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Vegetation Survey of Yap, Federated States of Micronesia

Marjorie C. Falanruw

Craig D. Whitesell

Thomas G. Cole

Colin D. MacLean

Alan H. Ambacher



The Authors:

MARJORIE C. FALANRUW, a research biologist with the American Pacific Islands Forestry Research Unit, is stationed in Yap. She holds degrees in biology from the University of California (bachelor's, 1965) and the University of Guam (master's, 1969). **CRAIG D. WHITESELL**, a research forester, is leader of the Station's American Pacific Islands Forestry Research Unit, in Honolulu. He has a bachelor's degree in forest management (1951) from West Virginia University and a master's in silviculture (1954) from Duke University. **THOMAS G. COLE**, a forester with the research unit in Honolulu, was stationed in Majuro, Marshall Islands, at the time of the survey reported here. He received a bachelor's degree in forest sciences (1977) from Texas A&M University. **COLIN D. MACLEAN** is principal mensurationist with the Forest Inventory and Analysis Unit, Pacific Northwest Forest and Range Experiment Station, in Portland, Oregon. He earned a bachelor's degree in forestry (1950) from the University of Maine, and a master's in forest management (1951) from the College of Environmental Science and Forestry, State University of New York. **ALAN H. AMBACHER** is supervisory cartographer in the Forest Service's Pacific Southwest regional office in San Francisco. He attended the Milwaukee School of Engineering.

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Cover: The Yapese have developed the art of food cultivation to a high degree. Here a path through an agroforest is lined with betel nut palms.

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INTRODUCTION

Yap is one of the four States in the Federated States of Micronesia. Knowledge of the extent and composition of its vegetation, including forest land, is needed for land-use planning. To fill this need, a formal agreement was drawn up between the High Commissioner of the U.S. Trust Territory of the Pacific Islands and two agencies of the U.S. Department of Agriculture—the Soil Conservation Service and the Forest Service—to map the vegetation of Yap. The four maps were prepared by the Forest Service in cooperation with the State Government of Yap and are intended to serve as a working tool for land-use planning and forest resource management, and to provide a basis for timber volume surveys.

This bulletin presents the vegetation maps of Yap and describes the different vegetation types, their ecological function, and uses. A breakdown of nonforest types is also provided.

GEOGRAPHY AND CLIMATE

Yap consists of four metamorphic, old volcanic high islands, and a group of about 15 coralline atolls. This bulletin applies

only to the high islands, which lie at lat. 9°33' N. and long. 138°09' E. in the western Caroline Islands (*fig. 1*). These islands consist of Yap, Maap, Rumung, and Gagil-Tamil, which lie within a broad fringing reef system that is about 30 km (19 statute mi) long and about 13 km (8 statute mi) at its widest point. The Yap Islands are located about 6,991 km (4,307 statute mi) southwest of Hawaii. The combined area of the four islands is 100.4 km² (39 mi²) and the highest point is 174 m (571 ft) (Nicholson 1969).

The climate of Yap is characterized by high temperatures, heavy rainfall, and high humidity. Mean annual rainfall for 1949 to 1980 was 3,028 mm (119 in). The driest months of the year are February to April, with an average of less than 180 mm (7 in) precipitation each month. On Yap, the wettest season of the year is July through October, when the average monthly rainfall is 330 mm (13 in). Mean annual temperature is 27 °C (81 °F), with a monthly variation of only 2 °C (3 °F) between the warmest and coolest months. The difference between the daytime maximum and nighttime minimum temperatures averages 7 °C (12 °F). Mean relative humidity ranges from 79 to 85 percent.

The vegetation of Yap has been much modified by man; other than mangroves, little native forest is left. Several factors have contributed to the great amount of disturbance to the native vegetation on Yap. Circa 1850, Yap's population was estimated to be five to six times as large as the 1980 census figure of 8,000 (Hunt and others 1954, Underwood 1969). While no definite figure is available on precontact populations, legends tell of the great number of people on Yap during this period (Hunt and others 1954). The pressure on natural resources to produce food for so many people must have been intense. This factor, combined with later Japanese agricultural practices, droughts, and

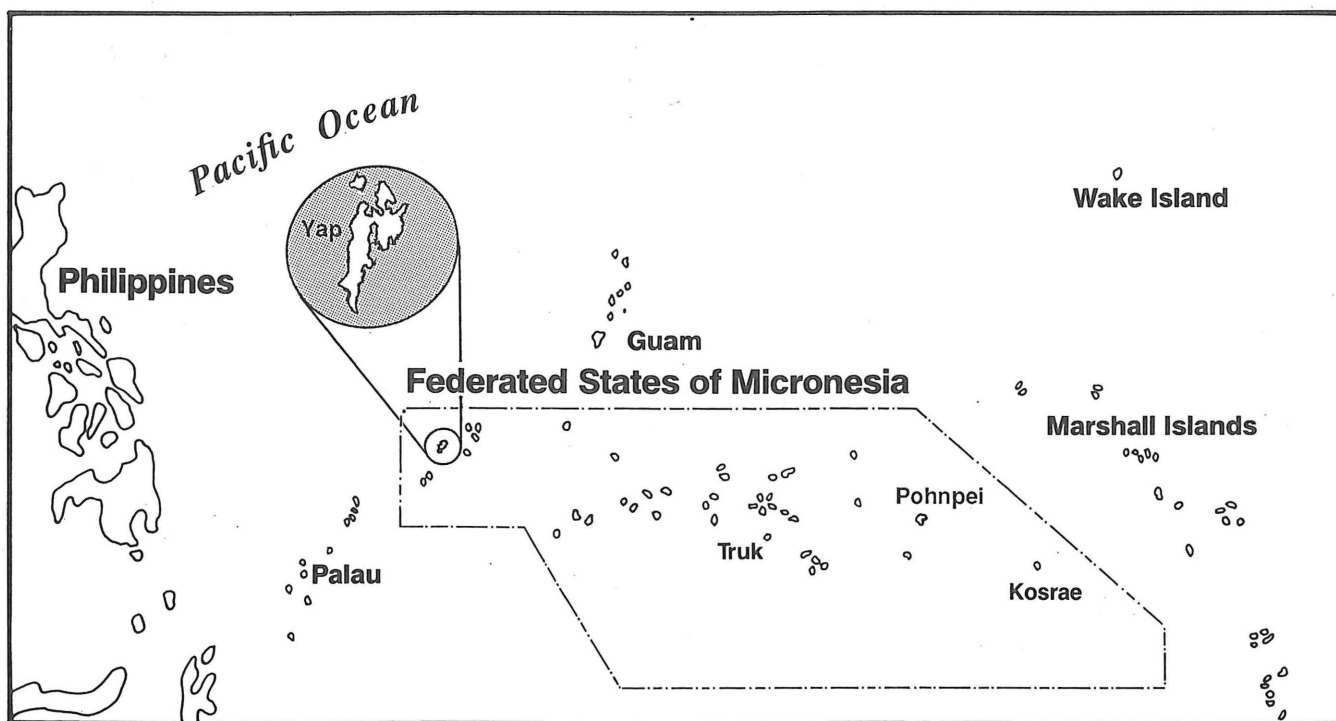


Figure 1—The state of Yap, Federated States of Micronesia, is located in the Western Caroline Islands, almost 7,00 km (4,300 mi) southwest of Hawaii.

repeated burning, has contributed to the destruction of the native vegetation, and the development or expansion of some savanna areas of degraded soils.

Throughout the years Yapese have developed food production systems that are now the best developed and most diverse among the high islands of Micronesia. These "agroforests" make up an estimated 26 percent of the vegetation of Yap (table 1, fig. 2).

Subsistence farming and copra production are the main agricultural enterprises on Yap. The main subsistence crops are taro, breadfruit, yams, coconuts, bananas, *Inocarpus*, and citrus. The local economy is also supported by fishing, handicrafts, tourism, and government employment. Soil scientists of the Soil Conservation Service have mapped and described 16 soil series and variants on Yap and provided guidelines for farmers, land managers, developers, and others (Smith 1983).

SURVEY METHODS

Yap's vegetation types were identified and delineated on black-and-white photographs taken in 1976 at a scale of 1:10,000. Since then, some changes have occurred. Except for the area of the new airstrip, however, updating the photography to account for these recent changes was not possible.

Table 1—Area of Yap, by land class and type, 1976

Land class and type	Symbol	Area	
		Hectares	Acres
Forest			
Upland forest	UP	2,556	6,316
Swamp forest	SW	155	383
Mangrove forest	MN	1,171	2,894
Total forest		3,882	9,593
Secondary Vegetation	SV	553	1,366
Agroforest			
Agroforest	AG	1,515	3,744
Agroforest (>20 pct coconut)	AG.CO	864	2,136
Coconuts	CO	159	392
Total agroforest		2,538	6,272
Nonforest			
Marsh, freshwater	M.F	165	407
Marsh, saline	M.S	6	15
Grassland/savanna	G	2,175	5,374
Cropland	C	46	115
Urban	U	244	602
Urban with agriculture	U/C, U/AG, U/AG.CO	61	150
Barren	B	8	21
Water	W	38	95
Total nonforest		2,743	6,779
Total area		9,716	24,010

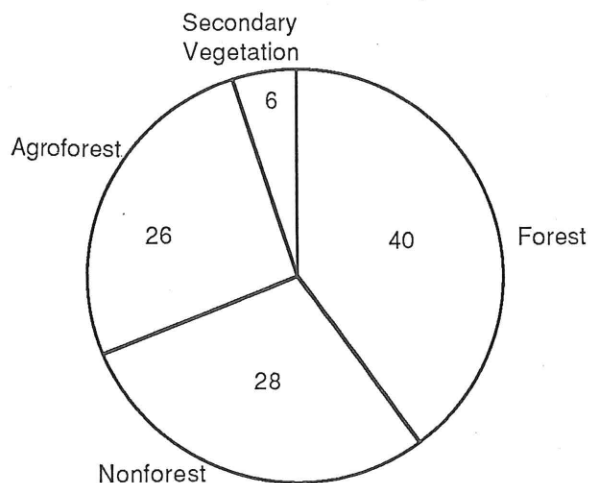


Figure 2—Four major land classes were found on Yap, Federated States of Micronesia, 1976. Although the forest class encompasses 40 percent of the land area, about half of this area is disturbed and contains inclusions of secondary vegetation.

Vegetation differences can often be recognized by examining photographs stereoscopically for differences in tone, texture, and image patterns. In some cases, individual plants may be recognized by their distinctive shape. Thus, after comparing photomimagery with ground conditions in the field, a skilled interpreter becomes fairly proficient at recognizing vegetative types on aerial photos. Overall accuracy depends on the scale, age, and quality of the photographs; skill of the interpreter; degree to which the types differ in image characteristics; and the amount of checking done on the ground by the interpreter.

Before vegetation typing could begin, a vegetation mapping scheme was needed. Because much of the island is inaccessible by road and funds were limited, vegetation types were restricted to those that could be recognized on the photos without intensive ground checking. In addition, type characteristics were limited to those useful to foresters and land-use planners.

After preliminary field reconnaissance, the classification scheme presented in this bulletin was adopted. Types were delineated on the photos after stereoscopic examination and ground checking along roads and trails. Then the photos were edited and sent to the Engineering Geomtronics Section of the Forest Service's Pacific Southwest Regional Office, for transfer to base maps and measurement of type areas (tables 1 and 2, figs. 2 and 3).

TYPE CLASSIFICATIONS

For mapping purposes, the islands of Yap were divided into four broad land classes—forest, secondary vegetation, agroforest and nonforest. Saltwater bays and other bodies of water are

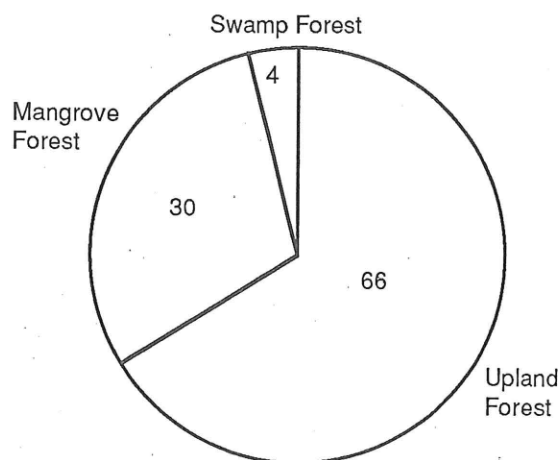


Figure 3—The forest land class was broken down into three types on Yap, Federated States of Micronesia, 1976. Both the swamp and upland forest types are heavily disturbed for agricultural purposes and contain much secondary vegetation.

listed under the nonforest class. Primary types under the major land classes include:

Forest—The forest class includes three types:

Upland forest (UP)

Swamp forest (SW)

Mangrove forest (MN)

Secondary vegetation (SV)—Secondary vegetation includes vines, shrubs, and small trees on recently disturbed areas.

Agroforest (AG)—The agroforest class is made of areas under cultivation for food crops, fruit, wood, and other products.

Nonforest—Nonforest areas include grasslands, marshes, degraded sites, and areas developed for urban use. Primary types in this class are:

Marsh (M)

Savanna grasslands (G)

Cropland (C)

Urban (U)

Barren (B)

Water (W)

The forest types are further subdivided into size and density classes (table 2), identified by these codes:

Code	Size class
0	Short, shrub-like stands smaller than 12.5 cm (5 in) in diameter at breast height (d.b.h.).
1	Trees averaging less than 30 cm (12 in) in d.b.h. but larger than or equal to 12.5 cm (5 in) in d.b.h.
2	Trees averaging 30 or more cm (>12 in) in d.b.h.
Code	Density class
H	High—crown closure of main canopy over 70 percent.
M	Medium—crown closure of main canopy between 30 and 70 percent.
L	Low—crown closure of main canopy less than 30 percent.

On the folded maps, vegetative areas are numbered and identified by symbols in the legend. In each code, the vegetation type

is shown first, followed by the size and crown density class. For example, MN1H would indicate mangrove less than 30 cm (12 in) but at least 12 cm (5 in) in d.b.h. and a high density crown closure. Where possible, dominant species are identified. In such cases, the density class is followed by a period, then by one or two letters of the genus name, MN1H.S, as when *Sonneratia alba* makes up at least 20 percent of the mangrove stand. Occasionally, mixed stands are identified by a slash between the primary vegetation type and a second type, with density and size classes given only for the primary type. For example, UP2L/SV.H would indicate scattered upland trees, 30 cm (12 in) or greater in d.b.h., with inclusions or patches of secondary vegetation having *Hibiscus tiliaceus* as its major component (table 3).

VEGETATION TYPE DESCRIPTIONS

Land classes and primary types are described by habitat and major overstory and understory species listed below. Full species citations and families of plants mentioned in the text are given in table 4.

Forest

Upland Forest (UP)

The forests of Yap have been greatly modified from their original condition. Many stands are a mixture of native, agroforest, secondary, and introduced species. A common component of better developed native forest is *Camposperma brevipetiolata*

Table 2—Area of forest land, by size class and density, on Yap, 1976

Type	Size class ¹	Density class ²			Total
		Low	Medium	High	
		<i>Hectares (acres)</i>			
Upland forest	0	85	95	29	209 (516)
Upland forest	1	295	1,198	60	1,553 (3,837)
Upland forest	2	90	696	8	794 (1,962)
Swamp forest	1	3	111	0	114 (283)
Swamp forest	2	0	41	0	41 (102)
Mangrove forest	0	0	0	26	26 (64)
Mangrove forest	1	16	143	944	1,103 (2,725)
Mangrove forest	2	0	7	35	42 (104)
Total forest					3,882 (9,593)

¹0—Short, shrub-like stands smaller than 12.5 cm (5 in) in d.b.h.

1—Trees averaging less than 30 cm (12 in) in d.b.h. but larger than or equal to 12.5 cm (5 in) in d.b.h.

2—Trees averaging 30 or more cm (>12 in) in d.b.h.

²Crown closure of main canopy: low, less than 30 pct; medium, 30–70 pct; high, greater than 70 pct.

Table 3—Vegetation type codes used for Yap, Federated States of Micronesia

Land class	Vegetation codes	Vegetation types, subtypes, and components
Forest	UP	Upland forest, size and density classes apply
	UP/SV	Secondary vegetation inclusions
	UP/SV.BB	Bamboo inclusions
	UP.AG	Agroforest component
	SW	Swamp forest, size and density classes apply
	SW/SV	Secondary vegetation inclusions
	SW/SV.H	Hibiscus inclusions
	SW/SV.BB	Bamboo inclusions
	SW.AG	Agroforest component
	MN	Mangrove forest, size and density classes apply
Secondary vegetation	MN.N	<i>Nypa</i> palm component
	MN.S	<i>Sonneratia</i> component
	SV	Secondary vegetation
	SV.BB	Bamboo component
	SV.H	Hibiscus component
Agroforest	SV.P	Pandanus component
	AG	Agroforest
	AG/SW	Swamp forest inclusions
	AG/SV	Secondary vegetation inclusions
	AG/SV.BB	Bamboo inclusions
	AG.CO	Coconut component
Nonforest	CO	Coconut plantation, size and density classes apply
	M.F	Freshwater marsh
	M.F.C	Freshwater cultivated marsh
	M.S	Saline marsh
	G	Savanna grassland
	G.B	Barren component
	G.CA	Abandoned cultivation
	G.D	Disturbed lands
	G.F	Fern component
	G.G	Grass component
	G.P	Pandanus component
	G.W	Wetlands component
	C	Open cultivation
	U	Urban
	U/AG	Agroforest inclusions
	U/AG.CO	Coconut inclusions
	U/B	Barren inclusions
	U/C	Cropland inclusions
	U/SV	Secondary vegetation inclusions
	.W	Water, including fresh, saline, and bays

NOTES:

Size classes and density codes are used only with the forest class and with the coconut plantation type.

Various combinations of components are used, especially within the savanna grassland type, as for G.B.F.P meaning Grassland with barren, fern, and pandanus components.

All components, inclusions, or understory species must be present on at least 20 percent of the mapped area.

(Hosokawa 1954). In association with *Campnosperma* are usually found the poison tree, *Semecarpus venenosus*, *Buchanania engleriana*, *Inocarpus fagifer*, *Pterocarpus indicus*, *Pentapthalangium volkensii*, and occasionally, *Garcinia rumiyo*. In some areas, large *Serianthes kanehirae* var. *yapensis*, *Ficus prolixa*,

and *Calophyllum inophyllum* occur. Characteristic species of the understory in better developed forests include *Barringtonia racemosa* (especially in wet situations), *Timonius albus*, *Ixora casei*, *Psychotria* spp., *Meryta senffiana*, and *Pandanus japensis*. Lianas are characteristically *Raphidophora* spp.

Several phases of more scrubby forest occur on Yap. Species characteristic of forests occurring in better drained areas such as the summits of Mt. Tabiwol and Mt. Madade, include *Diospyros ferrea*, *Psychotria* spp., *Aidia cochinchinensis*, *Ixora triantha*, *Timonius albus*, *Glochidion* spp., *Desmodium heterocarpum*, and occasionally *Garcinia rumiyo*. *Cycas circinalis* is sometimes found in the understory.

A characteristic type of low elevation native forest is found growing in savanna areas, usually in steep ravines. The most common tree species of these forests are *Trichospermum ikutai*, *Commersonia bartramia*, *Campnosperma brevipedunculata*, *Rhus taitensis*, and *Calophyllum inophyllum*. Species common to both the edges of these ravine forests and adjacent grassland areas include *Pandanus tectorius*, *Commersonia bartramia*, *Alphitonia carolinensis*, *Pouteria obovata*, and stunted individuals of *Trichospermum ikutai*.

Trees commonly found in coastal areas include *Terminalia catappa*, *Guettarda speciosa*, *Calophyllum inophyllum*, *Hernandia sonora*, *Vitex negundo*, and occasionally, *Pemphis acidula*, *Barringtonia asiatica*, and *Tournefortia argentea*. These species are characteristic of atoll forest. On Yap, however, they do not occur in areas large enough to delineate and are generally included with other categories.

Introduced species of trees characteristic of inhabited areas include *Adenanthera pavonina*, *Albizia lebbek*, *A. retusa*, *A. falcata*, *Cassia* spp., *Tectona grandis*, and *Swietenia mahagoni*. A stand of *Melaleuca quinquenervia* exists, and scattered *Swietenia mahagoni* occur in a number of native forest areas where it has naturalized.

Most of Yap is privately owned and utilized, at least intermittently, for agricultural production. This results in a characteristic patchwork pattern of forest, agroforest, and secondary vegetation—the fallow stage of Yapese gardening. Of the 2,556 ha (6,316 acres) mapped as upland forest, 1,271 ha (3,141 acres) or 50 percent had inclusions of secondary vegetation, coded UP/SV, or upland forest with agroforest, coded UP/AG (table 3).

Swamp Forest (SW)

Swamp forest occurs where soils are inundated with fresh or slightly saline water. The most common habitat for such forests are low wet areas just inland of mangroves, above tidal influences but lower in elevation than the surrounding terrain. Other sites exist inland where water collects in low areas along rivers, and in areas of impeded drainage. Occasionally, the distinction between swamp and other forest is not clear due to the poorly drained and waterlogged nature of Yap's soil.

The vegetation survey had departed from Hosokawa (1952) and Stemmerman and Proby (1978) by not recognizing "hibiscus swamp" as a separate forest type. Though *Hibiscus tiliaceus* often grows in swampy places, it is not confined to such habitat and is a common component of secondary vegetation.

Table 4—Plant species mentioned in text¹

Genus	Species and author	Family	Genus	Species and author	Family
Acrostichum	aureum L.	Pteridaceae	Hedyotis	spp.	Rubiaceae
Adenanthera	pavonina L.	Mimosaceae	Heritiera	littoralis Dry.	Sterculiaceae
Aidia	cochinchinensis Lour.	Rubiaceae	Hernandia	sonora L.	Hernandiaceae
Albizia	falcata (L.) Fosb.	Mimosaceae	Hibiscus	tiliaceus L.	Malvaceae
Albizia	lebbeck (L.) Benth.	Mimosaceae	Hyptis	capitata Jacq.	Verbinaceae
Albizia	retusa Benth.	Mimosaceae	Inocarpus	fagifer (Park.) Fosb.	Fabaceae
Alphitonia	carolinensis Hosok.	Rhamnaceae	Ipomoea	aquatica Forsk.	Convolvulaceae
Annona	muricata L.	Annonaceae	Ipomoea	spp.	Convolvulaceae
Areca	cathecu L.	Palmae	Ischaemum	spp.	Gramineae
Artocarpus	altilis L.	Moraceae	Ixora	casei Hance	Rubiaceae
Artocarpus	heterophyllum Lam.	Moraceae	Ixora	triantha Volk.	Rubiaceae
Averrhoa	bilimbi L.	Oxalidaceae	Lantana	camara L.	Verbenaceae
Averrhoa	carambola L.	Oxalidaceae	Leucaena	leucocephala (Lam.) de Wit	Mimosaceae
Bambusa	spp.	Gramineae	Ludwigia	hyssopifolia (G. Don) Exell	Onagraceae
Bambusa	vulgaris Schrad. ex Wendl.	Gramineae	Ludwigia	octovalvis (Jacq.) Raven	Onagraceae
Barringtonia	asiatica (L.) Kurz	Lecythidaceae	Lumnitzera	littorea (Jack.) Voigt	Combretaceae
Barringtonia	racemosa (L.) Spreng.	Lecythidaceae	Lycopodium	cernuum L.	Lycopodiaceae
Bruguiera	gymnorhiza (L.) Lam.	Rhizophoraceae	Macaranga	carolinensis Volk.	Euphorbiaceae
Buchanania	engleriana Volk.	Anacardiaceae	Mangifera	indica L.	Anacardiaceae
Calophyllum	inophyllum L.	Guttiferae	Melaleuca	quinquenervia (Cav.) Blake	Myrtaceae
Camponosperma	brevipetiolata Volk.	Anacardiaceae	Melastoma	malabathricum L.	Melastomataceae
Carica	papaya L.	Caricaceae	Melochia	spp.	Sterculiaceae
Cassia	spp.	Caesalpinaceae	Merremia	spp.	Convolvulaceae
Cassytha	filiformis L.	Lauraceae	Meryta	senffiana Volk.	Araliaceae
Casuarina	litorea L.	Casuarinaceae	Mimosa	invisa Mart	Leguminosae
Cayratia	spp.	Vitaceae	Mimosa	pudica L.	Leguminosae
Cerbera	manghas L.	Apocynaceae	Morinda	citrifolia L.	Rubiaceae
Ceriops	tagal (Perr.) C.B. Rob	Rhizophoraceae	Musa	paradisica L.	Musaceae
Citrus	aurantifolia (Christm.) Swingle	Rutaceae	Musa	sapientum L.	Musaceae
Citrus	aurantium L.	Rutaceae	Musa	textilis Nees.	Musaceae
Citrus	grandis (L.) Osbeck	Rutaceae	Musa	trogodytarum L.	Musaceae
Citrus	hystris DC.	Rutaceae	Myrtella	bennigseniana (Volk.) Diels	Myrtaceae
Citrus	macroptera Montr.	Rutaceae	Nepenthes	mirabilis (Lour.) Druce	Nepenthaceae
Citrus	mitis Blanco	Rutaceae	Nypa	fruticans Wurmb.	Palmae
Citrus	reticulata Blanco	Rutaceae	Pandanus	japensis Mart.	Pandanaceae
Citrus	sinensis (L.) Osbeck	Rutaceae	Pandanus	tectorius Park.	Pandanaceae
Cocos	nucifera L.	Palmae	Pangium	edule Reinw. ex Bl.	Flacourtiaceae
Colocasia	esculenta (L.) Schott	Araceae	Paspalum	distichum L.	Gramineae
Commersonia	bartramia (L.) Merr.	Sterculiaceae	Passiflora	foetida var. hispida (DC.) Killip	Passifloraceae
Crateva	speciosa Volk.	Capparidaceae	Pemphis	acidula Forst.	Lythraceae
Crotalaria	spp.	Papilionatae	Pennisetum	spp.	Gramineae
Cycas	circinalis L.	Cycadaceae	Pentaplangium	volkensii Lauterb.	Guttiferae
Cynometra	ramiflora L.	Caesalpinaceae	Phragmites	karka (Retz.) Trin. ex Steud.	Gramineae
Cyperus	javanicus Houtt.	Cyperaceae	Pongamia	pinnata (L.) Merr.	Fabaceae
Cyrtosperma	chamissonis (Schott) Merr.	Araceae	Pouteria	obovata (R.Br.) Baehni	Sapotaceae
Dalbergia	candenatensis (Dennst.) Prain	Fabaceae	Premna	obtusifolia R.Br.	Verbinaceae
Decaspermum	fruticosum Forst.	Myrtaceae	Psidium	guajava L.	Myrtaceae
Derris	elliptica (Roxb.) Benth.	Fabaceae	Psychotria	spp.	Rubiaceae
Derris	trifoliata Lour.	Fabaceae	Pterocarpus	indicus Willd.	Fabaceae
Desmodium	heterocarpum (L.) DC.	Fabaceae	Raphidophora	spp.	Araceae
Dioscorea	spp.	Dioscoreaceae	Rhizophora	apiculata Bl.	Rhizophoraceae
Diospyros	ferrea (Willd.) Bakh.	Ebenaceae	Rhizophora	mucronata Lam.	Rhizophoraceae
Dolicandrone	spathacea (L.F.) K. Shum.	Bignoniaceae	Rhus	taitensis Guill.	Anacardiaceae
Eleocharis	spp.	Cyperaceae	Scaevola	taccada (Gaertn.) Roxb.	Goodeniaceae
Eugenia	spp.	Myrtaceae	Schypiphora	hydrophyllacea Gaertn.	Rubiaceae
Eupatorium	odoratum L.	Compositae	Semecarpus	venenosus Volk.	Anacardiaceae
Excoecaria	agallocha L.	Euphorbiaceae	Serianthes	kanehirae var. yapensis Fosb.	Mimosaceae
Ficus	prolixa var. carolinensis (Warb.) Fosb.	Moraceae	Sonneratia	alba J.E. Smith	Sonneratiaceae
Ficus	tinctoria Forst. F.	Moraceae	Stachytarpheta	spp.	Verbenaceae
Fimbristylis	spp.	Cyperaceae	Swietenia	mahagoni (L.) Jacq.	Meliaceae
Garcinia	rumiyo Kaneh.	Guttiferae	Tacca	leontopetaloides (L.) O. Ktze.	Tacrecaceae
Gleichenia	linearis (Burm.F.) Clarke	Gleicheniaceae	Tectona	grandis L.F.	Verbenaceae
Glochidion	spp.	Euphorbiaceae	Terminalia	catappa L.	Combretaceae
Guettarda	speciosa L.	Rubiaceae	Timonius	albus Volk.	Rubiaceae
Hanguana	malayana (Jack) Merr.	Flagellariaceae	Tournefortia	argentea L.F.	Boraginaceae

continued

Table 4—Plant species mentioned in text (continued)

Genus	Species and author	Family
Trema	spp.	Ulmaceae
Trichospermum	ikutai Kaneh.	Tiliaceae
Vigna	marina (Burm.) Merr.	Fabaceae
Vitex	negundo var. bicolor (Willd.) Lam	Verbinaceae
Wedelia	triloba (L.) Hitchc.	Compositae
Wollastonia	biflora (L.) DC.	Compositae
Xylocarpus	granatum Koen.	Meliaceae

¹Scientific names of dicotyledonae, monocotyledonae, and palmae follow Fosberg and others (1979), Fosberg (1960) and Moore and Fosberg (1956) respectively.

Many areas which probably once supported swamp forest on Yap have been converted into taro patch systems. Swamp forests are now limited in area and are poorly developed and heavily disturbed. Species characteristic of swamp forest habitat just inland of mangroves include *Dolicandrone spathacea*, *Heritiera littoralis*, *Pongamia pinnata*, *Cynometra ramiflora*, *Dalbergia candenatensis*, *Derris trifoliata*, and *Acrostichum aureum*. A few almost pure stands of *Dolichandrone spathacea* can be found, and *Barringtonia racemosa* is common in wetter areas. The most common situation found, however, is swamp forest mixed with secondary vegetation or agroforest with taro patches. In fact, 85 percent of the total swamp forest area contain secondary vegetation or agroforest inclusions.

Swamp forest species growing along rivers do not generally cover areas extensive enough to be separately mapped and are generally included in the upland forest class. Woody species characteristic of these riverine areas and in wet inland depressions include *Barringtonia racemosa*, *Hibiscus tiliaceus*, *Semecarpus venenosus*, *Inocarpus fagifer*, *Ficus tinctoria*, *Pandanus jenkinsii*, *Cerbera manghas*, *Ixora casei*, and *Derris elliptica*.

Mangrove Forest (MN)

The most distinctive vegetation type on Yap is mangrove. These forests have specialized roots inundated at least periodically by sea water. Mangroves are found around most of Yap's coast, and are especially well developed on mud flats at the mouths of drainage systems. They serve as a natural filtering and nutrient buffering system between the island and lagoon, settling silt and providing for a slow sustained release of nutrients. Mangroves also serve as fish nurseries and habitat for birds and fruit bats, and provide house posts, craftwood, firewood, and fishing and gathering grounds.

The mangrove type is distinct on aerial photos due to its dark tone and smooth texture. The inland margins of mangroves, however, are sometimes hard to separate from the adjacent vegetation. The most common size class of mangroves on Yap are stands of medium stature (MN1). Another type of mangrove consists of areas of low tangled growth generally found where water circulation is limited and the soil more firm. These almost

impenetrable stands consist of *Rhizophora* trees and occasionally *Bruguiera gymnorhiza*. These areas are coded MNOH (table 3).

Species composition of mangroves varies by habitat. *Nypa fruticans* is generally found in the more brackish areas, in stands generally too narrow to map. Where *Nypa* palm makes up at least 20 percent of the stand, the area is typed as MN1M.N or MN1H.N.

Where other mangrove species can be recognized on photographs and make up at least 20 percent of the stand, they are indicated by type symbols. *Sonneratia alba* is often taller and has a less dense canopy and is coded MN1H.S. *Bruguiera gymnorhiza* and *Xylocarpus granatum* tend to grow along the landward edge of mangroves. However, they do not generally present a distinct canopy texture for consistent identification. *Lumnitzera littorea* also grows along the landward edge of mangrove areas, but usually does not occur in pure stands and, therefore, is not generally typed. *Schypiphora hydrophyllacea*, *Ceriops tagal*, and *Excoecaria agallocha* are other mangrove species which are not distinguished on the vegetation maps.

Secondary Vegetation

This vegetation class is somewhat intermediate between forest and nonforest. Secondary vegetated areas are generally covered with fast-growing weedy species. Quite often, these areas of secondary vegetation represent Yapese garden sites in the fallow phase. Due to the slash and burn agriculture and bulldozing, much of the native forest is now mixed with secondary vegetation. Of the total land area of 9,716 ha (24,010 acres) mapped on Yap, it was found that 2,799 ha (6,917 acres) or 29 percent are mixed with secondary vegetation. Besides the 553 ha (1,366 acres) in the secondary vegetation class, this figure includes SV inclusions in the agroforest, forest, swamp forest, and urban types.

On aerial photos, secondary vegetation is characterized by a low uneven canopy, usually of medium density. The type is readily identified by its hazy texture, especially when vines are present. Tall stands of bamboo which appear as plumes and are easily identified, are typed as SV.BB. Characteristic species, many introduced, of the secondary vegetation type on Yap include *Macaranga carolinensis*, *Hibiscus tiliaceus*, *Rhus taitensis*, *Melochia* spp., *Ishaemum* spp., *Morinda citrifolia*, *Glochidion* spp., *Trema* spp., *Commersonia bartramia*, *Cayratia* spp., *Merremia* spp., *Ipomoea* spp., *Bambusa* spp., *Passiflora foetida* var. *hispida*, *Mimosa invisa*, *M. pudica*, *Crotalaria* spp., *Cassia* spp., *Lantana camara*, *Premna obtusifolia*, *Hyptis capitata*, *Pennisetum* spp., and *Stachytarpheta* spp., and occasionally *Casuarina littorea*. Recently introduced and spreading are *Eupatorium odoratum* and *Wedelia triloba*, and *Leucaena leucocephala* especially in areas of coral rock.

Species characteristic of atoll forest and strand vegetation that occur along the sandy coasts of Yap are sometimes included in the secondary vegetation type when they occur in strips too narrow to be mapped.

Agroforest

Productive agroforests have been created by the Yapese. Fruit bats and birds also assist, by spreading seeds. Agroforests consist of a mixture of food and other useful trees found growing around villages. Scattered coconut trees and breadfruit trees are an indicator of agroforest. The canopy is often uneven, and may be interspersed with open areas of taro patches, croplands, and areas of secondary vegetation or upland forest too small to be separately mapped.

Most agroforests include coconut trees. If coconut trees make up 20 percent or more of the canopy, the area is classified as AG.CO. If the crown cover of an area is almost exclusively composed of coconut trees, it is classified as coconut plantation and coded CO.

On Yap, the agroforest class is part of a three-component system of food production which involves tree gardens, taro patches, and intermittent open gardens. The following description of this system is adapted from Falanruw 1980, 1982, and 1985. Tree species commonly found in the agroforest overstory are *Cocos nucifera*, *Artocarpus altilis*, *Areca cathecu*, *Mangifera indica*, *Inocarpus fagifer*, *Pangium edule*, *Artocarpus heterophyllus*, *Rhus taitensis*, and *Calophyllum inophyllum*. Common smaller trees include *Citrus aurantifolia*, *C. aurantium*, *C. hystrix*, *C. sinensis*, *C. mitis*, *C. reticulata*, *C. grandis*, *C. macroptera*, *Eugenia* spp., *Crateva speciosa*, *Averrhoa bilimbi*, *A. carambola*, *Musa paradisiaca*, *M. sapientum*, *M. textilis*, *M. troglodytarum*, *Annona muricata*, *Carica papaya*, and *Psidium guajava*. A wide variety of ornamental and useful shrubs are planted along paths through agroforests. Other useful shrubs and herbs grow in the understory, as do epiphytes, vines, and ground cover plants. They provide food, fuel, fiber, ornamentations, and medicines, meet other needs, and include some uncultivated species. Yap's tree gardens are relatively self-perpetuating and are tended on an intermittent basis throughout the year.

The second component of Yap's agroforest class consists of taro patches developed in low areas and often connected via water channels. Many varieties of *Cyrtosperma chamissonis* and *Colocasia esculenta* are grown. *Ipomoea aquatica* may be present in deeper areas of some of the larger taro patches.

The tree gardens and taro patches of Yap's agroforests function as a unit and are managed together. The canopy of the tree gardens protects the soil from erosion by the often torrential rainfall, and provides for the recycling of nutrients via the decomposition of leaves and debris. Ditches, often stone lined, drain the tree gardens and direct an aerated flow of water through a system of channels and taro patches, where silt and nutrients are trapped and utilized. The management of these areas involves removal of undesirable species, pruning and general care of useful trees, transfer of accumulated organic matter from fertile low areas to raised areas, and the harvesting and replanting of taro patches.

The third part of the Yapese system involves intermittent gardens of yams (*Dioscorea* spp.) and other crops. Areas of secondary vegetation or forest, found throughout agroforest areas, are usually cleared or partially cleared for such gardens. The common practice is to burn a small area during the dry season.

The opening or "skylight" created is then planted to a variety of crops. With the resultant ash fertilizer and beginning rains, crops generally grow fast and form a multilayered cover over the soil by the time the heavy rains come. After several harvests, these gardens are allowed to go fallow so that the canopy reforms and soil fertility is renewed.

Nonforest

Marshes (M)

Areas of grasses, sedges, and herbs growing in standing water most of the year are classified as marshes. Graminoid marshes give a characteristic smooth texture on the aerial photos. Two types of marshes are demarcated:

- Marsh, saline (M.S)—Areas generally along the coast adjacent to mangroves, or sometimes in depressions, where there are sand or mud flats periodically inundated by salt water or with standing pools of salt or brackish water. Common herbaceous species include *Cyperus javanicus*, *Derris trifoliata* (especially at the edge of mangroves), *Eleocharis* spp., *Fimbristylis* spp., *Paspalum distichum*, *Vigna marina*, and *Wollastonia biflora*. A number of woody species characteristic of strand, swamp forest, and mangrove may surround or be sparsely scattered in such marshes.

- Marsh, freshwater (M.F)—Areas generally located slightly above sea level, often landward of mangroves; or in depressions in upland areas. The vegetation in these areas may consist of tall reeds, especially *Phragmites karka*, sedges, and other herbaceous growth often including *Ludwigia hyssopifolia*, and *L. octovalvis*, and in some areas *Hanguana malayana*. The large fern *Acrostichum aureum* is often present in marshes which are more brackish. Freshwater marshes cultivated for *Cyrtosperma chamissonis* and *Colocasia esculenta* are designated M.F.C. Many taro patches are below the minimal size for mapping or occur in areas identified as agroforest. Our vegetation maps therefore do not reflect the actual area in taro.

Savanna Grasslands (G)

Savanna grasslands are areas of land with a layer of low herbaceous cover. Shrubs and trees, if present, are widely scattered. The soils are generally infertile poorly drained clays. Savanna grassland areas are thought to be the result of destruction of the forest vegetation, particularly by fire, loss of the humus layer, and exposure of the soil to rain and sun. Frequent fires prevent tree species from returning, and the soil becomes more and more degraded.

A number of subtypes of savanna grasslands have been demarcated and are identified by letters following the designation G:

- Bare—Areas with very poor soil, with patches of bare soil intermittent with low herbaceous growth of grasses and sedges or the fern *Gleichenia linearis* (designated G.B).

- Formerly cultivated—Grasslands which are known to have been cultivated recently or in the past, by the Yapese or the Japanese, as indicated by patterns of raised garden beds (designated

G.CA). Occasionally, elevated grave sites may be included in this type, as they give a similar pattern on the aerial photos, but they can be distinguished on the ground. The mapped incidence of abandoned agricultural areas is lower than their actual frequency due to the covering of dense grass, preventing identification.

- **Disturbed**—Land that bears the signs of having been disturbed by recent human activity such as bulldozing. Generally, these areas will remain degraded savanna land, due to the loss of the humus layer (designated G.D).

- **Fern land**—Areas where the predominant cover is a tangled growth of *Gleichenia linearis* fern, sometimes with a mix of other species including *Lycopodium cernuum*. Fires in such areas burn the vegetation completely, selecting against other species, whereas the *Gleichenia* resprouts (designated G.F).

- **Grasses and sedges**—A predominance of graminoid species (designated G.G).

- **Pandanus**—Savanna land with at least 20 percent *Pandanus tectorius* (designated G.P).

- **Shrubs**—Grasslands with a mix of graminoid species and shrubs. Stunted small trees such as *Trichospermum*, *Commer-sonia*, *Alphitonia*, and *Timonius albus* characteristic of the ravine scrub forest may occur. Also commonly found are *Decaspermum fruticosum*, *Myrtella bennigsiana*, *Melastoma malabathricum*, *Nepenthes mirabilis*, *Cassytha filiformis*, *Morinda citrifolia*, *Hyp-tis capitata*, *Scaevola taccada*, *Hedyotis* spp., *Tacca leontope-taloides*, and *Desmodium* spp. (designated G.S).

- **Wetlands**—Grasslands in low areas where the soil is usually very poorly drained. Vegetation is generally low grasses and sedges although some *Pandanus* may be present (designated G.W).

Cropland (C)

Areas of cultivated lands without tree cover. They are usually large sweet potato gardens. Most Yapese open canopy gardens are below the minimal size to be typed and are included with the agroforest or secondary vegetation classes.

Urban (U)

Towns, villages, and areas developed for nonforest use. Where buildings, roads, etc. are interspersed with vegetation, the area may be classed as Urban/Secondary vegetation (U/SV), Urban/Agroforest land (U/AG), Urban/Coconuts (U/AG.CO), Urban/Cropland (U/C), or Urban/Barren (U/B).

Barren (B)

This designation is applied to disturbed areas that lack natural vegetation, because of factors such as rocks, sterile soil, and bulldozing.

Water (W)

Includes both fresh and brackish water and enclosed salt water bays.

GLOSSARY

Agroforest: An area of mixed growth including trees, cultivated for fruit, food, wood, and other products.

D.b.h.: Diameter at breast height. Tree diameter outside bark measured at breast height, 1.3 m above the ground.

Forest land: Land at least 10 percent stocked by live trees and not currently developed for nonforest use.

Land class: A classification of land by major use or major vegetative characteristics.

Nonforest land: Land that has never supported forests or was formerly forested and is currently developed for nonforest use, or degraded.

Secondary vegetation: A vegetative type characterized by small fast-growing trees, which grow in disturbed areas. Vines are often present.

Vegetative types: Areas delineated on the maps as having similar plant composition to one of the types described in the section on type classification.

REFERENCES

- Falanruw, M. V. C. **Marine environment impacts of land-based activities in the Trust Territory of the Pacific Islands.** In: Marine and coastal processes in the Pacific: ecological aspects of coastal zone management; 1980 July 14–17; Univ. of Papua, New Guinea. Jakarta. Pusat, Indonesia: United Nations Educational, Scientific, and Cultural Organization; 1980: 23–47.
- Falanruw, M. V. C. **People pressure and management of limited resources on Yap.** In: McNeely, J. A.; Miller, K. R., ed. The role of protected areas in sustaining society. Proceedings of the World Congress on National Parks; 1982 October 11–22; Bali, Indonesia. Washington, DC: Smithsonian Institution Press; 1982: 348–354.
- Falanruw, M. V. C. **The traditional food production system of Yap Islands.** In: Proceedings, First International Workshop on Tropical Homegardens; 1985 December 2–9; Bandung, Indonesia. Tokyo: United Nations University; 1985: 1–25.
- Fosberg, F. Raymond. **The vegetation of Micronesia.** I. Bull. Amer. Mus. Nat. Hist. 1960; 119: 1–75.
- Fosberg, F. R.; Sachet, Marie-Helene; Oliver, Royce. **A geographical checklist of the Micronesian Dicotyledonae.** Micronesica 15(1–2): 41–295; 1979.
- Hosokawa, Takashide. **A synchrological study of the swamp forests in the Micronesian Islands.** Mem. Facr. Sci., Kyushu Univ. 1952; Ser. E. 1: 101–123.
- Hosokawa, Takashide. **On the Campnosperma forests of Yap, Ponape, and Kusaie in Micronesia.** Mem. Facr. Sci., Kyushu Univ. 1954; Ser. E. 1: 129–243.
- Hunt, Edward E., Jr.; Kidder, Nathaniel R.; Schneider, David M. **The depopulation of Yap.** Human Biology 26(1): 21–51; 1954.
- Moore, Harold E.; Fosberg, F. Raymond. **The palms of Micronesia and the Bonin Islands.** Genetes Herbarium 8(6): 423–478; 1956.

Nicholson, E. M. **Draft checklist of Pacific oceanic islands.** Micronesica 5(2): 327-463; 1969.

Smith, Christopher W. **Soil survey of islands of Yap, Federated States of Micronesia.** Honolulu, Hawaii: Soil Conservation Service, U.S. Department of Agriculture. 1983; 90 p.

Stemmerman, Lani; Proby, Fred. **Inventory of wetland vegetation in the Caroline Islands, volume I.** Pacific Ocean Division, U.S. Army Corps of Engineers; Honolulu, HI; 1978. 231 p.

Underwood, Jane Hainline. **Preliminary investigations of demographic features and ecological variables of a Micronesian island population.** Micronesica 5(1): 1-24; 1969.

Falanruw, Marjorie C.; Whitesell, Craig D.; Cole, Thomas G.; MacLean, Colin D.; Ambacher, Alan H. **Vegetation survey of Yap, Federated States of Micronesia.** Resour. Bull. PSW-21. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1987. 9 p. + 4 maps.

The vegetation of Yap, Federated States of Micronesia, in the western Caroline Islands was mapped for land-use planning, forest resource management, and timber volume surveys. The maps show the location and extent of vegetation types identified from 1976 aerial photographs. Forest area is estimated at 3,882 ha (9,593 acres), with an additional 553 ha (1,366 acres) in secondary vegetation. Twenty-six percent (2,538 ha or 6,272 acres) of the island is used for agroforestry.

Retrieval Terms: vegetation survey, vegetation maps, forest resources, Yap, Federated States of Micronesia, Caroline Islands, Micronesia