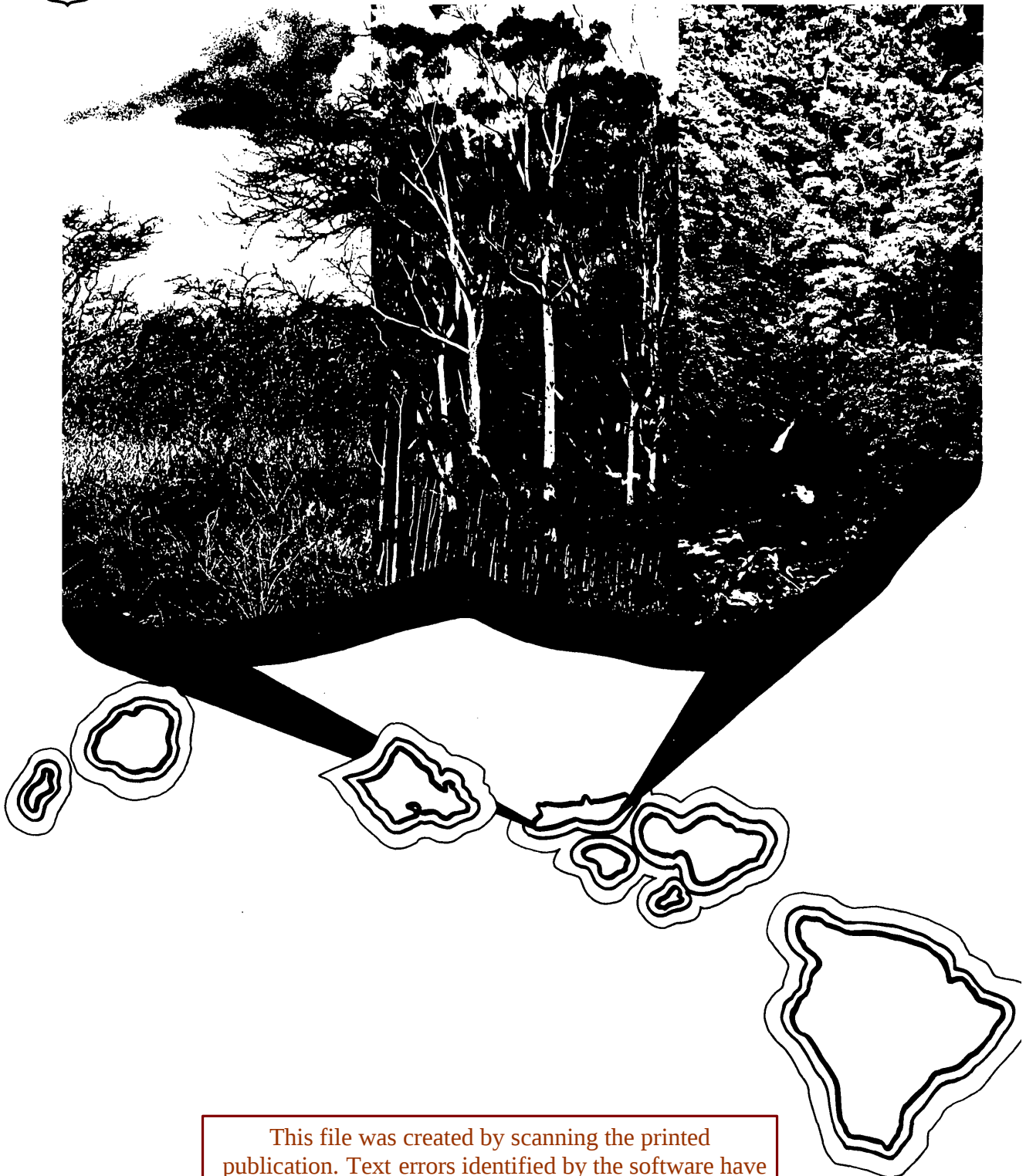




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Multiresource Forest Statistics for Molokai, Hawaii

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Abstract

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This report summarizes a 1983 multiresource forest inventory of the island of Molokai, Hawaii. **Tables** of forest area, timber volume, vegetation type, ownership, land class, and wildlife are presented.

Keywords: Forest surveys, multiresource inventory, statistics (forests), Hawaii.

Preface

Forest Inventory and Analysis is a nationwide project of the Forest Service, U.S. Department of Agriculture, authorized by the Forest and Rangeland Renewable Resources Research Act of 1978. Work units of the project, located at Forest Service Research Stations, conduct forest resource inventories throughout **the 50 States**. **The Pacific Northwest** Research Station at Portland, Oregon, is responsible for inventories in Alaska, California, Hawaii, Oregon, Washington, and the western Pacific.

Summary

The island of Molokai, Hawaii, totals 163,211 acres, of which an estimated 57,598 acres are forested--**23,494** acres classified as timberland and 34,104 acres as other forest land. Previous inventories show an additional estimated growing-stock volume of 4.2 million cubic feet on forest plantations, and an estimated total volume of 5.5 million cubic feet of a fuel-producing species growing on other forest land. Erosion occurs on only 7 percent of **the** island, the majority (85 percent) outside the forest reserve. Although conditions were less than optimal for the observation of wildlife, various species of birds and evidence of mammals were seen. The ratio of alien to native birds was about **8:1**. The native ecosystem continues to be affected by the invasion of introduced plants and animals. Fire is becoming a major threat in vegetation type conversion.

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Introduction

Resource information about Hawaii's forests is greatly needed. Only on a factual basis can plans be effectively made for proper management of these important lands. The increasing awareness and demands on our natural resources point out the need and value of effective resource information for planning and management locally, regionally, and nationally.

Earlier forest inventory work in Hawaii emphasized the collection of timber-volume data. This is reflected in the first inventory of Hawaii's forest resources, which was conducted in 1958-61 as a cooperative arrangement between the State of Hawaii and the Forest Service, U.S. Department of Agriculture. The results were published in the report "Forest Resources of Hawaii - 1961" (Nelson and Wheeler 1963). A second cooperative inventory was carried out between 1969 and 1971, and its results were published in the report "Hawaii's Timber Resources - 1970" (Metcalf and others 1978). This report provided a new assessment of the forest resource as well as important information on forest growth and mortality.

In addition, two inventories of Hawaii's planted forests were done (fig. 1). From 1965 to 1967, the two cooperating agencies made detailed inventories of the forest plantations and published the results (Wong and others 1968). In 1977, under the State of Hawaii Biomass Energy Tree Farm Program, an inventory was conducted of the younger forest plantations established in the 1960's and 1970's, and results were published in the report "Forest Plantation Survey - Biomass Energy Tree Farm Program" (State of Hawaii 1984). Most of the information on planted forests in this report is from these earlier inventories.

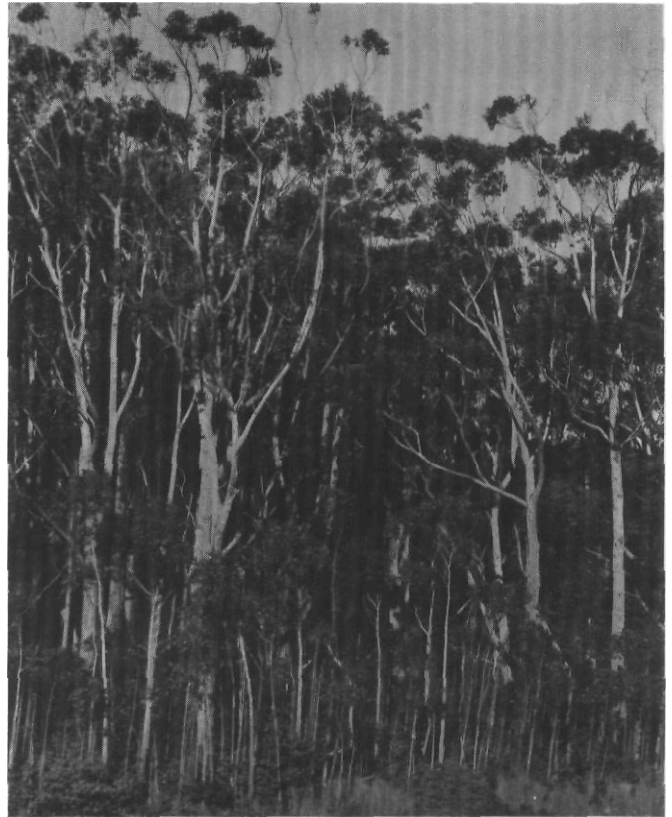


Figure 1--Mature 45-year-old *Eucalyptus saligna* plantation in the Molokai Forest Reserve.

Forest resource inventories within what was then called the Hawaii Division of Forestry emphasized the acquisition of timber volume data. Recent reevaluations, prompted by more comprehensive planning and assessment needs, have given rise to a multiresource inventory perspective.

Multiresource inventory is a relatively new concept in which collection of field data is designed to encompass the needs of as many disciplines as possible. It optimizes fieldwork and standardizes data collection, thereby facilitating transfer and use of information between disciplines.

The Resource Evaluation Section of the Hawaii Division of Forestry and Wildlife conducted a program evaluation in early 1981 which identified the mandates for resource data gathering, the present amount of compliance with those mandates, and recommendations for future programs. A key recommendation that was implemented was a thorough determination of the current inventory needs of the Division of Forestry and Wildlife. A list of these needs was incorporated into a study plan, and work was begun with preliminary technical assistance from the Forest Service's Pacific Northwest Research Station on an actual multiresource inventory design. The new design was necessary to incorporate existing timber volume data elements and new biomass requirements with other multiresource data elements.

Based on this framework, a cooperative agreement between the Hawaii Division of Forestry and Wildlife and the USDA Forest Service was formalized. Although the scope of the work under the agreement--Molokai Island--did not allow total acquisition of statewide resource information, it provided a mechanism for testing inventory procedures and developing report formats.

The island of Molokai was selected for the pilot study because of renewed public interest in energy self-sufficiency, manageable size, and diversity of land classes (fig. 2).^{1/}

The Molokai fieldwork was completed in 1983, and the results of the inventory are presented in this report.

^{1/} See "Terminology" for definitions of terms used in this report.



Figure 2--An example of the diverse vegetation types found in a stream bottom in Pelekunu Valley on Molokai's north shore. Many stream sites were used for taro cultivation by the Hawaiians and are now covered by kukui and guava forests.

Inventory Procedures

The survey design combines information from both aerial photo points and ground field plots in a double sampling procedure. A total of 855 sample points spread out over the island were analyzed from aerial photographs taken in 1977. A total of 11 categories, which included ownership, land class, vegetation type, and zoning, were recorded for each photo point. The area estimated (tables 1-4) for a given category is proportional to the number of photo sample points in that category.

Of the 855 points, 67 were selected as ground field plots throughout the island. These field plots provided a secondary sample for the inventory and ground checks for the photo interpretation. Additionally, on the field plots, a variety of data elements--ground type class, tree characteristics, measurements for computing timber volume, vegetation profiles, impact of noxious vectors, and wildlife observations--were collected.

Each field plot was carefully located and permanently referenced on the ground so that it can be located and remeasured in subsequent inventories. Each plot consisted of an array of subplots, depending on the "land class" of the sampled plot; for example, "timberland" plots had seven subplots, "other forest land" plots had five subplots. These measurements will provide valuable trend information as well as tree growth and mortality data.

Data gathering procedures are detailed in the "Field Manual: Multi-Resource Forest Inventory" (Costales and Buck 1983). The system of data acquisition was designed to provide the maximum amount of pertinent resource information while remaining economically feasible. Another key concern was the development of techniques that could be repeated in subsequent inventories. A volumetric system for measuring tropical trees was developed that allowed for a variety of product outputs. This system was rigorously field tested in the first inventory of Micronesia's forest lands, which used similar methods. In addition, the inventory supported studies such as a new localized system for recognizing standard vegetation types (Buck and Paysen 1984), which standardized data collection and enhanced compilation of information on vegetation types.

Observations

The findings of the multiresource inventory of Molokai are presented in tables 1-12. Tables 1-3 are derived from the 855 photo points which were the primary sample of this inventory. Minor differences within and between tables are attributed to rounding errors. The following discussion selects highlights from these tables and provides perspective by indicating their meaning in relative terms.

Ownership, Forest Reserves, and Vegetation Types

The island of Molokai comprises about 163,211 acres, of which 71 percent is privately owned (table 1). Public ownership is almost equally divided between the State of Hawaii and Hawaiian Home Lands. About 27 percent of the island is in forest reserve status, and almost 60 percent of this land is privately owned.

The two major forest vegetation types on Molokai are kiawe (see "Names of Plants" for scientific names) and 'ohi'a-lehua, each comprising about 33,000 acres (table 2). More than 83 percent of the kiawe and about 65 percent of the 'ohi'a acreage are under private ownership. Almost 70 percent of the forest reserve land on Molokai is comprised of the 'ohi'a vegetation type (table 3). Guava and kukui occupy about 20 percent of the remaining forest reserve lands.

Land Classes

The 1983 field plots were a subsample of the 855 photo points examined on 1977 aerial photographs. Field visits to these points revealed that some of the phot classifications were in error, either because of real changes in land use since 1977 or because of interpretation error (table 5). Area adjustments based on these field visits resulted in a 91.3-percent increase in the estimated area of grassland and a 67.8-percent reduction in the area of cultivated land. Although some of these differences may be a result of photo interpretation error, real change since 1977 is likely, in view of a reported decline in cultivation.

Timberland is the potential base for producing sustainable forest products; based on the 1983 ground sample, it constitutes just 14 percent (23,494 acres) of the island.

Volumetric Information

Timberland: Native and Naturalized Forests--Total tree volume on timberland on Molokai is estimated at 15.8 million cubic feet (table 6). About 74 percent of this volume is in pole timber trees. Sawtimber trees make up 21 percent of the total volume, and tree fern contributes the remaining 5 percent. Only 17 percent of the sawtimber volume is of saw-log quality.

'Ohi'a-lehua makes up 74 percent of the total tree volume on Molokai timberland (Table 7). About 83 percent of this 'ohi'a volume is in trees less than 11.0 inches in diameter. Christmas berry and guava each constitute about 7 percent of the total volume and 'olapa about 6 percent.

'Ohi'a-lehua constitutes the entire saw-log volume on Molokai timberland, about 1.5 million board feet.

The estimated total number of trees on Molokai timberland is more than 21 million (table 8). 'Ohi'a-lehua is the most abundant species with just under 8 million trees, 63 percent of which are between 1.0 and 5.0 inches in diameter. Guava is next with more than 7 million trees, 84 percent of which are less than 2.9 inches in diameter.

Forest Plantations--Molokai has 2,411 acres of established forest plantations, 72 percent of which are located in the forest reserve (table 9). The most common species planted are eucalypts (1,159 acres, 48 percent) and pine (756 acres, 31 percent). About 47 percent of the forest plantations are State owned, 42 percent are privately owned, and the remaining 11 percent are owned by the Department of Hawaiian Home Lands.

Forest plantations on Molokai contain more than 15 million board feet of sawtimber, 83 percent of which are eucalypt species (table 10). This sawtimber volume is equally divided between the State and private owners. Molokai has more than 4.2 million cubic feet of growing stock in its forest plantations. Eucalypts constitute 3.3 million cubic feet of this total, about 80 percent being *Eucalyptus robusta*.

Other Forest Land--Because of the interest in energy self-sufficiency in Hawaii, interest in forest-volume data on lands other than timberland has increased. This is especially true of the kiawe resource on Molokai (fig. 3). The design of this multiresource inventory did not adequately sample volume on these lesser stocked other forest lands. A separate, more intensive inventory for the kiawe resource showed an estimated 5.5 million cubic feet on 12,100 acres classified as other forest land.

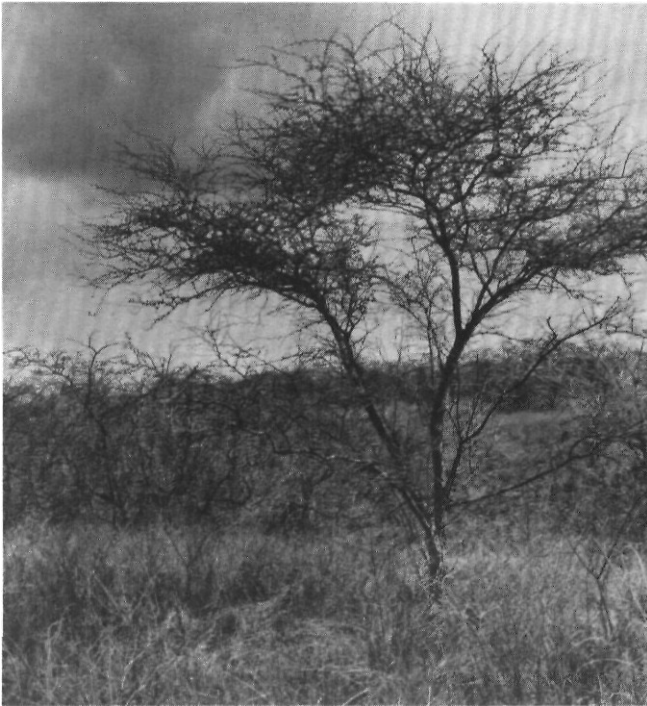


Figure 3--Typical kiawe vegetation found on the other forest land class in western Molokai. Kiawe wood is valuable for biomass and charcoal, its pods are valuable for cattle fodder and its flowers for honey. Introduced in 1828, it has naturalized successfully on the drier sites on all the main Hawaiian Islands.

Other Forest Resources

Watershed--The protection of Hawaii's watersheds is the primary mandate and reason for the existence of the Division of Forestry and Wildlife (fig. 4). One data element that can be measured to reflect the quality of the watershed is the presence or absence of erosion.

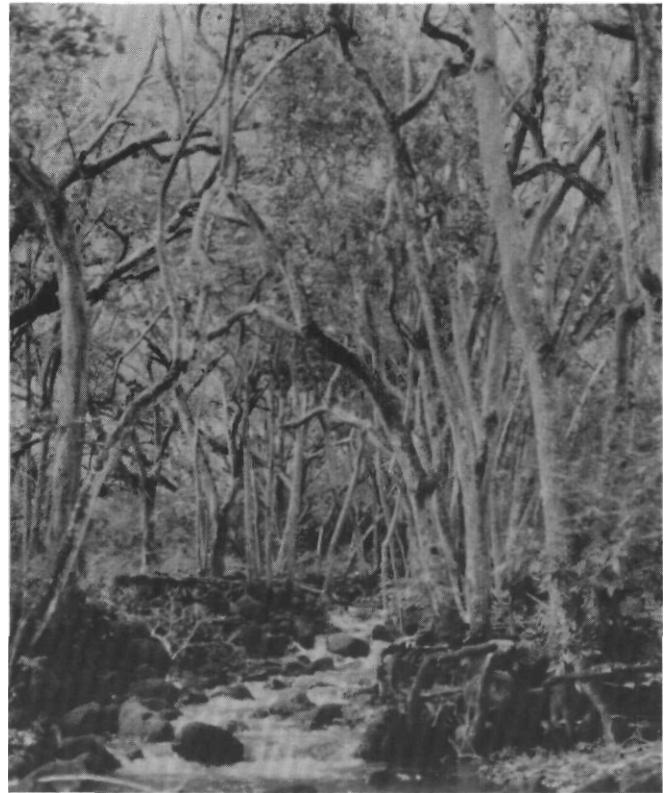


Figure 4--The most valuable economic resource of the Hawaiian forest is water. This stream bottom is protected by the kukui, named for the multiplicity of its uses to the ancient Hawaiians for light, fuel, medicine, dye, and ornaments. Its light green foliage graces the stream bottoms and ravines throughout the Hawaiian chain.

Our photographic sample indicated that an estimated 11,500 acres on Molokai, about 7 percent of the island, have moderate to severe erosion. About 85 percent of this eroded land is outside the forest reserve.

Wildlife--Although the time of year (end of July to mid-October) was not optimal (nonbreeding season, lower incidence of avian singing) and often less-than-optimal conditions existed (late in the day or windy), 10.-minute bird counts were conducted on 24 ground plots (table 11). Birds were absent on 2 of the 24 plots. Where birds were recorded, 14 species were counted; of these, 3 species were native forest birds, 4 species were introduced game birds, and the remaining 7 species were introduced songbirds.

Of 112 individual birds counted, 11 percent were native forest birds, 80 percent were introduced song birds, and 9 percent were introduced game birds.

Although no mammals were seen or heard on the plots, the presence of several species was inferred from evidence noted enroute to or at the plots. The mammals and observed bird species are listed under "Names of Animals" on page 17.

Table 12 relates bird species counted to forest type and elevation. Of the 24 plots where 10-minute bird counts were conducted, 6 were in 'ohi'a forests, 7 in kiawe forests, 3 in koa/haole, 3 in Christmas berry, 2 in grass, and 1 each in pukiawe, strawberry guava, and guava.

Native forest birds were detected at only three of the six 'ohi'a forest plots; all were above 3,100 feet in elevation. The other three 'ohi'a plots were below 1,968 feet in elevation.

The most common bird detected was the Japanese white-eye, found on 21 plots in every type of vegetation sampled from 60- to 3,310-foot elevation. Of the 14 game birds counted on 10 plots, only 1 (a black francolin) was counted above 1,000 feet.

Statistical procedures were not applied to the data because of insufficient sample sizes in each vegetation type. Also, environmental and logistic variables, such as time of year, time of day, weather, and amount of time spent at each plot, were not compensated for. These variables are known to have profound effects on estimates of animal density and occurrence.

Native Ecosystems--The Hawaiian forest contains flora and fauna found nowhere else in the world (fig. 5), but the introduction of exotic species threatens these unique communities. Because one of the objectives of this inventory was to identify and monitor areas with intact native ecosystems, field observations of the presence and extent of introduced species of plants were taken, and the depredations of axis deer and feral pigs, cats, and goats were noted. When noxious weeds with a propensity to replace native vegetation were found within the plot area, their location was mapped.

Introduced plant species were found on more than 90 percent of the subplot locations. Only two plots--both in the 'ohi'a-lehua vegetation type--had subplots free of introduced species. Animal impact was noted on more than half the subplots, and more than 90 percent of the impact was attributed to feral pigs or axis deer. The impact of pigs was recorded in the 'ohi'a-lehua vegetation type in the central mountains as well as in the mountainous grasslands of eastern Molokai. Impact of deer was found everywhere except in the wet lohi la-lehua forests of central Molokai (fig. 6).

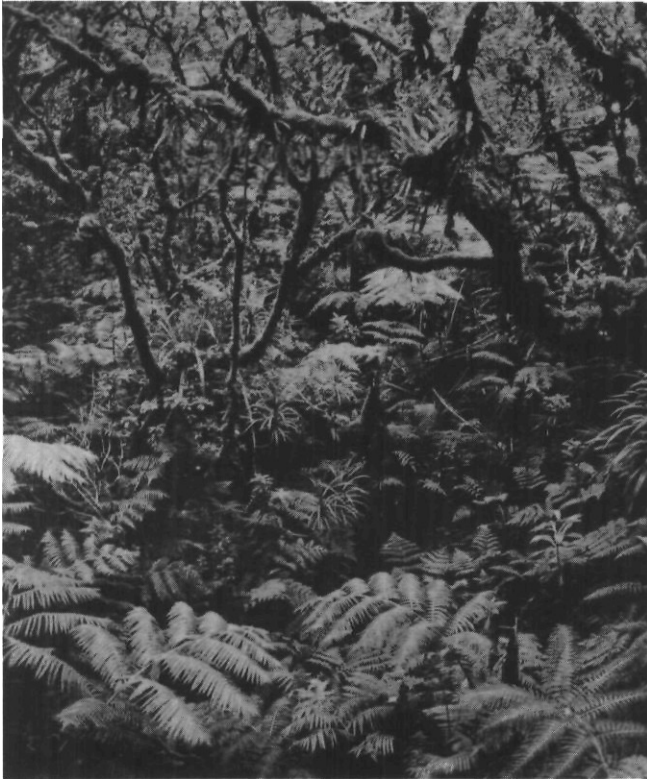


Figure 5--The beauty and elegance of an undisturbed Hawaiian montane forest. These forests are the habitat for many of Hawaii's endemic flora and fauna.

Discussion

Although many statistics are presented in this report, general observations and comments by the field personnel cannot be presented in table format. One shared observation was the extent to which the native flora has been altered on Molokai. On eastern Molokai, feral herbivores such as cattle and deer have turned former 'ohi'a-lehua forests into grassland, and native plants are found only in steep gulches and ravines. Fires have also transformed many forest areas into flammable grasslands, which are now prone to burn again. Feral pigs are having an impact on the remaining native 'ohi'a forests in central Molokai.



Figure 6--Former native forest land in central Molokai is maintained in grassland by introduced animals such as the axis deer and the feral pig.

Our data indicate that the forest plantations on Molokai produce about three times more volume per acre than either the 'ohi'a or kiawe forests. They also produce this higher volume in a much shorter time. As Molokai considers biomass in the form of wood fiber in its drive for energy self-sufficiency, this existing resource should be seriously considered.

Large amounts of data collected are not presented in this report. Some are used to correlate habitat variables such as vegetation type, elevation, and wildlife occurrence. All the data have been stored in a computer data base so they can be recalled in different formats and combinations on request. An example of such a request is the number of acres of State-owned 'ohi'a forest above 3,000 feet in elevation that is in a protected conservation zone.

The inventory data also provide a baseline or starting point to monitor changes and trends in land use, forest growth and mortality, and native ecosystems. Substantial efforts were made to ensure that all photo and ground plots are permanently referenced so they can be easily relocated. A field manual that documents all inventory procedures has been prepared to ensure accurate remeasurement of data.

Reliability of Inventory Data

Confidence intervals have been computed for the estimates of land area, wood volumes, and tree numbers. These confidence intervals mean that at odds of two out of three (68-percent probability), the true inventory values will be within the ranges shown. As area, volume, or tree data are divided into smaller breakdowns such as forest type or individual species, the sampling error increases. All confidence intervals for data presented in this report are available at the Hawaii Division of Forestry and Wildlife office.

The magnitude of possible errors in judgment, measurement, and compilation cannot be determined. The likelihood of such errors was minimized, however, through training and supervision of personnel, field checking of data, and the editing and machine verification of results of the compilation.

<u>Data item</u>	<u>Total data value</u>	<u>Sampling error (plus or minus)</u>
Land class	See table 5	
Timber, cubic volume (thousand cubic feet)	15,847.6	9,509
Number of live trees (thousand trees)	21,055.4	7,626

Terminology

Bolt--Six-foot sections of the upper stem or limbs of both rough wood and saw-log trees with a minimum middiameter of 10 inches.

Branch--Upper stem branches or limbs not meeting bolt specifications.

Cull--A volume deduction for rotten wood.

Cultivated land---Orchards, nurseries, and other areas under cultivation or regularly cropped, fallow areas.

D.b.h. --Diameter at breast height, a point 4-1/2 feet above the ground on the uphill side of a normally formed tree where the diameter is measured; and 1.6 feet above the stilt or swell for abnormal trees.

Dune land.-Sandy areas; beach fronts with very sparse vegetation or none.

Ecosystem--A community of interacting organisms and the environments (habitat) in which they live and with which they interact; a natural composite of plants, animals, and minerals in the presence of sunlight, water, and weather; an ecological unit in nature.

Endemic--Peculiar to a particular region (the Hawaiian Islands) and found nowhere else.

Exotic--Wildlife or plants that are introduced; alien.

Feral--Having escaped from domestication and reverted to a wild state; a domestic animal in the wild for several generations.

Forest land--Land that is, or has been, at least 10 percent stocked with trees, and is not now developed for nonforest use; also includes land 50 percent or more covered by shrubs. The minimum area recognized as forest land is 1 acre.

Forest plantations—Planted forests in which at least 10 percent of growing space is occupied by planted trees (exotic species).

Game--Wild birds or mammals pursued, hunted, or taken for food, recreation, or trophy.

Grassland--Nonforest land with 10 percent or more herbaceous cover; may be grazed or ungrazed; includes intensively pastured areas.

Growing-stock volume--Cubic-foot volume of sound wood in the main stem of sawtimber and poletimber trees from the stump to a minimum top outside bark of 5.0 inches.

Hawaiian Homes—Lands administered by the Department of Hawaiian Home Lands.

Indigenous--Occurring naturally in a given region but with a range that includes a wide geographic area; not introduced by humans.

International 1/4-inch rule--The standard board-foot log rule adopted nationally by the **USDA** Forest Service for the presentation of inventory volume statistics.

Land class--A classification of land by major use, such as timberland, other forest, and nonforest. The minimum area for classification is 1 acre.

Native--Endemic or indigenous.

Native and naturalized forest--Forests of native and exotic tree species established through natural processes.

Nonforest land--Land that has never supported forests or land that formerly supported forests but has been developed for nonforest uses.

Nongame--Wild birds, mammals, reptiles, or amphibians not pursued, hunted, or taken for food, recreation, or trophy.

Other forest land--Forest land incapable of yielding successive crops of trees for usable wood products because of adverse site conditions (poor drainage, sterile soils, steepness, rockiness, and dry climate--generally less than 30 inches annual rainfall). Includes forest lands that have low productivity for timber but may be productive for range, watershed, recreation, or wildlife habitat.

Poletimber trees--Growing stock trees 5.0 to 11 inches in d.b.h.

Poletimber volume--Cubic-foot volume for the portion of a poletimber tree up to a 4-inch top outside bark.

Rock and pali land--Nonforest land with more than 50 percent rock outcrops. Includes recent barren volcanic ash, cinder, lava flows, and very steep rugged land with slopes more than 100 percent (locally known as "pali").

Rough wood--Logs of sawtimber size that fail to meet saw-log specifications because of poor form or excessive limbs.

Saw log--Segment of a sawtimber tree at least 8.2 feet long or logs that meet specifications for standard lumber.

Sawtimber trees--Live trees with a diameter at breast height equal to or larger than 11.0 inches.

Sawtimber volume--Cubic-foot volume for sawtimber trees that includes the portion of the tree to 9.0 inches top diameter outside bark.

Timberland--Forest land capable of producing 20.0 cubic feet or more per acre per year of industrial wood (commercial roundwood other than firewood) and not withdrawn from timber utilization.

Tip--The portion of both rough wood, saw log, and poletimber trees above the point where stem diameter reaches 4 inches outside the bark.

Urban and other lands--Lands used for urban, suburban, and industrial purposes; includes uses not defined by other land classes.

Vegetation type--Dominant overstory species as determined by stereoscopic inspection of 1-acre plots on aerial photos.

Watershed--An area of land contributing to the supply of a stream, lake, marsh, groundwater basin, reservoir, or wetland; a draining area.

Wildlife--Birds, terrestrial mammals (does not include monk seal), reptiles (except sea turtles and sea snakes), and amphibians living a wild nondomesticated existence.

Tables

TABLE 1--AREA BY OWNER AND FOREST RESERVE STATUS, ISLAND OF HOLOKAI, HAWAII, 1983 1/

OWNERSHIP	IN RESERVE	OUTSIDE RESERVE	TOTAL 2/
ACRES			
STATE	17,562	5,345	22,907
HAWAIIAN HOMES	573	24,434	25,007
PRIVATE:			
CORPORATE	7,063	73,111	80,174
INDIVIDUAL	19,089	16,035	35,124
ALL OWNERS 2/	44,287	118,925	163,211

1/ Does not include the acreage in forest plantations reported in table 9.

2/ Totals may be off because of rounding.

TABLE 2--AREA BY VEGETATION TYPE AND OWNER, ISLAND OF MOLOKAI, HAWAII, 1983 1/

VEGETATION TYPE	STATE	HAWAIIAN HOMES	PRIVATE CORPORATE	PRIVATE INDIVIDUAL	TOTAL 2/
ACRES					
GRASS	382	8,017	25,388	4,963	38,750
KIAWE	573	4,772	26,725	1,145	33,215
'OHIA'-LEHUA	11,453	--	5,918	15,462	32,833
HAOLE KOA	1,909	2,100	2,482	2,863	9,354
GUAVA	2,291	--	513	3,054	5,918
KUKUI	1,909	191	191	2,482	4,773
CHRISTMAS BERRY	191	764	954	1,909	3,818
'A'ALI'I	382	--	1,527	573	2,482
JAVA PLUM	954	191	--	764	1,909
EUCALYPTUS	513	191	164	--	1,528
MANGROVE	--	--	--	191	191
OTHER SHRUBS	191	--	573	--	764
OTHER TREES	--	191	--	382	513
OTHER FORBS	--	--	191	--	191
AGRICULTURE	--	7,254	10,881	191	18,326
NONVEGETATED	764	764	2,100	191	3,819
UNKNOWN	1,336	513	1,909	954	4,772
ALL TYPES 2/	22,908	25,008	80,176	35,124	163,211

1/ Does not include the acreage in forest plantations reported in table 9.

2/ Totals may be off because of rounding.

TABLE 3 --AREA BY VEGETATION TYPE AND FOREST RESEHVC STATUS, ISLAND OF MOLOKAI, HAWAII, 1983 1/

VEGETATION TYPE	INSIDE FOREST RESERVE	OUTSIDE FOREST RESERVE	TOTAL <u>2/</u>
<i>ACRES</i>			
GRASS	764	37,987	38,751
KIAWE	--	33,215	33,215
'OHIA'-LEHUA	30,161	2,672	32,833
YAOLE KOA	--	9,354	9,354
GUAVA	3,200	1,718	5,918
KUKUI	4,009	764	4,773
CHRISTMAS BERRY	--	3,818	3,818
'A'ALI'I	1,145	1,336	2,481
JAVA PLUM	573	1,336	1,909
EUCALYPTUS	954	573	1,527
MANGROVE	--	191	191
OTHER SHRUBS	382	382	764
OTHER TREES	--	573	573
OTHER FORBS	--	191	191
AGRICULTURE	--	8,325	8,325
NONVEGETATED	--	3,819	3,819
UNKNOWN	2,100	2,672	4,772
ALL TYPES <u>2/</u>	44,288	118,925	163,211

1/ Does not include the acreage in forest plantations reported in table 9.

2/ Totals may be off because of rounding.

TABLE 4--AREA BY LAND CLASS, ISLAND OF MOLOKAI, HAWAII, 1977 AND 1983 1/

LAND CLASS	1977 PHOTO INVENTORY	1983 GROUND INVENTORY
<i>ACRES</i>		
TIMBERLAND	40,278	23,494
OTHER FOREST	43,523	34,104
CULTIVATED	18,325	5,898
GRASSLAND	37,414	71,598
DUNE LAND	1,718	1,050
ROCK AND PALI	19,662	25,540
URBAN AND OTHER	2,291	1,527
ALL CLASSES <u>2/</u>	163,211	163,211

1/ Does not include the acreage in forest plantations reported in table 9.

2/ Totals may be off because of rounding.

TABLE 5--AREA BY LAND CLASS AND OWNER, ISLAND OF MOLOKAI, HAWAII, 1983 1/

LAND CLASS	STATE	HAWAIIAN HOMES	PRIVATE CORPORATE	PRIVATE INDIVIDUAL	ALL OWNERS	SAMPLING ERROR
<i>ACRES</i>						<i>PERCENT</i>
TIMBERLAND	5,590	840	11,187	5,879	23,496	22.5
OTHER FOREST	5,154	5,431	14,998	8,523	34,106	20.1
CULTIVATED	--	3,627	2,176	95	5,898	52.4
GRASSLAND	3,900	13,370	43,760	10,564	71,594	10.6
DUNE LAND	286	382	382	--	1,050	100.0
ROCK AND PALI	7,881	973	7,008	9,678	25,540	14.7
URBAN AND OTHER	95	382	668	382	1,527	100.0
ALL CLASSES	22,906	25,005	80,179	35,121	163,211	--

1/ Does not include the acreage in forest plantations reported in table 9.

TABLE 6 - TREE VOLUME ON TIMBERLAND BY CLASS OF TIMBER, ISLAND OF MOLOKAI, HAWAII, 1983 ^{1/}

CLASS OF TIMBER	TREE FERNS ^{2/}	HAROWOODS	ALL SPECIES ^{3/}
<i>THOUSAND CUBIC FEET</i>			
SAWTIMBER:			
ROUGH WOOD	0	833.4	833.4
SAW LOG	0	565.0	565.0
UPPER STEM	0	363.1	363.1
TIP	0	24.7	24.7
BOLT	0	586.2	586.2
BRANCH	0	921.7	921.7
TOTAL ^{3/}	0	3,294.7	3,294.7
POLETIMBER:			
POLETIMBER	0	8,510.8	8,510.8
TIP	0	738.1	738.1
BRANCH	0	2,532.0	2,532.0
TOTAL ^{3/}	0	11,780.9	11,780.9
TREE FERNS	112.0	0	772.0
TOTAL VOLUME ^{3/}	772.0	15,075.6	15,847.6
CULL	0	1,405.5	1,405.5

^{1/} Does not include the volume in forest plantations reported in table 10.

^{2/} Includes the bole from the ground to a point 3 feet below the base of the live fronds.

^{3/} Totals may be off because of rounding.

TABLE 7--TOTAL TREE VOLUME ON TIMBERLAND BY SPECIES AND DIAMETER CLASS, ISLAND OF MOLOKAI, HAWAII, 1983 ^{1/}

SPECIES	DIAMETER CLASS (INCHES)							ALL CLASSES 2/
	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0 AND LARGER	
THOUSAND CUBIC FEET								
'OHI'A-LEHUA	3,584.4	3,365.5	2,849.9	1,130.1	300.2	575.6	0	11,805.7
CHRISTMAS BERRY	374.3	233.1	137.7	0	349.6	0	0	1,094.7
GUAVA	1,048.8	0	0	0	0	0	0	1,048.8
'OLAPA	0	187.2	0	0	745.1	0	0	932.3
HAPU'U 'I'I 3/	134.0	201.0	134.0	0	0	0	0	469.0
HAPU'U PULU 3/	0	236.0	67.0	0	0	0	0	303.0
MANGO	0	0	0	0	0	0	194.2	194.2
ALL SPECIES 2/	5,141.7	4,223.7	3,188.9	1,130.1	1,394.9	575.6	194.2	15,847.6

^{1/} Does not include the volume in forest plantations reported in table 10.

^{2/} Totals may be off because of rounding.

^{3/} Diameter class is determined at a point 1.6 feet above ground for tree ferns and at d.b.h. for all other species

TABLE 8.--NUMBER OF LIVE TREES ON TIMBERLAND BY SPECIES AND DIAMETER CLASS, ISLAND OF HOLOKAI, HAWAII. 1983

SPECIES	DIAMETER CLASS (INCHES)										17.0 AND LARGER	ALL CLASSES <u>1/</u>
	0-0.9	1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9			
	THOUSAND TREES											
'OHIA' A-LEHUA	0	2,252.4	2,718.1	1,751.5	715.8	301.2	105.7	45.1	18.9	0	7,914.7	
GUAVA	1,359.7	2,405.4	775.9	339.6	0	0	39.8	0	0	0	4,920.4	
STRAWBERRY GUAVA	1,321.0	777.0	0	0	0	0	0	0	0	0	2,098.0	
'QLAPA	0	775.8	620.6	0	75.5	0	0	17.4	0	0	1,489.2	
PULO	232.9	1,164.0	0	0	0	0	0	0	0	0	1,396.9	
CHRISTMAS BERRY	155.4	388.5	155.4	172.7	35.0	20.1	0	20.1	0	0	947.1	
HAPU'U 'I'I <u>2/</u>	194.3	0	155.2	0	115.4	43.8	0	0	0	0	508.7	
KANAWAO	388.6	0	0	0	0	0	0	0	0	0	388.6	
'AHA' U	310.3	0	0	0	0	0	0	0	0	0	310.3	
KOLEA	155.2	155.2	0	0	0	0	0	0	0	0	310.3	
HAPU'U PULU <u>2/</u>	0	0	0	83.8	135.2	45.1	0	0	0	0	264.7	
OLOMEA	194.3	0	0	0	0	0	0	0	0	0	194.3	
'AKIA	0	155.4	0	0	0	0	0	0	0	0	155.4	
PUKIAWE	0	155.2	0	0	0	0	0	0	0	0	155.2	
MANGO	0	0	0	0	0	0	0	0	0	1.5	1.5	
ALL SPECIES <u>1/</u>	4,311.5	8,228.9	4,425.2	2,353.6	1,076.8	410.9	145.5	82.5	18.9	1.5	21,055.4	

1/ Totals may be off because of rounding.2/ Diameter class is determined at a point 1.6 feet above ground for tree ferns and at d.b.h. for all other species.TABLE 9.--AREA OF FOREST PLANTATIONS BY FOREST RESERVE, OWNER, AND FOREST TYPE, ISLAND OF MOLOKAI, HAWAII. 1967 AND 1919 1/

FOREST RESERVE AND OWNERSHIP	EUCALYPTUS ROBUSTA	EUCALYPTUS SALIGNA	EUCALYPTUS SPECIES	IRONWOOD	FORMOSA KOA	OTHER HARDWOODS	PINE SPECIES	OTHER CONIFERS	TOTAL
ACRES									
MOLOKAI FOREST RESERVE:									
STATE	262	21	108	5	--	34	<u>2/</u> 670	39	1,139
HAWAIIAN HOMES	--	--	--	--	--	--	--	--	--
PRIVATE	222	112	165	--	--	7	86	7	599
TOTAL	484	133	213	5		41	756	46	1,738
OUTSIDE THE FOREST RESERVE:									
STATE	--	--	--	--	--	--	--	--	--
HAWAIIAN HOMES	74	--	--	77	54	39	--	14	258
PRIVATE	60	--	135	89	--	119	--	12	415
TOTAL	134		135	166	54	158		26	673
ALL PLANTATIONS:									
STATE	262	21	108	5	--	34	<u>2/</u> 670	39	1,139
HAWAIIAN HOMES	14	--	--	11	54	39	--	14	258
PRIVATE	282	112	300	89	--	120	86	19	1,014
TOTAL	618	133	408	171	54	199	756	72	2,411

1/ Data from Uong and others (1968), except as noted.2/ Data from State of Hawaii (1979).

TABLE 10--VOLUME OF SAWTIMBER AND GROWING STOCK BY SPECIES AND OWNER IN FOREST PLANTATIONS, ISLAND OF MOLOKAI, HAWAII, 1967 AND 1979 ^{1/}

SPECIES	STATE	HAWAIIAN HOMES	PRIVATE	ALL OWNERS
THOUSAND BOARD FEET ^{2/}				
SAWTIMBER:				
EUCALYPTUS BLACKBUTT	29	--	169	198
EUCALYPTUS ROBUSTA	3,416	956	6,038	10,410
EUCALYPTUS SALIGNA	1,122	--	259	1,381
OTHER EUCALYPTUS SPP.	134	10	1,022	1,166
SLASH PINE	^{3/} 2,084	--	--	2,084
LOBLOLLY PINE	^{3/} 394	--	--	394
OTHER SOFTWOODS	29	--	32	61
TOTAL	7,208	966	7,520	15,694
THOUSAND CUBIC FEET				
GROWING STOCK:				
EUCALYPTUS BLACKBUTT	5	--	37	42
EUCALYPTUS ROBUSTA	1,016	261	1,326	2,603
EUCALYPTUS SACIGNA	132	1	168	301
OTHER EUCALYPTUS SPP.	44	3	304	351
SLASH PINE	^{3/} 469	--	--	469
LOBLOLLY PINE	^{3/} 364	--	--	364
OTHER SOFTWOODS	68	--	10	78
TOTAL	2,098	265	1,845	4,208

^{1/} Data from Wong and others (1968), except as noted.

^{2/} International 1/4-inch rule.

^{3/} Data from State of Hawaii (1979).

TABLE 11--10-MINUTE BIRD COUNT, ISLAND OF MOLOKAI, HAWAII, 1983

PLOT NUMBER	AMAKIHI	ADRE	BLACK FRANCOLIN	SPR SIAN SYLARK	RAY F MOUIN	PUSE FI GH	'I'IWI	JP NEESE HI 1-2YS	NORTHERN CARDINAL	NORTHERN O-L EIB	NUTMEG MANNIKIN	NO CESTED 440 IN	S O RED D 48	YER D 48	ALL BIRDS	
3								3				2			5	
4				1				1							2	
1															0	
8					1			1	2			1			5	
10			1					1				2		2	6	
19															0	
24					3				2			2	1	1	9	
29								1							1	
34					1			1							2	
38								1	1	1				2	5	
39														1	1	
40						1		1							2	
41			1				1	2							4	
43	3	4						1							8	
45		4													4	
41						2		5							1	
51				1				2					1	2	6	
55								7							1	
56								2			4				6	
58								3			1				4	
60								3			2				5	
61								5							5	
62						1		6							1	
65								5							5	
TOTAL	3	8	1	3	5	4	1	5	7	5	1	1	7	2	8	112

TABLE 12--NUMBER OF BIRDS COUNTED BY FOREST TYPE. PLOT NUMBER, ELEVATION, AND SPECIES, ISLAND OF MOLOKAI, HAWAII, 1983

FOREST TYPE, PLOT NUMBER, AND ELEVATION (FEET)	NATIVE FOREST BIRDS			INTRODUCED SONG BIRDS							GAME BIRDS			
	'AMAKIHI	'APAPANE	I IOWA	JAPANESE WINGS-EYE	HOUSE FINCH	RED-CROWNED CARDINAL	SYLPH	NUTMEG MANIKIN	NORTHERN MOCKINGBIRD	NORTHERN CARDINAL	SENA OWL	SPOTTED OWL	BLACK FLYCATCHER	GUAVA FLYCATCHER
'Ohi'a:														
45 (4,002)		4												
43 (3,313)	3	4		1										
41 (3,182)			1	2									1	
29 (1,968)				7										
62 (1,574)				6	1									
55 (1,246)				7										
Pukiaue:														
47 (3,083)				5	2									
Grass:														
60 (2,886)				3				2						
24 (98)				2						2	1	1		3
Kiawe:														
38 (525)				1				1	1	2				
3 (360)				3		2								
7 (262)														
10 (262)				1		2	1							
8 (197)				1		1				2				1
4 (98)				1			1							
39 (66)											1			
Strawberry guava:														
56 (1,640)				2				4						
Christmas berry:														
61 (1,312)				5										
65 (820)				5										
58 (689)				3			1							
Haole koa:														
51 (977)				2			1				2	1		
19 (121)														
34 (66)				1									1	
Guava:														
40 (361)				8	1									

Names of Plants 2/

<u>Category</u>	<u>Common name</u>	<u>Scientific name</u>
Trees		
Endemic	'Akia	<i>Wikstroemia</i> spp. Enal.
Exotic	Eucalyptus	<i>Eucalyptus</i> spp. L'H'er.
Exotic	Eucalyptus blackbutt	<i>Eucalyptus globulus</i> Labill.
Exotic	Eucalyptus robusta	<i>Eucalyptus robusta</i> Sm.
Exotic	Eucalyptus saligna	<i>Eucalyptus saligna</i> Sm.
Exotic	Guava	<i>Psidium guajava</i> L.
Exotic	Ironwood	<i>Casuarina</i> spp. Adans.
Exotic	Java plum	<i>Eugenia cumini</i> (L.) Druce
Exotic	Kiawe	<i>Prosopis pallida</i> (Humb. & Bonl. ex Willd.) HBK.
Endemic	Kolea	<i>Myrsine lessertiana</i> A. DC.
Exotic	Kukui	<i>Aleurites moluccana</i> (L.) Willd.
Exotic	Loblolly pine	<i>Pinus taeda</i> L.
Exotic	Mango	<i>Mangifera indica</i> L.
Exotic	Mangrove	<i>Rhizophora mangle</i> L.
Endemic	'Ohi'a-lehua	<i>Metrosideros polymorpha</i> (Gaud.) Rock.
Endemic	'Olapa	<i>Cheirodendron trigynum</i> (Gaud.) Heller
Endemic	Pilo	<i>Coprosma</i> Spp.
Exotic	Slash pine	<i>Pinus elliotii</i> Engelm.
Exotic	Strawberry guava	<i>Psidium cattleianum</i> Sabine
Tree ferns		
Endemic	Hapu'u 'i'i	<i>cibotium chamissoi</i> Kaulf.
Endemic	Hapu'u pulu	<i>cibotium glaucum</i> (J. Sm.) hook. & Arnott
Shrubs		
Endemic	'A'ali'i	<i>Dodonea</i> spp. Mill.
Exotic	Christmas berry	<i>Schinus terebinthifolius</i> Raddi
Exotic	Haole koa	<i>Leucaena leucocephala</i> (Lam.) de Wit
Endemic	Kanawao	<i>Broussaisia arguta</i> Gaud.
Endemic	Olomea	<i>Perrottetia sandwicensis</i> Gray
Indigenous	Pukiawe	<i>Styphelia tameiameiae</i> (Cham.) F. Muell.
Ferns		
Endemic	'Ama'u	<i>Sadleria</i> spp. <i>pallida</i> (Hk. & Arn.)

2/ The source for most plant names is St. John (1973); for tree ferns the source is Becker (1976).

Names of Animals 3/

<u>Category</u>	<u>Common name</u>	<u>Scientific name</u>
Endemic forest birds	'Apapane	<i>Himatione sanguinea</i> (Gmelin)
	'I'iwi	<i>Vestiaria coccinea</i> (Forster)
	Maui 'amakihi	<i>Hemignathus virens</i> (Gmelin) <i>wilsoni</i> (Rothschild)
Exotic (introduced) game birds	Black francolin	<i>Francolinus francolinus</i> (Linnaeus)
	Gray francolin	<i>Francolinus pondicerfianus</i> (Gmelin)
	Spotted dove	<i>Streptopelia chinensis</i> (Scopoli)
Exotic (introduced) birds	Zebra dove	<i>Geopelia striata</i> (Linnaeus)
	Eurasian skylark	<i>Alauda arvensis</i> (Linnaeus)
Exotic game mammals	Japanese white-eye	<i>Zosterops japonicus</i> (Temminck and Schlegel)
	Northern cardinal	<i>Cardinalis cardinalis</i> (Linnaeus)
	House finch	<i>Carpodacus mexicanus</i> (Muller)
	Northern mockingbird	<i>Mimus polyglottos</i> (Linnaeus)
	Nutmeg mannikin	<i>Lonchura punctulata</i> (Linnaeus)
	Red-crested cardinal	<i>Paroaria coronata</i> (Miller)
	Axis deer	<i>Axis</i> (Smith) <i>axis</i> (Erxleben)
	Feral cat	<i>Felis catus</i> (Linnaeus)
	Feral goat	<i>Capra hircus</i> (Linnaeus)
	Feral pig	<i>Sus scrofa</i> (Linnaeus)

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Metric Equivalents

1,000 acres = 404.7 hectares
 1,000 cubic feet = 28.3 cubic meters
 6,000 board feet = 28.3 cubic meters
 1 cubic foot per acre = 0.07 cubic meter per hectare
 1 foot = 0.3048 meter
 1 inch = 2.54 centimeters
 1 mile = 1.609 kilometers

3/ The source for bird names is American Ornithologists' Union (1983) and Pyle (1983); for mammals the source is Novak and Paradiso (1983).

References

- American Ornithologists' Union. Check-list of North American Birds, 6th ed. Lawrence, KS: Alden Press Inc.; 1983. 877 p.
- Becker, Richard E. The phytosociological position of tree ferns (*Cibotium* spp.) in the montane rain forests on the island of Hawaii. Honolulu, HI: University of Hawaii; 1976. 368 p. Ph. D. dissertation.
- Buck, Michael G.; Paysen, Timothy E. A system of vegetation classification applied to Hawaii. Gen. Tech. Rep. PSW-76. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1984. 11 p.
- Costales, Patrick G.; Buck, Michael G. Field manual - Hawaii multiresource forest inventory. Honolulu, HI: State Department of Land and Natural Resources, Division of Forestry and Wildlife; 1983. 66 p.
- Metcalf, Melvin E.; Nelson, Robert E.; Petteys, Edwin Q.P.; Berger, John M. Hawaii's timber resources - 1970. Resour. Bull. PSW-15. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1978. 20 p.
- Nelson, Robert E.; Wheeler, Philip R. Forest resources of Hawaii - 1961. Honolulu, HI: State Department of Land and Natural Resources, Division of Forestry and Wildlife; 1963. 43 p. In cooperation with: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.
- Novak, Ronald M.; **Paradiso**, John L. Walker's mammals of the world. 4th ed. Baltimore, MD: The Johns Hopkins University Press; 1983. 1,362 p.
- Pyle, Robert L. Checklist of the birds of Hawaii. Elepaio. **44(5)**: 47-58; 1983.
- St. John, Harold. List and summary of the flowering plants in the Hawaiian Islands. Mem. 1. Lawai, Kauai, HI: Pacific Tropical Botanical Garden; 1973. 519 p.
- State of Hawaii, Department of Land and Natural Resources, Division of Forestry and Wildlife. Forest plantation survey --Biomass Energy Tree Farm Program. Honolulu, HI: State Department of Land and Natural Resources, Division of Forestry and Wildlife; 1979. 22 p.
- State of Hawaii, Department of Land and Natural Resources, Division of Forestry and Wildlife. Hawaii wildlife plan. Honolulu, HI: Department of Land and Natural Resources, Division of Forestry and Wildlife; 1984. 113 p.
- State of Hawaii, Department of Land and Natural Resources, Division of Forestry and Wildlife. Molokai kiawe volume report. Honolulu, HI: Department of Land and Natural Resources, Division of Forestry and Wildlife; 1982. 6 p.
- Wong, Wesley, H.C.; Nelson, Robert E.; Wick, Herbert L. Plantation timber on the Island of Molokai - 1967. Resour. Bull. PSW-9. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1968. 25 p.

Buck, Michael G.; Costales, Patrick G.; McDuffie, Katharine. Multiresource forest statistics for Molokai, Hawaii. Resour. Bull. PNW-136. Portland, OR: **U.S.** Department of Agriculture, Forest Service, Pacific Northwest Research Station; 1986. 18 p.

This report summarizes a 1983 multiresource forest inventory of the island of Molokai, Hawaii. Tables of forest area, timber volume, vegetation type, ownership, land class, and wildlife are presented.

Keywords: Forest surveys, multiresource inventory, statistics (forests), Hawaii.

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