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Technical Report 68

**Vegetation Maps of the Upland Plant
Communities on the Islands of Hawai'i,
Maui, Moloka'i, and Lana'i**

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June 1989

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Abstract

A set of vegetation maps describing the upland plant communities on four of the major Hawaiian Islands was prepared as part of a survey conducted by the U.S. Fish and Wildlife Service in 1976 - 1981 to determine the current status of native forest birds and their associated habitats. During this project, 68 map sheets were produced at the scale of 1:24,000, overlaying U.S. Geological Survey topographic quad maps for selected portions of the islands of Hawai'i, Lana'i, Maui, and Moloka'i. Map units were differentiated on the basis of tree canopy cover, tree height, and dominant species composition of the tree and understory vegetation layers. A hierarchical classification system was developed that allows for presentation and discussion of the vegetation units at three levels of detail.

Copies of the 1:24,000-scale map sheets for all areas mapped during this project are currently available for distribution on request. Efforts are now being directed toward the production of an additional set of map sheets displaying the major vegetation units on the islands of Hawai'i and Maui at the scale of 1:100,000.

Introduction

Vegetation maps are useful in providing a regional habitat framework for ecological investigations of individual species or biological communities. The degree of detail expressed in a vegetation map is a function of the mapping objective (i.e., what com-

ponents are to be displayed) and the scale at which it is prepared (Table 1). A small-scale map is limited to units that are fairly generalized and may include considerable variation. A large-scale map, on the other hand, can display units that are quite detailed and relatively homogeneous.

Review of Some of the Previous Vegetation Maps for Hawai'i

Numerous maps have previously been prepared depicting various aspects of the Hawaiian vegetation. Some of these maps show general vegetation units for all of the Islands, while others are limited to smaller areas, usually mapped in greater detail. The most frequently cited vegetation map has been Ripperton and Hosaka's (1942) "Vegetation Zones of Hawai'i." This map fits into the intermediate-scale range of maps with all of the Islands except Hawai'i mapped at 1:500,000. The island of Hawai'i was mapped at the scale of 1:1.5 million. Ripperton and Hosaka's map provides a good, but very generalized overview of potential vegetation zones for all of the major Islands, based on a combination of existing vegetation, climatic patterns, and topography.

Two other intermediate-scale maps were prepared by Knapp (1965) and Lamoureux (1973). Knapp's map delineates major vegetation zones, primarily based on moisture and temperature regimes. Lamoureux's map is very similar to Ripperton and Hosaka's (1942) map, also displaying generalized vegetation zones for all of the Islands.

In the mid 1960's, the U.S. Forest Service and the Hawai'i State Division of Forestry produced the

Table 1. Summary of the types of vegetation information that can be displayed on maps at various scales. (Adapted from Mueller-Dombois and Ellenberg 1974.)

Map Scale	Scale Range	Information Which Can be Displayed	Minimum Unit Size (Approximately)
Small Scale	1:1 million	Generalized potential vegetation	> 2,500 ha
Intermediate	1:1 million to 1:100,000	Regional maps, potential vegetation	2,500 - 25 ha
Large	1:100,000 to 1:10,000	Generalized actual plant associations	25 - 0.25 ha
Very Large	1:10,000 to 1:100	Detailed plant associations, individual trees 2500	2,500 m ² - 1 m ²
Chart Maps	1:100	Foliage cover for individual shrubs and herbaceous plants	< 1 m ²

"Hawai'i Forest Type Maps" at the scale of 1:62,500, based on aerial photographs taken between 1950 and 1954 (Nelson 1967). These maps were prepared for all forested areas on all the major Hawaiian Islands, except National Park lands. The Forest Type map units provide information on 1) land use class, 2) forest type (i.e., tree species composition), 3) density of tree cover, and 4) tree stand size class in terms of sawtimber classes. Despite the greater level of mapping detail at this large scale, the Hawai'i Forest Type maps were prepared at the reconnaissance level, with only a limited amount of unit verification in the field.

Several other detailed vegetation maps have been prepared for smaller areas on many of the Islands. A map by Mueller-Dombois and Fosberg (1974) displays vegetation types within and adjacent to Hawai'i Volcanoes National Park on the island of Hawai'i. This map, at the scale of 1:52,000, presents both a detailed and accurate description of the dominant trees and understory plant associations in the Park. Whiteaker (1983) prepared a similar map of the plant communities in Haleakala National Park on Maui. Other recent vegetation maps of relatively small areas include those by Smathers (1967), Harrison (1972), Higashino and Mizuno (1976), Jacobi (1978), and McEldowney (1983).

Initiation of a New Vegetation Mapping Program

In 1976 the U.S. Fish and Wildlife Service (USFWS) began an extensive field survey to determine the current distribution, abundance, and status of the native forest birds and their habitats on all of the major Hawaiian Islands except 'Oahu (Scott, Jacobi, and Ramsey 1981; Scott et al. 1986). Because of the lack of recent, detailed vegetation maps covering the USFWS study areas, a new mapping program was initiated as a component of the Hawai'i Forest Bird Survey (HFBS). The maps serve as the habitat basis for analyzing the bird and plant species information collected during the HFBS.

The new vegetation map series was also set up to provide a habitat base for another research program, the 'Ohi'a Forest Study, directed by Dr. D. Mueller-Dombois of the Department of Botany at the University of Hawai'i. This second project investigated the dynamics of the native rain forests on the windward side of the island of Hawai'i, and focused on deter-

mining the causes and results of a recent, widespread dieback of the dominant tree species, 'ohi'a (*Metrosideros polymorpha*), in that area (Petteys, Burgan, and Nelson 1975; Mueller-Dombois 1980; Jacobi 1983; Jacobi, Gerrish, and Mueller-Dombois 1983).

Methods

The HFBS vegetation map series was designed to overlay U.S. Geological Survey (USGS) topographic quadrangle maps at the scale of 1:24,000 (Figs. 1 and 2). The basic patterns of the vegetation were initially mapped on black and white aerial photographs taken by the USGS in 1976 - 1977 at the approximate scale of 1:40,000. This primary mapping step was accomplished using a Leitz MS-27 mirror stereoscope with 3X and 6X magnification. The boundaries delineated on the aerial photographs were then compiled into preliminary composite overlays on 1:24,000-scale orthophoto quad sheets using a Kern PG-2 stereoplotter. This optical plotter allowed for a very accurate transfer of the lines mapped on the aerial photographs to the base maps. Through a process of iterative scaling and parallax correction of control points on the photo model, we were able to consistently compile lines onto the topographic base maps to within 0.5 mm of their plotted location. This degree of accuracy during the compilation step virtually eliminated line plotting errors in the mapping procedure. Any errors detected in the map unit boundaries can be traced directly back to the original delineation of the vegetation patterns on the aerial photographs.

One of the most important steps in the preparation of vegetation maps at this large scale is verification of the mapped units in the field. In conjunction with the HFBS, all mapped areas were field-checked along a series of transects established through each study area. On the island of Hawai'i, transects were spaced 3.2 km (2 mi) apart and oriented perpendicular to elevational contours (Fig. 3). Transects were located approximately 1.6 km (1 mi) apart in most of the other study areas. Sampling points, called stations, were established at 134-m (440-ft) intervals along each transect. Various types of data were recorded at these stations, including bird population counts and detailed information on the structure and composition of the vegetation. Information was also

recorded on the phenology of certain tree and shrub species, and on the presence and impacts of large feral mammals (principally pigs, goats, sheep, axis deer, and cattle) (Scott, Jacobi, and Ramsey 1981). The locations of selected stations were noted on aerial photographs carried in the field. We were also able to plot the starting and ending points of each transect, and could usually identify where prominent landmark features, such as roads, streams, or ridges, were crossed.

During the HFBS, over 4,200 km² were surveyed using 9,600 stations located along 1,300 km of transect. In addition, through the 'Ohi'a Forest Study, more detailed data on the plant communities were collected on sixty-two 20 X 20 m relevés (sample plots) established throughout the windward 'ohi'a forests on the island of Hawai'i (Fig. 4).

Our field surveys were augmented by aerial reconnaissance of each study area to more closely examine questionable vegetation patterns identified on the aerial photos, and to check areas between transects that were not adequately surveyed in our sampling grid. For example, nearly 10 hours were spent in a fixed-wing aircraft, and 15 hours in a helicopter, to conduct the aerial reconnaissance for the island of Hawai'i. The helicopter was particularly useful for obtaining close-up views and photographs of the vegetation from tree-top level.

The field and aerial survey data were then combined with the vegetation patterns identified on the aerial photographs to update the initially compiled map boundaries, and to complete the final labeling of the map units. The last step in the mapping process was to determine the area of each mapped vegetation unit using a Numonics 1200 planimeter.

Discussion of the HFBS Vegetation Classification System

The vegetation types identified during the HFBS were generally based on Mueller-Dombois and Fosberg's (1974) classification system for Hawai'i Volcanoes National Park. However, because the HFBS dealt with a larger and much more variable area, we expanded their system to allow more

flexibility and consistency in defining the map units for our study areas.

The HFBS vegetation classification includes three hierarchical levels: Level 3 - Reconstructed Map Units, Level 2 - General Map Units, and Level 1 - Detailed Map Units. Level 3 is the most general mapping level, representing an interpretation of the natural vegetation units in a particular area as they might now occur without human-related changes. The greatest amount of detail was mapped at Level 1. Each hierarchical level allows for a different perspective with regard to actual or potential vegetation units in the different study areas. A subsequent paper will discuss this classification in detail.

The most intensive mapping was conducted on the island of Hawai'i where all study areas were mapped at Level 1. The maps for the other islands were prepared at the more general Level 2 (Table 2).

Table 2 Summary of the 1:24,000-scale vegetation maps that were prepared for the islands of Hawai'i, Maui, Moloka'i, and Lana'i.

Island	# of Map Sheets	Area Mapped (ha)	% of Island	# of Level 2 Units	# of Level 1 Units
Hawai'i	49	495,454	47%	81	371
Maui	12	48,586	26%	31	---
Moloka'i	3	13,058	19%	18	---
Lana'i	3	1,961	5%	7	---

Description of the Level 1 Vegetation Type Symbols

Six different types of information were available to be coded in the Level 1 vegetation type symbols for the areas mapped on the island of Hawai'i: 1) tree canopy cover, 2) tree canopy height, 3) dominant tree species composition, 4) species association type, 5) dominant understory species composition, and 6) other information pertinent to the map unit (Appendix 1). Each map symbol was coded in a consistent format: information referring to the tree component was always listed first; species association type and understory composition were given next, enclosed in parentheses and separated by a colon; and finally, a symbol element for other information relating to the unit may have been coded after the parentheses. For tree-

less vegetation types, the symbol elements pertaining to tree crown cover, height, and species composition were omitted.

1) **Tree Canopy Cover.** Tree cover was defined as the vertical projection of a tree's foliage outline on the ground, expressed as a percentage of a reference area. This definition assumed a relatively homogenous distribution of the leaves within the canopy and did not take into account either crown thickness or foliage layering.

Four tree canopy cover classes were recognized: closed or open canopy, and scattered or very scattered trees. The definition of closed canopy used (60% cover) coincides with Mueller-Dombois and Fosberg's (1974) closed forest unit. This cover class can easily be determined in the field or on aerial photographs when most of the tree crowns are interlocking. The cover range for an open tree canopy was 25 - 60%, generally corresponding to the traditional definition of a woodland (Mueller-Dombois and Ellenberg 1974). For tree cover < 25%, two cover classes were recognized: scattered trees (5 - 25% cover) and very scattered trees (< 5% cover). This latter class was established because of the importance of even very reduced tree cover to certain bird populations.

2) **Tree Canopy Height.** Tree height was divided into three classes: scrub trees (2 - 5 m tall), low trees (5 - 10 m), and tall trees (10 m).

3) **Tree Species Composition.** Species name abbreviations for all trees composing 25% of the total crown cover were listed next in the map symbol. If a species did not attain this minimum cover value it was combined with other tree species and listed using a tree species association symbol ("xt" or "nt", referring to "introduced trees" and "native trees", respectively). Introduced tree species were always grouped together and indicated by the "xt" symbol, regardless of their canopy cover.

For most symbols, more than one tree species or association element was coded, separated by either a dash, comma, or slash. A dash indicates codominance. A comma means that the species or association coded first was dominant. The slash denotes combinations of elements in a mosaic pattern too small to separate at the mapping scale. For symbols with more than one tree element, a canopy

height symbol was coded for each element only if they were in different tree layers.

4) **Species Association Type** was used to indicate the species composition for any coded native tree or understory plant association component (Appendix 2). For example, the native tree association symbol (nt) in a dry habitat (D:) is composed of one group of species, whereas in a moist (M:) or wet habitat (W:), other groups of species predominate.

5) **Understory Species Composition** was generally coded using only species association symbols. If more than one symbol element was listed for the understory, they were separated by either a dash or a comma to again show dominance or codominance. The bare ground symbol (xx) indicates that at least 25% of the ground was not covered by vascular plants.

6) **Other Information.** Elements in this last category were used to provide additional information on certain vegetation units. This information may further define the characteristics of that unit, such as when the element "pio" was used to indicate pioneer or early seral vegetation, or may provide additional information on the condition of the unit: "sng" = numerous dead or dying trees present, "bur" = recently burned, "clr" = recently cleared, and "fum" = recently defoliated by volcanic fume.

Discussion of the Level 2 Vegetation Type Symbols

The more general Level 2 map unit symbols were based on tree and understory species composition and on relatively wide ranges of tree crown cover. Symbol components include the species association type designations (D:, M:, or W:) and species name abbreviations or association codes, following the same dominance or codominance conventions used for the Level 3 symbols. As with the Level 3 symbols, information relating to the understory is enclosed in parentheses. Tree canopy cover was divided into three categories: 1) closed or open forest (> 25% tree cover), 2) scattered trees (< 25% cover), or 3) treeless. The symbol format of Level 2 units differs from Level 3 by the species association type listed first, followed by the codes relating to either the tree component or the understory component, depending on the tree cover (Appendix 3). The tree species or association abbreviations were listed in front of the

understory codes if the tree cover was greater than 25%. Conversely, map units with scattered trees (i.e., < 25% cover) have the tree components listed after the parentheses.

Availability of Vegetation Maps Prepared During the HFBS

Blue-line copies of the 1:24,000-scale vegetation map sheets for all areas mapped during the HFBS are currently available for general use. Efforts are now being directed toward the preparation of an additional set of map sheets displaying Level 2 units for the islands of Hawai'i and Maui at the scale of 1:100,000. These smaller-scale maps will allow for a better regional overview of the distribution of the major vegetation types in Hawai'i than is possible with the 1:24,000-scale maps.

Requests for copies of the 1:24,000-scale maps, or for information on the status of the 1:100,000-scale maps, should be addressed to:

U.S. Fish and Wildlife Service
Hawaii Research Station
P.O. Box 44
Hawai'i National Park,
Hawai'i 96718
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U.S. Fish and Wildlife Service
Office of Environmental Services
P.O. Box 50167
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Acknowledgments

The successful completion of the HFBS vegetation mapping project was mainly due to the excellent cooperation and assistance provided by many different individuals and agencies. I particularly thank the following people for their valuable help and support during various stages of this project.

The development of the mapping strategy was aided by many useful suggestions from J.M. Scott, F.R. Warshauer, and C. van Riper III (members of the HFBS); D. Mueller-Dombois, K.W. Bridges, C.W. Smith, and L. Stemmermann (Dept. of Botany, Univ. Hawai'i); E. Petteys and M. Buck (State of Hawai'i, Division of Forestry and Wildlife). I also appreciated the many helpful comments on the manuscript provided by L. Cuddihy, P. Higashino, C. Robbins, J.M. Scott, and J. Williams.

Field-checking of the map units was accomplished with the help of F.R. Warshauer, H. McEldowney, R. Schuster, L. Stemmermann, P. Higashino, C. Crivellone, G. Gerrish, R. Cooray, D. Mueller-Dombois, A. Holt, and N. Balakrishnan. Compilation and drafting of the preliminary map sheets was completed by C. Crivellone, H. McEldowney, P. Higashino, S. Doyle, J. Williams, and P. Ashman of the U.S. Fish and Wildlife Service. E. Wingert and his staff at the Dept. of Geography, Univ. Hawai'i, photographically compiled the vegetation map overlays and topographic base maps onto single sheets for easier duplication.

I also thank the staff at the Hawai'i Volcano Observatory (U.S. Geological Survey) for the use of their equipment (particularly the Kern PG-2) and aerial photographs. Additional equipment and photographs were made available for this project by the State of Hawai'i, Division of Forestry and Wildlife.

Finally, I thank the numerous landowners throughout the State for allowing the HFBS access onto their lands to survey the plant and bird communities.

Primary financial support for this project was provided by the U.S. Fish and Wildlife Service (Patuxent Wildlife Research Center and Pacific Islands Office). Additional support for the mapping program were made available to the 'Ohi'a Forest Study (D. Mueller-Dombois, Dept. of Botany, Univ. Hawai'i) through grants from the National Park Service (Contract CX8000 6 0006) and the National Science Foundation (Grant DEB-7910993).

APPENDIX 1.

Elements that may be coded for the Level 1 Vegetation Type Symbols.

Example:

1 2 3 4 5 6
 \ | / | / /
 o3Me,2nt (W:tf,ns)sng

1. Tree Canopy Crown Cover

- c = Closed canopy, most crowns interlocking; >60% cover
- o = Open canopy, some or no interlocking crowns; >25-60% cover
- s = Scattered trees; 5-25% cover
- vs = Very scattered trees; <5% cover

2. Tree Canopy Height

- 1 = Low scrub trees, monopodial; 2-5 m tall
- 2 = Scrub trees, moderate stature > 5-10 m tall
- 3 = Tall stature trees; > 10 m tall

3. Tree Species Composition

A) Species Name or Association Abbreviations

- Ac = *Acacia koa* (koa)
- Al = *Aleurites moluccana* (kukui)
- Ch = *Cheirodendron trigynum* (olapa)
- Di = *Diospyros ferrea* (lama)
- Ep = *Euphorbia sp.* ('akoko)
- Me = *Metrosideros polymorpha* ('ohi'a)
- Mr = *Myrica faya* (fayatree)
- My = *Myoporum sandwicense* (naio)
- nt = Native trees
- Psc = *Psidium cattleianum* (strawberry guava, waiawi)
- Sa = *Sapindus saponaria* (mane, soapberry)
- So = *Sophora chrysophylla* (mamane)
- xt = Introduced trees

B) Species Dominance

Species Composition*	Relative Dominance:
A	Only A present
A-B	A and B codominant
A,B	A dominant, B subdominant
A/B	Mosaic with either A or B present
A,B-C	A dominant, B and C subdominant
A-B,C	A and B codominant, C subdominant
A-B-C	A,B,C codominant

*Substitute the appropriate species name or association abbreviation for the letters A, B, or C.

4. Species Association Type

- D = Dry habitat species
- M = Mesic (moist) habitat species
- W = Wet habitat species

Note: See Appendix 2 for a description of typical species composition for the various tree and understory association types in different habitats.

5. Understory Species Composition

A) Species Name or Association Abbreviation (Note: species name abbreviations for trees may also be used if the understory is dominated by individuals of that species, less than 2 m tall).

- bg = Structured bog
- mf = Matted ferns: *Dicranopteris* spp., *Hicriopteris* sp., *Sticherus* sp.
- mg = Mixed native-introduced grasses, sedges, or rushes
- ng = Native grasses
- ns = Native shrubs
- Pm = *Passiflora mollissima* (banana poka - introduced)
- Sp = *Sphagnum* sp.
- tf = Native treeferns, *Cibotium* spp. (hapu'u)
- xg = Introduced grasses, sedges, or rushes
- xh = Introduced herbaceous species
- xs = Introduced shrubs
- xx = Bare ground (at least 25% of the area without vegetation)

B) Species Dominance (use same format as for tree species)

6. Other Information

- bur = Recently burned
- clr = Recently cleared or logged
- fum = Volcanic fume defoliation
- msc = Miscellaneous unit - mix of native and introduced species in low elevation areas
- pio = Pioneer vegetation, seral stage on recent lava flow
- sng = Many standing dead or defoliated trees

APPENDIX 2.

Typical species composition of the various association groups coded in the map unit symbols for different habitat types. [Nomenclature for flowering plants follows St. John (1973); common names are from Porter (1972) and St. John (1973).]

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
bg - Structured bog				
Wet habitat [W:bg]				
N	<i>Carex alligata</i>	--		CYPERACEAE
N	<i>Carex spp.</i>	---		CYPERACEAE
N	<i>Oreobolus furcatus</i>	---		CYPERACEAE
N	<i>Rhynchospora spp.</i>		pu'uko'a	CYPERACEAE
N	<i>Deschampsia australis</i>	H	---	GRAMINEAE
N	<i>Panicum hillebrandianum</i>		Hillebrand's panicgrass	GRAMINEAE
X	<i>Juncus spp.</i>		rush	JUNCACEAE
N	<i>Vaccinium spp.</i>		'ohelo	ERICACEAE
N	<i>Metrosideros polymorpha</i>		'ohi'a, 'ohi'a-lehua	MYRTACEAE
N	<i>Viola maviensis</i>		---	VIOLACEAE
mf - Matted ferns				
Wet habitat [W:mf]				
N	<i>Dicranopteris spp.</i>		uluhe	GLEICHENIACEAE
N	<i>Hicriopteris pinnata</i>		uluhe-lau-nui	GLEICHENIACEAE
N	<i>Sticherus owhyhensis</i>		---	GLEICHENIACEAE
Mesic habitat [M:mf]				
N	<i>Dicranopteris spp.</i>		uluhe	GLEICHENIACEAE
mg - Mixed-native-introduced grasses, sedges, or rushes				
Wet habitat [W:mg]				
N	<i>Carex alligata</i>		---	CYPERACEAE
X	<i>Cyperus spp.</i>		---	CYPERACEAE
N	<i>Machaerina angustifolia</i>		'uki	CYPERACEAE
N	<i>Uncinia uncinata</i>		---	CYPERACEAE
X	<i>Andropogon virginicus</i>		broomsedge	GRAMINEAE
N	<i>Deschampsia australis</i>	H	---	GRAMINEAE
X	<i>Holcus lanatus</i>		velvetgrass	GRAMINEAE
N	<i>Sachne distichophylla</i>		ohe	GRAMINEAE
X	<i>Paspalum conjugatum</i>		Hilograss	GRAMINEAE
X	<i>Juncus spp.</i>		rush	JUNCACEAE
Mesic habitat [M:mg]				
N	<i>Machaerina angustifolia</i>		'uki	CYPERACEAE
N	<i>Uncinia uncinata</i>		---	CYPERACEAE
X	<i>Anthoxanthum odoratum</i>		sweet vernal	GRAMINEAE
N	<i>Deschampsia australis</i>	H	---	GRAMINEAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
Mesic habitat [M:mg] (Cont'd)				
X	<i>Holcus lanatus</i>		velvetgrass	GRAMINEAE
N	<i>Isachne distichophylla</i>		ohe	GRAMINEAE
X	<i>Microlaena stipoides</i>		meadow ricegrass	GRAMINEAE
X	<i>Pennisetum clandestinum</i>		kikuyugrass	GRAMINEAE
Dry habitat [D:mg]				
N	<i>Carex macloviana</i>		---	CYPERACEAE
N	<i>Carex wahuensis</i>	H	---	CYPERACEAE
N	<i>Machaerina gahniaeformis</i>		'uki	CYPERACEAE
N	<i>Deschampsia australis</i>	H	---	GRAMINEAE
N	<i>Eragrostis spp.</i>		lovegrass	GRAMINEAE
N	<i>Panicum spp.</i>		panicgrass	GRAMINEAE
X	<i>Paspalum dilatatum</i>		---	GRAMINEAE
X	<i>Pennisetum clandestinum</i>		kikuyugrass	GRAMINEAE
X	<i>Pennisetum setaceum</i>		fountaingrass	GRAMINEAE
X	<i>Poa spp.</i>		bluegrass	GRAMINEAE
X	<i>Setaria geniculata</i>	L	foxtail grass	GRAMINEAE
N	<i>Trisetum glomeratum</i>	H	he'u-pueo	GRAMINEAE
N	<i>Luzula hawaiiensis</i>	H	---	JUNCACEAE

ng Native grasses

Dry habitat [D:ng]

N	<i>Carex wahuensis</i>	H	---	CYPERACEAE
N	<i>Machaerina gahniaeformis</i>		'uki	CYPERACEAE
N	<i>Agrostis sandwicensis</i>	H	Hawaiian bentgrass	GRAMINEAE
N	<i>Deschampsia australis</i>	H	---	GRAMINEAE
N	<i>Eragrostis spp.</i>		lovegrass	GRAMINEAE
N	<i>Panicum spp.</i>		panicgrass	GRAMINEAE
N	<i>Trisetum glomeratum</i>	H	he'u-pueo	GRAMINEAE
N	<i>Luzula hawaiiensis</i>	H	---	JUNCACEAE

ns Native shrubs

Wet habitat [W:ns]

N	<i>Athyrium microphyllum</i>		'akolea	ASPIDIACEAE
N	<i>Athyrium sandwichianum</i>		ho'i'o	ASPIDIACEAE
N	<i>Dryopteris parallelogramma</i>		lau-kahi	ASPIDIACEAE
N	<i>Sadleria spp.</i>		'ama'u, 'ama'uma'u	BLECHNACEAE
N	<i>Lycopodium cernuum</i>		wawae-iole	LYCOPODIACEAE
N	<i>Astelia spp.</i>		pa'iniu	LILIACEAE
N	<i>Smilax sandwicensis</i>		hoikuahiwi	LILIACEAE
N	<i>Freycinetia arborea</i>	L	'ie'ie	PANDANACEAE
N	<i>Alyxia olivaeformis</i>		maile	APOCYNACEAE
N	<i>Vaccinium calycinum</i>		'ohelo-kau-la'au	ERICACEAE
N	<i>Cyrtandra spp.</i>		ha'i wale	GESNERACEAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
ns Native shrubs (Cont'd)				
Wet habitat [W:ns]				
N	<i>Phyllostegia</i> spp		kapana	LABIATAE
N	<i>Stenogyne</i> spp.		ma'ohi'ohi	LABIATAE
N	<i>Clermontia</i> spp.		'oha-wai, 'oha	LOBELIACEAE
N	<i>Cyanea</i> spp.		haha	LOBELIACEAE
N	<i>Trematolobelia</i> spp.		koli'i	LOBELIACEAE
N	<i>Labordia</i> spp.		kamakahala	LOGANIACEAE
N	<i>Peperomia</i> spp.		'ala'ala-wai-nui kane	PIPERACEAE
N	<i>Rubus hawaiiensis</i>	H	'akala	ROSACEAE
N	<i>Nertera granadensis</i>		makole	RUBIACEAE
N	<i>Broussaisia arguta</i>		kanawao, pu'aha-nui	SAXIFRAGACEAE
N	<i>Pipturus</i> spp.		mamaki	URTICACEAE
N	<i>Touchardia latifolia</i>	L	olona	URTICACEAE
Mesic habitat [M:ns]				
N	<i>Athyrium sandwichianum</i>		ho'i'o	ASPIDIACEAE
N	<i>Dryopteris parallelogramma</i>		lau-kahi	ASPIDIACEAE
N	<i>Sadleria</i> spp.		'ama'u, 'ama'uma'u	BLECHNACEAE
N	<i>Microlepia strigosa</i>		palapalai	DENNSTAEDTIACEAE
N	<i>Lycopodium cernuum</i>		wawae-iole	LYCOPODIACEAE
N	<i>Alyxia olivaeformis</i>		maile	APOCYNACEAE
N	<i>Vaccinium calycinum</i>		'ohelo-kau-la'au	ERICACEAE
N	<i>Phyllostegia</i> spp.		kapana	LABIATAE
N	<i>Stenogyne</i> spp.		ma'ohi'ohi	LABIATAE
N	<i>Clermontia</i> spp.		'oha-wai, 'oha	LOBELIACEAE
N	<i>Cocculus</i> spp.	L	huehue	MENISPERMACEAE
N	<i>Peperomia</i> spp.		'ala'ala-wai-nui kane	PIPERACEAE
N	<i>Rubus hawaiiensis</i>	H	'akala	ROSACEAE
N	<i>Gouldia terminalis</i>		manono	RUBIACEAE
N	<i>Hedyotis</i> spp.		pilo	RUBIACEAE
N	<i>Wikstroemia</i> spp.	L	'akia	THYMELIACEAE
N	<i>Pipturus</i> spp.		mamaki	URTICACEAE
N	<i>Touchardia latifolia</i>	L	olona	URTICACEAE
Dry habitat [D:ns]				
N	<i>Sadleria cyatheoides</i>		'ama'u	BLECHNACEAE
N	<i>Pteridium aquilinum</i>		kilau	DENNSTAEDTIACEAE
N	<i>Chenopodium oahuense</i>		'aheahea, 'aweoweo	CHENOPODIACEAE
N	<i>Dubautia</i> spp.		kupaoa	COMPOSITAE
N	<i>Styphelia tameiameia</i>		pukiawe	EPACRIDACEAE
N	<i>Vaccinium peleanum</i>	H	'ohelo	ERICACEAE
N	<i>Vaccinium reticulatum</i>		'ohelo	ERICACEAE
N	<i>Geranium</i> spp.	H	hinahina	GERANIACEAE
N	<i>Stenogyne</i> spp.		ma'ohi'ohi	LABIATAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
Dry habitat [D:ns] (Cont'd)				
N	<i>Cocculus spp.</i>	L	huehue	MENISPERMACEAE
N	<i>Myoporum sandwicense</i>		naio	MYOPORACEAE
N	<i>Sida spp.</i>		'ilima	MYRTACEAE
N	<i>Argemone glauca</i>		pua-kala	PAPAVERACEAE
N	<i>Osteomeles anthyllidifolia</i>		'ulei	ROSACEAE
N	<i>Coprosmaea nodeoides</i>		kukae-nene	RUBIACEAE
N	<i>Coprosma montana</i>	H	pilo	RUBIACEAE
N	<i>Morinda trimera</i>	L	noni	RUBIACEAE
N	<i>Dodonaea spp.</i>		a'ali'i	SAPINDACEAE
N	<i>Waltheria americana</i>	L	hi'aloa	STERCULIACEAE
N	<i>Wikstroemia spp.</i>		'akia	THYMELAEACEAE

nt Native trees

Wet habitat [W:nt]

N	<i>Pritchardia spp.</i>		lo'ulu, hawane	PALMAE
N	<i>Rhus sandwicensis</i>	L	neneleau	ANACARDIACEAE
N	<i>Ilex anomala</i>		kawa'u	AQUIFOLIACEAE
N	<i>Cheirodendron trigynum</i>		olapa, olapalapa	ARALIACEAE
N	<i>Tetraplasandra meiandra</i>		'ohe	ARALIACEAE
N	<i>Perrottetia sandwicensis</i>	L	olomea	CELASTRACEAE
N	<i>Antidesma platyphyllum</i>	L	hame	EUPHORBIACEAE
N	<i>Myrsine lessertiana</i>		kolea-lau-nui	MYRSINACEAE
N	<i>Myrsine sandwicensis</i>		kolea-lau-li'i	MYRSINACEAE
N	<i>Metrosideros polymorpha</i>		'ohi'a, 'ohia-lehua	MYRTACEAE
N	<i>Pittosporum spp.</i>		ho'awa	PITTOSPORACEAE
N	<i>Bobea spp.</i>		'ahakea	RUBIACEAE
N	<i>Coprosma spp.</i>		pilo	RUBIACEAE
N	<i>Gouldia hillebrandii</i>	L	manono	RUBIACEAE
N	<i>Gouldia terminalis</i>		manono	RUBIACEAE
N	<i>Psychotria spp.</i>		kopiko	RUBIACEAE
N	<i>Pelea clusiaefolia</i>		alani	RUTACEAE
N	<i>Urera spp.</i>		opuhe	URTICACEAE

Mesic habitat [M:nt]

N	<i>Charpentiera spp.</i>		papala	AMARANTHACEAE
N	<i>Rhus sandwicensis</i>	L	neneleau	ANACARDIACEAE
N	<i>Ilex anomala</i>		kawa'u	AQUIFOLIACEAE
N	<i>Perrottetia sandwicensis</i>	L	olomea	CELASTRACEAE
N	<i>Diospyros ferrea</i>	L	lama	EBENACEAE
N	<i>Antidesma platyphylla</i>	L	hame	EUPHORBIACEAE
N	<i>Xylosma hawaiiense</i>	L	maua	FLACOURTIACEAE
N	<i>Pseudomorus sandwicensis</i>	L	a'ia'i	MORACEAE
N	<i>Myrsine lessertiana</i>		kolea-lau-nui	MYRSINACEAE
N	<i>Myrsine sandwicensis</i>		kolea-lau-li'i	MYRSINACEAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
Mesic habitat [M:nt](Cont'd)				
N	<i>Eugenia sandwicensis</i>	L	'ohi'a-ha	MYRTACEAE
N	<i>Metrosideros polymorpha</i>		'ohi'a, 'ohi'a-lehua	MYRTACEAE
N	<i>Pisonia spp.</i>	L	papala-kepau	NYCTAGINACEA
N	<i>Osmanthus sandwicensis</i>	L	olupua	OLEACEAE
N	<i>Pittosporum spp.</i>		ho'awa	PITTOSPORACEAE
N	<i>Bobea spp.</i>		'ahakea	RUBIACEAE
N	<i>Coprosma spp.</i>		pilo	RUBIACEAE
N	<i>Gouldia hillebrandii</i>	L	manono	RUBIACEAE
N	<i>Gouldia terminalis</i>		manono	RUBIACEAE
Dry habitat [D:nt]				
N	<i>Pleomele spp.</i>	L	halapepe	LILIACEAE
N	<i>Rauvolfia spp.</i>	L	hao	APOCYNACEAE
N	<i>Reynoldsia sandwicensis</i>	L	'ohe, 'ohe'ohe, makai	ARALIACEAE
N	<i>Diospyros ferrea</i>	L	lama	EBENACEAE
N	<i>Xylosma hawaiiense</i>	L	maua	FLACOURTIACEAE
N	<i>Erythrina sandwicensis</i>	L	wiliwili	LEGUMINOSAE
N	<i>Mezoneuron kawaiiense</i>	L	uhiuhi	LEGUMINOSAE
N	<i>Sophora chrysophylla</i>		mamane	LEGUMINOSAE
N	<i>Myoporum sandwicense</i>		naio	MYOPORACEAE
N	<i>Myrsine lanaiensis</i>		kolea	MYRSINACEAE
N	<i>Metrosideros polymorpha</i>		'ohi'a, 'ohi'a-lehua	MYRTACEAE
N	<i>Osmanthus sandwicensis</i>	L	olupua	OLEACEAE
N	<i>Alphitonia ponderosa</i>	L	kauwila, kauila	RHAMNACEAE
N	<i>Colubrina oppositifolia</i>	L	kauwila, kauila	RHAMNACEAE
N	<i>Canthium odoratum</i>	L	lahe'e	RUBIACEAE
N	<i>Santalum spp.</i>		'ilihi	SANTALACEAE
N	<i>Planchonella spp.</i>	L	'ala'a	SAPOTACEAE

tf - Native treeferns

Wet habitat [W:tf]

N	<i>Cibotium chamissoi</i>		haup'u 'i'i	DICKSONIACEAE
N	<i>Cibotium glaucum</i>		hapu'u	DICKSONIACEAE

xg-Introduced grasses, sedges, or rushes

Wet habitat [W:xg]

X	<i>Cyperus spp.</i>		---	CYPERACEAE
X	<i>Andropogon virginicus</i>		broomsedge	GRAMINEAE
X	<i>Holcus lanatus</i>		velvetgrass	GRAMINEAE
X	<i>Microlaena stipoides</i>		meadow ricegrass	GRAMINEAE
X	<i>Paspalum conjugatum</i>		Hilograss	GRAMINEAE
X	<i>Sacciolepis indica</i>		Glenwoodgrass	GRAMINEAE
X	<i>Setaria palmaefolia</i>	L	palmgrass	GRAMINEAE
X	<i>Juncus spp.</i>		rush	JUNCACEAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
Mesic habitat [M:yg]				
X	<i>Cyperus spp.</i>		---	CYPERACEAE
X	<i>Andropogon virginicus</i>		broomsedge	GRAMINEAE
X	<i>Anthoxanthum odoratum</i>		sweet vernal	GRAMINEAE
X	<i>Axonopus affinis</i>		carpetgrass	GRAMINEAE
X	<i>Dactylis glomerata</i>		orchardgrass	GRAMINEAE
X	<i>Holcus lanatus</i>		velvetgrass	GRAMINEAE
X	<i>Microlaena stipoides</i>		meadow ricegrass	GRAMINEAE
X	<i>Paspalum spp.</i>		---	GRAMINEAE
X	<i>Pennisetum clandestinum</i>		kikuyugrass	GRAMINEAE
Dry habitat [D:yg]				
X	<i>Bulbostylis capillaris</i>		---	CYPERACEAE
X	<i>Andropogon glomeratus</i>		bush bentgrass	GRAMINEAE
X	<i>Andropogon virginicus</i>		broomsedge	GRAMINEAE
X	<i>Anthoxanthum odoratum</i>		sweet vernal	GRAMINEAE
X	<i>Axonopus affinis</i>		carpetgrass	GRAMINEAE
X	<i>Bromus spp.</i>		---	GRAMINEAE
X	<i>Danthonia sp.</i>	H	---	GRAMINEAE
X	<i>Festuca spp.</i>		fescue	GRAMINEAE
X	<i>Holcus lanatus</i>		velvetgrass	GRAMINEAE
X	<i>Hyparrhenia rufa</i>	L	thatchinggrass	GRAMINEAE
X	<i>Melinis minutiflora</i>		molassesgrass	GRAMINEAE
X	<i>Paspalum dilatatum</i>		--	GRAMINEAE
X	<i>Pennisetum clandestinum</i>		kikuyugrass	GRAMINEAE
X	<i>Pennisetum setaceum</i>		fountaingrass	GRAMINEAE
X	<i>Poa spp.</i>		bluegrass	GRAMINEAE
X	<i>Rhynchelytrum repens</i>		Natal redtop	GRAMINEAE
X	<i>Setaria geniculata</i>	L	foxtail grass	GRAMINEAE

xh-Introduced herbaceous species

Dry habitat [D:xh]

X	<i>Erigeron spp.</i>		fleabane, hairyhorseweed	COMPOSITAE
X	<i>Heterotheca grandiflora</i>		telegraph plant	COMPOSITAE
X	<i>Hypochoeris radicata</i>		gosmore	COMPOSITAE
X	<i>Rumex acetosella</i>		sheep sorrel	POLYGONACEAE
X	<i>Verbascum sp.</i>	H	mullein	SCROPHULARIACEAE

xs-Introduced shrubs

Wet habitat [W:xs]

X	<i>Nephrolepis multiflora</i>	L	kupukupu, pamoho	NEPHROLEPIDACEAE
X	<i>Arundina bambusaefolia</i>	L	bamboo orchid	ORCHIDACEAE
X	<i>Hedychium spp.</i>		ginger	ZINGIBERACEAE
X	<i>Ageratina riparia</i>		pa-makane	COMPOSITAE
X	<i>Eupatorium adenophorum</i>		Maui pa-makani	COMPOSITAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
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xs-Introduced shrubs(Cont'd)

Wet habitat [W:xs]

X	<i>Melastoma malabathricum</i>	L	Malabar melastome	MELASTOMATACEAE
X	<i>Psidium cattleianum</i>		strawberry guava	MYRTACEAE
X	<i>Epilobium spp.</i>		---	ONAGRACEAE
X	<i>Rubus penetrans</i>		Florida blackberry	ROSACEAE
X	<i>Rubu rosaefolius</i>		thimbleberry	ROSACEAE

Mesic habitat [M:xs]

X	<i>Nephrolepis multiflora</i>	L	kupukupu, pamoho	NEPHROLEPIDACEAE
X	<i>Hedychium spp.</i>		ginger	ZINGIBERACEAE
X	<i>Schinus terebinthifolius</i>	L	Christmas berry	ANACARDIACEAE
X	<i>Eupatorium adenophorum</i>		Mau'i pa-makani	COMPOSITAE
X	<i>Pluchea odorata</i>		fleabane	COMPOSITAE
X	<i>Ricinus communis</i>	L	castor bean	EUPHORBIACEAE
X	<i>Buddleja asiatica</i>		Asiatic butterfly bush	LOGANIACEAE
X	<i>Lythrum maritimum</i>		pukamole	LYTHRACEAE
X	<i>Melastoma malabathricum</i>	L	Malabar melastome	MELASTOMATACEAE
X	<i>Tibouchina urvilleana</i>		lasiandra	MELASTOMATACEAE
X	<i>Psidium cattleianum</i>		strawberry guava	MYRTACEAE
X	<i>Psidium guajava</i>	L	guava	MYRTACEAE
X	<i>Rubus penetrans</i>		Florida blackberry	ROSACEAE
X	<i>Rubus rosaefolius</i>		thimbleberry	ROSACEAE
X	<i>Stachytarpheta spp.</i>	L	vervain	VERBENACEAE

Dry habitat [D:xs]

X	<i>Schinus terebinthifolius</i>	L	Christmas berry	ANACARDIACEAE
X	<i>Opuntia megacantha</i>		prickly pear pa-nini	CACTACEAE
X	<i>Pluchea odorata</i>		fleabane	COMPOSITAE
X	<i>Verbesina encelioides</i>		golden crown-beard	COMPOSITAE
X	<i>Ricinus communis</i>	L	castor bean	EUPHORBIACEAE
X	<i>Cassia leschenaultiana</i>	L	partridge pea	LEGUMINOSAE
X	<i>Indigofera suffruticosa</i>	L	indigo	LEGUMINOSAE
X	<i>Buddleja asiatica</i>		Asiatic butterfly bush	LOGANIACEAE
X	<i>Lythrum maritimum</i>		pukamole	LYTHRACEAE
X	<i>Psidium guajava</i>	L	guava	MYRTACEAE
X	<i>Lantana camara</i>	L	lantana	VERBENACEAE
X	<i>Stachytarpheta spp.</i>	L	vervain	VERBENACEAE
X	<i>Verbena litoralis</i>		verbena	VERBENACEAE

xt-Introduced trees

Wet habitat [W:xt]

X	<i>Araucaria heterophylla</i>		Norfolk Island pine	ARAUCARIACEAE
X	<i>Pinus spp.</i>		pine	PINACEAE
X	<i>Cryptomeria japonica</i>		tsugi	TAXODIACEAE

OR ¹	TAXON	ELEV ²	COMMON NAME	FAMILY
xt-Introduced trees(Cont'd)				
Wet habitat [W:xt]				
X	<i>Toona ciliata</i>		toon	MELIACEAE
X	<i>Eucalyptus spp.</i>		---	MYRTACEAE
X	<i>Melaleuca leucadendra</i>		paperbark	MYRTACEAE
X	<i>Psidium cattleianum</i>		strawberry guava	MYRTACEAE
Mesic habitat [M:xt]				
X	<i>Araucaria heterophylla</i>		Norfolk Island pine	ARAUCARIACEAE
X	<i>Pinus spp.</i>		pine	PINACEAE
X	<i>Cryptomeria japonica</i>		sugi	TAXODIACEAE
X	<i>Mangifera indica</i>	L	mango	ANACARDIACEAE
X	<i>Cassia bicapsularis</i>	L	---	LEGUMINOSAE
X	<i>Toona ciliata</i>		toon	MELIACEAE
X	<i>Eucalyptus spp.</i>		---	MYRTACEAE
X	<i>Eugenia jambos</i>	L	rose apple	MYRTACEAE
X	<i>Melaleuca leucadendra</i>		paperbark	MYRTACEAE
X	<i>Psidium cattleianum</i>		strawberry guava	MYRTACEAE
X	<i>Psidium guajava</i>	L	guava	MYRTACEAE
X	<i>Grevillea robusta</i>	L	silk oak	PROTEACEAE
Dry habitat [D:xt]				
X	<i>Schinus terebinthifolius</i>	L	Christmas berry	ANACARDIACEAE
X	<i>Leucaena leucocephala</i>	L	koa-haole, ekoa	LEGUMINOSAE
X	<i>Eucalyptus spp.</i>		---	MYRTACEAE
X	<i>Psidium guajava</i>	L	guava	MYRTACEAE
X	<i>Grevillea robusta</i>	L	silkoak	PROTEACEAE

¹OR (Origin):
N = Native species;
X = Introduced species

²ELEV (Elevation)
H = Generally found above 200 m elevation
L = Generally found below 1200 m elevation

APPENDIX 3.

List of the Level 2 Map Units for the areas mapped during the HFBS.

MAP/UNIT SYMBOL	DESCRIPTION OF VEGETATION	ISLANDS ¹
D:(mg)My-So	Dry mixed grassland with scattered mamane and naio trees	HI
D:(mg,ns)Ac-nt	Dry mixed grass, native shrub community with scattered koa and other native trees	HI
D:(mg-ns)Ac,nt	Dry mixed grass-native shrub community with scattered koa and other native trees	HI
D:(mg-ns)Ac-Me-nt	Dry mixed grass-native shrub community with scattered koa, 'ohi'a, and other native trees	HI
D:(mg-ns)Ac-So,nt	Dry mixed grass-native shrub community with scattered koa mamane, and other native trees	HI
D:(mg-ns)My-So	Dry mixed grass-native shrub community with scattered mamane and naio trees	HI
D:(mg-ns)So	Dry mixed grass-native shrub community with scattered mamane trees	HI,MA
D:(ns)Me-nt	Dry native shrub community with scattered 'ohi'a and other native trees	HI
D:(ns)nt	Dry native shrub community with scattered mixed native trees	MO,MA
D:(ns,mg)	Dry native shrub with mixed grass community	HI,MA
D:(ns-xg-xs/xx)	Dry sparsely vegetated mixed native shrub, exotic grass, and shrub community	LA
D:(ns-xs)Me	Dry native-exotic shrub community with scattered 'ohi'a	HI
D:(xg)	Dry exotic grassland	HI,MA
D:(xg)AcMe,nt	Dry exotic grassland with scattered koa, 'ohi'a, and other native trees	HI
D:(xg)Ac-So,nt	Dry exotic grassland with scattered koa, mamane, and other native trees	HI
D:(xg)Ac-nt	Dry exotic grassland with scattered koa and other native trees	HI
D:(xg)My-So	Dry exotic grassland with scattered mamane and naio trees	HI

MAP/UNIT SYMBOL	DESCRIPTION OF VEGETATION	ISLANDS ¹
D:(xg)So	Dry exotic grassland with scattered mamane trees	HI
D:(xg)nt-xt	Dry exotic grassland with scattered native and exotic trees	HI,MO,MA
D:(xg,ns)Me,nt	Dry exotic grassland with some native shrubs, scattered 'ohi'a, and other native trees	HI
D:(xg,ns-xs)nt	Dry exotic grassland with native and exotic shrubs and scattered native trees	HI,MO,MA
D:(xs,ns)	Dry exotic shrub community with some native shrubs	HI,MA
D:(xx,ns)Me	Dry sparsely vegetated native shrub community with scattered scrub 'ohi'a trees	HI
D:Ac,nt(Dg-ns)	Dry koa community with mixed native trees and a mixed grass-native shrub understory	HI
D:Ac,nt(ns-xg-xs)	Dry koa community with mixed native trees and a native shrub-exotic grass and shrub understory	HI
D:Ac-Me(ns-xg)	Dry koa-'ohi'a community with a native shrub exotic grass understory	HI
D:Ac-Me-nt(mg-ns)	Dry koa-'ohi'a-mixed native trees community with a mixed grass-native shrub understory	HI
D:Ac-So(Dg-ns)	Dry koa-mamane community with a mixed grass-native shrub understory	HI
D:Ac-So(xg,ns)	Dry koa-mamane community with an exotic grass and scattered native shrub understory	HI
D:Al-nt(ns-xg/xs)	Dry kukui-mixed native trees community with a native shrub-exotic grass and shrub understory	HI
D:Me,nt(ns,mg)	Dry 'ohi'a forest with mixed native trees and a native shrub and mixed grass understory	HI,MO
D:Me,nt(ns-xg-xs)	Dry 'ohi'a forest with mixed native trees and a native shrub-exotic grass-shrub understory	HI
D:My,So(xg,ns)	Dry naio scrub forest with scattered mamane and an exotic grass and native shrub understory	HI
D:My,nt(ns,xg)	Dry naio scrub forest with other native trees and native shrub-exotic grass understory	HI
D:My-So(mg-ns)	Dry mamane-naio scrub forest with a mixed grass and native shrub understory	HI

MAP/UNIT SYMBOL	DESCRIPTION OF VEGETATION	ISLANDS ¹
D:So(mg-ns)	Dry mamane woodland with a mixed grass-native shrub understory	HI
D:So(xg,ns)	Dry mamane woodland with an exotic grass and scattered native shrub understory	HI
D:So-nt(xg,ns)	Dry mamane-mixed native trees community with an exotic grass-native shrub understory	HI
D:nt(ns-xg/xs)	Dry mixed native tree community with a native shrub-exotic grass and shrub understory	HI,MO,MA
D:nt(xg,ns-xs)	Dry mixed native tree community with an exotic grass and native and exotic shrub understory	HI
D:xt(ns,mg)	Dry exotic tree community with a native shrub and mixed grass understory	HI
D:xt,nt(xg)	Dry exotic tree community with scattered native trees and an exotic grass understory	HI,MA
M:(mg)	Mesic mixed grassland	MA
M:(mg,ns)Ac-Me-nt	Mesic mixed grass and native shrub community with scattered koa, 'ohi'a, and native trees	HI
M:(mg,ns)Me-nt	Mesic mixed grass and native shrub community with scattered 'ohi'a and other native trees	HI,MA
M:(ns)	Mesic native shrub community	MA
M:(ns)Me pio	Mesic pioneer native shrub community with scattered scrub 'ohi'a trees	HI
M:(ns)pio	Mesic pioneer native shrub community	HI
M:(ns)Me	Mesic native shrub community with scattered 'ohi'a trees	HI,MO,MA
M:(ns-xs)nt	Mesic native and exotic shrub community with scattered native trees	LA
M:(xg)	Mesic exotic grassland	MA
M:(xg)Ac-Me-nt	Mesic exotic grassland with scattered koa, 'ohi'a, and other native trees	HI,MA
M:(xg)Ac,nt	Mesic exotic grassland with scattered koa and other native trees	HI
M:(xg)xt	Mesic exotic grassland with scattered exotic trees	MO
M:(xg,ns)Me,nt	Mesic exotic grass and native shrub community with scattered 'ohi'a and other native trees	HI,MO

MAP/UNIT SYMBOL	DESCRIPTION OF VEGETATION	ISLANDS ¹
M:(xs)Me,nt	Mesic exotic shrub community with scattered ohī'a and other native trees	HI,MO
M:(xs)Me,xt	Mesic exotic shrub community with scattered 'ohī'a and exotic trees	HI
M:Ac,nt(ns-xg)	Mesic koa forest with other native trees and a native shrub-exotic grass understory	HI,MA
M:Ac-Me,nt(ns)	Mesic koa-'ohī'a forest with other native trees and a native fern and shrub understory	HI,MA
M:Ac-Me,nt(ns-xg-xs)	Mesic koa-'ohī'a forest with other native trees and a native-exotic shrub and grass understory	HI,MA
M:Ac-So,nt(xg,ns)	Mesic koa-mamane forest with other native trees and an exotic grass, native shrub understory	HI
M:Me,nt(mf-ns)pio	Mesic pioneer 'ohī'a forest with other native trees and a matted-fern, native shrub understory	HI
M:Me,nt(ns,mf)	Mesic 'ohī'a forest with other native trees and a native shrub, matted-fern understory	HI,MO,MA
M:Me,nt(ns-xg-xs)	Mesic 'ohī'a forest with other native trees and native shrub-exotic grass and shrub understory	HI,MO,MA
My-So-nt(xg)	Mesic mamane-naio-exotic tree community with an exotic grass understory	HI
M:nt(ns,xs)	Mesic mixed native tree community with a native shrub and exotic shrub understory	LA
M:nt,xt(xg,xs)	Mesic native tree community with scattered exotic trees and exotic grass-shrub understory	HI,MO
M:xt(ns)	Mesic exotic tree community with a native shrub understory	HI
M:xt,nt(ns-xg-xs)	Mesic exotic tree community with some native trees and native and exotic grass-shrub understory	LA,HI,MO,MA
W:(bg,ns)	Wet open bog with scattered native shrubs	HI,MO,MA
W:(mf-mg,ns)Ac-Me-nt	Wet matted-fern, mixed sedge-rush-native shrub community with scattered koa and 'ohī'a	HI
W:(mf-ns-xs)Me-xt	Wet matted-fern, native and exotic shrub community with scattered 'ohī'a and exotic trees	HI,LA
W:(mf/ns)Me-nt	Wet matted-fern and/or native shrub community with scattered ohī'a and other native trees	HI,MO,MA

MAP/UNIT SYMBOL	DESCRIPTION OF VEGETATION	ISLANDS ¹
W:(mg,ns)Me-nt	Wet mixed sedge-rush-native shrub community with scattered 'ohi'a and other native trees	HI,MA
W:(mg-ns)	Wet mixed grass-rush-sedge and native shrub community	HI,MA
W:(ns-xs)Me-nt	Wet native-exotic shrub community with scattered 'ohi'a and other native trees	HI
W:(tf,ns)Me-nt	Wet treefern and native shrub community with scattered 'ohi'a and other native trees	HI
W:(xg)xt	Wet exotic grass-sedge-rush community with scattered exotic trees	HI
W:(xg,xs)	Wet exotic grass and shrub community	HI
W:(xs)xt	Wet exotic shrub community with scattered exotic trees	LA
W:Ac-Me,nt(mf/ns,tf)	Wet koa-'ohi'a forest with other native trees and native shrub, matted-fern, and treefern understory	HI,MA
W:Ac-Me,nt(tf,ns)	Wet koa-'ohi'a forest with other native trees and a treefern, native shrub understory	HI
W:Ac-Me,nt(xs,ns)	Wet koa-'ohi'a forest with other native trees and an exotic and native shrub understory	HI,MA
W:Me(mf,ns)pio	Wet pioneer 'ohi'a forest with a matted-fern and native shrub understory	HI
W:Me,nt(ns-xg/xs)	Wet 'ohi'a forest with other native trees and a native shrub-exotic grass and shrub understory	HI,MO,MA
W:Me,nt(ns/mf,tf)	Wet 'ohi'a forest with native shrubs/matted fern and some treeferns in the understory	HI,MO,MA
W:Me,nt(tf,ns)	Wet 'ohi'a forest with other native trees and a treefern and native shrub understory	HI
W:xt,Me(mf-ns)	Wet exotic tree and 'ohi'a forest with a matted fern and native shrub understory	HI
W:xt,nt(xs)	Wet exotic tree plantation with some native trees and an exotic shrub understory	HI,MA

¹ISLANDS:
HI = Hawai'i;
LA = Lana'i;
MA = Maui;
MO = Moloka'i

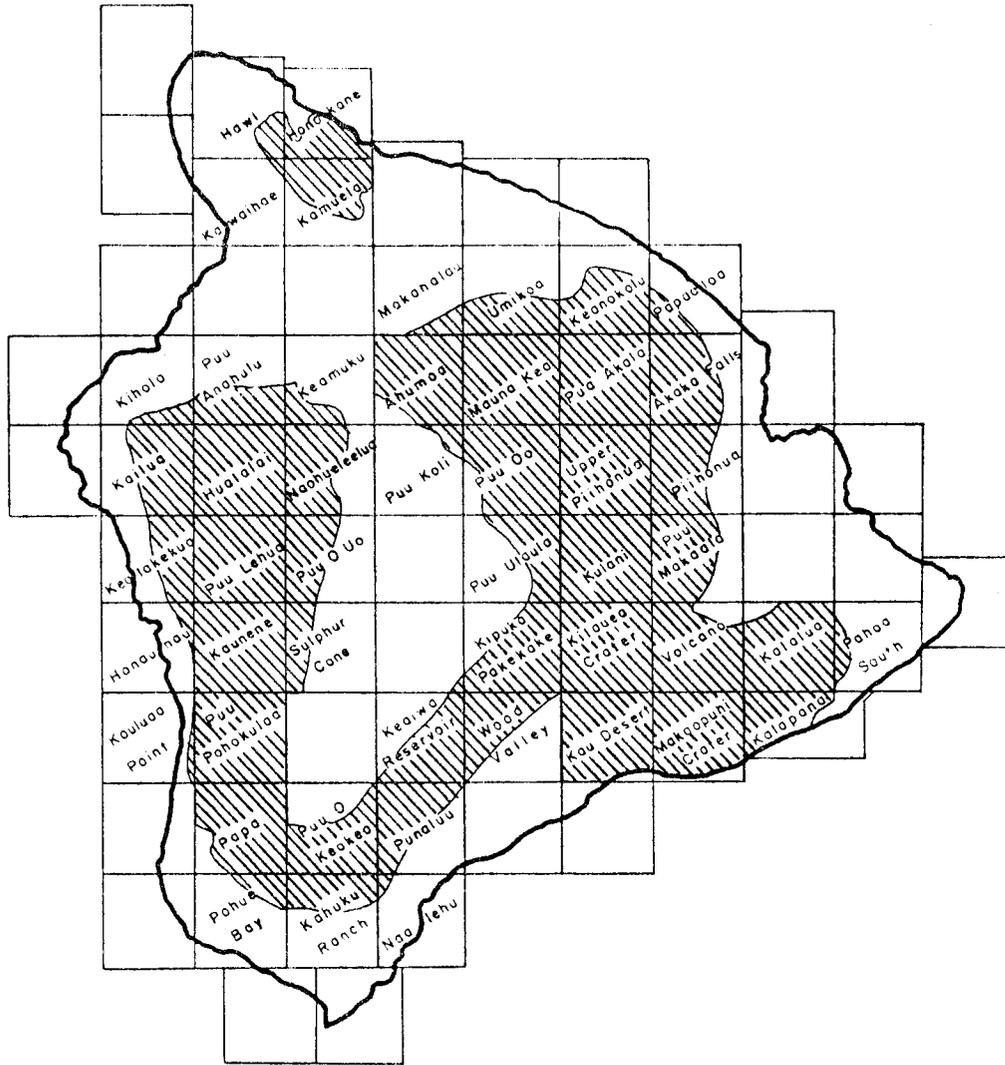


Fig 1. U.S. Geological Survey quadrangle maps for the island of Hawai'i for which vegetation type overlays were prepared during the Hawai'i Forest Bird Survey

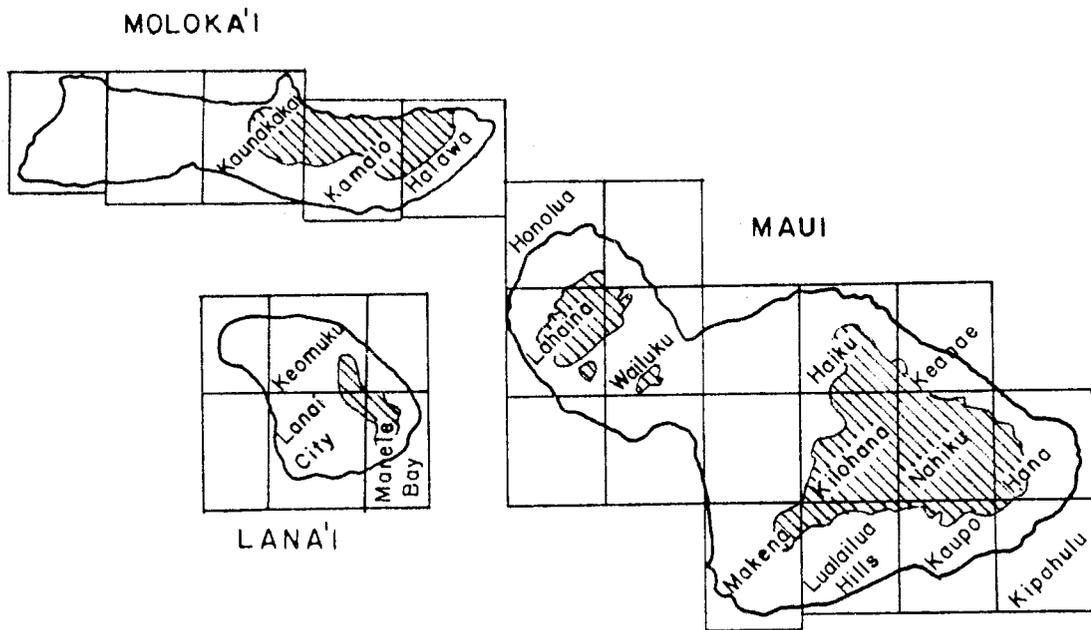


Fig 2. U.S. Geological Survey quadrangle maps for the islands of Moloka'i, Maui, and Lana'i for which vegetation type overlays were prepared during the Hawai'i Forest Bird Survey

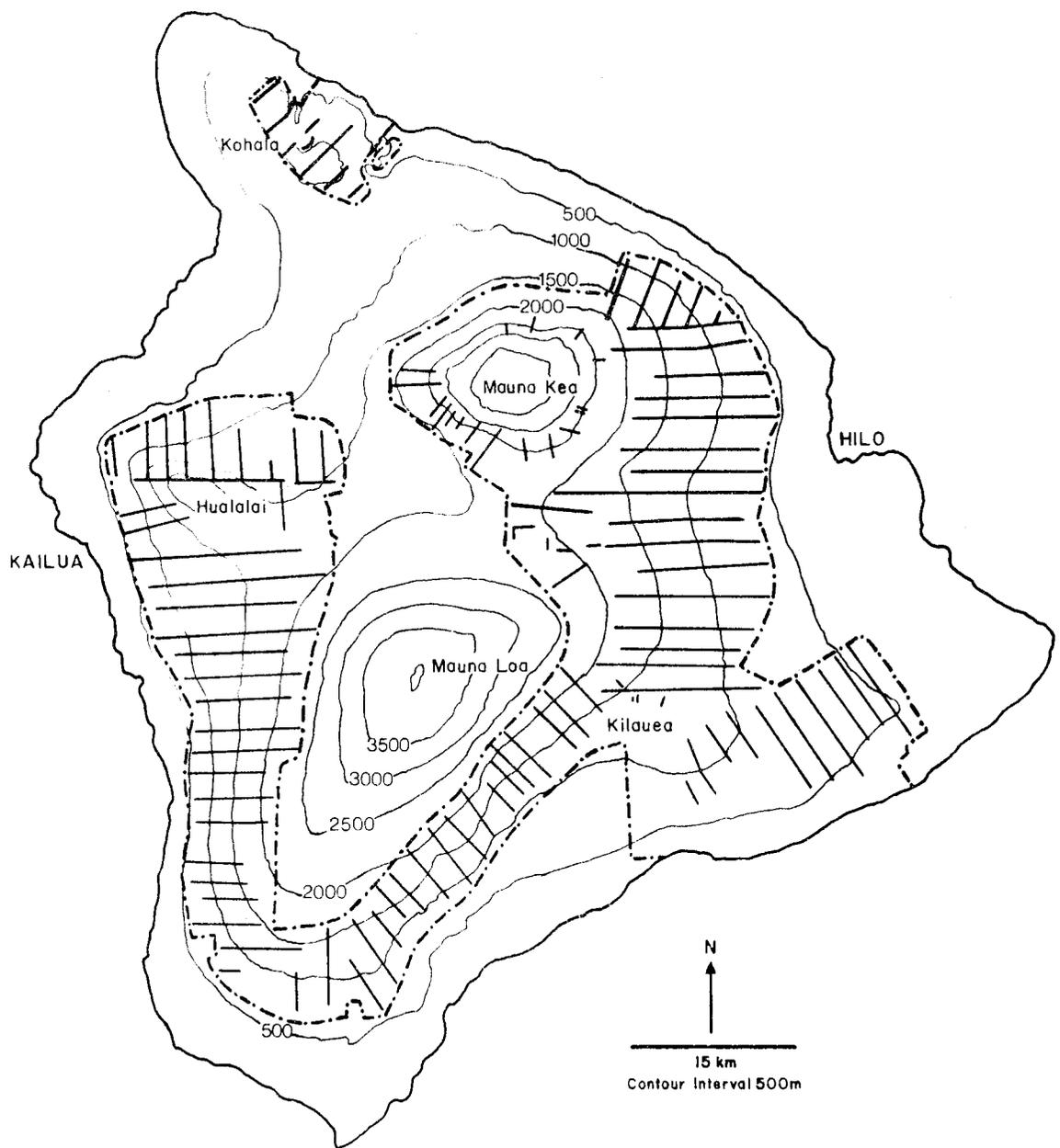


Fig 3. Location of study areas and transects established on the island of Hawai'i during the Hawai'i Forest Bird Survey

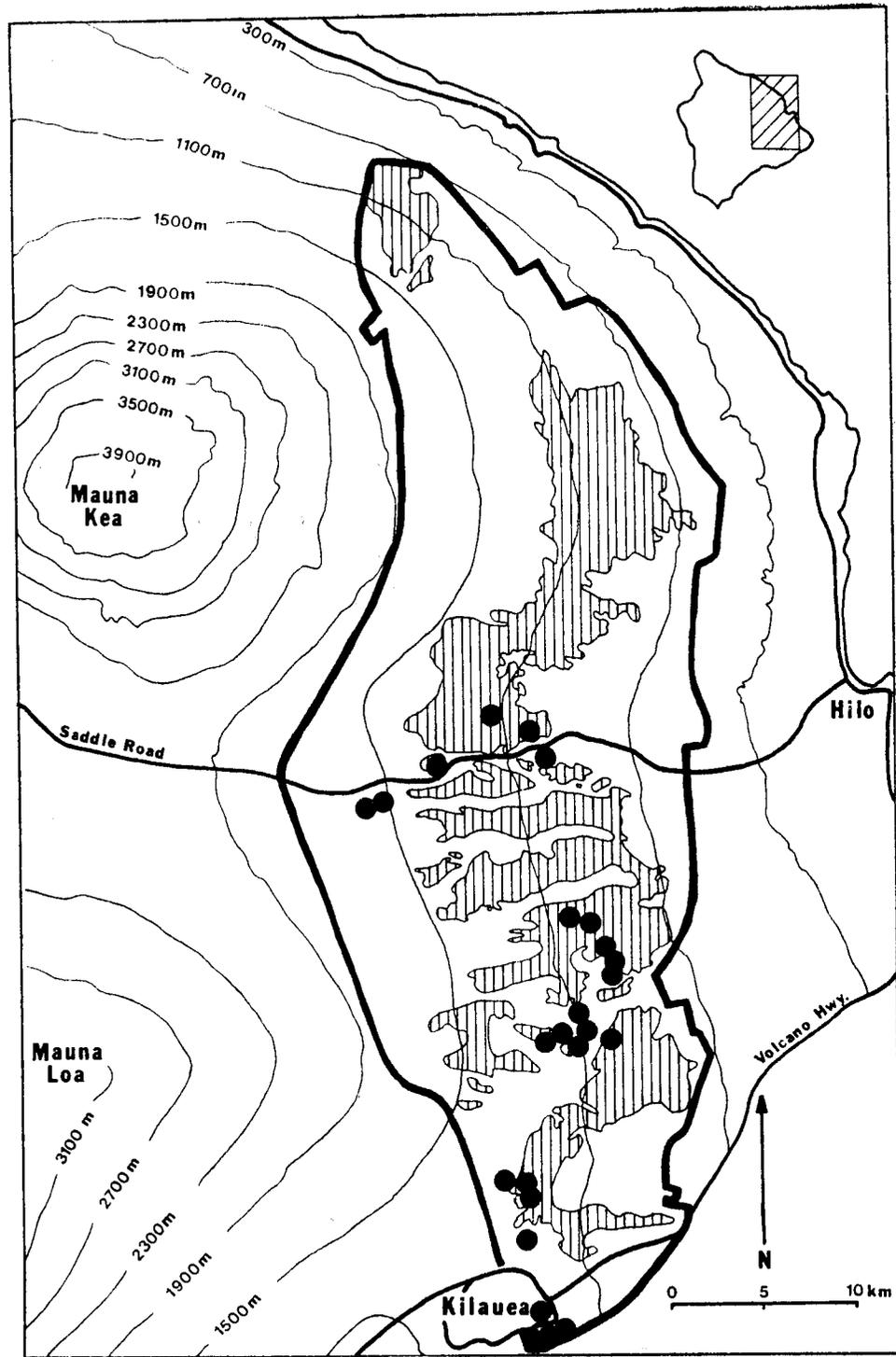


Fig 4. Map of the eastern portion of the island of Hawai'i showing the locations of the 62 study plots (black dots) sampled during the 'Ohi'a Forest Study in relation to areas of forest dieback (elevation contours in meters.)