villages. Can this be true?

We look forward to responses from the applicant to clarify these and other issues not addressed in the Draft EIS.

Sincerely,

Deborah J. Ward
Sierra Club Conservation Committee, Moku Loa Group.

Koa Timber Commercial Forestry Operation 2/12/03

Comments on proposed logging

I am opposed to the plan to harvest the Koa timber on the 13000 acres as proposed by the Koa Timber, Inc. This island is gradually losing its native forests for a number of reasons, including destruction by ranchers and logging. From what I have seen, the State has not done a good job of protecting our native forests. The land in question here is conservation land, and as such it should not be logged.

The EIS has a list of " beneficial impacts". High on the list is controlling strawberry guava. I think that by removing the Koa cover, more sunlight will reach the ground, and the guava will flourish. Spraying the guava with herbicide may set the guava back, but many applications of herbicide will be needed to kill all the seedlings that will spring up. This much herbicide will probably kill all native plants other than trees. This is more like a scorched earth plan than native plant regeneration. Removing the pigs would certainly be good, but this could be done without removing the forest. From my observations, our native bat is declining. Removing the Koa forest can only impact the bats negatively.

There is a lot about Koa replanting that is not understood. While it has been successful in places like Hakalau NWR, there are other attempts at Koa replanting that have to a large extent failed. The amount of herbicide needed to eliminate the guava may preclude the Koa regenerating. Or the activity in the forest may introduce the fungus disease that is killing some Koa plantings. We should not risk losing this 13000 acres of native forest because we may end up with 13000 more acres of degraded land.

I think that logging this forest will not result in a regenerated Koa forest, free of pigs and strawberry guava. But, I believe that this company is currently logging another forest of similar size. Let them prove that they can log this other forest and achieve a regenerated forest free from alien plants and animals. If they can do this, then let them come back for permission to log this conservation land -- but not before.

David Caccia
PO Box 1788
Honokaa, HI 96727

David Caccia

Patrick Conant
P.O. Box 1172
Volcano HI 96785

January 27, 2003

Mr. Kyle Dong
Koa Timber Inc.
91-188 Kalaeloa Blvd.
Kapolei, HI 96707

Dear Mr. Dong,

I am submitting here my comments on the Draft Environmental Impact Statement prepared by PlanPacific Inc. for TMK parcels 3-2-7-01:01 and 3-2-8-01:02. My comments pertain mostly to the Forestry Management Plan (FMP), since my limited expertise is relevant to that section of the EIS.

Relevant to your FMP, is section 2.4.5 of the EIS, Impacts and Mitigations. Under the section on mitigation, item 3, it is stated that written policies on endangered and alien species will be enforced (pg 34). Similarly, under the section titled "Controlling alien species" (pg36), protocols for cleaning tools boots and equipment are mentioned (the proposal to steam clean mainland equipment is commendable). Such policies and protocols will have a profound impact on the potential introduction as well as management of alien species in the project area The EIS does not have details as to what these policies and protocols will be. Will your Advisory Committee have oversight over these policies? I suggest your EIS is incomplete without listing these policies and protocols.

Relevant to the weed seed contamination issue, I suggest you contact Greg Santos of the Big Island Invasive Species Committee, at ph. 9613299 to explain the risks of moving Miconia seeds up into the forest on contaminated equipment etc. Miconia is already in the gullies on Onomea Ranch so you should keep crews and equipment away from any Miconia in the area to avoid contamination with seeds. Fortunately, your "helicopter staging area" appears to be above the infested area. Mr. Santos would also like to be notified if any worker sees Miconia anywhere in the forest above the pastures

With respect to the Forest Management Plan itself, I have additional comments. On page 9 of this appendix, under the section on Helicopter Harvesting, part b.Operation, it is mentioned that "trails covered with ferns" would be built to each tree. This sentence needs explanation. I assume you are referring to tree ferns that occur in the area that would be cut down to form a trail. Will fern "fronds" or "trunks" be used? If the trunks are used this will have some longer term impact on the canopy in the area than would using fronds. Tree fern trunks should not be imported from outside the site since two invasive weeds, yellow himalayan raspberry (Rubus ellipticus) and Melastoma septemnervium, have both have been found germinating on tree fern trunks shipped off of the Big Island. You might look into biodegradable ground covers to minimize soil disturbance so ferns will not need to be cut. I doubt the loggers will be able to limit their activities to a trail less than 10 ft wide once the koa tree is felled. What about the necessary helipads in the forest? How many will there be in relation to trees cut? Will the helipads get similar "fern trail" treatment? Will they be restored and monitored for weeds when the harvest is over?

In the section titled Site Preparation (pg17), scarification of soil is mentioned. In my previous letter dated April 16 2001, I mentioned the need in the Environmental Assessment for a description of the method of scarification of the soil used to stimulate koa germination. Scarification in almost any form is an invitation to alien weeds, this is essentially why feral pigs are a problem. If koa seedlings are not present already, will the scarifying be more extensive? What size area around which trees (all?) will be scarified? The scarification process needs to be addressed in your plans, to discourage alien species invasion at harvest sites.

In your section titled Reforestation, under Regeneration Maintenance, it states that "competing vegetation will be removed when necessary". It seems unlikely that there are many native plants in the area that grow as fast as young koa. Therefore it would be wise to train your crews to distinguish alien from native plants. Removing native plants will be counter to the restoration process you are trying to encourage.

Under Invasive Species Control (pg19) it is stated that glyphosate will be used as a foliar spray to control strawberry guava. This chemical will be woefully inadequate for what you are trying to accomplish. I suggest you contact a local herbicide expert on controlling woody species of weeds. You may need to use a bark application on individual trees with the appropriate herbicide. I am pleased to see that at least some pig control will be done, although it now seems disappointingly less ambitious than the Environmental Assessment implied it would be. An annual hunt will not make much of a dent in the damage pigs are causing to the forest. Hunters with un-cleaned boots with weed seeds on them could cause more harm than good.

In your next section on Biological Monitoring, (pg. 20) I expected to see some methodology for post-harvest monitoring of the disturbed sites for weed invasion, since such a discussion was absent from the two previous sections, but it is not here either. Consequently, there is no mention of how many years such monitoring would continue to insure that the native cover is restored. The two brief sections on reforestation and biological monitoring seem only concerned with the welfare of planted koa and seem to ignore the many other plants that actually compose a native forest.

In closing I would like to state again (see my previous letter) that I am opposed to logging in conservation zoned intact native forest and the U.S. Fish and Wildlife Service also holds this same opinion (letter from P. Henson, USFWS, in your Consultation section). I remain unconvinced that the mitigation work performed to prevent weed invasion and restore the disturbed sites will be successful. The project area is part of the watershed for East Hawaii where any disturbance to the vegetation cover may allow invasion of alien weeds, and may also ultimately lower the ability of the watershed to store rainfall.

Thank you for sending me a copy of the draft EIS so I could provide this input.

Sincerely,

Patrick Conant

Patrick Conant

c. Office of Environmental Quality Control
SOH DLNR-Div. of Land Management
University of Hawaii Environmental Center

Re: Conservation District Use Application HA3066 Feb. 16, 2003

To: Mr. Gilbert Coloma-Agaran,
Chairperson, Board of Land and Natural Resources
1151 Punchbowl St., Room 220
Honolulu, HI 96813

Cc Office of Environmental Quality Control
State Office Tower
235 S. Beretania St., Suite 702
Honolulu, HI 96813

Cc Earth Justice
Marjorie Ziegler
223 S. King St., Suite 400
Honolulu, HI 96813-4501

Cc State Dept. of Land and Natural Resources
Division of Land Management
Attn Dawn Hegger
P.O. Box 621
Honolulu, HI 96809

Cc Plan Pacific, Inc.
Attn Robin Foster
345 Queen St., Suite 802
Honolulu, HI 96813

Original Copy – Koa Timber, Inc.
Attn Kyle Dong
91-188 Kalaeloa Blvd.
Kapolei, HI 96707

Re: Conservation District Use Application HA 3066

After revising the most recent EIS issued by Koa Timber, Inc., I feel I've read only a sweetened-up version of their November, 2001 EIS version, prepared by Wilson, Okamotot and Associsiates, which allowed them the right to log in Pauka'a by helicopter. So many promises and commitments to do such great deeds for one of Hawaii's last great untouched forests! Such claims to such great stewardship! Has any one, from any government regulatory agency taken the time to see the after math of Koa Timber, Inc., logging that they have done so far? Shouldn't the evidence presented in itself show what kind of stewards of the land that they are?

Or is it that all their cutting of trees was in the Agriculture Zone and Koa Timber, Inc. had not obligations to do what they said they would do for the Conservation-Resource Zone?

So, it appears, especially from the sky, if one to observe this past logging activities by air, as I have heard, one would certainly notice the complete lack of forest management practices that they promise and preach. This is especially true in the bull dozes areas of Paukaa that they harvested by helicopter. Here it would be seen that they dozed and felled trees far mauka up the "Pohakupaa" stream, which is the North fork of Honolii stream. The topographic maps clearly show that this area is above the Agriculture Zone boundary. It seems that the Agricultural Zoned boundaries were not even taken into consideration as a stopping line for KTI. Was there even a survey done? How is the DLNR going to enforce an issue like this when the boundary line is not even known? Even if all this activity was in the Ag-zone, it is still an ecological disaster zone.

The area KTI worked appears to be completely inundated with invasive noxious weeds, It looks like trees were cut with no regard for size or diameter. It appears the no replanting efforts ere even taken. One could surmise that no efforts were taken to protect any endangered species!

This all brings me to the first of my major concerns – enforcement of this project. How is the State of Hawaii, which seems already financially strapped and therefore, under man powered, going to enforce a project like this?

A second and utmost concern of mine, is that Kaiwiki Homesteads (Kaiwiki Road) has been overlooked as a sensitive land use area. KTI seems to have conveniently overlooked the fact that this residential area is in direct impact from the noise pollution from the Huey H1H helicopters used to harvest logs by KTI. For the past 2 years my family and I have had to endure the incredible noise pollution caused by the helicopters that lift the trees. This is all while KTI logged in this manner, free of permits in Ag zoned land in Paukaa. The helicopters that they use are a terrible source of noise pollution and an incredible disturbance in an otherwise quiet residential area.

Please consider Kaiwiki Homesteads as a Sensitive Land Use, now that KTI needs the States' permission to log right next to Kaiwiki Homesteads.

Please refer to Map Figure 8 and pages 44 and 45, EIS.

The least that should be done for Kawiki Homesteads is a 2-mile buffer zone, but again I doubt the enforceability of this mitigation measure. Let's have some mitigation here because there's a definite impact of noise pollution! The EIS also appears to overlook the impact of noise pollution by helicopters to a; creatures, such as the I'o, Hawaiian Hawk.

Another concern of mine is that the State would consider even letting such a large-scale operation take place while there are endangered species at risk. As even stated in Appendix E, there is little, or no data known about the Hawaiian Hoary Bat, the I'o Hawaiian Hawk, Newell's Shearwater, Akiapola'au, Hawai'i creeper and the Hawaiian Akepo. The State should leave the forest as it is, until better information has been compiled! DLNR should take a hard look and study the area that Koa Timber Inc. has already harvested by helicopter!

Hawai'i already has the fastest rate of disappearing plants and animals, more than any other State in the Union. Why take the risk of adding to the extinct list? I can tell you first hand, that during Koa Timber Inc.'s. operation in the Pauka'a Ag. Zone, my own sightings of the I'o has dropped dramatically. Sightings of the other creatures that I mentioned above, sightings are non-existent. .

Re: Conservation District Use Application HA3066 Feb. 16, 2003

The impact of, rather, the lack of impact of glyphosphate, otherwise known as "RoundUp" and "Rodeo". This poison has little effect except to temporarily stunt Waiwe. The Division of Forestry can back this claim as they have recommended "Garlon" or "Remedy" as a way to kill Guava and Waiwe in the past. It seems a better study of what poison to use is needed! And, not to mention, the fact that it rains more than 200 inches of rain a year in this area! Since these herbicides rinse off during rain, it seems a difficult task to prevent weeds from overtaking new Koa seedlings. Will KTI be required to spray herbicide only on sunny days? Will they be required to return to spray again if rain renders the herbicide ineffective? It is necessary to spray each and every stump of guava or Waiwe, to even stand a chance of killing these weeds. It's like my Hawaiian friend says "it just makes the Waiwe mad and she makes more!" Who is going to enforce spraying and monitor regrowth of weeds and Koa seedlings?! DLNR does not have the manpower; neither does the State Dept of Forestry.

I could go on and on regarding the inconsistencies of the EIS presented. KTI has already demonstrated it's hypocritical methods of "forest management" as shown by their practices in upper Pauk'a'-Pohakupa'a Stream area.

I strongly feel that this project should not be approved and that work should cease! The problem boils down to lack of enforcement. We can not expect the State to monitor all of which is proposed; the loss of this forest area is not worth the meager gains, especially to the endangered flora and fauna. The projected tax revenues to the County or State, combined with the income of the few local jobs promised, would not even cover the costs of adequate enforcement of proposed mitigation measures. It is of the best interest for all involved to leave this forest "as is"!

Sincerely,

John Flaherty
360 Kawiki Rd.
Hilo, HI 96720
(808) 938-4387

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Feb.20,2003

Micah Miller
2410 Kaiwiki Road
Hilo,HI
96720

Koa Timber, Inc.
91-188 Kalaeloa Blvd.
Kapolei, HI 96707

Contact: Kyle Dong
Sir:

Thank you for the opportunity to review and comment on the Draft EIS prepared for the Koa Timber Forestry Operation project located in Hilo, TMK 2-7-1:01.

1) NOISE: In December 2000 you began harvesting, using helicopters to transport logs to the mill site above the old landing strip. On some days there were over 20 trips made, bringing logs every 10 to 20 minutes. Then you brought in a huge chopper from Maui and had two working loudly. There are over 30 homes in upper Kaiwiki Homesteads within a one mile radius of the mill site. Our Community Association was not notified nor did we receive a copy of the Nov. 2001 Draft EIS, despite being your nearest neighbors.
2) STEWARDSHIP DATA: At the Public Hearing on 11 April 2001you application for a CDU promulgated a "100 year plan" of forest stewardship. You have had 2 years experience husbanding your Ag lands. Who are the members of the Advisory Committee? Who is the forester monitoring koa regeneration and alien species control? Give out the data which would demonstrate your stewardship. Don't just say you are going to do it.
3) HERBICIDE: Glycophosate is ineffective on waiawi. Any effective herbicide could not be sprayed onto tall stands of waiawi without destroying all other vegetation.
4) SCARIFICATION: Ground disturbance will create koa regeneration. This is impossible using a helicopter and chainsaw crew. Without scarification the continued growth of waiawi will consume the site where the koa tree grew. Possible the chopper will lose an irretrievable log. It's a lose/lose situation.
5) PROXIMITY: The CDUA includes the Forest Reserve located between Honoli'i and Pohakupa'a Streams. Due to the proximity of the mill site to upper Kaiwiki Homesteads, loud noise pollution would effect the community adversely, again.
6) LOSS OF HABITAT: There are several pairs of I'o that frequent these areas, competing for nesting territory. Heli-logging of the Forest Reserve will remove the native forest forever, with loss of habitat as well as no regeneration of koa.

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Until there is a realistic way to accomplish responsible forest stewardship and management, these Forest Reserves are best left alone. These should be no use of the Conservation District unless regeneration or replanting are guaranteed, and surveys are done to prove successful results.

Sincerely,

Micah Miller

Micah Miller
Director, Kaiwiki Community Association

June 9, 2003

Ms. Jacquelin Miller, Ph.D
University of Hawaii at Manoa
Environmental Center
2500 Dole Street
Krauss Annex 10
Honolulu, HI 96822

Subject: Koa Timber Commercial Forestry Operations

Dear Ms. Miller:

Thank you for your comment letter dated February 21, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Desmond K. Wery
County of Hawaii
Fire Department
Hilo, Hawaii 96720

Subject: Koa Timber Commercial Forestry Operations

Dear Mr. Wery:

Thank you for your comment letter dated January 30, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Patricia Engelhard
Department of Parks and Recreation
101 Pauahi St, Suite 6
Hilo, Hawaii 96720

Subject: Koa Timber Commercial Forestry Operations

Dear Ms. Engelhard:

Thank you for your comment letter dated February 20, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Christopher J. Yuen
Planning Department
101 Pauahi Street, Suite 3
Hilo, Hawaii 96720

Subject: Draft Environmental Impact Statement for Timber Harvesting Project
TMK Nos. 2-7-01:01 and 2-8-01:02

Dear Mr. Yuen:

Thank you for your comment letter dated February 21, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1, Paragraph 2, Inventory

ACI: *See FMP page 10-16*

Comment: Page 1, Paragraph 3 and 4

ACI: *See FMP page 10-16*

Comment: Page 2, Paragraph 3

ACI: *We will be applying for a environmental certification.*

Comment: Page 2, Paragraph 4

ACI: *See FMP page 4, paragraph 6 and see Appendix __*

Thank you for your comments.

June 9, 2003

Lawrence K. Mahuna
County of Hawaii
Police Department
349 Kapiolani Street
Hilo, Hawaii 96720

Subject: Koa Timber Commercial Forestry Operations

Dear Mr. Mahuna:

Thank you for your comment letter dated January 15, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Russ K. Saito
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, Hawaii 96813

Subject: Koa Timber Commercial Forestry Operations

Dear Mr. Saito:

Thank you for your comment letter dated January 15, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Ms. June Harrigan Lum
Department of Health
Environmental Planning Office
PO Box 3378
Honolulu, HI 96801

Subject: Additional Comments to DEIS and CDUA Koa Timber Commercial Forestry Operations TMK: 2-7-001:001 and 2-8-001:002 File No. HA 3066

Dear Ms. Harrigan-Lum:

Thank you for your comment letter dated January 27, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1, Paragraph 2-Dust control

ACI: See FMP page 25-harvesting by helicopter

Comment: Page 2, Paragraph 1-Wastewater Plan

ACI: A portable lavatory will be used to handle any wastewater generated on site.

Thank you for your comment letter dated February 4, 2003 regarding the subject EIS. We offer the following response:

Comment: Page 2-Paragraph 1: "We suggest that polluted runoff reduction be adopted as a Forest Management Plan objective:

ACI: *We will be following our Forest Management Plan. See FMP page 3-5.*

Comment: Page 2, Paragraph 2 & 3-Water Body Protection and Improvement

ACI: *See FMP page 28,Paragraph 1-Harvest buffer*
See FMP page 31-Flora-Strawberry guava
See FMP page 28-31-Practices employed forreplanting...
See FMP page 25 Section b, Paragraph 1-Practices employed to reduce run-off associated with private roads

Comment: Page 3, Related concerns

ACI:

1. *Ownership verification-Hawaii Forest Preservation, LLC*
2. *Ahupua'a count: See Environmental Impact Study: Archaeological Inventory Survey section*
3. *Diversion of lower kapue streamflow: Diversion was created by Dept. of Water supply and we are not responsible for this diversion: See Environmental Impact Study:Archaeological Inventory Survey section*
4. *Honoli'i Stream quality-document source of information resedimentation and bacteria-See FMP page 28:200 foot buffer on Water quality protection*
5. *Biological monitoring-See FMP page 28, Paragraph 2 and FMP page 32, Paragraph 2*

Comment: Page 3, Paragraph 6-Participation in TMDL process

ACI: We are not adding any sediments or pollutants to the stream to cause any pollution in the streams. See FMP page 28: Water Quality Protection.

Thank you for your comments.

June 9, 2003

Mr. Michael G. Buck, Administrator
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, HI 96813

Subject: Draft EIS for Koa Timber Commercial Forestry Operations
South Hilo, Hawai'i; TMK 3-2-7-001:001 and 3-2-8-001:002

Dear Mr. Buck:

Thank you for your comment letter dated February 19, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: "...inventory data used to determine harvest levels are gross estimates and provide an insufficient base by which to conduct sustained harvest planning for koa..."

ACI: *Briefly summarize methodology and new inventory data detailed in the revised FMP. Refer to revised Forest Management Plan (FMP page 10-13).*

Comment: "The Forestry Management Plan and the DEIS lack a specific proposal for a long-term monitoring program for both compliance with the harvesting plan and the occurrence of invasive weeds. "A specific proposal is needed in the forest management plan to identify a 5-year funding commitment for the monitoring of invasive weeds following harvest in each area."

ACI: *Refer to revised Forest Management Plan (FMP page 1-14) and see Appendix C-bonding.*

Comment: "The DEIS lacks a detailed explanation of the proposed program for controlling invasive weeds and pig activity and preventing damage to bird, bat, and insect habitat in conjunction with harvest."

ACI: *Refer to revised Forest Management Plan (FMP page 19-23 and 30)*

Comment: "Proposed harvest during January-March, which is the high rainfall season, may increase soil erosion and complicate field operations. It is also the period when native forest birds are breeding and hawks are constructing their nests."

ACI: *Refer to revised Forest Management Plan (FMP page 24-Harvesting)*

Comment: "Information is not adequate to support a permit for harvesting a large, relatively undisturbed native forest area. Given the expense of obtaining inventory data and conducting monitoring over such a large area, the applicant should consider a reduced scope and project area and a 5-10 year demonstration of the harvest program.

ACI: *Refer to revised Forest Management Plan (FMP page 19-23-Reforestation)*

Comment: "...the EIS should specifically describe the fiscal and legal instruments proposed to assure that a portion of the revenues...will be reinvested in specific mitigation actions proposed."

ACI: *Refer to revised Forest Management Plan (see Budget Supplement)*

Comment: "...we believe that it is highly improbable that each acre of an extensively-managed 10,000-acre forest could produce and yield 7.5 koa trees at 18 inches DBH every year in perpetuity. The proposed volume and revenue projections therefore do not appear to be accurate or sustainable."

ACI: *Refer to revised Forest Management Plan (FMP page 3, paragraph 5: "One to six trees per acre, every seven years...")*

Comment: "...In most cases ACI's figures for koa growth parameters appear to be higher than our understanding of the true values from these (DOFAW-monitored growth) plots...they (ACI) continue to employ speculative assumptions and data."

ACI: *Refer to revised Forest Management Plan (FMP page 14-18)*

Comment: DOFAW needs detailed information on the following to adequately evaluate the timber management component of the proposal:

- Designated harvest units with maps showing the units
- Sequence (schedule) of which units will be cut
- Criteria for selection of cut trees
- Criteria for leave trees
- How regeneration will achieved and monitored
- What stocking rate will be achieved
- What species of native plants will be used for regeneration
- Methodology for invasive species control and monitoring

ACI: *Refer to revised Forest Management Plan (FMP page19-21, 24,26, 29-31)*

Comment: "The monitoring of invasive weeds, pig activity, koa regeneration, and native bird activity should be accomplished through the establishment and measurement of on-the-ground transects..." with transects spaced in a statistically robust manner and measuring stations spaced along each transect. Data from the initial sampling should be included in the Forest Management Plan. Initial data collected should be used to determine appropriate time intervals for transect station re-measurements."

ACI: *Refer to revised Forest Management Plan (FMP page 16-18)*
Attached DOFAW Memorandum dated January 14, 2002:

Comment: "In the objective is to restore the original diversity of the native forest in both species and structure, then the plan should state quantifiable targets for species diversity and structure for each vegetation zone in harvest areas. The plan should address target species and densities for reforestation."

ACI: *Refer to revised Forestry Management Plan (FMP page 16-18)*

Comment: "Describe the helicopter operation relating to the days or weeks skidding of logs will occur, and the schedule and frequency, including time of day, that this system will be operating."

ACI: *Refer to revised Forestry Management Plan (FMP page23 and 25)*

Thank you for your comments.

June 9, 2003

Mr. Anthony J.H. Ching
Department of Business, Economic Development & Tourism
Land Use Commission
PO Box 3378
Honolulu, HI 96801

Subject: Additional Comments to DEIS and CDUA Koa Timber Commercial Forestry Operations TMK: 2-7-001:001 and 2-8-001:002 File No. HA 3066

Dear Mr. Ching:

Thank you for your comment letter dated January 22, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1-Number 2-Advisory Committee-size, composition, meeting schedule, how input would affect or guide project operations

ACI: *Advisory committee is now deleted. Third party monitoring by Dr. Randy Senock, Ron Terry and Wade Lee.*

Comment: *Archaeological areas*

ACI: *See Environmental Impact Statement Appendix G and we will have an environmental committee.*

Comment: *Soil Erosion*

ACI: *See FMP page 27*

Thank you for your comments.

June 9, 2003

Mr. Michael G. Buck, Administrator
Division of Forestry and Wildlife
1151 Punchbowl Street, Room 325
Honolulu, HI 96813

Subject: Draft EIS for Koa Timber Commercial Forestry Operations
South Hilo, Hawai'i; TMK 3-2-7-001:001 and 3-2-8-001:002

Dear Mr. Buck:

Thank you for your comment letter dated February 19, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: "...inventory data used to determine harvest levels are gross estimates and provide an insufficient base by which to conduct sustained harvest planning for koa..."

ACI: *Briefly summarize methodology and new inventory data detailed in the revised FMP. Refer to revised Forest Management Plan (FMP page 10, paragraph 1).*

Comment: "The Forestry Management Plan and the DEIS lack a specific proposal for a long-term monitoring program for both compliance with the harvesting plan and the occurrence of invasive weeds. "A specific proposal is needed in the forest management plan to identify a 5-year funding commitment for the monitoring of invasive weeds following harvest in each area."

ACI: *Refer to revised Forest Management Plan (FMP page 1-14)*

Comment: "The DEIS lacks a detailed explanation of the proposed program for controlling invasive weeds and pig activity and preventing damage to bird, bat, and insect habitat in conjunction with harvest."

ACI: *Refer to revised Forest Management Plan (FMP page 19-23 and 30)*

Comment: "Proposed harvest during January-March, which is the high rainfall season, may increase soil erosion and complicate field operations. It is also the period when native forest birds are breeding and hawks are constructing their nests."

ACI: *Refer to revised Forest Management Plan (FMP page 24-Harvesting)*

Comment: "Information is not adequate to support a permit for harvesting a large, relatively undisturbed native forest area. Given the expense of obtaining inventory data and conducting monitoring over such a large area, the applicant should consider a reduced scope and project area and a 5-10 year demonstration of the harvest program.

ACI: *Refer to revised Forest Management Plan (FMP page 29-23-Reforestation)*

Comment: "...the EIS should specifically describe the fiscal and legal instruments proposed to assure that a portion of the revenues...will be reinvested in specific mitigation actions proposed."

ACI: *Refer to revised Forest Management Plan (see Budget Supplement)*

Comment: "...we believe that it is highly improbable that each acre of an extensively-managed 10,000-acre forest could produce and yield 7.5 koa trees at 18 inches DBH every year in perpetuity. The proposed volume and revenue projections therefore do not appear to be accurate or sustainable."

ACI: *Refer to revised Forest Management Plan (FMP page 2-3-Property description)*

Comment: "...In most cases ACI's figures for koa growth parameters appear to be higher than our understanding of the true values from these (DOFAW-monitored growth) plots...they (ACI) continue to employ speculative assumptions and data."

ACI: *Refer to revised Forest Management Plan (FMP page 14-18)*

Comment: DOFAW needs detailed information on the following to adequately evaluate the timber management component of the proposal:

- Designated harvest units with maps showing the units
- Sequence (schedule) of which units will be cut
- Criteria for selection of cut trees
- Criteria for leave trees
- How regeneration will achieved and monitored
- What stocking rate will be achieved
- What species of native plants will be used for regeneration
- Methodology for invasive species control and monitoring

ACI: *Refer to revised Forest Management Plan (FMP page19-21, 24, 29-31)*

Comment: "The monitoring of invasive weeds, pig activity, koa regeneration, and native bird activity should be accomplished through the establishment and measurement of on-the-ground transects..." with transects spaced in a statistically robust manner and measuring stations spaced along each transect. Data from the initial sampling should be included in the Forest Management Plan. Initial data collected should be used to determine appropriate time intervals for transect station re-measurements."

ACI: *Refer to revised Forest Management Plan (FMP page 16-18)*

Attached DOFAW Memorandum dated January 14, 2002:

Comment: "In the objective is to restore the original diversity of the native forest in both species and structure, then the plan should state quantifiable targets for species diversity and structure for each vegetation zone in harvest areas. The plan should address target species and densities for reforestation."

ACI: *Refer to revised Forestry Management Plan (FMP page 16-18)*

Comment: "Describe the helicopter operation relating to the days or weeks skidding of logs will occur, and the schedule and frequency, including time of day, that this system will be operating."

ACI: *Refer to revised Forestry Management Plan (FMP page23 and 25)*

Thank you for your comments.

June 9, 2003

Mr. Anthony J.H. Ching
Department of Business, Economic Development & Tourism
Land Use Commission
PO Box 3378
Honolulu, HI 96801

Subject: Additional Comments to DEIS and CDUA Koa Timber Commercial Forestry Operations TMK: 2-7-001:001 and 2-8-001:002 File No. HA 3066

Dear Mr. Ching:

Thank you for your comment letter dated January 22, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1-Number 2-Advisory Committee-size, composition, meeting schedule, how input would affect or guide project operations

ACI: *Advisory committee is now deleted. Third party monitoring by Dr. Randy Senock, Ron Terry and Wade Lee.*

Comment: *Archaeological areas*

ACI: *See Environmental Impact Statement Appendix G and we will have an environmental committee.*

Comment: *Soil Erosion*

ACI: *See FMP page 27*

Thank you for your comments.

June 9, 2003

Mr. Rodney K. Haraga
Department of Transportation
869 Punchbowl Street
Honolulu, HI 96813

Subject: Koa Timber Commercial Forestry Operations DEIS TMK: 3-2-7-01:01 and 3-2-8-01:02

Dear Mr. Haraga:

Thank you for your comment letter dated February 26, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1-Paragraph 2-no impact if number of truck trips remains at existing level.

ACI: *See FMP page 24.*

Comment: Page 1, paragraph 2-coordination with Airport Division for required permits

ACI: *WE have subcontracted licensed Truck drivers and licensed helicopter operators that will follow the State of Hawaii designated laws.*

Thank you for your comments.

June 9, 2003

Ms. Genevieve Salmonson
Office of Environmental Quality Control
235 South Beretania Street, Suite 702
Honolulu, Hawaii 96813

Subject: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations, Hawaii

Dear Ms. Salmonson:

Thank you for your comment letter dated February 20, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment 1: "Therefore, DLNR should continually monitor the operations for Koa Timber, Inc. The Land Board should review the CDUA permit on a regular basis to add or modify permit conditions to protect native ecosystems and conservation lands."

ACI: *Need response from DLNR.*

Comment 2: "All perennial streams should be surveyed before the timber operations begin. The steams should be monitored during the operations and steps should be take to maintain or improve the conditions of the streams."

ACI: *See FMP pg 28. Water Quality protection: Water quality will be monitored before and after harvesting operations, along with a general review of riparian species and soil stability within the buffer zone. If necessary, the 200-foot buffer can be increased to help mitigate any undesirable logging residue.*

Comment 3: "The EIS should fully analyze the noise impacts of the helicopter operations on human and animals. How much noise do the helicopters generate? Where are the noise sensitive human and animal communities in relationship to the helicopter's travel path?

ACI: *See FMP pg 25, Log Extraction: A flight pattern will be established for each harvest unit. Helicopters will use this corridor during their daily transportation of workers as well as for log extraction. The flight pattern will seek to minimize potential noise by using a route that provides the maximum buffer to the nearest residence. Flight paths will not go over homes or buildings.*

During log extraction, the flight corridor from the harvest unit will vary slightly based on the location of the felled trees and weather conditions. The flight pattern will always end within the property boundary.

Thank you for your comments.

June 9, 2003

Mr. Ernest Kimoto
Office of Hawaiian Affairs
711 Kapiolani Boulevard, Suite 500
Honolulu, Hawaii 96813

Subject: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations, TMK (3)-2-7-01:01

Dear Mr. Kimoto:

Thank you for your comment letter dated January 28, 2003 regarding the subject EIS. We offer the following response:

Cultural Impacts:

Comment: "However, the EIS does note that should Hawaiians who want to resume cultural practices in the area come forward, then "access to the forest should be permitted for gathering related to cultural and religious practices."

ACI: *Access for Native Hawaiians and cultural activities are welcomed to be practiced on our land. Please schedule at your convience.*

Thank you for your comments.

June 9, 2003

J. B. Friday
Cooperative Extension Service
875 Komohana Street
Hilo, Hawaii 96720

Subject: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations

Dear Mr. Friday:

Thank you for your comment letter dated February 11, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment 1: Page 1, Paragraph 3: "The forest management plan..."

ACI: *See FMP pg 29-30 Reforestation*

Comment 2: Page 2, Paragraph 1 and 2-Harvest, sizing and health: "The forest inventory showed...In addition to harvesting..."

ACI: *See FMP pg 19, Paragraph 2*
See FMP pg 24, #1 Selection of trees

Comment 3: Page 2, Paragraph 3-Strawberry guava: "The other major wild card..."

ACI: *See FMP pg 31, Paragraph 2-Strawberry guava*

Comment 4: Page 2, Paragraph 4-Permanent Monitoring Plots: "All this is not to say that I thing koa..."

ACI: *See FMP pg 16-18*

Comment 5: Page 3, Paragraph 1-Information from current operations: "Different strategies of weed control..."

ACI: *See FMP pg 12-14, Tables 1, 2 and 3*

Thank you for your comments.

June 9, 2003

Mr. Paul Henson
Fish and Wildlife Service
300 Ala Moana Boulevard, Room 3-122
Box 50088
Honolulu, Hawaii 96850

Subject: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations, South Hilo, Hawaii; TMKs 3-2-7-01:01 and 3-2-01:02

Dear Mr. Henson

Thank you for your comment letter dated February 21, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment 1: "Habitat-Species Protection...the Service remains concerned that logging will degrade old-growth native forest within a Conservation District adjacent to Hakalau Forest NWR....we are concerned that opening the project area to public hunting and commercial forestry will facilitate the invasion of invasive species via access trails and seeds transported by dogs, hunters, and work crews."

ACI: *See FMP pg 28,Rare and Endangered Species: Prior to harvesting, professional biologists (botanists, ornithologists, etc.) will survey the harvest area for (1) endangered or threatened birds, including the Hawaiian hawk; (2) the endangered Hawaiian Hoary Bat; and (3) endangered or threatened plant species. If any endangered or threatened species are found to be active, then activities for the area will be modified to minimize impact.*

Comment 2: "Adaptive Management Approach...The Service recommends the applicant revise the DEIS to formally articulate an adaptive management approach, for which we provide suggestions in the enclosed addendum."

ACI: *Advisory Committee is no deleted. Third party monitoring by Dr. Randy Senock, Ron Terry, and Wade Lee.*
See FMP pg 4, Paragraph 7-project goals
See FMP pg 29-31 Reforestation
See FMP pg 10-14 Forest inventory and monitoring

Comment 3: "Addendum-Wetland and Riparian Impacts..."

ACI: *See FMP pg 28, Paragraph 1*
See FMP pg 4, Paragraph 1-set asides

Comment 4: "Addendum-Additional Specific Comments-Sustained Harvest Estimate..."

ACI: *See FMP pg 10, Forest inventory and monitoring*
See FMP pg 19-25, Harvest levels and scheduling

Comment 5: "Addendum-Additional Specific Comments-Economic Impacts..."

ACI: We have joined the bat co-op, Wade Lee will be our representative for the Bat Coalition with recommendations Reginald David.

Thank you for your comments.

June 9, 2003
Gordon Tribble
U.S. Geological Survey
677 Ala Moana Blvd.
Suite 415
Honolulu, Hawaii 96813

Subject: Koa Timber Commercial Forestry Operations

Dear Mr. Gordon Tribble:

Thank you for your comment letter dated January 16, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Ms. Andrea T. Gill
Hawaii Forest Industry Association
PO Box 10216
Hilo, Hawaii 96721

Subject: Draft Environmental Impact Statement for Koa Timber Commercial Forestry Operations

Dear Ms. Gill:

Thank you for your comment letter dated February 20, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment 1: Page 2, Paragraph 2, 3, 4, 5- Natural regeneration, soil disturbance & sunlight: "The proposed helicopter...Since the helicopter logging creates minimal soil disturbances, the natural regeneration of koa in the harvested sites could be disappointing...It is unclear from the DEIS how natural... We are concerned that felling koa...The forest management plan documents...The forest management..."

ACI: *See FMP pg 29-30 Reforestation*
See FMP pg 24-25 Methodology

Comment 2: Page 2, Paragraph 6 and 7-Weed control: "It will take an enormous effort...Weed suppression strategies..."

ACI: *See FMP pg 29-31*

Comment 3: Page 2, Paragraph 8-Erosion, sedimentation, deterioration of water quality: "The DEIS notes that Koa Timber, Inc. will apply..."

ACI: *See FMP pg 27-28*

Comment 4: Page 3, Paragraph 1-Monitoring and evaluation: "If proper monitoring..."

ACI: *See FMP pg 4, Paragraph 6-continuing evaluation of silvicultural activities*
See FMP pg 10, Paragraph 1 thru 3-annual updates
See FMP pg 16-18

Thank you for your comments.

June 9, 2003

Steven G. Jones
1191 Second Avenue
Suite 2200
Seattle, WA 98101

Subject: Koa Timber Commercial Forestry Operations

Dear Mr. Jones:

Thank you for your comment letter dated January 15, 2003 regarding the subject EIS.

There is no comment required.

June 9, 2003

Deborah J. Ward
Moku Loa Group, Hawaii Chapter
PO Box 1137
Hilo, Hawaii 96721

Subject: Koa Timber Commercial Forestry Operations

Dear Ms. Ward:

Thank you for your comment letter dated February 10, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 3-Paragraph 5, Independent oversight

ACI: *Advisory committee is now deleted. Third Party monitoring by Dr. Randy Senock, Ron Terry and WadeLee.*

Comment: Regular reports with Board of Land and Natural Resources

ACI: *See FMP Page 23, Table 12 and following 2 paragraphs-annual reports*
See FMP Page 19-23

Comment: Regarding water quality

ACI: *See FMP page 28*, Dr. Ron Terry

Comment: Helicopter Noise

ACI: *See FMP Page 25-Section C*

Comment: Regarding Green Certification

ACI: *We will be applying for an environmental certification.*

Comment: Page 3-Paragraph 2-Sustained Harvest Estimate

ACI: *See FMP Page 21*

Comment: Page 3-Paragraph 6-Strawberry guava

ACI: *See FMP Page 31-Flora*

Comment: Page 3-Paragraph 7-Feral pigs

ACI: *See FMP Page 31-Fauna*

Comment: Page 4-Paragraph 4-Stream protection

ACI: *See FMP Page 28*

Comment: Page 4-Paragraph 5-Helipad sites, size, and construction

ACI: *See FMP Page 25*

Comment: Page 4-Paragraph 7

ACI: *See FMP Page 29-Reforestation*

Comment: Page 4-Paragraph 8-Hoary bat

ACI: *See FMP Page 28, Paragraph 2*
See FMP Page 23, Paragraph 3

Comment: Page 5-Paragraph 1, 2, 3-Economic Impact

ACI: See Appendix C
We will insure Appendix C for Botanical report.

Comment: Controlling alien species

ACI: See EIS Section 2.4.5 Impacts and Mitigation, Paragraph 1, 2, 3, 16, 17, 18 and see October 23, 2002 Report by Steven Lee Montgomery, Consulting Biologist (Appendix D of DEIS)

Thank you for your comments.

June 9, 2003

David Caccia
PO Box 1788
Honokaa, Hawaii 96727

Subject: Koa Timber Commercial Forestry Operation

Dear Mr. Caccia:

Thank you for your comment letter dated February 12, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Paragraph 2: Strawberry Guava

ACI: *See FMP Page 31-Flora*

Comment: Paragraph 4: Pigs

ACI: *See FMP Page 31-Fauna*

Comment: Paragraph 4: Endangered Species

ACI: *See FMP Page 28, Paragraph 2*
See FMP Page 23, Paragraph 3

Thank you for your comments.

June 9, 2003

Patrick Conant
PO Box 1172
Volcano, Hawaii 96785

Subject: Koa Timber Commercial Forestry Operation

Dear Mr. Conant:

Thank you for your comment letter dated January 27, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1, Paragraph 2: "Relevant to your FMP, is section 2.4.5 of the EIS, Impacts and Mitigations. Under the section mitigation, item 3, it is stated..."

ACI: *See FMP Page 4, Paragraph 6-Third-party monitoring*

Comment: Page 1, Paragraph 3: "Relevant to the weed seed contamination issue, I suggest you..."

ACI: *See FMP Page 31-Flora*

Comment: Page 1, Paragraph 4: "With respect to the Forest Management Plan itself, I have additional comments. On page 9 of this appendix, under the section on Helicopter..."

ACI: *See FMP Page 24, Section 1, Paragraph 5-Foot trails*
See FMP Page 25, Section b-foot trails

Comment: Page 1, Paragraph 4-helipads: "With respect to the Forest Management Plan itself, I have additional comments. On page 9 of this appendix, under the section on Helicopter..."

ACI: *See FMP page 25-26*

Comment: Page 2, Paragraph 1-soil scarification: "In the section titled Site Preparation (pg 17), scarification of soil is mentioned. In my previous letter..."

ACI: *See FMP Page 29, Paragraph 1, 2, 3*

Comment: Page 2, Paragraph 3: "Under Invasive Species Control (pg 19) it is stated that glyphosate..."

ACI: *See FMP Page 31, Flora, Strawberry Guava*
See FMP Page 31, Fauna

Comment: Page 2, Paragraph 4: "In your next section on Biological Monitoring (pg 20) I expected to see some methodology for post-harvest..."

ACI: *See FMP Page 16, 17, 18-Monitoring and Forest Inventory*

Thank you for your comments.

June 9, 2003

John Flaherty
360 Kaiwiki Road
Hilo, Hawaii 96720

Subject: Conservation District Use Application HA 3066

Dear Mr. Flaherty:

Thank you for your comment letter dated February 16, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 2-Enforcement

ACI: Contact DLNR for boundaries. They are the governoring board for our conservation district use application. Also see FMP page 16-18.

Comment: Page 3-Noise

ACI: *See FMP Page 25-Section C*

Comment: Page 3-Endangered species

ACI: *See FMP page 28, Paragraph 2*

Comment: Page 4-Herbicide

ACI: *See FMP Page 31-Flora*

Thank you for your comments.

June 9, 2003

Micah Miller
2410 Kaiwiki Road
Hilo, Hawaii 96720

Subject: Draft for EIS prepared for the Koa Timber Commercial Forestry Operation project located in Hilo, TMK 2-7-1:01

Dear Mr. Miller:

Thank you for your comment letter dated February 20, 2003 regarding the subject EIS. We offer the following response:

General Comments:

Comment: Page 1-Noise

ACI: *See FMP Page 25, Section C*

Comment: Page 1-Stewardship

ACI: *We will be applying for a environmental certification.*

Comment: Page 1-Herbicide

ACI: *See FMP Page 31-Flora*

Comment: Page 1-Sacrification

ACI: *See FMP page 29, Paragraph 1, 2, 3*

Comment: Page 1-Proximity

ACI: *See FMP Page 25, Section C*

Comment: Page 1-Loss of Habitat

ACI: *See FMP Page 28, Paragraph 2*

Thank you for your comments.