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The Multiresource Forest Inventory for Kauai, Hawaii

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Abstract

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This report summarizes a 1986 multiresource forest inventory for Kauai, Hawaii. Tables and figures of forest acreage, timber volume, vegetation types, ownership, land classes, bird counts, and introduced plants are presented.

Keywords: Multiresource inventory, forest survey, statistics (forests), native forests, introduced plants, Kauai, Hawaii.

Summary

The island of Kauai Hawaii, comprises over 347,000 acres, of which an estimated 188,500 are forested; 37,200 acres are classified as timberland, 71,400 acres as other forest land, and 79,900 acres as pali land. The two dominant forest types on the island are the native 'ohi'a and the naturalized silk-oak. An estimated 42.7 million cubic feet of total tree volume is on timberland and 24.2 million cubic feet is on other forest land. Slight surface erosion was recorded on one-fourth of the forest sample plots. Nineteen bird species were seen or heard; the ratio of introduced to native birds was 2:1.

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Introduction

Multiresource inventory (MRI) is a relatively new concept, especially in the tropics, in which field data collection is designed to answer questions involving many disciplines (for example, mensuration, wildlife, and recreation). The MRI approach encourages administrators and inventory specialists to address resource interactions. It also can optimize field work and standardize data collection.

The USDA Forest Service is directed to inventory the Nation's timber supply. Because of Hawaii's unique vegetation, topography, and geographic location, State personnel have historically conducted this forest inventory. The Hawaii Division of Forestry and Wildlife therefore collaborated with the Forest Service to design a MRI meeting the information needs of both agencies.

A major objective of the Hawaii MRI was to create a network of permanent ground plots throughout the State that will provide information on tree growth and mortality, and forest trends. The MRI extends beyond the traditional timber volume inventory to address other important issues such as watershed protection, noxious weeds and feral animal impact, and the protection of native Hawaiian forests (see "Terminology").

This report on the MRI of Kauai is one of a series of statewide MRI reports. Results from the Molokai inventory are published (Buck and others 1986) as are the results for the Oahu MRI (Buck and others 1988).

Geography and Historic Background

The Hawaiian archipelago, the most isolated island chain in the world, extends across 1,500 miles of the Pacific Ocean. The eight main islands have an area of 6,450 square miles. Kauai (fig. 1) is the fourth largest island with 8.5 percent of the State's area and 5 percent of the State's population.

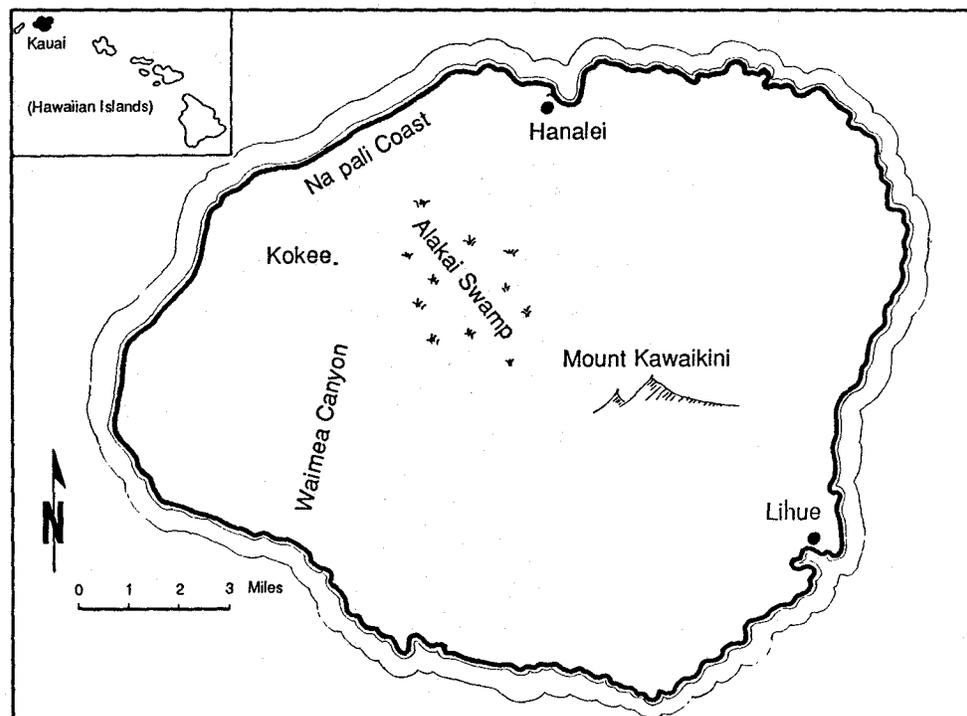


Figure 1—Island of Kauai, Hawaii.

Geologically, Kauai is the oldest of the main islands. It was formed by a single shield volcano, which has eroded over millions of years into spectacular landforms (fig. 2). Waimea Canyon, often referred to as the "Grand Canyon of the Pacific," has cliffs dropping over 2,500 feet. The Alakai Swamp, a forested plateau over 4,000 feet in elevation, is one of the wettest places on earth with recorded annual rainfall of over 500 inches. The highest point on Kauai is Mount Kawaikini, 5,243 feet, in the southeastern corner of the Alakai Swamp. The wide range in rainfall and the topographic diversity of the island have produced several forest types from semiarid woodlands to subtropical rain forests and montane cloud forests.



Figure 2—Nualolo Valley on the Na Pali coast of Kauai is accessible only by air or water. Remains of the rock walls used by the Hawaiians for agricultural production are visible.

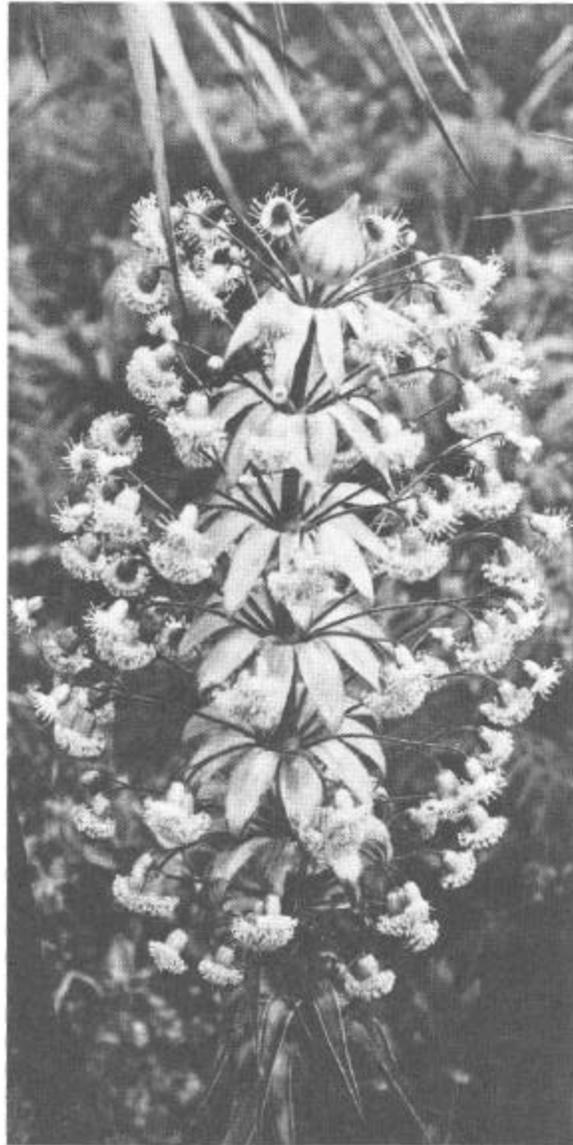


Figure 3—The flower of the endemic iliau (*Wilkesia gymnoxiphium*), which grows in dry forest areas of western Kauai and nowhere else in the world.

On their arrival over 1,000 years ago, early Polynesians found a unique and diverse native forest. About 90 percent of the native Hawaiian plant species and 19 percent of the genera are endemic; they are found only in the Hawaiian archipelago and nowhere else in the world (fig. 3). Although the Polynesians cleared much of the lowland forests for agriculture and dwelling sites, the montane forest was left relatively undisturbed.

Since the arrival of Europeans in 1778, increased changes have affected Hawaii's forest ecosystems. Four factors played a major role in early forest alteration and destruction: the harvesting of sandalwoods¹ (*Santalum* spp.) for its fragrant **animals** such as cattle and goats; deforestation for fuelwood, ranching, and crop production; and fires in native forests during dry periods. Coupled with this forest disturbance was the eventual extinction of many native birds, plants, and invertebrates. These impacts were accompanied by the usually accidental-but sometimes intentional-establishment of introduced species. Many of these introduced and now naturalized plant species have proven valuable for watershed rehabilitation. Others have become serious problems and continue to spread throughout Hawaii's remaining native forests.

In 1903, the Division of Forestry was formed to protect and develop the islands' water resources. This was in response to the deterioration of the forested montane watersheds. Early forestry work on Kauai included establishing forest reserves, fencing to restrict ranch animals, and tree planting. Today, the Division of Forestry and Wildlife, as a unit of the Department of Land and Natural Resources, is responsible for the administration and management of State forest reserves and game management areas. Watershed management is the highest priority.

Inventory Procedures

The total area surveyed on Kauai was over 347,000 acres excluding areas in forest plantations and inland bodies of water over 40 acres. Forest plantations were excluded because previous inventories provided accurate and specific data (Honda and others 1967, State of Hawaii 1979). Forest plantation data included here will be from these inventories.

The Kauai MRI design combined information from aerial photographs and field plots in a two-phase sampling procedure. In the first phase, 1,796 systematic sample points were located on aerial photographs with each point representing about 200 acres. The black and white photographs were taken in 1977 at a scale of 1:48,000. A 1-acre area around each point on the aerial photographs was interpreted for land class, vegetation type, and erosion. Additional information, such as rainfall, elevation, land use zoning, and ownership was recorded for each point.

In the second phase, 137 ground checks were randomly selected in proportion to the area in each land class. All the ground checks were visited in 1987 to determine current land class and vegetation type. These ground checks provided a check for the photo interpretation sample, which was statistically adjusted. Field plots were established only for ground checks in the timberland and other forest land classes. The locations of the 29 field plots were carefully referenced for remeasurement in subsequent inventories. Field plots were not established in shrub-dominated areas having less than a 10-percent tree cover.

¹Scientific names for all plants and animals are given at the end of this paper.

The Kauai field plot consists of a cluster of seven sample points spread out over a 3.5-acre area (fig. 4). Five of these points are volume points where sample trees provide estimates of forest stand volume, condition, and growth. Additional data collected at these points include impact of animals and distribution of noxious plants. A 10-minute bird count was done at point 1, and incidental wildlife observations were recorded throughout the plot area. The bird counts were not meant to be censuses, but rather observations of the incidence and distribution of bird species in different habitat types.

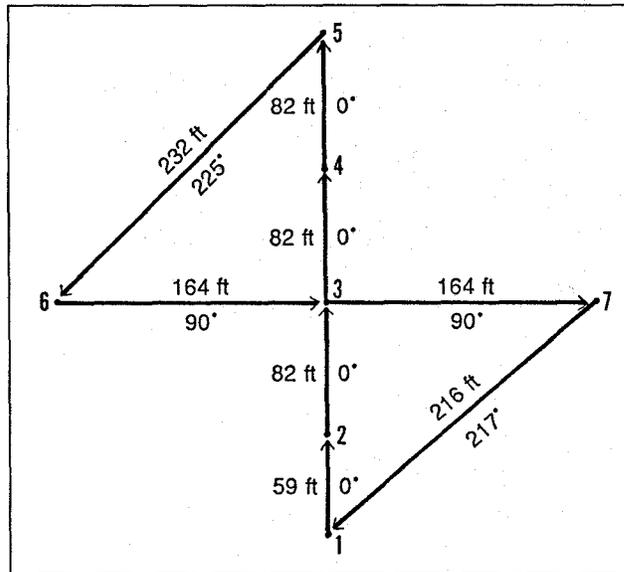


Figure 4—The multiresource seven-point field plot.

Two vegetation profile points were established in addition to the volume points. Vegetation was measured by species and crown cover in four vegetative layers, and the points were systematically photographed. Data from the profiles are used to identify forest structure characteristics and eventually will help predict successional trends. Other data, such as recreational use and potential, erosion type and severity, stand origin, and recent disturbances, were recorded for the total plot. A classification scheme based on the dominant plant species in defined vegetative layers was used to name the representative vegetation community for each field plot (Buck and Paysen 1984). Data-gathering procedures are detailed in the "Field Manual: Hawaii Multiresource Forest Inventory."²

Findings

The findings of the area and volumetric statistics for Kauai are presented in tables 1-11 and figures 5-6. The following discussion highlights data from these tables and figures. Additional area) and volumetric information is available from the Hawaii Division of Forestry and Wildlife, Honolulu.

²Unpublished document, 1983, "Field Manual: Hawaii Multiresource Forest Inventory," by Patrick G. Costales and Michael G. Buck, State Department of Land and Natural Resources, Division of Forestry and Wildlife, Honolulu. 66 p.

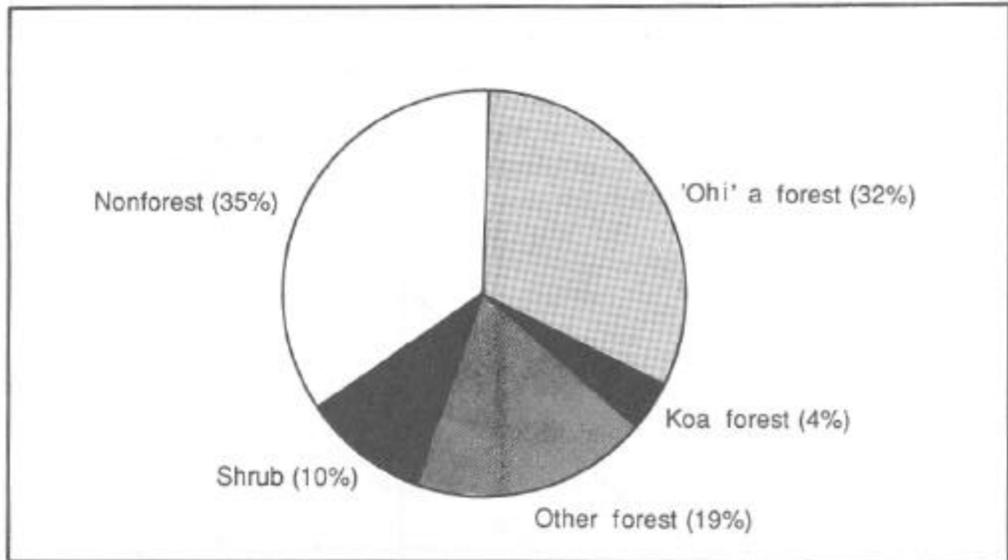


Figure 5—Percentage of major vegetation classes, Kauai, Hawaii, 1986.

Vegetation Types

An estimated 188,500 acres of forest on Kauai occupy 55 percent of the island (fig. 5). The native 'ohi'a (*Metrosideros* spp.), is the predominant forest type with over 109,000 acres or 58 percent of the forest acreage (table 1). Over 36,000 acres of shrubs occur on the island; the dominant species is haole koa (*Leucaena leucocephala*) with over 13,000 acres. Over 122,000 acres are classified as nonforest with cultivated land and grassland comprising over 64,000 and 34,000 acres, respectively. Over 5,900 acres are forest plantations (table 2); the majority are eucalypts (*Eucalyptus* spp.).

Forest Reserves

Kauai has over 88,000 acres of forest reserve land (table 3); 64 percent is native 'ohi'a and koa (*Acacia koa*) forests. On Kauai, 119,000 acres of forest are not in forest reserves; this includes over 65,000 acres of 'ohi'a and koa forests.

Land Classes

The largest land class on Kauai is pali land, with over 134,000 acres, or 39 percent of the island (table 4). The two forest land classes comprise 31 percent of the island followed by the cultivated land class with 19 percent. Only 3.3 percent of the island's area is in the urban land class.

Timberland, which is forest land considered to be the potential land base for producing sustainable forest products, is just 11 percent (37,200 acres) of the island. State and private-corporate ownership of Kauai's timberland is 45 and 31 percent, respectively. Other forest land, which is forest land incapable of producing sustainable forest products because of excessive slope or unstable soils, is almost 21 percent (71,400 acres) of the island.

Pali land is very steep, mountainous land and plays an important role in watershed protection on Kauai. Over 58 percent of the forest reserves on Kauai are pali land (table 5), and over 75 percent of Kauai's 'ohi'a forests are in this land class.

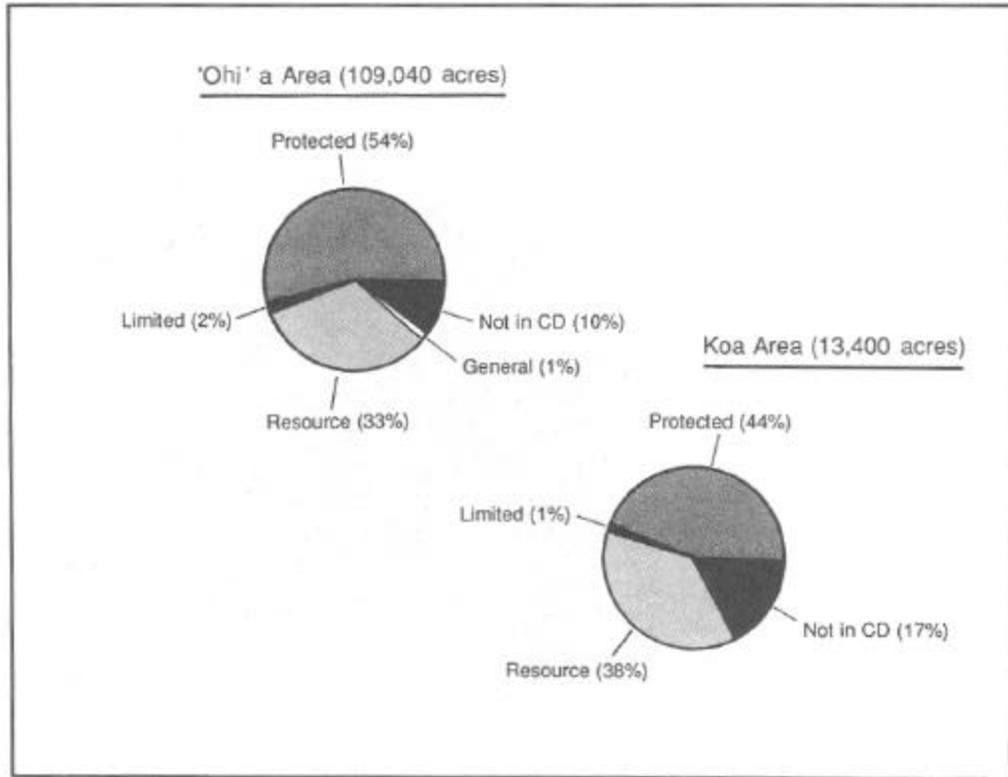


Figure 6—Area of 'ohi'a and koa in conservation district (CD) subzones, Kauai, Hawaii, 1986.

Conservation District

The conservation district is one of the four land use zones established in Hawaii in 1961. These lands are under the regulatory control of the Department of Land and Natural Resources and are subdivided into four subzones: protected, limited, resource, and general. Within the conservation district zone is 22,804 acres of the timberland, 43 percent of which is in the resource subzone (table 6). About 90 percent of the 'ohi'a forests are within the conservation district zone, and 54 percent are in the protected subzone (fig. 6).

Volumetric Information

Timberland-Total tree volume on timberland is estimated at 42.7 million cubic feet (table 7). Introduced and naturalized trees constitute 72 percent of this volume with Java plum (*Eugenia cumini*), silk-oak (*Grevillea robusta*), and albizia (*Albizia falcata*) the dominant species (fig. 7). There is 26.1 million cubic feet in treks of sawtimber size, yet only 46 percent of this volume is of saw-log quality (table 8). Java plum and 'ohi'a make up 70 percent of the trees in the 5-10.9-inch d.b.h. (diameter at breast height) class on Kauai's timberland (table 9).

Other forest land- Ohi'a comprises 51 percent of the estimated 24.2 million cubic feet of total tree volume in the other forest land class (table 10). Native trees are 78 percent of the trees in the 5-10.9-inch size class (table 11).

Forest plantations- An estimated 9.2 million cubic feet of tree volume is in Kauai's forest plantations; 71 percent of which is eucalypts (table 2).

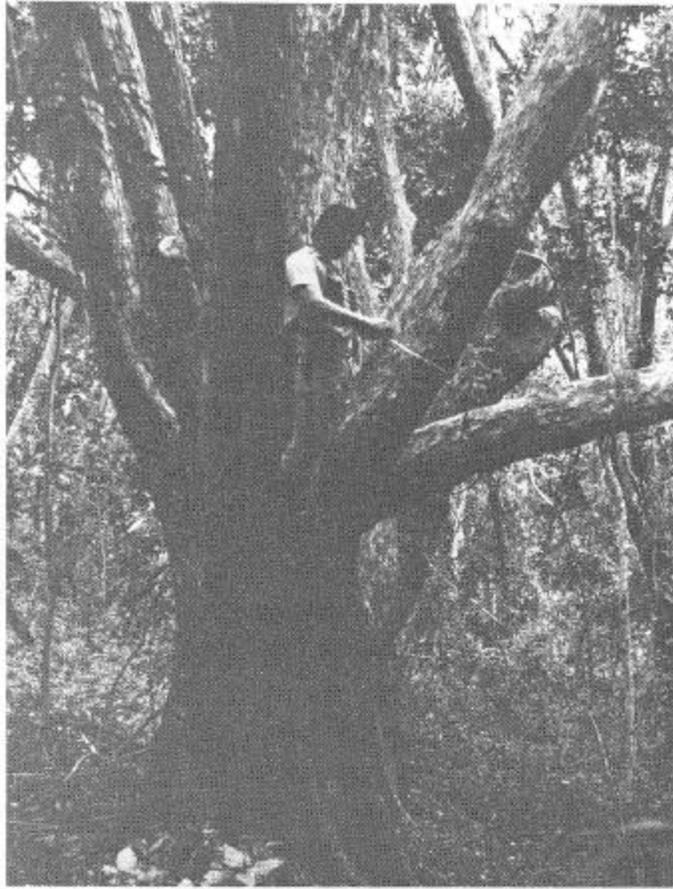


Figure 7—Camphor tree (*Cinnamomum camphora*), an introduced hardwood from China, was planted on Kauai in the late 1940's. This tree displays the variability that makes volumetric estimates difficult.

Watersheds

The presence and severity of erosion can be used as a measure of the quality of a watershed. The islandwide photographic sample indicated 13 percent (45,100 acres) of the island had slight to moderate erosion and 6 percent (20,825 acres) had severe erosion. Eighty-four percent of the severely eroded land is in the pali land class, of which over half is nonvegetated. Most of the severely eroded area is in Waimea Canyon and along lower ridges on Kauai's west side. Although many of the steep pali lands are naturally erosive, other areas in the lower Kokee area could benefit from watershed rehabilitation efforts (fig. 8).

Twenty-four percent of the field plots had evidence of surface erosion. All the erosion found in the native forest plots was accompanied by slight-to-moderate animal impact, mostly from pigs. Animal impact was in the form of trails, vegetation browsing, and soil disturbance.



Figure 8—Severely eroded lands in western Kauai's dry forest areas. Many of these areas were grazed historically by cattle and other introduced herbivores.

Recreation

Seven of the 29 field plots had evidence of current recreational use. The predominant uses were hiking, followed by hunting and fishing (fig. 9). Twenty percent of the plots were considered to have good potential for recreational development, and two-thirds of those had evidence of use. Factors used to rate recreation potential included access, safety, and desirability.



Figure 9—Many of Kauai's streams have been stocked with trout and bass. Although these introductions may have a negative effect on endemic freshwater fauna, they provide an important recreational resource for Hawaii's anglers.

Native Forest
Ecosystems

Four general areas of native forests occur on Kauai. The Alakai Swamp has the largest block of undisturbed native forest on the island (fig. 10). The Kokee area, on the western side of the island, has wet, native 'ohi'a forests at higher elevations and dry, scrub koa forests at lower elevations. A third native forest area is found along the pali walls in the backs of many valleys. The remaining native forests are remnant patches within scattered lowland areas. Of the 29 field plots established on Kauai, 9 were dominated by native plants in all vegetative layers; an additional 7 plots had a dominant native overstory layer, but introduced plants were part of the vegetative community; and the remaining 13 plots were dominated by introduced plants in all vegetative layers.



Figure 10—An undisturbed montane rain forest in the Alakai Swamp. Annual rainfall of over 400 inches produces the heavy epiphyte loading seen on the stems and branches of these trees.

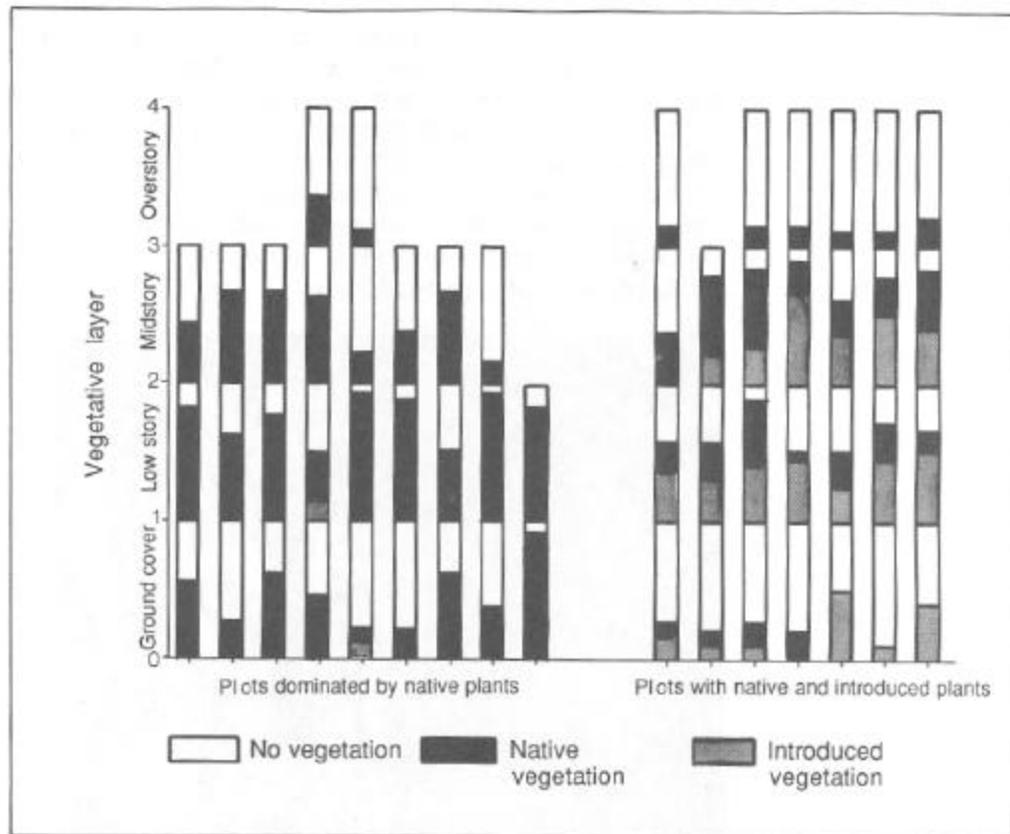


Figure 11—Percentage of plant crown cover in vegetative layers for native forest field plots, Kauai, Hawaii, 1986.

Vegetation profile data indicated general trends for introduced plant establishment and growth within native forests. Analysis was done by looking at plant crown cover area in different vegetative layers. The majority of the vegetation profiles with more than 10 percent introduced plant cover in the ground cover layer had introduced plants in the upper story layers (fig. 11). The majority of the vegetation profiles with over 25 percent native plant cover in the ground cover layer or 50 percent native cover in the low story layer had little or no introduced plants within the profile. Data suggest that once introduced plants (especially shade-tolerant trees such as guava) become established past a certain threshold level, native plant displacement occurs. These threshold levels are similar to vegetation profiles in native forests on Oahu (Buck and others 1988).

Animals play an important role in dispersing introduced plant seeds. Studies have found that fruits of guava (*Psidium* spp.) and banana poka (*Passiflora mollissima*) fruit are major components in the diets of deer and pigs.³ Guava species were found in all the vegetation profiles of field plots having native and introduced plants. Introduced

³ Unpublished document, 1983, "Status, Trends, and Utilization of Game Mammals and Their Habitats on the Island of Kauai." State of Hawaii P-R Project. W5-R-8:R-II-C.

birds can also disperse seeds (Smith 1985). Japanese white-eye and other frugivorous birds in the Kokee area feed on two aggressive introduced plants, blackberry (*Rubus penetrans*) and firebush (*Myrica faya*). Humans, especially hikers, also play a key role in spreading seeds of introduced plants by accidentally transporting seeds from one island to another. This is the probable reason for the recent infestation of the noxious shrub, clidemia (*Clidemia hirta*), on Kauai.

Diversity in native plant species can decrease when aggressive, introduced plants, such as guava or banana poka, are established (fig. 12). Vegetation profile data from field plots dominated by native plants showed an average of 15 plant species occurring in the 5-meter-radius (16.4-foot-radius) sample areas; 14 species were native and 1 was introduced. The vegetation profiles in field plots with native and introduced plants had an average of 17 plant species, 11 native and 6 introduced. In contrast, the vegetation profiles in field plots dominated by introduced plants had an average of 10 plant species with only 2 native and 8 introduced. These data indicate reduced diversity of native species with an increased component of introduced plants.



Figure 12—Many forest areas in Kokee are infested with banana poka, a vine from South America introduced as an ornamental plant. The rare *Cyanea* spp., an endemic palmlike plant, is in the left foreground in front of a tree smothered by the banana poka vine.

Wildlife

Nineteen bird species, 13 of which are introduced, were seen or heard during the formal 10-minute counts (table 12). The most widely distributed bird species was the introduced Japanese white-eye, which occurred in 86 percent of the bird counts. It was recorded in various forest types from dry scrubland to wet rain forests and at elevations of 180-3,660 feet. One probable reason for the success of the Japanese white-eye is its diet that includes fruit, nectar, and insects. The most widely distributed native bird species was the 'apapane, which occurred in 41 percent of the bird counts. Data indicated that the relative abundance of native forest birds decreases and abundance of introduced bird species increases as the introduced plant component within the forests increases.

Data also indicated an elevational gradient with native birds absent in lowland native forest types but present in introduced forest types at higher elevations. Native birds were observed feeding on nectar from banana poka and eucalyptus flowers in introduced silk-oak and eucalyptus forests. The noted elevational gradient is similar to the known range of a mosquito species, which is a vector for an introduced avian malaria negatively affecting native forest birds. More than one factor contributes to the restrictive range of Kauai's native forest birds, especially endangered species. A larger sample with supplementary data on disease vectors and interspecific competition between native and introduced birds is necessary before any definitive conclusions on limiting factors for native forest birds can be made.

Discussion

The MRI provided a benchmark for additional studies focusing on trends and potential problems in Hawaii's forests. For example, Hurricane Iwa caused serious damage to the Kokee area in 1982 (fig. 13) by creating gaps and clearings in the forests (fig. 14). Noticeable reestablishment of koa seedlings and vigorous koa sapling growth has occurred within stands of mature koa and koa-'ohi'a forests damaged by Iwa (fig. 15). Introduced plants such as strawberry guava (*Psidium cattleianum*) are becoming established in the forest gaps created by the hurricane. Strawberry guava is shade tolerant, fruits prolifically, and has many effective seed dispersers. Future inventories will provide data on the recovery and future plant composition of the native forests in the Kokee area.

Although forests of the Alakai Swamp were not severely damaged by Hurricane Iwa, certain areas had evidence of feral pig disturbance. Future inventories will help to monitor the condition of the Alakai and the effects of these kinds of disturbances on the native forest.

Although many statistics are presented in this report, some general observations and comments by the field personnel cannot be presented in tabular format. One observation by all field personnel working on the Kauai MRI was about the variety, uniqueness, and spectacular beauty of the forests. It will be a challenge for everyone concerned with forest management in Hawaii to find the proper balance among protection, use, and appreciation for Kauai's forests.



Figure 13—A eucalyptus plantation battered by Hurricane Iwa in 1982. Trees in this plantation were over 200 feet tall.



Figure 14—A hurricane-created gap in a mature koa-'ohi'a forest in Kokee. Note the banana poka vines along the left side of the photograph.

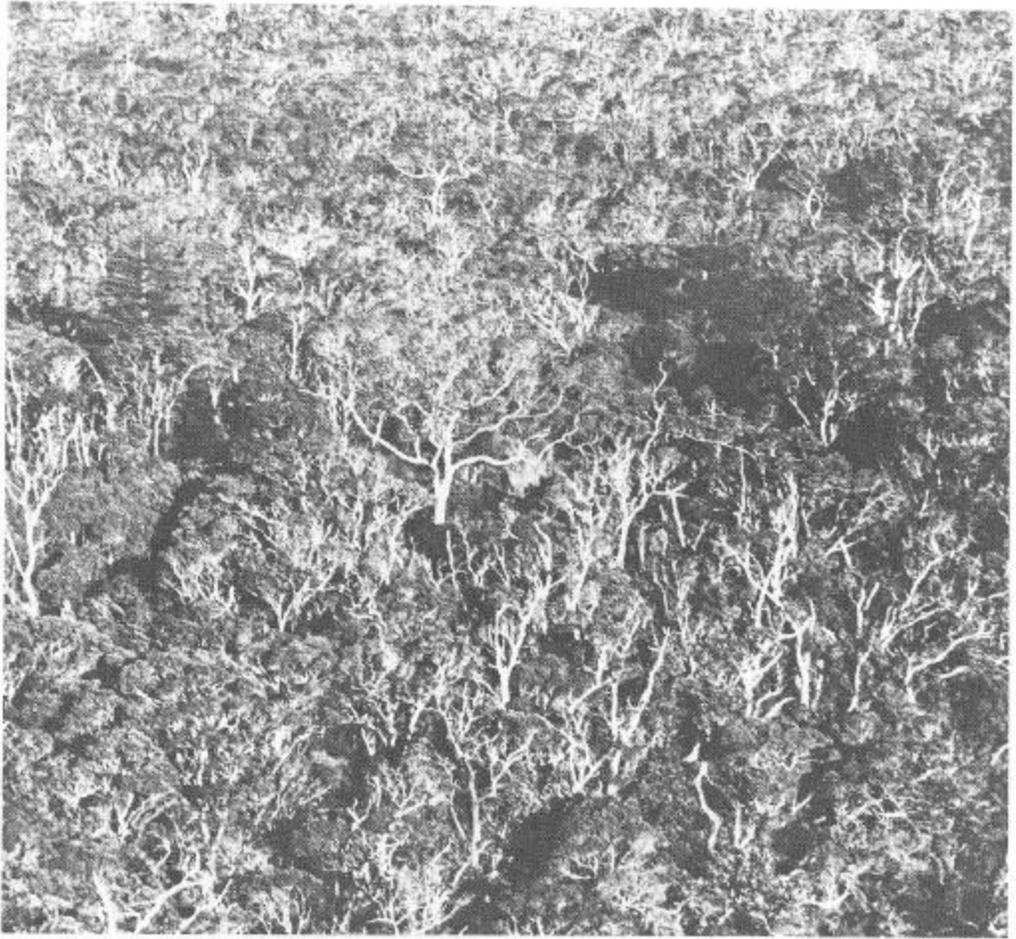


Figure 15—Regrowth of koa from seed and sprouts within hurricane-damaged koa stands in Kokee.

Reliability of Inventory Data

Confidence intervals have been computed for the estimates of land area, wood volume, and tree numbers. These confidence intervals mean that at odds of two out of three (67 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, Honolulu. The magnitude of possible errors in judgment, measurement,

and compilation cannot be determined. The likelihood of such errors were minimized through training and supervision of personnel, field checking of data, and editing and machine verification of entry and compilation of data.

Data item	Total data value	Sampling error (plus or minus)
Land class (acres)	See table 4	
Timber, cubic volume (thousand cubic feet)		
All forest land	67,008	16,015 (23.9 percent)
Timberland	42,797	14,978 (35.0 percent)
Other forest land	24,211	8,594 (35.5 percent)
Number of live trees (thousand trees)		
All forest land	70,872	16,725 (23.6 percent)
Timberland	41,615	16,895 (40.6 percent)
Other forest land	29,257	8,045 (27.5 percent)

Terminology

Bolt--Six-foot sections, with good form and no cull, of sawtimber trees with a minimum middiameter of 10 inches.

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

Conservation district lands--Zoned lands whose uses are under certain regulations of the Department of Land and Natural Resources. The four subzones in the conservation district are protected, resource, limited, and general. The protected and limited subzones are the most restrictive; the resource and general subzones provide for sustained use of natural resources with approved management.

Crown cover area--The leaf area in a horizontal plane at the top of a specified vegetative layer.

Cultivated land--Pineapple and sugarcane fields, orchards, and other areas under cultivation, or regularly cropped, fallow areas.

D.b.h.--Diameter at breast height, a point 4.5 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 abnormally formed trees.

Dune land--Sandy areas; beach front with very sparse or no vegetation.

Endemic--Peculiar to a particular region, in this case the Hawaiian Islands, and found nowhere else in the world.

Feral--Having escaped from domestication and reverted to a wild state.

Forest land--Land at least 10 percent stocked with trees and 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. This land includes both timberland and other forest land.

Forest plantations--Forests with at least 10 percent of growing space occupied by planted trees (introduced species).

Forest reserve--State-owned forest land managed by the Hawaii Division of Forestry and Wildlife; also includes privately owned forest land surrendered to the State for management purposes.

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

Hawaiian Homes Commission--Organization administering land set aside for use by those of Hawaiian ancestry.

Indigenous--Occurring naturally in a given region but also found nearby in a wide geographic area (for example, other Pacific islands).

Introduced--Birds, plants, or animals brought to the Hawaiian Islands by people.

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, indigenous, and Polynesian plant introductions.

Naturalized forest--Forests of introduced 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 use.

Noxious plants--Any plant species considered harmful to forest resources and that has the propensity to spread unless control measures are taken.

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 of rainfall per year). Includes forest lands having low productivity for timber but that may be productive for range, watershed, recreation, or wildlife habitat.

Pali land--Very steep, mountainous land with slopes of more than 80 percent; includes land that is more than 50-percent rock outcropping and recent barren volcanic ash, cinder, and lava flows.

Poletimber trees--Trees 5.0 to 10.9 inches d.b.h.

Rough wood--Logs of sawtimber size failing 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 and meeting specifications for standard lumber (good form, minimal cull).

Sawtimber trees--Live trees with a d.b.h, equal to or greater than 11.0 inches.

Sawtimber volume--Cubic-foot volume for sawtimber trees that includes the portion of the tree to a minimum 9-inch top diameter outside bark.

Timberland--Forest land capable of producing 20 cubic feet or more per acre per year of industrial wood (commercial roundwood other than firewood) because of suitable site conditions (good drainage, deep and fertile soils, adequate rainfall) and not withdrawn from timber use. This land class is characterized by its potential for restocking with trees.

Tip--The portion of sawtimber and poletimber trees above the point where stem diameter outside bark is 4 inches (0.1-inch upper stem diameter).

Total tree volume--Total aboveground woody volume of the tree including branches.

Upper stem--The portion of sawtimber trees extending from a lower stem diameter outside bark of 9 inches to a minimum upper stem diameter outside bark of 4 inches.

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

Vegetation profile--A circular 5-meter radius sample area where plant crown cover is measured in four defined vegetative layers.

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

Vegetative layer--A vertical stratification of plant structure within a forest. The four vegetative layers used are ground cover (ground to 1 foot), low story (1 to 6 feet), midstory (6 to 30 feet), and overstory (more than 30 feet).

Tables

Table 1—Area by vegetation type and owner, Kauai, Hawaii, 1986^a

Vegetation type	Owner						All owners
	State	Federal	County	Hawaiian Homes	Private corporate	Private individual	
	Acres						
Trees:							
'Ohi'a	50,736	152	18	1,032	51,415	5,690	109,043
Koa	7,844	--	--	1,031	4,191	373	13,439
Kukui	4,058	--	--	1,111	2,222	242	7,633
Silk-oak	6,854	--	--	2,345	6,403	2,023	17,625
Guava	3,659	--	--	1,536	5,263	1,685	12,143
Java plum	2,802	193	580	97	4,928	2,802	11,402
Kiawe	2,551	1,160	--	2,435	3,942	271	10,359
Eucalyptus ^b	2,190	--	--	515	387	64	3,156
Other trees ^b	1,031	--	--	129	1,933	644	3,737
Subtotal	81,725	1,505	598	10,231	80,684	13,794	188,537
Shrubs:							
Haole koa	5,134	--	--	1,617	5,276	1,797	13,824
Lantana	3,826	--	--	2,377	1,894	638	8,735
Malabar melastome	1,594	48	--	--	2,271	161	4,074
Christmas berry	433	--	18	138	1,467	1,444	3,500
Hau	773	--	--	--	1,353	64	2,190
Other shrubs ^c	1,804	--	--	580	1,224	129	3,737
Subtotal	13,564	48	18	4,712	13,485	4,233	36,060
Nonforest:							
Grass	6,948	28	158	1,705	12,972	12,357	34,168
Forbs	2,256	76	--	138	1,442	207	4,119
Cultivated	18,746	386	--	1,739	36,718	7,150	64,739
Urban	773	580	580	--	2,319	6,957	11,209
Other ^d	5,081	83	--	414	1,961	718	8,257
Subtotal	33,804	1,153	738	3,996	55,412	27,389	122,492
All types	129,093	2,706	1,354	18,939	149,581	45,416	347,089

-- = none found.

^a Totals may be off because of rounding.

^b Other trees include black wattle, hala, Norfolk-Island pine, octopus tree, paper bark, and wiliwili.

^c Other shrubs include a'ali'i, rose myrtle, naupaka, and pukiawe.

^d Includes water, nonvegetated, and other areas.

Table 2—Area and volume of forest plantations by owner and species, Kauai, Hawaii, 1986

Species	Owner			All owners
	State	Hawaiian Homes	Private	
	<i>Acres</i>			
<i>Eucalyptus robusta</i>	470	239	564	1,273
<i>Eucalyptus saligna</i>	1,052	68	--	1,120
Other <i>Eucalyptus</i> spp.	117	120	119	356
Other hardwoods ^a	510	16	552	1,078
Conifers ^b	1,466	590	20	2,076
Total	3,615	1,033	1,255	5,903
	<i>Thousand cubic feet^c</i>			
<i>Eucalyptus robusta</i>	949	469	2,052	3,470
<i>Eucalyptus saligna</i>	2,432	88	--	2,520
Other <i>Eucalyptus</i> spp.	92	148	331	571
Other hardwoods	1,027	12	244	1,283
Conifers	1,331	--	103	1,434
Total	5,831	717	2,730	9,278

-- = none found.

^a Other hardwoods include albizia, blackwood acacia, silk-oak, and tropical ash.

^b Other conifers include Norfolk-Island pine, slash and loblolly pine, redwood, and sugi.

^c Volume is for main stem only to a 4-inch top diameter outside bark.

Sources: Honda and others 1966, State of Hawaii 1979.

Table 3—Area by vegetation type and forest reserve status, Kauai, Hawaii, 1986^a

Vegetation type	Inside forest reserve	Outside forest reserve	Total
<i>Acres</i>			
Trees:			
'Ohi'a	50,702	58,338	109,040
Koa	6,223	7,215	13,438
Kukui	2,029	5,604	7,633
Silk-oak	4,110	13,515	17,625
Guava	3,099	9,044	12,143
Java plum	1,160	10,243	11,403
Kiawe	116	10,243	10,359
Eucalyptus	1,288	1,868	3,156
Other trees ^b	773	2,963	3,736
Subtotal	69,500	119,033	188,533
Shrubs:			
Haole koa	1,714	12,110	13,824
Lantana	2,822	5,913	8,735
Malabar melastome	1,223	2,851	4,074
Christmas berry	334	3,165	3,499
Hau	451	1,739	2,190
Other shrubs ^c	644	3,092	3,736
Subtotal	7,188	28,870	36,058
Nonforest:			
Grass	5,198	28,970	34,168
Forbs	2,043	2,077	4,120
Cultivated	387	64,354	64,741
Urban	--	11,209	11,209
Other ^d	3,810	4,446	8,256
Subtotal	11,438	111,056	122,494
All types	88,126	258,959	347,085

-- = none found.

^a Totals may be off because of rounding.

^b Other trees include black wattle, hala, Norfolk-Island pine, octopus tree, paper bark, and wiliwili.

^c Other shrubs include a'ali'i, rose myrtle, naupaka, and pukiawe.

^d Includes water, nonvegetated, and other areas.

Table 4—Area by land class and owner, Kauai, Hawaii, 1986^a

Land class	Owner						All owners	Sampling error
	State	Federal	County	Hawaiian Homes	Private corporate	Private individual		
	----- Acres -----							Percent
Timberland	16,813	290	72	4,711	11,475	3,865	37,226	20.2
Other forest land	28,449	864	376	6,169	26,620	9,002	71,480	14.2
Pali land	60,352	393	163	5,676	61,464	6,137	134,185	6.4
Cultivated	18,746	387	--	1,739	36,719	7,150	64,741	4.9
Grassland	1,449	--	161	644	8,858	11,917	23,029	15.7
Urban	966	580	580	--	2,319	6,957	11,402	12.8
Other ^b	2,320	193	--	--	2,125	387	5,025	19.5
Total	129,095	2,707	1,352	18,939	149,580	45,415	347,088	

-- = none found.

^a Totals may be off because of rounding.

^b Includes dune land, bog, water, and other areas.

Table 5—Area by land class and forest reserve status, Kauai, Hawaii, 1986^a

Land class	Inside forest reserve	Outside forest reserve	Total
	----- Acres -----		
Timberland	11,088	26,138	37,226
Other forest land	21,620	49,861	71,481
Pali land	51,842	82,342	134,184
Grassland	1,449	21,580	23,029
Cultivated	387	64,353	64,740
Urban	193	11,209	11,402
Other ^b	1,546	3,479	5,025
Total	88,125	258,962	347,087

^a Totals may be off because of rounding.

^b Includes dune land, bog, water, and other areas.

Table 6—Area of selected land classes by conservation district (CD) subzones, Kauai, Hawaii, 1986

Land class	Conservation district subzone					Total
	Protected	Limited	Resource	General	Not in CD	
	<i>Acres</i>					
Timberland	5,822	870	16,004	48	14,422	37,166
Other forest land	14,059	2,774	26,332	229	28,086	71,480
Pali land	59,451	4,377	46,823	109	23,425	134,185

Table 7—Total tree volume on timberland by species and diameter class, Kauai, Hawaii, 1986

Species	Diameter size class (inches)				
	5.0-10.9	11.0-16.4	16.5-28.5	28.6 and larger	All classes
	<i>Thousand cubic feet</i>				
Native:					
Koa	488	3,540	2,271	1,180	7,479
'Ohi'a	2,521	372	407	--	3,300
Kukui	495	241	--	--	736
Other native ^a	228	250	--	--	478
Total	3,732	4,403	2,678	1,180	11,993
Naturalized:					
Java plum	4,381	1,410	1,926	--	7,717
Silk-oak	947	2,678	3,164	--	6,789
Albizia	--	593	1,004	3,241	4,838
Guava	1,377	472	--	--	1,849
Ironwood	261	904	498	--	1,663
Other species ^b	1,922	1,357	3,476	1,193	7,948
Total	8,888	7,414	10,068	4,434	30,804
All species	12,620	11,817	12,746	5,614	42,797

-- = none found.

^a Other natives include kauila and olapa.

^b Other naturalized species include eucalypts and camphor tree.

Table 8—Total tree volume on timberland by species and class of timber, Kauai, Hawaii, 1986

Species	Total pole-timber	Sawtimber							Total saw-timber	Total volume
		Rough wood	Saw log	Upper stem	Bolts	Crotch	Branch	Tip		
<i>Thousand cubic feet</i>										
Native:										
Koa	215	2,382	1,234	689	952	25	659	27	5,968	6,183
'Ohi'a	2,316	110	--	127	--	--	169	1	407	2,723
Kukui	--	107	--	--	--	--	135	--	242	242
Other native ^a	228	--	131	45	--	--	70	4	250	478
Total	2,759	2,599	1,365	861	952	25	1,033	32	6,867	9,626
Naturalized:										
Silk-oak	947	1,117	3,235	642	219	--	608	23	5,844	6,791
Albizia	--	1,003	2,475	176	189	283	304	12	4,442	4,442
Java plum	2,621	704	149	112	--	--	111	10	1,086	3,707
Guava	1,029	133	--	103	73	--	155	7	471	1,500
Ironwood	--	93	1,072	121	--	--	112	4	1,402	1,402
Other species ^b	1,922	950	3,809	444	339	123	334	27	6,026	7,948
Total	6,519	4,000	10,740	1,598	820	406	1,624	83	19,271	25,790
All species	9,278	6,599	12,105	2,459	1,772	431	2,657	115	26,138	35,416

"--" = none found.

^a Other natives include kauila and olapa.

^b Other naturalized species include eucalypts and camphor tree.

Table 9—Number of trees on timberland by species and diameter class, Kauai, Hawaii, 1986

Species	Diameter size class (inches)				All classes
	1.0-4.9	5.0-10.9	11.0-20.5	20.6 and larger	
<i>Thousand trees</i>					
Native:					
'Ohī'a	4,772	889	22	--	5,683
Koa	1,468	69	205	28	1,770
Kukui	415	73	34	--	522
Other native ^a	2,202	54	20	--	2,276
Subtotal	8,857	1,085	281	28	10,251
Naturalized:					
Bamboo	19,374	--	--	--	19,374
Guava	5,448	313	23	--	5,784
Java plum	3,239	1,008	82	19	4,348
Silk-oak	428	66	127	24	645
Ironwood	--	83	45	--	128
Albizia	--	--	38	25	63
Other species ^b	734	165	106	17	1,022
Subtotal	29,223	1,635	421	85	31,364
All species	38,080	2,720	702	113	41,615

-- = none found.

^a Other natives include alani, kauila, kawa'u, kopiko, 'ohe'ohe, 'ohi'a-ha, and olapa.

^b Other naturalized species include eucalypts and camphor tree.

Table 10—Total tree volume on other forest land by species and diameter class, Kauai, Hawaii, 1986

Species	Diameter size class (inches)				All classes
	5.0-10.9	11.0-16.4	16.5-28.5	28.6 and larger	
<i>Thousand cubic feet</i>					
Native:					
'Ohī'a	6,789	4,942	698	--	12,429
Koa	568	1,025	242	--	1,835
Tree fern	46	--	--	--	46
Other native ^a	1,115	501	--	--	1,616
Subtotal	8,518	6,468	940	--	15,926
Naturalized:					
Ironwood	3,612	797	1,507	--	5,916
Silk-oak	--	2,369	--	--	2,369
Subtotal	3,612	3,166	1,507	--	8,285
All species	12,130	9,634	2,447	--	24,211

-- = none found.

^a Other natives include kalia, 'ohī'a-ha, and papala.

Table 11—Number of trees on other forest land by species and diameter class, Kauai, Hawaii, 1986

Species	Diameter size class (inches)				All classes
	1.0-4.9	5.0-10.9	11.0-20.5	20.6 and larger	
<i>Thousand trees</i>					
Native:					
'Ohia	7,569	2,057	361	--	9,987
Koa	831	148	71	11	1,061
Tree fern	144	--	--	--	144
Other native ^a	8,673	473	64	--	9,210
Subtotal	17,217	2,678	496	11	20,402
Naturalized:					
Guava	6,222	--	--	--	6,222
Kiawe	1,661	--	--	--	1,661
Ironwood	--	737	172	--	909
Silk-oak	--	--	63	--	63
Subtotal	7,883	737	235	--	8,855
All species	25,100	3,415	731	11	29,257

-- = none found.

^a Other natives include 'ahakea, 'akia, 'akoko, alani, hame, sandalwood, kalia, kawa'u, manono, 'ohi'a-ha, olapa, olopua, papala, and pilo.

Table 12—Number of birds counted by forest type, elevation, and species, Kauai, Hawaii, 1986

Bird Species	Forest type (number of plots)										
	Above 2,500 feet elevation				Below 2,500 feet elevation						
	'Ohi'a (4)	Koa (4)	Silk-oak (1)	Eucalyptus (1)	'Ohi'a (7)	Koa (1)	Silk-oak (1)	Guava (2)	Java plum (2)	Kiawe (2)	Other ^a (3)
Native species:											
'Akepa	2	--	--	--	--	--	--	--	--	--	--
'Amakihi	3	7	--	--	--	--	--	--	--	--	--
'Anianiau	7	7	4	--	--	--	--	--	--	--	--
'Apapane	30	17	3	2	3	--	--	--	--	--	--
'Elepaio	5	7	1	--	--	--	--	--	--	--	--
'Iwi	6	1	--	--	--	--	--	--	--	--	--
Introduced species:											
Common myna	2	--	1	--	--	--	2	--	3	2	3
Japanese white-eye	2	10	3	--	22	5	11	7	7	10	16
Melodious laughing-thrush	2	4	--	--	7	5	2	1	2	2	2
Northern cardinal	--	1	2	--	1	--	--	4	3	--	6
Nutmeg mannikin	2	3	--	--	--	2	--	--	14	--	--
Red junglefowl	1	4	2	--	--	1	--	--	2	--	--
White-rumped shama	--	3	--	--	1	2	1	--	1	5	--
Zebra dove	1	--	1	--	--	--	1	1	2	4	2
Other ^b	2	11	2	1	2	2	--	--	4	3	--

^a Other forest types include albizia, bamboo, camphor tree, and ironwood.

^b Other bird species include cattle egret, erckel's francolin, house finch, house sparrow, and spotted dove.

Names of Plants⁴

Origin	Common Name	Scientific Name
Trees		
Endemic	'Ahakea	<i>Bobea</i> spp. Gaud.
Endemic	Akia	<i>Wikstroemia</i> spp. Endl.
Endemic	'Akoko	<i>Euphorbia</i> spp. L.
Endemic	Alani	<i>Pelea</i> spp. Gray
Introduced	Albizia	<i>Albizia falcataria</i> (L.) Fosb.
Introduced	Bamboo	<i>Bambusa</i> spp. Schreb.
Introduced	Black wattle	<i>Acacia decurrens</i> (Wendl.)
Introduced	Blackwood acacia	<i>Acacia melanoxylon</i> R. Br. in Ait. f.
Introduced	Camphor tree	<i>Cinnamomum camphora</i> (L.) Sieb.
Introduced	Eucalyptus	<i>Eucalyptus</i> spp. L'Her.
Introduced	Guava	<i>Psidium</i> spp. L.
Introduced	Guava, strawberry	<i>Psidium cattleianum</i> Sabine
Indigenous	Hala	<i>Pandanus</i> spp. Stickm.
Endemic	Hame	<i>Antidesma platyphyllum</i> Mann
Introduced	Ironwood	<i>Casuarina</i> spp. Adans.
Introduced	Java plum	<i>Eugenia cumini</i> (L.) Druce
Endemic	Kalia	<i>Elaeocarpus bifidus</i> H. & A.
Endemic	Kauila	<i>Alphitonia ponderosa</i> Hbd.
Endemic	Kawa'u	<i>Ilex anomala</i> H. & A.
Introduced	Kiawe	<i>Prosopis pallida</i> (Humb. & Bonpl. ex Willd.) HBK.
Endemic	Koa	<i>Acacia koa</i> Gray

See footnote on page 32

Endemic	Kopiko	<i>Psychotria</i> spp. L.
Polynesian introduction	Kukui	<i>Aleurites moluccana</i> (L.) Willd.
Introduced	Loblolly pine	<i>Pinus taeda</i> L.
Endemic	Manono	<i>Gouldia</i> spp. Gray
Introduced	Norfolk-Island pine	<i>Araucaria heterophylla</i> (Salisb.) Franco
Introduced	Octopus tree	<i>Brassaia actinophylla</i> Endl.
Endemic	'Ohe'ohe	<i>Tetraplasandra</i> spp. Gray
Endemic	'Ohi'a	<i>Metrosideros</i> spp. Banks ex Gaertn.
Endemic	'Ohi'a-ha	<i>Eugenia sandwicensis</i> Gray
Endemic	Olapa	<i>Cheirodendron</i> spp. Nutt. ex Seem.
Endemic	Olopua	<i>Osmanthus sandwicensis</i> (Gray) Knobl.
Endemic	Papala	<i>Charpentiera obovata</i> Gaud.
Introduced	Paper bark	<i>Melaleuca leucadendra</i> (Stickm.) L.
Introduced	Redwood	<i>Sequoia sempervirens</i> (D. Don in Lamb.) Endl.
Endemic	Sandalwood	<i>Santalum</i> spp. L.
Introduced	Silk-oak	<i>Grevillea robusta</i> A. Cunn. in R. Br.
Introduced	Slash pine	<i>Pinus caribaea</i> Morelet
Introduced	Sugi	<i>Cryptomeria japonica</i> (L. f.) D. Don
Introduced	Tropical ash	<i>Fraxinus uhdei</i> (Wenzig) Lingelsh
Endemic	Wiliwili	<i>Erythrina sandwicensis</i> Deg.

Shrubs

Endemic	A'ali'i	<i>Dodonaea</i> spp. Mill.
Introduced	Blackberry	<i>Rubus penetrens</i> Bailey
Introduced	Christmas berry	<i>Schinus terebinthifolius</i> Raddi
Introduced	Clidemia	<i>Clidemia hirta</i> (L.) D. Don
Endemic	Cyanea	<i>Cyanea</i> spp. Gaud.
Introduced	Firebush	<i>Myrica faya</i> Ait.
Introduced	Haole koa	<i>Leucaena leucocephala</i> (Lam.) de Wit
Indigenous	Hau	<i>Hibiscus tiliaceus</i> L.
Endemic	Iliau	<i>Wilkesia gymnoxiphium</i> Gray
Introduced	Lantana	<i>Lantana camara</i> L.
Introduced	Malabar melastome	<i>Melastoma malabathricum</i> L.
Endemic	Naupaka	<i>Scaevola</i> spp. L.
Endemic	Pilo	<i>Coprosma</i> spp. J. R. & G. Forst.
Endemic	Pukiawe	<i>Styphelia douglasii</i> (Gray) F. Muell. ex Skottsbo.
Introduced	Rose myrtle	<i>Rhodomyrtus tomentosa</i> (Ait.) Hassk.

Vines

Introduced	Banana poka	<i>Passiflora mollissima</i> (HBK.) Bailey
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Ferns

Endemic	Tree fern	<i>Cibotium glaucum</i> (J. Sm.) Hook. and Arnott
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⁴ The source for flowering plant names is St. John (1973); for ferns the sources are Becker (1976) and Neal (1965).

Names of Animals⁵

Common name

Scientific name

Introduced Birds

Cattle egret	<i>Bubulcus ibis</i> (Linnaeus)
Common myna	<i>Acridotheres tristis</i> (Linnaeus)
Erckel's francolin	<i>Francolinus erckelii</i> (Rüppell)
House finch	<i>Carpodacus mexicanus</i> (Müller)
House sparrow	<i>Passer domesticus</i> (Linnaeus)
Japanese white-eye	<i>Zosterops japonicus</i> Temminck and Schlegel
Melodious laughing-thrush	<i>Garrulax canorus</i> (Linnaeus)
Northern cardinal	<i>Cardinalis cardinalis</i> (Linnaeus)
Nutmeg mannikin	<i>Lonchura punctulata</i> (Linnaeus)
Red junglefowl	<i>Gallus gallus</i> (Linnaeus)
Spotted dove	<i>Streptopelia chinensis</i> (Scopoli)
White-rumped shama	<i>Copsychus malabaricus</i> (Linnaeus)
Zebra dove	<i>Geopelia striata</i> (Linnaeus)

Native Birds

'Akepa	<i>Loxops coccineus</i> (Gmelin)
'Amakihi	<i>Hemignathus virens</i> (Gmelin)
'Anianiau	<i>Hemignathus parvus</i> (Stejneger)
'Apapane	<i>Himatione sanguinea</i> (Gmelin)
'Elepaio	<i>Chasiempis sandwichensis</i> (Gmelin)
'I'iwi	<i>Vestiaria coccinea</i> (Forster)

⁵ The sources for bird names are American Ornithologists' Union (1983) and Pyle (1983); for mammals, the source is Novak and Paradiso (1983).

Mammals

Black-tailed deer *Odocoileus hemionus* (Linnaeus)

Feral pig *Sus scrofa* (Linnaeus)

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Metric Equivalents

1,000 acres = 404.7 hectares
1,000 cubic feet = 28.3 cubic meters
1 foot = 0.3048 meter
1 inch = 2.54 centimeters
1 mile = 1.609 kilometers

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This report summarizes a 1986 multiresource forest inventory for Kauai, Hawaii. Tables and figures of forest acreage, timber volume, vegetation types, ownership, land classes, bird counts, and introduced plants are presented.

Keywords: Multiresource inventory, forest survey, statistics (forests), native forests, introduced plants, Kauai, Hawaii.

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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