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The Multiresource Forest Inventory for Oahu, Hawaii

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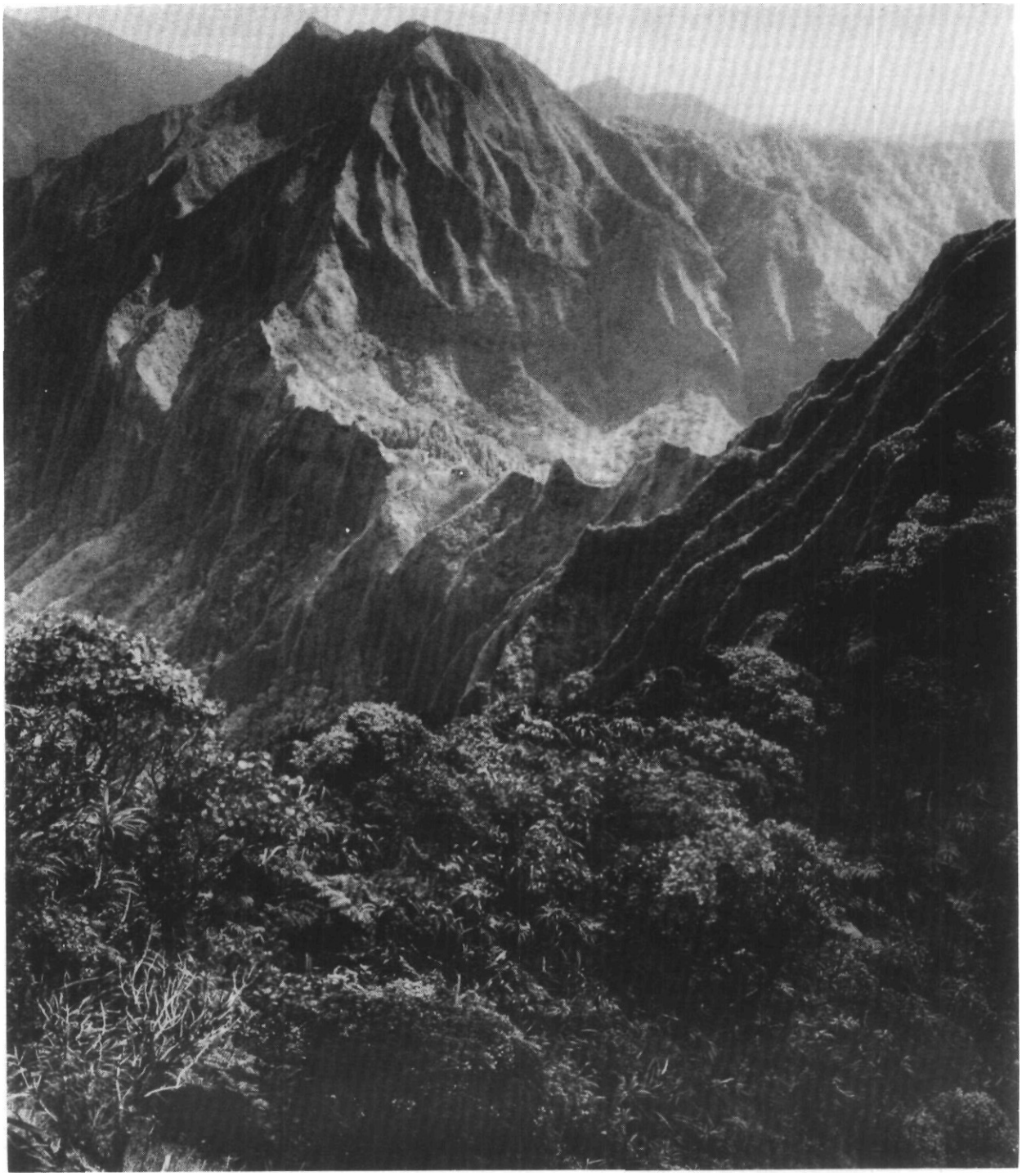

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Abstract

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This report summarizes a 1986 multiresource forest inventory for Oahu, Hawaii. Tables and figures of forest area, 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, Oahu, Hawaii.

Summary

The island of Oahu, Hawaii, comprises over 370,000 acres, of which an estimated 134,300 are forested; 27,400 acres are classified as timberland, 70,700 acres as other forest land, and 36,200 acres as pali land. The two dominant forest types on the island are the native 'ohi'a and koa species. An estimated 31 million cubic feet of total tree volume is on timberland and 40 million cubic feet is on other forest land. Slight surface erosion was recorded on one-fourth of the forest sample plots. Twenty-two bird species were seen or heard; the ratio of introduced birds to native birds was 16:1. Areas of intact native forest exist, but they are threatened by the spread of introduced plants.

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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 protection of the watershed, impacts of noxious weeds and feral animals, and the protection of native Hawaiian forests (see "Terminology").

This report on the MRI of Oahu 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 Kauai 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 in the Pacific Ocean. The eight main islands have an area of 6,450 square miles. Oahu (fig. 1) is the third largest island with 10 percent of the State's area and 80 percent of the State's population.

Oahu was formed by two shield volcanoes whose eroded remnants now make up the Waianae Mountains and the Koolau Range. The highest point on the island is the 4,025-foot Mount Kaala in the Waianae Mountains. Rainfall ranges from less than 20 to over 250 inches a year and, combined with the diverse topographic features, has produced several forest types from semiarid woodlands to subtropical rain forests.

On their amval over 1,000 years ago, the 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. Although the Polynesians cleared much of the lowland forests for agriculture and dwelling sites, the montane forest was left relatively undisturbed.

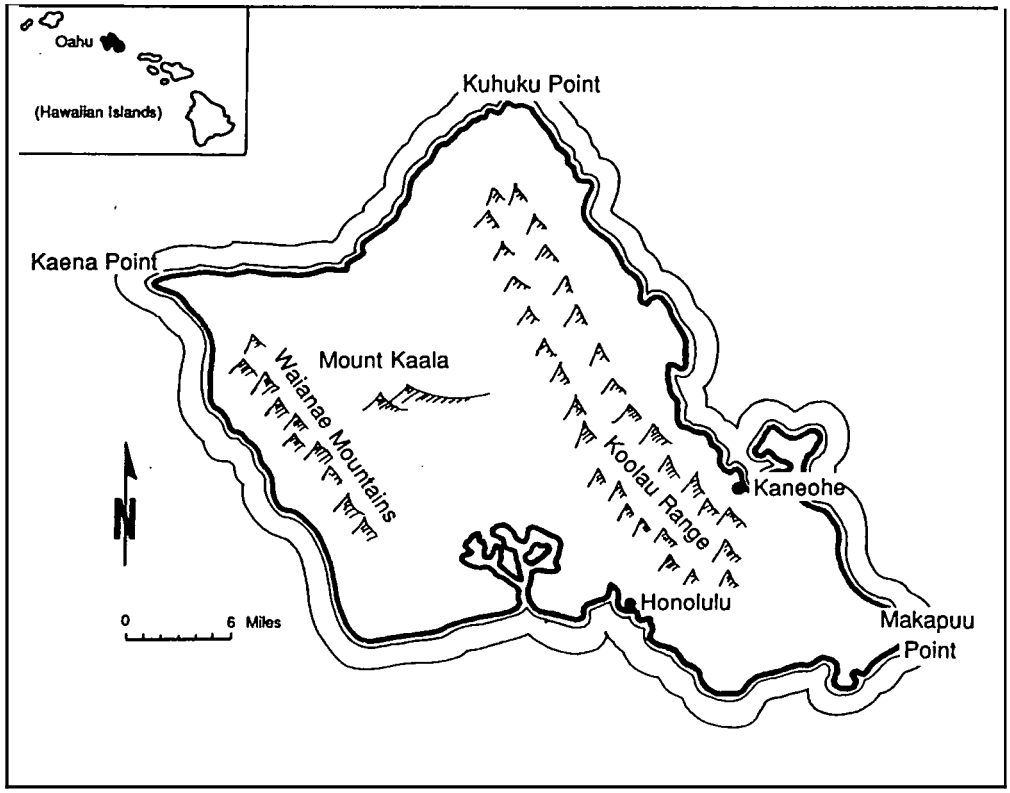

Figure 1—Island of Oahu, Hawaii.

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 harvest of sandalwood (*Santalum* spp.)[1] for its fragrant heartwood; the introduction of 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 accidental—but sometimes intentional-establishment of introduced species. Many of the 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 Hawaii 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 Oahu included establishing forest reserves, fencing to restrict ranch animals, and tree planting. Today, the Hawaii 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.

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

Inventory Procedures

The total area surveyed on Oahu was over 370,000 acres excluding forest plantations and inland bodies of water over 40 acres. Forest plantations were excluded because a previous inventory provided accurate and specific data (Nelson and others 1968). Forest plantation data included here are from the 1966 inventory.

The Oahu MRI design combined information from aerial photographs and field plots in a two-phase sampling procedure. In the first phase, 1,800 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, 133 ground plots were randomly selected in proportion to the area in each land class. All the ground plots were visited in 1986-87 to determine current land class and vegetation type. These ground plots provided a check for the photo interpretation sample, which was statistically adjusted. Field plots were established only for ground plots in the timberland and other forest land classes. The locations of the 37 field plots were carefully referenced for remeasurement in subsequent inventories.

The Oahu field plot consists of a cluster of seven sample points spread out over a 3.5-acre area (fig. 2). 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 impacts 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.

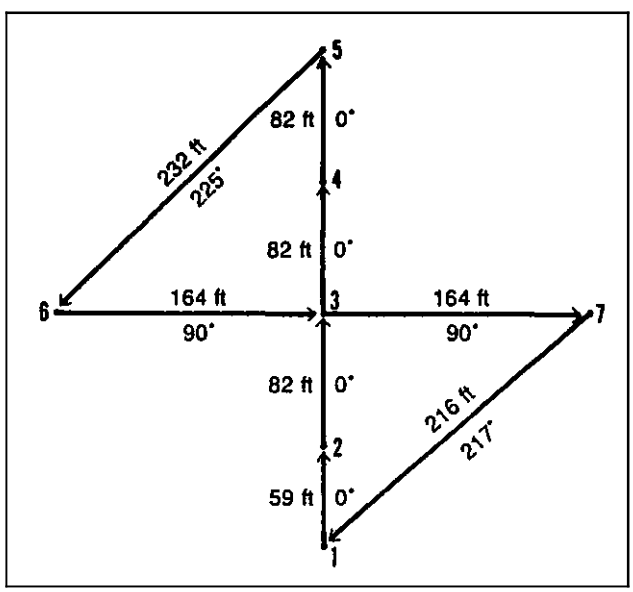

Figure 2—The multiresource seven-point plot.

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 Oahu are presented in tables 1-11 and figures **3, 4** and 7. The following discussion highlights data from these tables and figures. Additional areal and volumetric information is available from the Hawaii Division of Forestry and Wildlife, Honolulu.

Vegetation Types

An estimated 134,300 acres of forest on Oahu occupy 36 percent of the island (fig. 3). Two native tree species, 'ohi'a *(Metrosideros* spp.) and koa *(Acacia **koa),*** are the predominant forest vegetation types, comprising 28 and 21 percent of the forest area, respectively (table 1). An additional 6,900 acres of forest plantations occur on the island; the majority are *Eucalyptus* species (table **2).**

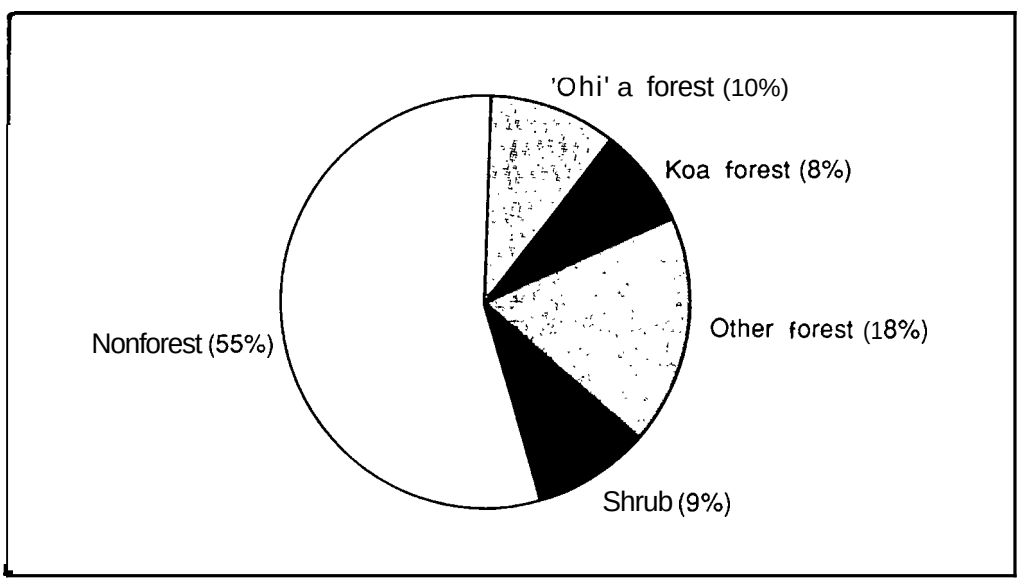

Figure 3—Percentage of the major vegetation classes, Oahu, Hawaii, 1986.

[2] Unpublished 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.

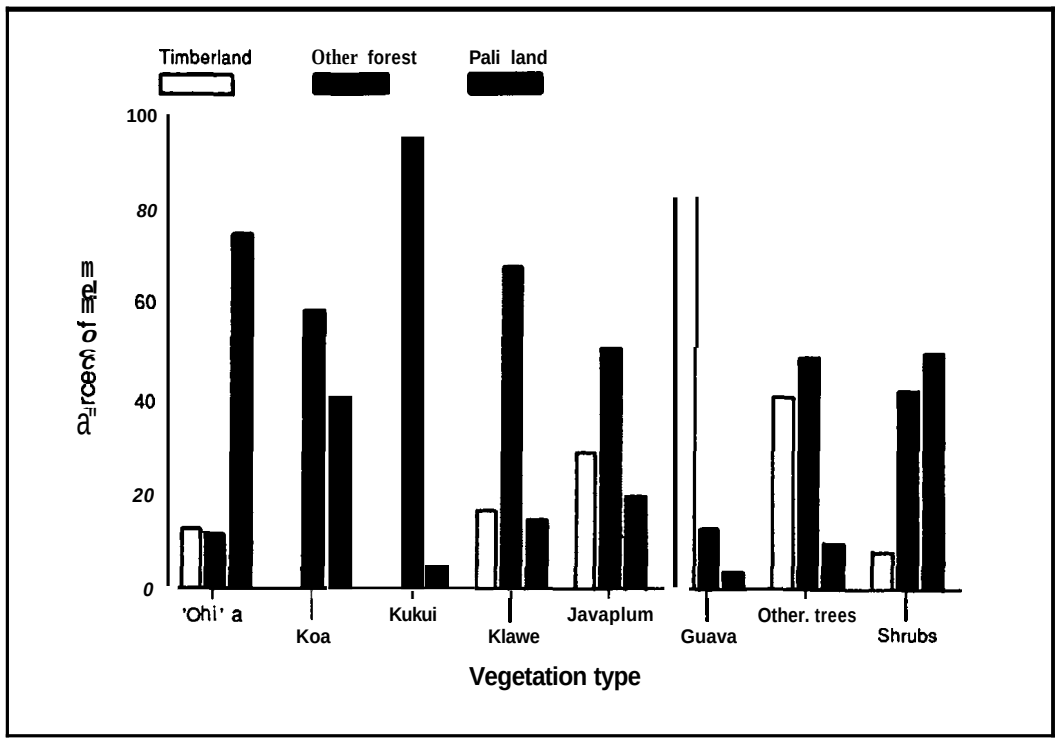

Figure 4—Percentage of the total area of select vegetation types by *land* dass, Oahu, Hawaii, 1986.

Christmas berry *(Schinusterebinthifolius)* comprises over 20,500 of the 33,900 acres of shrubland found on the island of Oahu. Over 201,600 acres are classified as non-forest of which **44** percent is urban and 28 percent is cultivated.

Land Classes

Urban and pali lands are the two largest land classes comprising 23 and **22** percent, respectively, of the area **0n** Oahu (table 3). The two forest land classes comprise 26 percent of the island; they are followed by cultivated land (15 percent) and grass-land **(12** percent).

Timberland, which **is** forest land considered to be the potential land base for producing sustainable forest products, comprises just 7 percent (27,400 acres) of the island. Private corporate and State ownership of Oahu's timberland is 57 and 21 percent, respectively. Less than 1 percent of the koa forests are on timberland (fig. **4)** compared to over 80 percent **of** the guava ***(Psidium*** spp.) forests.

Other forest land is forest land incapable of producing sustainable forest products because of excessive slope *or* unstable soils. Over 70,700 acres of other forest land exist on Oahu. More than one-half of the 28,500 acres of koa forests are in this land class.

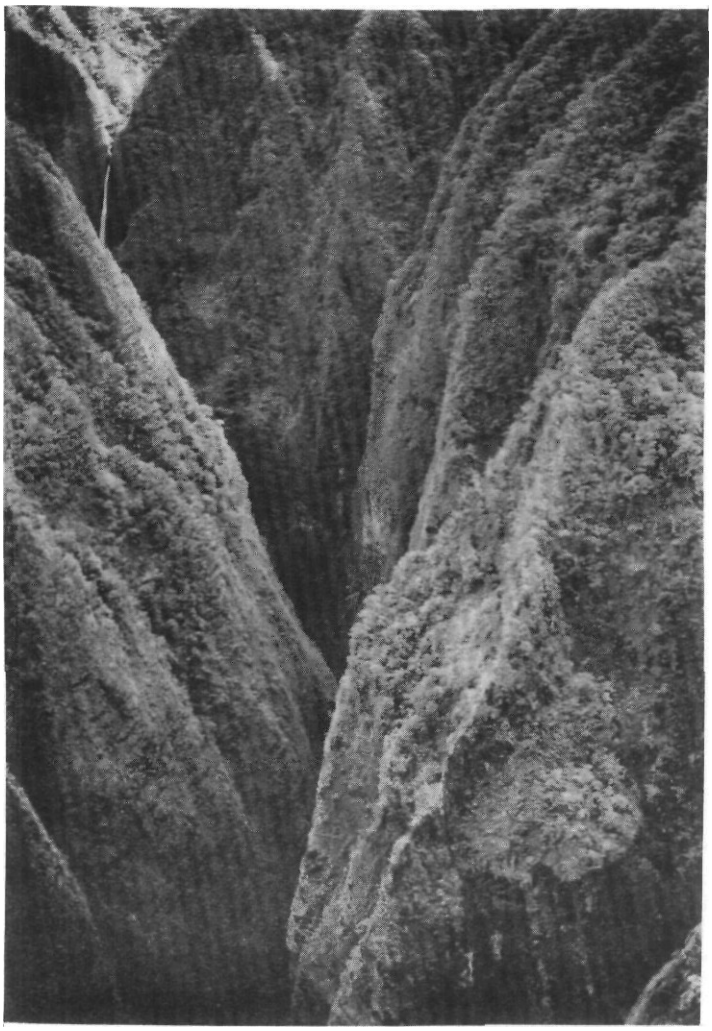

Figure 5—**Vegetative cover on Oahu's steep pali land is essential for watershed protection.**

Pali land is very steep, mountainous land and plays an important role in watershed protection on Oahu (fig 5). Over 75 percent of the 'ohi'a forests are in the pali land class (fig. 6).

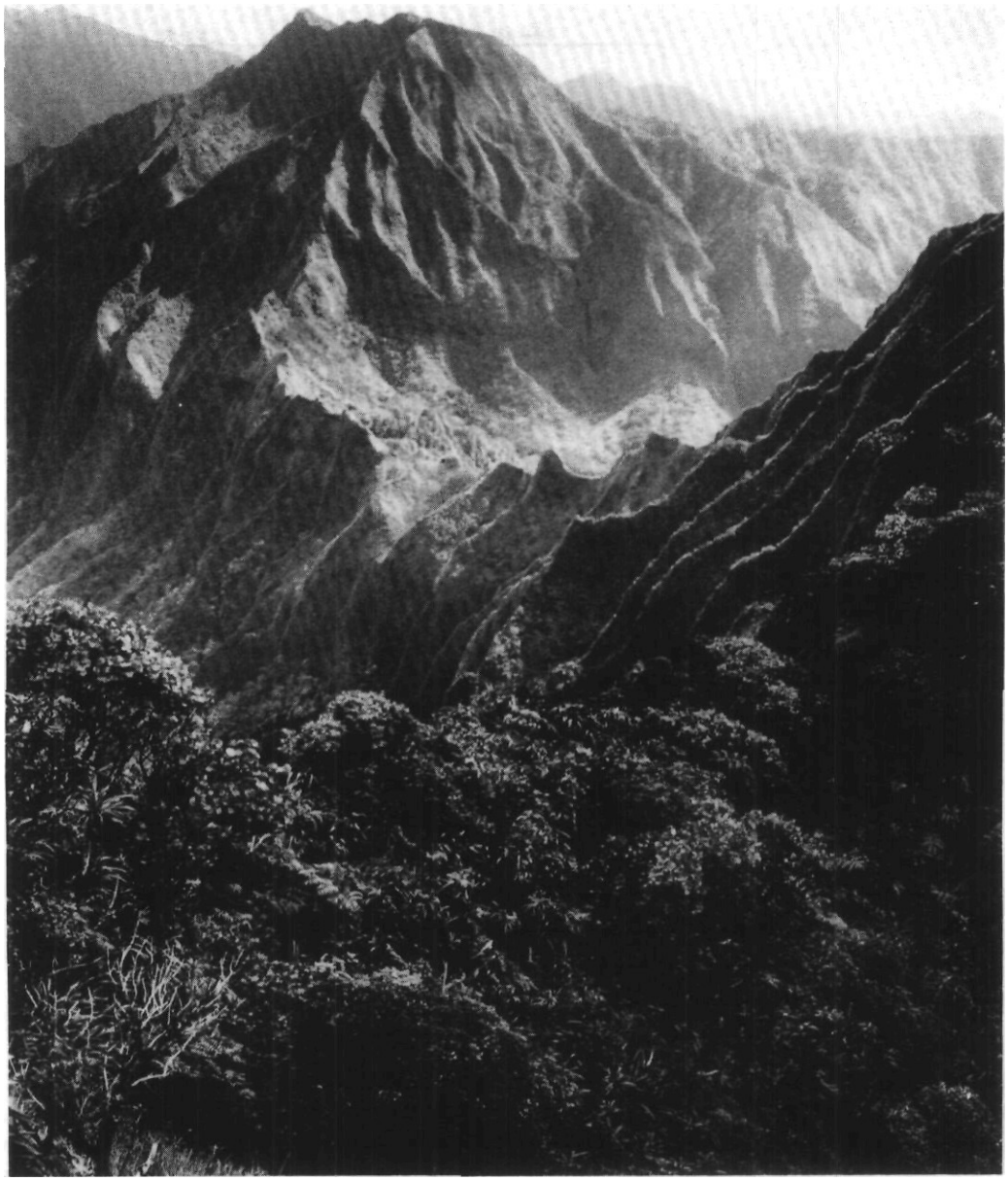

Figure 6—An example of a native forest vegetation type on the steep summit areas, Koolau Range.

Forest Reserves

Oahu has **34,900** acres of forest reserve land (table **4),** which is **9** percent of the island's area; **46** percent of this area is native 'ohi'a and koa forest. An additional 108,700 acres of forests are not in forest reserves and include 76 percent of the 'ohi'a and koa forests on the island. Pali land is **42** percent of the forest reserve acreage (table 5).

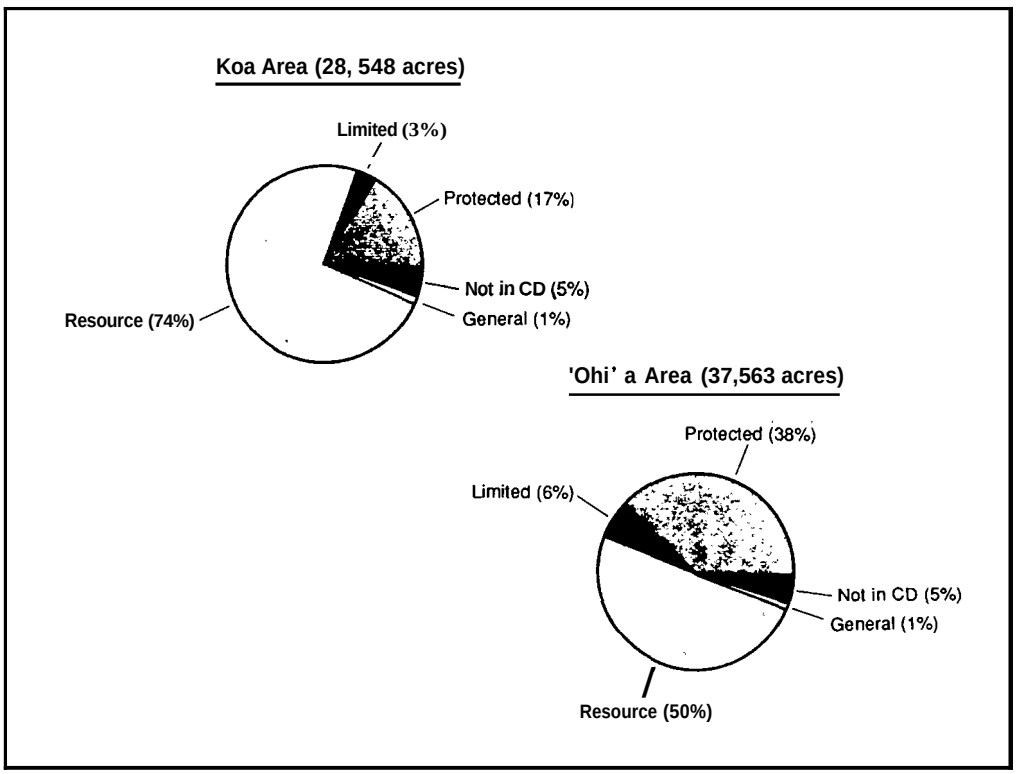

Figure 7—Area of koa and 'ohi'a in conservation district (CD) **subzones, Oahu, Hawaii, 1986.**

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 divided into four subzones: protected, limited, resource, and general. Ninety-four percent of the 'ohi'a and koa forests are in the conservation district zone (fig. **7).** More than one-half of the timberland and **74** percent of the pali land are in the conservation district zone (table **6).**

Volumetrlc Informatlon

Tlmberland–Total tree volume on timberland is estimated at **31** million cubic feet (table 7). Over 50 percent of the timberland volume is Java plum *(Eugenia cumini)* and mango *(Mangifera indica);* **25.9** million cubic feet is in trees of sawtimber size, yet only **23** percent of this volume is of saw-log quality (table ***8).*** Java plum comprises **60** percent of the trees larger than **11** inches in diameter on timberland (table **9).**

Other forest land--Koa comprises **40** percent, 'ohi'a and other native species **17** percent, and kukui ***(Aleurites moluccana)*** **11** percent of the estimated **40** million cubic feet of volume on other forest land (table **10).** Sixty-five percent of the trees in the 5-10.9-inch d.b.h. (diameter at breast height) size class are native (table **11).** Koa comprises **33** percent of those trees larger than **11** inches in diameter (fig. ***8).***

Forest plantations--An estimated **10** million cubic feet of tree volume is in Oahu's forest plantations, **78** percent of which is *Eucalyptus* species (table **2).**

Figure 8—A large koa *tree* in a native forest on other forest land, Koolau Range.

Watershed

Presence or absence of erosion can be measured to reflect the quality of a watershed. Although less than 1 percent of the photographic sample points on Oahu showed signs of erosion, 27 percent of the field plots had evidence of erosion. Most of the erosion in the field plots was slight surface erosion on steep slopes, which could not be detected on aerial photographs. Over one-half of the field plots with slight surface erosion also had evidence of impact by feral pigs or cattle.

Recreation

Fourteen of the 37 field plots sampled had evidence of current recreational use. The predominant uses were hiking, followed by hunting, trail biking, and driving off-road vehicles. Five field plots have good recreation potential, as determined by access, safety factors, and desirability.

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Twenty-two bird species were heard or seen during 41 bird counts (table 12). These bird counts were conducted on the 37 field plots and an additional 4 pali land ground plots with native forest cover. The Japanese white-eye and two species of bulbuls were the most numerous and widely distributed of the 18 introduced bird species; they occurred in 93 and 73 percent of the plots, respectively. Native forest birds seen were the 'apapane, 'amakihi, and the 'elepaio. The 'apapane and Oahu 'amakihi were the most numerous of the native birds seen or heard, which is similiar to findings from intensive forest bird studies done on Hawaii, Maui, Kauai, and Molokai (Scott and others 1986).

Animal impact was recorded on 16 of the 37 field plots. Disturbance from cattle was observed in the low-elevation naturalized forests. The rooting, wallowing, and bedding activities of the feral pig (Sus scrofa) was evident from 900 feet to the summit of the Koolau Range. The small Indian mongoose *(Herpestes* auropunctatus) was observed from sea level to the highest peaks on Oahu in both native and naturalized forest types.

Native Forest Ecosystems

The best preserved native forest ecosystems on Oahu are found in the leeward midslopes of the Koolau Range in koa and koa/'ohi'a forests with an understory dominated by uluhe *(Dicranopteris linearis).* Other common native tree species in these areas include manono *(Gouldia* spp.), kopiko (Psychotria spp.), 'ahakea *(Bobea* spp.), lama *(Diospyros* spp.), and kalia (*Elaeocarpus* spp.) (fig. 9). Small pockets of intact native forest vegetation occur in the Waianae Mountains.

Introduced plants were found on all Oahu field plots. Clidemia *(Clidernia hirta),* a noxious shrub from tropical America, is spreading throughout the Koolau Range.[3] Clidemia was present in all the Koolau field plots in native forests (table 13). Two other noxious plants, strawberry guava *(Psidium cattleianum)* and yellow guava (*Psidium guajava),* were present on over two-thirds of the field plots having a native species overstory.

Vegetation profile data indicated some general trends for introduced plant establishment and growth within native forests. Vegetation profiles with more than 10-percent cover of introduced plants in the ground layer had introduced plants in the upper vegetative layers (fig. 10). Data also showed that the majority of the plots with over 50-percent native plant cover in the low-story layer had few or no introduced plants in the upper story layers and no more than 5-percent introduced plant cover in the ground layer. These data indicate that once a certain threshold level of introduced plants (especially shade-tolerant species such as guava) becomes established within the native forest displacement of native species occurs.

The establishment of introduced plants within native forests accelerates with seed dispersal by introduced birds and animals (Smith 1985). Mongooses, for example, disperse seeds of strawberry guava and other introduced plants (Baldwin and others 1952), and guava is also an important component of the diet of the feral pig.[4] Hikers transport seeds of clidernia, especially from Oahu to other islands.

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[3] Unpublished report, 1977, 'Status of *Clidemia hirta,*" by Victor M. Tanimoto, on file at the Division of Forestry and Wildlife, Honolulu. 3 p.

[4] 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.

Figure 9—Many areas of intact native forest **exist in** the **leeward midslopes of the Koolau Range. Researchers are standing under an 'ekaha or birds nest fern *(Aspleniumnidus).***

The rooting and wallowing of feral pigs accelerate the establishment of introduced plants by disturbing the native understory vegetation. Two-thirds of the native forest field plots had evidence of pig impact. Introduced plant cover averaged 35 percent in the low story in field plots with pig impact compared to 13 percent in plots with no pig impact. Overstory values for introduced plants in plots with pig impact were over 20 percent compared to less than 2 percent for plots with no pig impact. Guava was present in over 80 percent of the pig-impacted field plots. Although clidemia increased in crown area with increasing pig activity, it was also established in plots

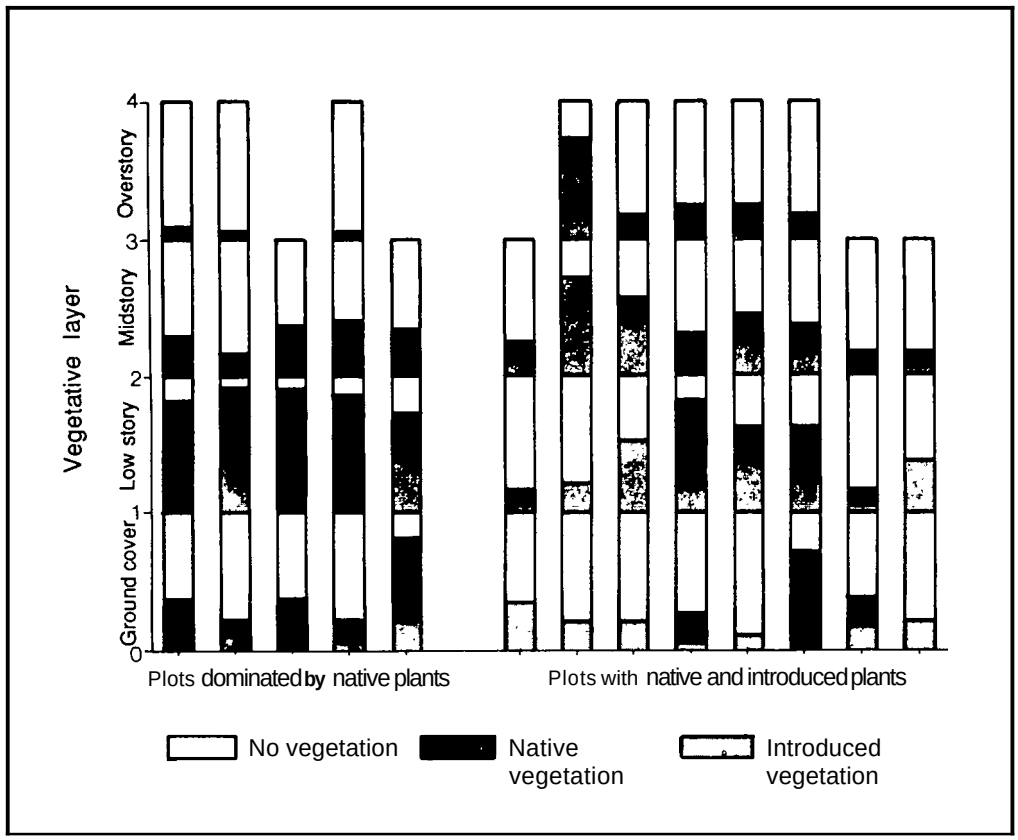

Figure 10—Percentage of plant crown cover in vegetative layers for native forest field plots, Oahu, Hawaii, 1986.

without pig impact, which indicated birds were the probable dispersal agent. Other disturbances found in the native forest included wind damage, impact from military training exercises, and illegal marijuana cultivation.

Discussion

The MRI provides a benchmark for additional studies focusing on trends and potential problems in Hawaii's forests. For example, noxious plants, particularly strawberry guava and clidemia, are a major component in the native forests on Oahu, especially in the Koolau Range (fig. 11). The introduced blackberry *(Rubuspenetrans*), another noxious plant, is well established in the summit areas of the Waianae Mountains. Subsequent inventories will provide data on the rate and extent of spread of these introduced plants.

Slight sheet erosion was observed in guava forests having a closed canopy cover; this resulted in little or no vegetative growth on the forest floor (fig. 12). Similar observations were made where clidemia formed a continuous canopy in the understory. On the other hand, uluhe (or false staghorn fern, which dominates the steeper midslopes of the Koolau Range) forms an extensive root mat and seems effective in limiting erosion on the forest watersheds on Oahu (fig. 13). Future studies of watersheds with these vegetative covers will be useful in determining any negative hydrological repercussions.

Figure 11—A rare endemic *Trematolobelia macrostachys* (rosette plant in center of photo) found in the summit areas, Koolau Range. Clidemia, a noxious introduced plant, is growing directly behind it.

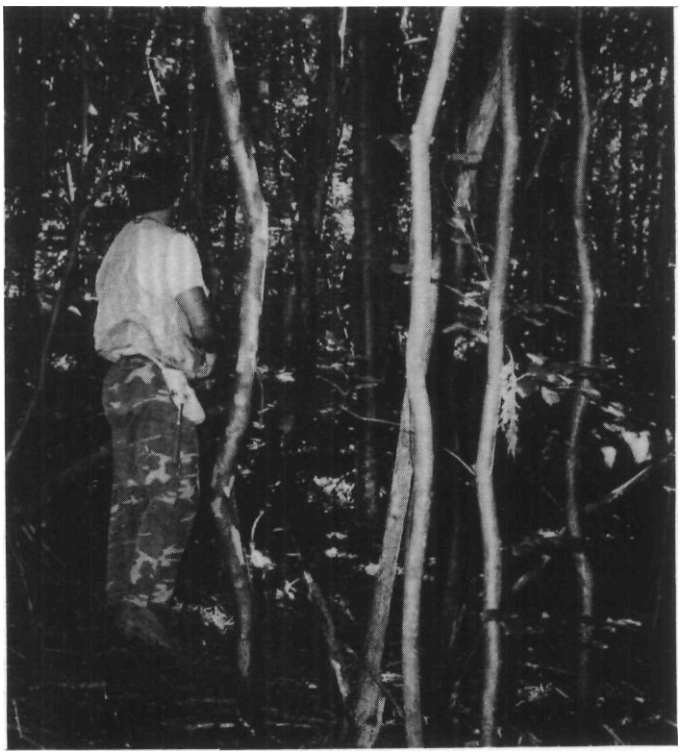

Figure 12—A solid stand of strawberry guava naturalized on abandoned agricultural land. Note the lack of vegetative cover on the forest floor.

Figure 13—Uluhe, or false staghorn fern, is the dominant vegetation in open areas in the steeper midelevation slopes of the Koolau Range and seems to form an effective watershed cover.

Other introduced plants such as ironwood (Casuarina spp.), Christmas berry (*Schinus terebinthifolius*), and Java plum have become naturalized and have formed new forest communities that are now moving through their own successional patterns (fig. 14). Little is known about these naturalized forests, yet they represent an increasingly large portion of Hawaii's forest area. A direction for future research might be analyzing the effects these forest communities have on basic ecosystem functions.

Figure 14—Natural reproduction of introduced Norfolk-Island pine in a mature forest plantation.

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 Oahu MRI was the forests' spectacular beauty. Few places in the world have such diverse and unique forest areas so close to major population areas (fig. 15). It will be a challenge for everyone concerned with forest management in Hawaii to find the proper balance among protection, use, and appreciation for Oahu's forests.

Figure 15—Many homes and parks dose to urban Honolulu are adjacent to and in forested areas.

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 confirmation, and the 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 **3**	
Timber, cubic volume (thousand cubic feet):		
All forest land	**71,058**	**15,704 (22.1** percent)
Timberland	**31,042**	**13,193 (42.5** percent)
Other forest land	**40,016**	**10,204 (25.5** percent)
Number of live trees (thousand trees):		
All forest land	**88,453**	**12,472 (14.1** percent)
Timberland	**26,911**	**7,535** (28.0 percent)
Other forest land	**61,542**	**11,939 (19.4** 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.

Conservatlon dlstrlct lands-Zoned lands whose uses are under 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 proper management.

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

Cultlvated land–Pineapple and sugarcane fields, orchards, nurseries, 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.

Endemlc--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 sfafe.

Forest land--Land at least 10-percent stocked with trees and not currently 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 is occupied by planted trees (introduced species).

Forest Reserve status--Stabowned 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.

Hawalian Homes **Commlssion--**Organization administering land set aside for use by those of Hawaiian ancestry.

Indlgenous--Occurring naturally in a given region but also found in nearby geographic regions (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 having 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 a year); includes forest lands having low productivity for timber but that may be productive for range, watershed, recreation, or wildlife habitat.

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

Poletimber Crees-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 stern 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 miminum 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 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 (1-6 feet), midstory (6-30 feet), and overstory (more than 30 feet).

Tables

Table 1—Area by vegetation type and owner, Oahu, Hawaii, 1986[a]

Vegetation type	Owner						All owners
	State	Federal	County	Hawaiian Homes	Private corporate	Private individual	
	Acres						
Trees:							
'Ohi'a	12,813	1,720	1,322	822	18,699	2,186	37,563
Koa	7,754	1,752	653	--	17,160	1,229	28,548
Kiawe	1,542	3,075	866	672	9,266	1,933	17,354
Java plum	2,136	915	413	148	5,958	1,409	10,978
Guava	2,336	850	598	37	5,326	1,140	10,287
Ironwood	1,131	206	411	--	3,700	719	6,167
Kukui	719	103	--	--	1,542	411	2,775
Other trees[b]	5,677	1,876	1,034	359	9,469	2,271	20,686
Subtotal	34,108	10,497	5,297	2,038	71,120	11,298	134,358
Shrubs:							
Christmas berry	4,394	2,289	1,244	266	10,489	1,867	20,549
Haole koa	2,056	2,293	1,265	395	5,692	1,107	12,808
Other shrubs[c]	--	411	--	--	206	--	617
Subtotal	6,450	4,993	2,509	661	16,387	2,974	33,974
Nonforest:							
Cultivated	1,791	3,815	1,625	333	41,405	6,803	55,773
Grass	6,468	5.753	1,899	1,043	25,156	4,784	45,102
Forbs	3,243	461	608	206	6,459	361	11,338
Urban and other[d]	3,236	24.433	23,009	446	25,710	12,630	89,464
Subtotal	14,738	34,462	27,141	2,028	98,730	24,578	201,677
All types	55,296	49,952	34,947	4,727	186,237	38,850	370,009

– = none found.
[a] Totals may be off because of rounding.
[b] Other species include albizia, bamboo, eucalyptus, Formosa koa, mango, mangrove, octopus tree, hala and paper bark.
[c] Other shrubs include hau and naupaka.
[d] Includes water, dune land, bog, and other areas.

Table 2—Area and volume of forest plantations by owner and species, Oahu, Hawaii, 1966

Species	Owner			Total
	State	Other public	Private	
		Acres		
Eucalyptus spp.	1,171	650	1,794	3,615
Other hardwoods[a]	569	485	2,110	3,164
Conifers[b]	141	4	50	195
Total	1,881	1,139	3,954	6,974
		Thousand cubic feet[c]		
Eucalyptus spp.	3,543	1,211	3,727	8,481
Other hardwoods	497	175	1,222	1,894
Conifers	424	6	113	543
Total	4,464	1,392	5,062	10,918

[a] Other hardwoods include silk-oak, ironwood, paper bark, albizia, and camphor tree.
[b] Conifers include Norfolk-Island pine, sugi, and kauri.
[c] Volume is main stem only to a 4-inch top diameter outside bark.
Source: Nelson and others 1968.

Table 3—Area by land class and owner, Oahu, Hawaii, 1986[a]

Land class	Owner							Sampling error
	State	Federal	County	Hawaiian Homes	Private corporate	Private individual	All owners	
	Acres							*Percent*
Timberland	5,631	2,324	1,072	268	15,640	2,502	27,438	24.8
Other forest land	15,343	6,503	3,094	795	39,275	5,744	70,754	15.6
Pali land	21,984	7,499	3,997	2,100	37,827	7,371	80,778	12.4
Cultivated	2,226	3,501	1,645	211	41,138	6,602	55,323	11.9
Grassland	5,946	5,362	1,589	1,071	26,379	4,568	44,916	17.9
Urban	4,071	23,088	22,093	275	24,760	11,667	85,953	8.8
Other[b]	95	1,675	1,454	7	1,219	396	4,846	100.0
Total	55,296	49,952	34,944	4,727	186,238	38,850	370,008	

[a] Totals may be off because of rounding.
[b] Indudes water, dune land, bog, and other areas.

Table 4—Area by vegetation type and forest reserve status, Oahu, Hawaii, 1986[a]

Vegetation type	Inside forest reserve	Outside forest reserve	Total
		Acres	
Trees:			
'Ohi'a	9,524	28,039	37,563
Koa	6,601	21,947	28,548
Kiawe	241	17,113	17,354
Java plum	1,865	9,113	10,978
Guava	1,412	8,867	10,287
Ironwood	1,336	4,831	6,167
Kukui	617	2,158	2,775
Other trees[b]	3,986	16,699	20,686
Subtotal	25,591	108,767	134,358
Shrubs:			
Christmas berry	2,491	18,058	20,549
Haole koa	474	12,334	12,808
Other shrubs[c]	--	617	617
Subtotal	2,965	31,009	33,974
Nonforest:			
Cultivated	7	55,763	55,770
Grass	3,261	41,842	45,102
Forbs	2,718	8,620	11,338
Urban and other[d]	403	89,056	89,459
Subtotal	6,389	195,281	201,669
Total	34,959	335,042	370,001

– = none found.
[a] Totals may be off because of rounding.
[b] Other trees include albizia, bamboo, eucalyptus, Formosa koa, mango, mangrove, octopus tree, hala, and paper bark.
[c] Other shrubs includes hau and naupaka.
[d] Includes water, dune land, bog, and other areas.

Table 5—Area by land class and forest reserve status, Oahu, Hawaii, 1986[a]

Landclass	Inside forest reserve	Outside forest reserve	Total
		Acres	
Timberland	3,754	23,684	27,438
Other forest land	11,426	59,328	70,754
Pali land	14,688	66,087	80,775
Cultivated	460	54,862	55,322
Grassland	3,387	41,528	44,915
Urban	1,224	84,726	85,950
Other[b]	7	4,838	4,845
Total	34,946	335,053	369,999

[a] Totals may be off because of rounding.
[b] Includes dune land, bog, and other areas.

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

Land class	Conservation district subzone					
	Protected	Limited	Resource	General	Not in CD	Total
			Acres			
Timberland	1,372	1,372	10,152	1,098	13,444	27,438
Other forest land	10,613	3,538	27,594	4,245	24,764	70,754
Pali land	15,348	5,654	33,927	4,846	21,003	80,778

Table 7—Total tree volume on timberland by species and diameter class, Oahu, 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
	Thousand cubic feet				
Native:					
Koa	--	--	1,421	255	1,676
'Ohi'a	938	--	--	--	938
Other trees[a]	728	--	--	--	728
Subtotal	1,666	--	1,421	255	3,342
Naturalized:					
Java plum	1,114	3,543	4,100	--	8,757
Mango	224	--	1,165	6,041	7,430
Monkeypod	--	--	639	2,745	3,384
Albizia	--	--	505	2,712	3,217
Guava	563	456	--	--	1,019
Other trees[b]	1,550	1,160	1,183	--	3,893
Subtotal	3,451	5,159	7,592	11,498	27,700
All species	5,117	5,159	9,013	11,753	31,042

– = none found
[a] Other native trees include sandalwood, hala, lama, and manono.
[b] Other naturalized trees indude camphor tree, Formosa koa, jhalna, and tropical ash.

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

Species	Sawtimber							Total sawtimber	Total poletimber	Total volume
	Rough wood	Saw log	Upper stem	Bolts	Crotch	Branch	Tip			
	Thousand cubic feet									
Native:										
Koa	944	224	109	121	--	274	5	1,677	--	1,677
'Ohi'a	--	--	--	--	--	--	--	--	934	934
Other trees*	--	--	--	--	--	--	--	--	733	733
Subtotal	944	224	109	121	--	274	5	1,677	1,667	3,344
Naturalized:										
Java plum	5,242	617	701	209	--	812	62	7,643	1,115	8,758
Mango	3,059	2,086	404	671	381	584	21	7,207	224	7,430
Monkeypod	1,230	1,280	62	590	110	105	6	3,383	--	3,383
Albizia	718	1,606	57	234	142	455	5	3,217	--	3,217
Guava	236	--	51	--	--	165	4	456	565	1,021
Other trees[b]	1,535	224	282	--	--	281	19	2,341	1,549	3.890
Subtotal	12,020	5,813	1,557	1,704	633	2,402	117	24,247	3,453	27,699
All species	12,964	6,037	1,666	1,825	633	2,676	122	25,924	5,120	31,043

– = none found.
[a] Other native trees include hala, sandalwood, lama, and manono.
[b] Other naturalized trees include camphor tree, Formosa koa, jhalna, and tropical ash.

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

Species	Diameter size class (inches) 1.0-4.9	5.0-10.9	11.0-20.5	20.6 and larger	All species
	Thousand trees or shrubs				
Native:					
'Ohi'a	1,798	156	--	--	1952
Koa	--	--	24	8	32
Other trees[a]	212	182	--	--	394
Subtotal	2,010	338	24	8	2,380
Naturalized:					
Strawberry guava	6,600	32	16	--	6,648
Yellow guava	2,982	42	--	--	3,024
Formosa koa	2,030	--	10	--	2,040
Java plum	762	230	252	34	1,278
Mango	212	192	--	34	438
Albizia	--	--	--	14	14
Monkeypod	--	--	--	12	12
Other trees[b]	1,862	584	76	--	2,522
Subtotal	14,448	1,080	354	94	15,976
Shrubs:					
Christmas berry	1,480	236	--	6	1,722
Ti	1,692	--	--	--	1,692
Haole koa	1,523	--	--	--	1,523
Other shrubs[c]	3,618	--	--	--	3,618
Subtotal	8,313	236	--	6	8,555
All species	24,771	1,654	378	108	26,911

– = none found.
[a] Other native trees include hala, hame, and lama.
[b] Other naturalized trees include brush box, camphor tree, jhalna. octopus tree, rose apple, silk-oak, and tropical ash.
c Other shrubs indude buddleia, clidemia, and hau.

Table 10—Total tree volume on other forest land by species and diameter class, Oahu, 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
	Thousand cubic feet				
Native:					
Koa	3,229	3,785	4,119	5,093	16,226
'Ohi'a	2,011	1,703	1,045	--	4,759
Kukui	470	2,814	1,307	--	4,591
Tree fern	164	--	--	--	164
Other trees[a]	1,456	537	--	--	1,993
Subtotal	7,330	8,839	6,471	5,093	27,733
Naturalized:					
Java plum	701	1,382	281	--	2,364
Guava	1,443	804	--	--	2,247
Mango	--	--	981	422	1,403
Monkeypod	--	937	--	--	937
Other trees[b]	739	2,784	1,015	794	5,332
Subtotal	2,883	5,907	2,277	1,216	12,283
All species	10,213	14,746	8,748	6,309	40,016

– = none found.
[a] Other native trees include 'ahakea, hala, sandalwood, and manono.
[b] Other naturalized trees include ironwood, kiawe, octopus tree, opiuma, and silkoak.

Table 11—Number of trees and shrubs on other forest land by species and diameter class, Oahu, Hawall, 1986

Species	Diameter size class (inches) 1.0-4.9	5.0-10.9	11.0-20.5	20.6 and larger	All classes
	Thousand trees or shrubs				
Native:					
'Ohi'a	3,124	794	160	17	4,095
Koa	2,899	670	282	74	3,925
Kukui	414	52	132	9	607
Tree fern	--	129	--	--	129
Other trees[a]	208	263	21	--	492
Subtotal	6,645	1,908	595	100	9,248
Naturalized:					
Strawberry guava	10,670	--	--	--	10,670
Yellow guava	4,618	292	68	--	4,978
Kiawe	2,485	--	--	8	2,493
Java plum	1,450	376	91	--	1,917
Monkeypod	--	--	38	--	38
Mango	--	--	--	24	24
Other trees'	6,410	332	165	--	6,907
Subtotal	25,633	1,000	362	32	27,027
Shrubs:					
Haole koa	12,010	460	--	--	12,476
Christmas berry	5,198	826	--	--	6,024
Ti	1,864	--	--	--	1,864
Other shrubs[c]	4,902	--	--	--	4,902
Subtotal	23,974	1,292	--	--	25,266
All species	56,252	4,200	958	132	61,542

– = none found.
[a] Other native trees indude 'ahakea, sandalwood, manono, na'ena'e, and hala.
[b] Other naturalized trees indude date palm, eucalyptus, ironwood, octopus tree, opiuma, and silk-oak.
[c] Other shrubs include clidemia, naupaka, and lantana.

Table 12—Number and percentage of relatlve frequency of birds by species and forest type, Oahu, Hawaii, 1986

Bird species	Forest Type (number of plots)								
	'Ohi'a (4)	Koa/ 'Ohi'a (5)	Koa (4)	Java plum (3)	Christmas berry (5)	Kiawe (4)	Haole koa (3)	Other forests' (10)	Total (41)
	Number (percent)								
Native:									
'Amakihi	9 (50)	2 (40)	--	--		--	--	2 (17)	13 (14)
Apapane	14 (100)	6 (40)	--	--	1 (100)	--	--		21 (17)
'Elepaio	2 (25)	1 (20)	--	--	--	--	--	--	3 (5)
Introduced:									
Japanese white-eye	16 (100)	26 (100)	16 (100)	11 (67)	20 (100)	22 (75)	10 100)	48 (90)	178 (93)
Bulbul	8 (100)	9 (100)	4 (60)	8 (67)	5 (60)	42 100)	5 (67)	14 (60)	98 (73)
White-Nmped shama	4 (50)	6 (80)	4 (40)	2 (67)	7 (100)	--	--	10 (60)	33 (54)
Japanese bush-warbler	4 (50)	6 (50)	3 (40)	--	3 (60)	--	--	2 (20)	21 (34)
Common mynah	--	--	--	20 (67)	--	3 (50)	5 (67)	5 (20)	33 (17)
Red-crested cardinal	--	--	--	3 (33)	1 (20)	6 (75)	10 (100)	5 (40)	26 (31)
Northern cardinal	3 (75)	3 (40)	6 (80)	--	10 (80)	6 (75)	6 (67)	7 (40)	43 (56)
House finch	--	--	11 (20)	2 (33)	2 (40)	6 (50)	3 (67)	1 (10)	25 (22)
House sparrow	--	--	15 (60)	--	--	6 (50)	6 (67)	2 (20)	29 (22)
Zebra dove	--	--	1 (20)	4 (33)	--	29 (75)	26 (100)	9 (50)	69 (32)
Spotted dove	1 (25)	--	2 (20)	8 (100)	3 (60)	4 (50)	6 (67)	9 (40)	32 (30)
Other bird species[b]	2 (25)	--	--	3 (33)	2 (40)	1 (25)	1 (33)	6 (30)	15 (22)

– = none found.
[a] Other forest types include eucalyptus, Formosa koa, lo'ulu palm, ironwood. albizia. camphor, hala, mango, wiliwili, and guava.
[b] Other bird species include melodious laughing thrush, northern mockingbird, nutmeg mannikin, yellow-faced grassquit, cattle egret, black-crowned night heron, common peafowl, and Erckel's francolin.

Table 13—introduced plant occurrence and feral pig Impact in native forest field plots, Kooiau Range, Oahu, Hawaii, 1986

Vegetation type	Elevation	Pig impact	Volume points			
			Total introduced plant cover in vegetative layers			
			Overstory		Lowstory	
			Percent	Dominant species	Percent	Dominant species
	Feet					
Koa	1,312	Slight	30	Clidemia, guava	50	Clidemia, lantana
Koa	459	Slight	25	Guava	30	Clidemia, lantana
Koa/'ohi'a	1,411	None	0	--	5	Clidemia, lantana
Koa/'ohi'a	1,214	None	0	--	25	Clidemia
Koa/'ohi'a	1,017	None	5	Guava	10	Clidemia, lantana
Koa/'ohi'a	886	Slight	20	Guava	20	Clidemia, lantana
'Ohi'a	1,805	Moderate	20	Guava	35	Clidemia, guava
'Ohi'a	755	Slight	15	Guava, clidemia	25	Lantana, clidemia

Names of Plants'

Origin	Common name	Scientific name
Trees		
Endemic	'Ahakea	*Bobea* spp. Gaud.
Introduced	Albizia	*Albizia falcataria* (L.) Fosb.
Introduced	Bamboo	*Bambusa* spp. Schreb.
Introduced	Brush box	*Tristania conferta* R. Br. in Ait. f.
Introduced	Camphor tree	*Cinnamomum zeylanicum* Bl.
Introduced	Christmas berry	*Schinus Icrebinini Solius* Raddi
Introduced	Date palm	*Phoenix dactylifera* L.
Introduced	Eucalyptus	*Eucalyptus* spp. L'Her.
Introduced	Formosa koa	*Acacia confusa* Merr.
Introduced	Guava	*Psidium* spp. L.
Introduced	Guava, strawberry	*Psidium cattleianum* Sabine
Introduced	Guava, yellow	*Psidium guajava* L.
Indigenous	Hala	*Pandanus* spp. Stickm.
Endemic	Hame	*Antidesma platyphyllum* Mann
Introduced	Haole koa	*Leucaena leucocephala* (Lam.) de Wit
Introduced	Ironwood	*Casuarina* spp. Adans.
Introduced	Java plum	*Eugenia wmini* (L.) Druce
Introduced	Jhalna	*Terminalia myriocarpa* Heurck & Meull.-Arg.
Endemic	Kalia	*Elaeocatpus bifidus* H. & A.
Introduced	Kauri	*Agathis* spp. Salisb.

See *footnote* *on* *following page.*

Introduced	Kiawe	*Prosopis pallida* (Humb. & Bonpl. ex Willd.) HBK.
Endemic	Koa	*Acacia koa* Gray
Endemic	Kopiko	*Psychotria* spp. L.
Polynesian introduction	Kukui	*Aleurites moluccana* (L.) Willd.
Endemic	Lama	*Diospyros* spp. L.
Endemic	**Lo'ulu** palm	*Prifchardia* spp. Seem. & H. Wendl.
Introduced	Mango	*Mangifera* indica L.
Indigenous	Mangrove	*Rhizophora* spp. (L.)
Endemic	Manono	*Gouldia* spp. Gray
Introduced	Monkeypod	*Samanea saman* (Jacq.) Merr.
Introduced	Norfolk-Island pine	*Araucaria heterophylla* (Salisb.) Franco
Introduced	Octopus tree	*Brassaia actinophylla* Endl.
Endemic	'Ohi'a	*Metrosideros* spp. Banks ex Gaertn.
Introduced	'Opiuma	*Pithecellobium dulce* (Roxb.) Benth.
Introduced	Paper bark	*Melaleuca leucadendra* (Stickm.) L.
Introduced	Rose apple	*Eugenia jambos* L.
Endemic	Sandalwood	*Sanfalum* spp. L.
Introduced	Silk-oak	*Grevillea robusta* A. Cunn. in R. Br.
Introduced	Sugi	*Cryptomeriajaponica* (L. f.) D. Don
Introduced	Tropical ash	*Fraxinus uhdei* (Wenzig) Lingelsh.
Endemic	Wiliwili	*Erythrina sandwicensis* Deg.

[5] The source for flowering plant names is St. John (1973); for ferns, the sources are Becker (1976) and Neal (1965).

Shrubs

Introduced	Buddleja	*Buddleja asiatica* Lour.
Introduced	Blackberry	*Rubus penetrens* Bailey
Introduced	Christmas berry	*Schinus terebinthifolius* Raddi
Introduced	Clidemia	*Clidemia hirta* (L.) D. Don
Indigenous	Hau	*Hibiscus tiliaceus* L.
Introduced	Lantana	*Lantana camara* L.
Endemic	Na'ena'e	*Dubautia* spp. Gaud.
Endemic	Naupaka	*Scaevola* spp. L.
Polynesian introduction	Ti	*Cordyline terminalis* (L.) Kunth
Endemic	Trematalobelia	*Tremafolobeliamacrosfachys* (H. & A.) Zahlbr.

Ferns

Endemic	'Ekaha	*Asplenium nidus* L.
Endemic	Tree fern	*Cibotium glaucum* (J. Sm.) Hook. and Arnott
Indigenous	Uluhe	*Dicranopteris linearis* (Burm.) Underw.

Names of Animals'

Common name	Scientific name
Introduced *Birds*	
Bulbul, red-whiskered	*Pycnonotus jocosus* (Linnaeus)
Bulbul, red-vented	*Pycnonotus cafer* (Linnaeus)
Cattle egret	*Bubulcus ibis* (Linnaeus)
Common myna	*Acridotheres tristis* (Linnaeus)
Common peafowl	*Pavo cristatus* (Linnaeus)
Erckel's francolin	*Franwlinus erckelii* (Rüppell)
House finch	*Carpodacus mexicanus* (Müller)
House sparrow	*Passer domesficus* (Linnaeus)
Japanese bush-warbler	*Cettia diphone* (Kittlitz)
Japanese white-eye	*Zosterops japonicus* Temminck and Schlegel
Melodious laughing-thrush	*Garrulax canorus* (Linnaeus)
Northern cardinal	*Cardinalis cardinalis* (Linnaeus)
Northern mockingbird	*Mimus polyglottos* (Linnaeus)
Nutmeg mannikin	*Lonchura punctulata* (Linnaeus)
Red-crested cardinal	*Paroaria coronata* (Miller)
Spotted dove	*Streptopelia chinensis* (Scopoli)
White-rumped shama	*Copsychus malabaricus* (Scopoli)
Yellow-faced grassquit	*Tiaris olivacea* (Linnaeus)
Zebra dove	*Geopelia striata* (Linnaeus)

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

Native Birds

'Apapane	*Himatione sanguinea* (Gmelin)
'Amakihi	*Hemignathus virens* (Gmelin)
'Elepaio	*Chasiempis sandwichensis* (Gmelin)
Black-crowned night heron	*Nycticorax nycticorax* (Linnaeus)

Mammals

Feral pig	***Sus*** *scrofa* (Linnaeus)
Small Indian mongoose	*Herpestes auropunctatus* (Linnaeus)

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Metric Equivalents

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

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

Keywords: Muttiresource inventory, forest survey, statistics (forests), native forests, introduced plants, Oahu, Hawaii.

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