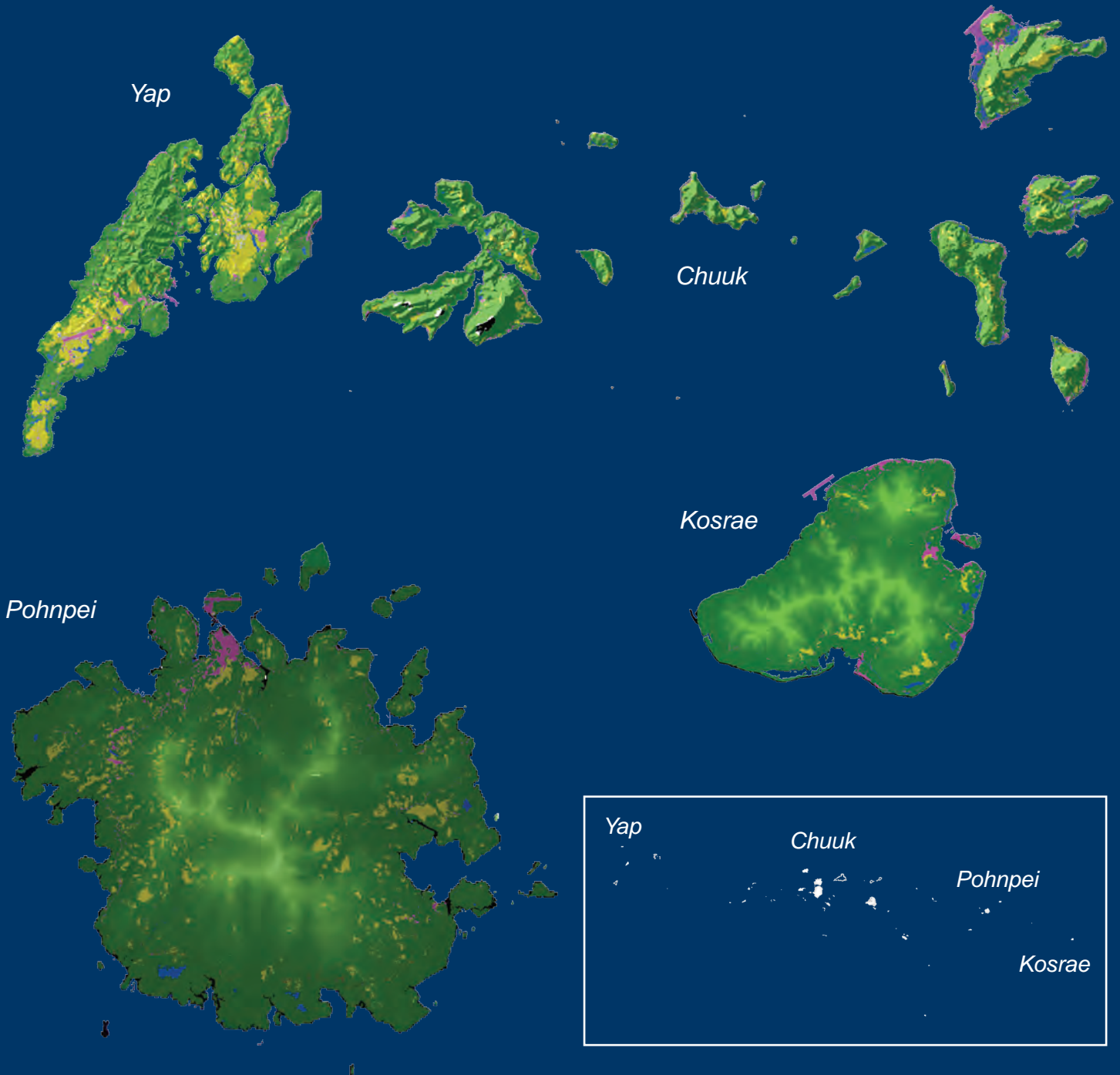


Federated States of Micronesia's Forest Resources, 2006

Joseph A. Donnegan, Sarah L. Butler, Olaf Kuegler, and Bruce A. Hiserote



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Abstract

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The Forest Inventory and Analysis program collected, analyzed, and summarized field data on 73 forested field plots on the islands of Kosrae, Chuuk, Pohnpei, and Yap in the Federated States of Micronesia (FSM). Estimates of forest area, tree stem volume and biomass, the numbers of trees, tree damages, and the distribution of tree sizes were summarized for this statistical sample. Detailed tables and graphical highlights provide a summary of FSM's forest resources and a comparison to prior vegetation mapping and inventory work.

Keywords: Federated States of Micronesia, Kosrae, Chuuk, Pohnpei, Yap, biomass, damage, Forest Inventory and Analysis, forest inventory, volume, land cover.

Summary

The Forest Inventory and Analysis (FIA) program conducted a systematic inventory of the forests of Kosrae, Chuuk, Pohnpei, and Yap in the Federated States of Micronesia (FSM) in 2005 and 2006 to estimate forest area, tree stem volume, biomass, carbon storage, tree damages, and the composition and percentage cover of understory vegetation species. Seventy-three permanent field plots were installed in a variety of forest types. By using recently acquired high-resolution satellite imagery, land cover was mapped into five broad classes: forest, nonforest vegetation, urban, barren, and inland water. Soil survey information was used to help refine the classification of forests. Our estimates for this inventory are derived from a sample based on 161,917 acres on the four main islands in the FSM. Forest covers about 89 percent of the FSM. About 3 percent of the landscape was classified as urban land. We estimated gross tree stem volume to be about 609 million cubic feet for all size classes including seedlings and saplings. Aboveground dry biomass for tree stems 5 inches and greater was estimated to be about 9.2 million tons. Approximately 11 percent of the trees sampled in the inventory had some form of damage. Damage by other vegetation was the most prevalent damage agent, followed by human disturbance. The most frequently identified damage types were lost apical dominance, vines in the crown, and conks. The FSM's forests are characterized by a wide range of tree diameters with relatively high species diversity compared to other Pacific Islands. In total, 96 tree species and 206 understory species were measured on the FIA plots. The average number of tree species per one-sixth-acre plot was seven. Federated States of Micronesia foresters and ecologists were especially helpful with species identification in the field, knowledge of the landscape, and assistance with private and communal land access.

Introduction

This report on the forest resources of the four largest islands of the Federated States of Micronesia (FSM) (fig. 1) was based on a cooperative forest inventory conducted in 2005 and 2006 by the U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest Inventory and Analysis (FIA) program¹ and Pacific Island foresters. This work is an adaptation of the national FIA inventory system and was tailored to help answer local, national, and international questions about the status and trends in tropical forested ecosystems. Our partnership has concentrated on sharing technical forestry skills among cultures and agencies. The fieldwork for this inventory was conducted by a multinational crew including FSM foresters and mainland U.S. foresters and ecologists.

The FIA partnership yielded a systematic, sample-based field inventory for forested lands in the FSM in conjunction with support for updating prior vegetation mapping work (Falanruw et al. 1987a, 1987b; MacLean et al. 1986; Whitesell et al. 1986) that estimated land cover and forest-type area. We also update the resource inventory work of MacLean et al. (1988) and extend the sample to include additional lands, information on understory species composition, detailed tree size distribution, biomass, carbon mass, and damages for living and dead trees. The inventory was designed to provide resource managers with a broad overview of the current situation so they can better manage their forested and nonforested lands, and manage or mitigate any changes in the resource. The summarization of the field data is intended to help managers plan sustainable land use practices as well as plan sustainable supplies of wood, control invasive species and erosion, manage disturbances such as fire, and mitigate damages caused by humans and other animals.

Objectives

The objectives of this inventory are to:

- Estimate the current area of forest land by forest type group and stand size class.
- Estimate tree volume, biomass, and carbon storage by species and diameter class.
- Estimate the numbers of trees affected by damaging agents, such as insects and diseases, and estimate the numbers of dead trees.
- Share measurement and analysis techniques among groups involved in the inventory.

¹ The Forest Inventory and Analysis program is now part of the Resource Monitoring and Assessment program of the Pacific Northwest Research Station.

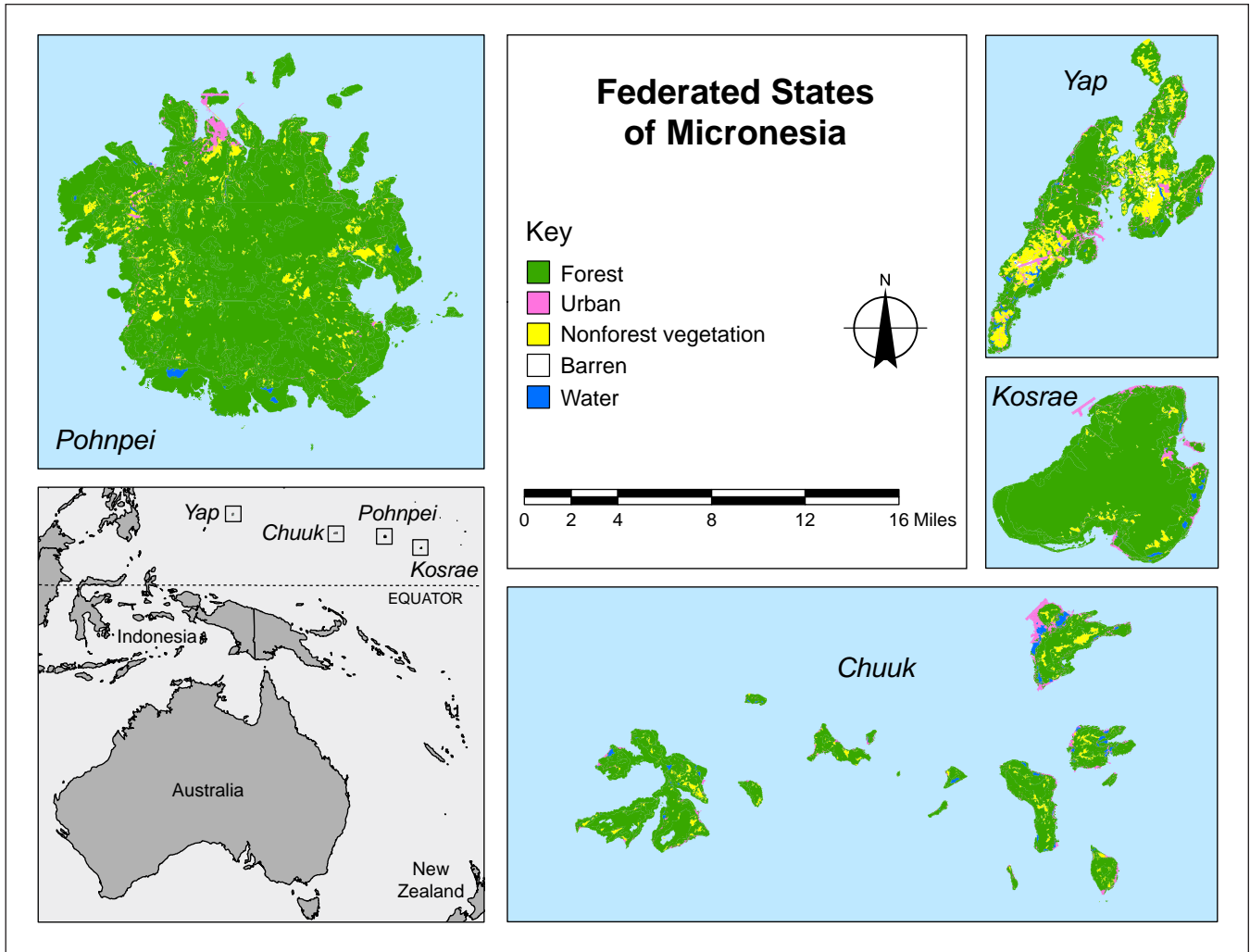


Figure 1—The Federated States of Micronesia, part of the Caroline Islands chain, spans an ocean distance of approximately 1,800 miles east to west in the northwestern Pacific Ocean. Land cover was mapped from 2005 to 2006 QuickBird satellite data. The Forest Inventory and Analysis program collected data on the four largest islands of Chuuk, Kosrae, Pohnpei, and Yap.

Methods

Site Description

The FSM is an independent nation located in the northwestern Pacific Ocean and comprises four primary states: Chuuk, Kosrae, Pohnpei, and Yap. Each state, except Kosrae, has numerous outer islands and atolls that are grouped within the Caroline Islands chain spanning an ocean distance of about 1,800 miles east to west. The land area of the FSM totals about 270 square miles. This forest inventory covers the four largest land masses of Chuuk, Kosrae, Pohnpei, and Yap, making up about 253 square miles (94 percent) of the total land area. The FSM signed a compact of free association with the United States (signed into law in 1986) and regularly partners with U.S. federal agencies toward the goal of sustaining natural resources.

The states within the FSM are distinct in vegetation and culture owing to vast separation by ocean and a corresponding east-west climatic gradient. Although hot and humid across the gradient, trending from west to east (Yap, Chuuk, Pohnpei, to Kosrae) precipitation increases and becomes less seasonal (fig. 2). Temperatures in the western states of Yap and Chuuk show slight seasonal increases for April and May; however, mean monthly temperatures are fairly consistent across states, varying within a narrow range of about 2 °F (fig. 3) (Western Regional Climate Center 2009). The western states of the FSM are adjacent to a typhoon belt and occasionally experience major typhoons. The typhoons are characterized by heavy rainfall, strong winds, and coastal surges that inundate low-lying areas. Recent coastal surges from high sea levels in Kosrae and other low-lying areas (winter 2007–2009) caused severe flooding and coastal erosion. Changes in sea level and the frequency of coastal surges has become an immediate concern for Pacific Island inhabitants.

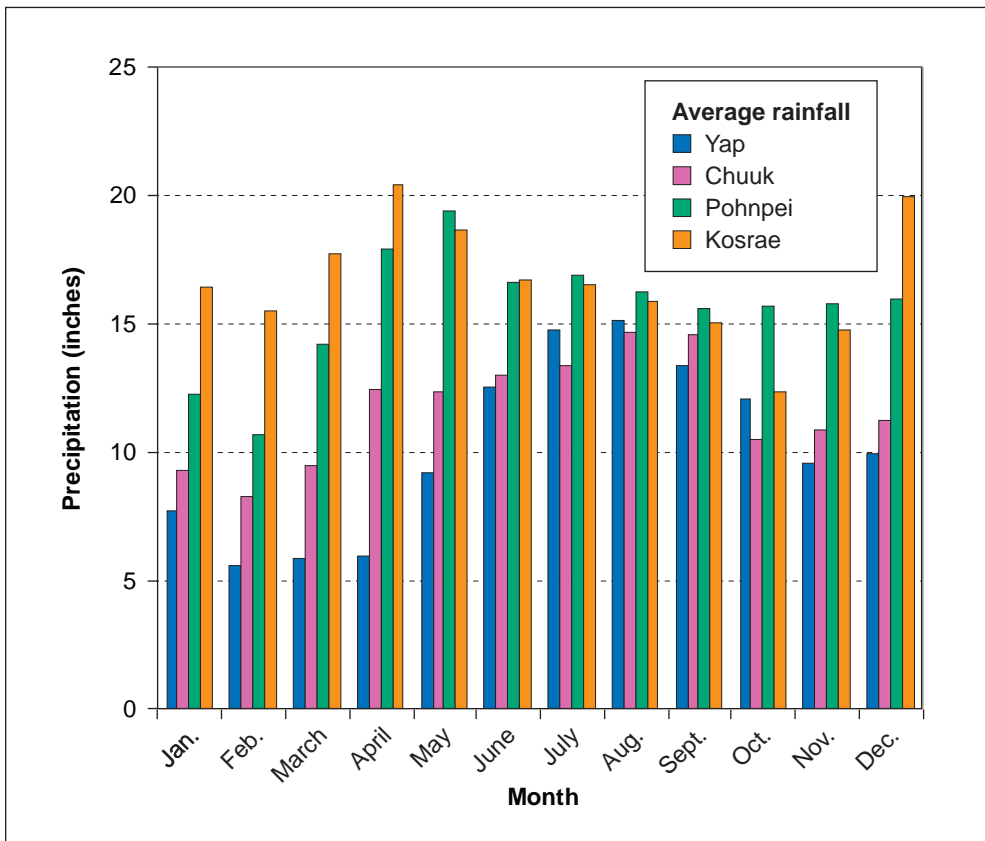


Figure 2—Across the Caroline Islands chain, moving west to east (Yap, Chuuk, Pohnpei, to Kosrae), annual precipitation increases and tends to exhibit less month-to-month variability.

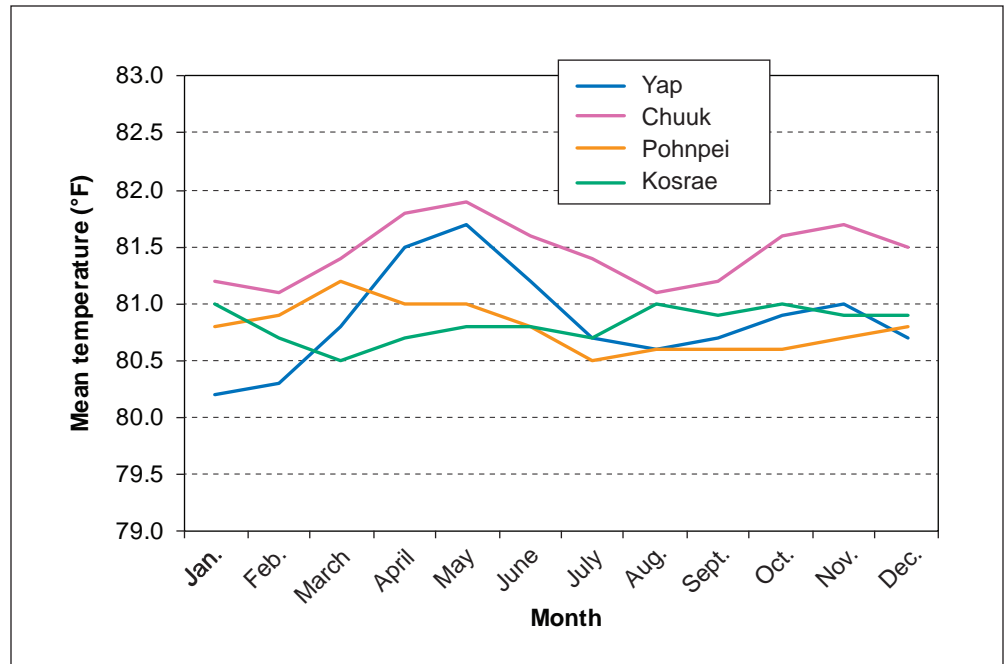


Figure 3—Mean monthly temperatures across the Caroline Islands vary little seasonally (Western Regional Climate Center 2009).

Geologically, the states are distinct. Yap is unique in its gentle topography, geological complexity, and lack of significant limestone exposure. The majority of Yap is composed of volcanic and metamorphic rock with some coral-derived sands and clay mangrove soils along the coastal margins (Mueller-Dombois and Fosberg 1998, Nedachi et al. 2001). Upland soils are generally well-drained, schist-derived loam and clay (Smith 1983). Chuuk is a nearly circular arc of 19 volcanic islands termed an “almost-atoll,” surrounded by a barrier reef (Laird 1983b, Mueller-Dombois and Fosberg 1998). Inland, the topography is steep and rugged with lowland coastal margins of organic peat mangrove soils along with some areas of fine sand. Upland soils are generally well drained with very deep stony silty clay loams (Laird 1983b). Pohnpei is a circular, high volcanic island with steep mountains, rolling hills, and extensive mangrove areas along its margins (fig. 4). Soils in the uplands are well-drained, stony clay loams, whereas those in the lowland mangroves are organic clays (Laird 1982). Kosrae is also a high volcanic island with steep topography and a band of relatively flat lowland coast of extensive mangroves (fig. 5). Upland soils are gravelly silty clay loams with thick silt loams occurring in mangrove areas (Laird 1983a).



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Figure 4—Pohnpei is a high volcanic island with varied topography supporting upland forests at higher elevations and mangrove species at the seaward margins.



Fulaniko Mika

Figure 5—Forest Inventory and Analysis field crews commute to work through Kosrae mangrove forests.

Vegetation Types

The native lowland vegetation has been heavily modified over thousands of years of human activity. Tree gardening and agroforestry has been practiced for millenia by using unique systems of guided vegetation succession and spatial rotation (Raynor and Fownes 1991), resulting in remnant agroforestry species occurring throughout the extensive, formerly settled landscape. Throughout the Pacific Islands, plants used for medicine and food are found in now-remote areas, likely owing to those areas formerly supporting more dense human populations. Most of these agroforest species are found on gently sloping or flat lands. A recent and more alarming trend is to cultivate species of commercial value on steeper slopes at higher elevation (e.g., kava), where forests are more intact and soils are much more likely to erode.

The vegetation types described below use the mapping work of Liu and Fischer (2007) as the basis for classification with the species composition derived by overlaying the 2005–2006 forest inventory plot data onto the mapped types. In our current classification systems, we avoid the terms “primary” and “secondary” forest; these terms suggest a dichotomy between disturbed and undisturbed forest, when in reality, these forests have been disturbed by humans multiple times over several thousand years. Additionally, the history of land use is uncertain, as is the time required to recover from secondary back to an undocumented primary forest.

Upland forest—

At higher elevations, especially on Pohnpei and Kosrae, dense native rain forest remains. Yap and Chuuk upland forest exists as patchy native remnants (Mueller-Dombois and Fosberg 1998). Listed in descending abundance (as is the case for all forest types in this section) the following species were found on forest inventory plots within the areas mapped as upland forest: *Eugenia stelechantha*, *Hibiscus tiliaceus*, *Spathodea campanulata*, *Cananga odorata*, *Pandanus cominsii*, *Commersonia bartramia*, *Cyathea* spp., *Exorrhiza ponapensis*, *Musa* spp., *Aglaia ponapensis*, *Camptosperma brevipetiolata*, *Horsfieldia nunu*, *Adenanthera pavonina*, *Macaranga carolinensis*, *Myristica insularis*, *Elaeocarpus carolinensis*, *Parinari laurina*, *Cyathea ponapeana*, *Ficus tinctoria*, *Pterocarpus indicus*, *Barringtonia racemosa*, *Dendrocnide harveyi*, *Ficus prolixa*, *Glochidion* spp., *Syzygium carolinense*, *Antidesma kusaiense*, *Ficus* spp., *Elaeocarpus kusanoi*, *Claoxylon carolinianum*, *Premna* spp., *Premna obtusifolia*, *Neubergia celebica*, *Pandanus tectorius*, *Semecarpus venenosus*, *Barringtonia asiatica*, *Pangium edule*, *Mangifera indica*, *Artocarpus altilis*, *Timonius* spp., *Antidesma* spp., *Ponapea hosinoi*, *Garcinia rumiyo*, *Psychotria* spp., *Pandanus* spp., *Diospyros ferrea*,

Morinda spp., *Rhus taitensis*, *Cocos nucifera*, *Cycas* spp., *Trichospermum ikutai*, *Araucaria* spp., *Fagraea berteriana*, *Ptychococcus ledermanninus*, *Calophyllum inophyllum*, *Aidia cochinchinensis*, *Cinnamomum* spp., *Pittosporum* spp., *Inocarpus fagifer*, *Cerbera manghas*, *Pandanus dubius*, *Cinnamomum carolinense*, *Cynometra ramiflora*, *Eugenia* spp., *Palaquium karrak*, *Ponapea ledermanniana*, and *Macaranga* spp.

Palm forest—

Dominant species found on FIA plots that were mapped as palm forest include *Exorrhiza ponapensis*, *Aglaia ponapensis*, *Cyathea* spp., *Eugenia* spp., *Pandanus cominsii*, *Sterculia palauensis*, *Syzygium carolinense*, *Camptosperma brevipetiolata*, *Myristica insularis*, *Aidia cochinchinensis*, *Cananga odorata*, *Cinnamomum carolinense*, *Garcinia ponapensis*, and *Timonius* spp.

Disturbed forest—

This forest type has been heavily disturbed recently and contains a mixture of native and nonnative species representing forests recovering from disturbance, native forests invaded by nonnatives, and forests that are establishing in disturbed areas from a mix of seed sources. Tree species include *Hibiscus tiliaceus*, *Horsfieldia nunu*, *Elaeocarpus carolinensis*, *Adenanthera pavonina*, *Morinda citrifolia*, and *Neubergia celebica*.

Mangrove forest—

Mangroves occur around the coasts of most islands in the FSM. They help to buffer storms, preserve the coastline, and offer wood and food resources. Dominant species found within this type are *Bruguiera gymnorrhiza*, *Scyphiphora hydrophyllacea*, *Xylocarpus granatum*, *Rhizophora mucronata*, *R. apiculata*, *Sonneratia alba*, *R. stylosa*, *Lumnitzera littorea*, *Hibiscus tiliaceus*, *Pandanus tectorius*, *Rhizophora* spp., *Morinda citrifolia*, *Thespesia populnea*, and *Calophyllum inophyllum*.

Agroforest—

Agroforest in the tropical Pacific is characterized by an abundance of fruit and nut trees interspersed with other canopy species. Agroforest tends to occur within and near settlements. Some of the most common species found in this forest type include *Hibiscus tiliaceus*, *Musa* spp., *Cananga odorata*, *Artocarpus altilis*, *Macaranga carolinensis*, *Glochidion* spp., *Areca catechu*, *Barringtonia racemosa*, *Cocos nucifera*, *Rhus taitensis*, *Pandanus* spp., *Mangifera indica*, *Premna obtusifolia*, *Horsfieldia nunu*, *Swietenia mahogoni*, *Bruguiera gymnorrhiza*, *Averrhoa bilimbi*, *Morinda citrifolia*, *Aidia cochinchinensis*, *Inocarpus fagifer*, *Heterospathe elata*,

Heritiera littoralis, *Rhizophora apiculata*, *Pandanus tectorius*, *Ficus prolixa*, *Pterocarpus indicus*, *Sonneratia alba*, *Citrus reticulata*, *Toona ciliata*, *Calophyllum inophyllum*, *Exorrhiza ponapensis*, *Adenantha pavonina*, *Cyathea* spp., *Commer-sonia bartramia*, *Pittosporum* spp., *Swietenia macrophylla*, *Allophylus timorensis*, *Eugenia* spp., *Ficus* spp., *Musa nana*, *Swietenia* spp., and *Carica papaya*.

Inventory Methods

The FSM inventory was based on the FIA inventory design that was implemented across the mainland United States beginning in 2000. We adapted the national design to include additional branching and rooting forms, additional tree crown measurements, and special-interest species ranging from invasive plants to pathogens to culturally or economically important species of various life forms. Additionally, we used topography to define site productivity or drought resilience (for perhumid climates). In the mainland FIA program, plots are spaced within forest land on a 3.3-mile grid. With the assistance of the government of the FSM, plots were spaced across all vegetation types at about 1.9-mile intervals, yielding a triple intensification of the mainland inventory plot grid.

The FIA plot cluster is composed of four 24-foot-radius subplots (fig. 6). Three of those subplots are equally spaced, as if on spokes of a wheel, around the central subplot. The distance from the middle of the central subplot to the middle of each subplot on the three spokes is 120 feet.

A variety of information was collected at the plot, subplot, and tree level (USDA FS 2005). Differences in forest-type conditions are also mapped. For example, roads that intersect subplots are mapped, as are clear boundaries in forest tree size classes. The primary variables collected include plot location, slope, aspect, elevation, subplot slope position and shape, tree species, diameters, heights, damages, branching and rooting forms, decay, epiphytic loadings, crown characteristics, tree locations, and regeneration information. The fieldwork for this inventory was performed in February 2005 and January to April 2006.

Analysis Methods

The FIA estimates that are derived for forest land are based on a system that uses aerial photography or satellite imagery to define different types of land (strata) across the landscape. The simplest stratification is separating land into forest and nonforest strata. However, stratifications can be assisted or refined by using ancillary data such as topography, soil information, life zone or climatically based information, and prior inventories of vegetation groups. Because boundaries and research questions often change through time, FIA generally chooses to post-stratify the plot sample by using a consistent spatial distribution of plots across forested landscapes.

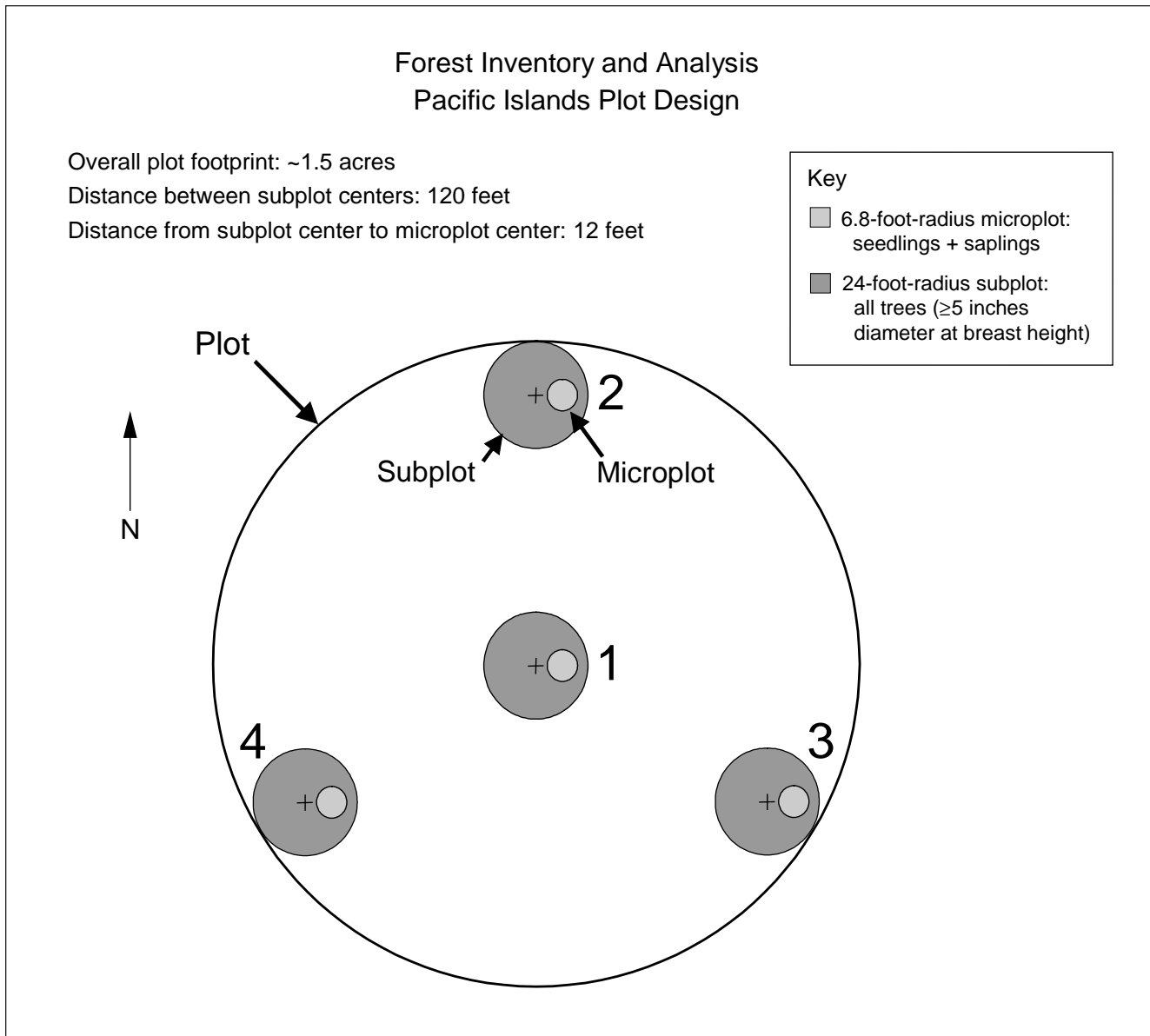


Figure 6—The plot design used for the continental U.S. Forest Inventory and Analysis program was adopted with slight simplification for the inventory in the Pacific Islands.

The FSM stratification for estimating numbers of trees, volume, biomass, and carbon was conducted via a classification of 2005–2006 QuickBird satellite data. The initial land-cover classification divided the landscape into forest, urban, nonforest vegetation, barren, and water land types. At least 10 percent tree cover was used as the basis for the forest-land classification, and includes both agroforests and mangrove forests. Nonforest vegetation includes other vegetation types with less than 10 percent tree cover. A geographic information system was used to sum acreage for each type. The acreage each field plot represents was derived by

dividing the total acreage of forest by the number of field plots. Adjustments were made for plots that could not be visited owing to hazardous conditions or denial of access. Average stand size (mean diameters of trees) was expanded from the plots to the landscape level by using the same expansion factors. Note that the FIA stratification area differs from that of the area mapped for detailed vegetation classification.

Wood volume was estimated for individual trees by approximating the centroid method (Wood et al. 1990, Yavuz 1999) using tree height and two stem diameter measurements. These measurements are expanded to tree-level volume estimates by using equations for sections of a cone. Both gross stem volume and net stem volume estimates were calculated. Net stem volume subtracts damage and rotten defects from gross stem volume. Biomass for individual tree stems was estimated by using the specific gravity for known species (13 out of 101 species in the FSM had known specific gravities). For species where specific gravity was not known, an average specific gravity of 0.5 grams per cubic centimeter was used. These estimates of aboveground tree biomass are derived from bole volume and include only biomass for the main stem, excluding branches, roots, and foliage.

Traditional site productivity estimates require forest stand age, derived from the annual rings of forest trees. Because tropical trees do not produce consistent annual rings, a modified topographic relative moisture index (TRMI) (Parker 1982) was examined as a proxy for site productivity. The TRMI used a weighted, additive combination of slope steepness, slope shape, and slope position to assess the potential moisture retention in a forested stand. Remeasurement data from these plots at the next inventory cycle will provide a better estimate of productivity than TRMI. In very wet environments, TRMI may be best considered a drought-resilience proxy, predicting where soil and water accumulates, owing to topography, across a landscape. We also recognize moisture is not likely to be the only factor limiting tree growth and that a prolonged excess of moisture can be detrimental to the growth of many tree species. In highly porous limestone-derived soils and karst topography, drainage may occur very rapidly, making moisture channeling less important than substrate water retention.

Forest-type mapping was conducted independently by the Pacific Southwest Region's Remote Sensing Lab (S&PF-RSL) with support from FIA. Land cover polygons were generated from QuickBird imagery and labeled with assistance from FSM foresters. The 2005–2006 QuickBird satellite imagery was used for the detailed mapping and served as the basis for land cover estimates.

Reliability of FIA Data

The area of forested land cover types classified from the QuickBird satellite imagery was assumed to be accurate and used as the basis for the expansion of the numbers of trees, tree volume, and tree biomass from the plot to the forest-type scale. Possible sources of error not accounted for in our estimates include errors in the land cover map owing to incorrect interpretation of the image, errors from rounding when working with pixel-based imagery, and measurement errors on field plots. Standard errors for the expansion of our estimates from field plots to the forested landscape were calculated according to the proportion of area occupied by forest. Forest areas were treated as known rather than estimated, and variance was calculated by using methods in Cochran (1977). Using one standard error as our basis for evaluation gives a 68 percent chance that the true total gross tree stem volume for the FSM lies between 508.4 and 645.8 million cubic feet. There is a 68 percent chance that the true number of trees (>1 inch diameter) for the FSM lies within the range of 86,180,204 to 102,070,530. Readers are cautioned to examine the standard errors associated with species-level estimates for the number of individuals and volume by tree species in table 1.

Resource Highlights

Land Cover

The FSM is currently about 89 percent forested, which includes agroforest and plantation forest vegetation (fig. 7, table 2). About 3 percent of the landscape was classified as urban land including roads, and about 9 percent was classified as nonforest vegetation including savanna and agricultural lands. The area used for land cover estimates totaled 161,917 acres.

Prior vegetation surveys (Falanruw et al. 1987a, 1987b; MacLean et al. 1986; Whitesell et al. 1986) delineated vegetation types by using 1975 and 1976 aerial photography, and estimated forest cover to be 83 percent of total land, including agroforest and plantations (fig. 7, table 2). About 1 percent of the land area was classified as urban. Nonforest vegetation was estimated to be about 15 percent of the total land cover. Total acreage from the 1986–1987 maps was 147,248 acres, calculated from the original maps that FIA scanned and digitized with support from S&PF-RSL.

Note that the methodology and the area sampled for land cover estimates differ from those used for prior estimates. The 1986–1987 work defined forested lands on the basis of a canopy cover of approximately ≥ 30 percent. The recent effort used a forest-land canopy threshold of ≥ 10 percent to remain consistent with recent FIA

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees in the Federated States of Micronesia

Scientific name	Common names	Number measured	Estimated number (≥ 1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥ 5 inches diameter)	Standard error for estimated volume (±)
<i>Adenanthera pavonina</i> L.	metkam	38	1,339,253	803,501	25,859,494	17,409,140
<i>Aglaia ponapensis</i> Kaneh.	karasyu, marasau	30	2,427,270	705,723	4,116,025	3,092,672
<i>Aidia cochinchinensis</i> Lour.	kahmant	5	203,862	168,963	362,429	219,350
<i>Allophylus timorensis</i> (DC.) Bl.	kitak, nguh, lah, ngu, angel, ngo	1	11,365	13,226	499,009	580,723
<i>Antidesma kusaiense</i> Kanihira		4	479,342	438,769	132,130	81,687
<i>Antidesma</i> spp. L.		1	221,861	212,128		
<i>Araucaria</i> spp. Juss.		3	35,959	39,330	234,005	255,943
<i>Areca catechu</i> L.	pu, buu, pu	23	912,405	988,802	860,963	749,043
<i>Artocarpus altilis</i> (Park.) Fosb.	mai, kuru, mos, sou, maouli, mai	60	2,354,974	878,232	20,225,035	4,890,004
<i>Averrhoa bilimbi</i> L.	kumim	5	187,027	189,719	125,685	97,766
<i>Barringtonia asiatica</i> (L.) Kurz	wi, kawausu, bus-bus, gul, kun	5	334,581	339,691	168,378	132,687
<i>Barringtonia racemosa</i> (L.) Spreng.	wihnmoar, kange, kaengal, waathul, son	29	1,428,024	938,652	1,453,897	780,136
<i>Bruguiera gymnorrhiza</i> (L.) Lam.	lom, tongo, alol, song, ong	56	2,181,056	995,557	17,129,767	7,609,627
<i>Calophyllum inophyllum</i> L.	tetau, isho, voi, eet, eetuh, ragich, biyuch, rekich	7	73,376	47,211	5,919,333	5,617,324
<i>Camposperma brevipedunculata</i> Volk.	thong, elak, ka, ramluw,	57	1,675,205	635,247	45,629,068	18,033,930
<i>Cananga odorata</i> (Lam.) Hook. f. & Thoms.	pwurenwai, ilanlang, rekich	109	5,296,449	2,609,831	8,669,129	3,382,801
<i>Carica papaya</i> L.	mohmiyap, es, bweibwai, kippwau	1	10,207	12,820	49,418	62,066
<i>Cerbera manghas</i> L.	sos	1	17,810	17,029	82,349	78,736
<i>Cinnamomum carolinense</i> Koidz.	mattieu, masro,	2	31,147	20,996	212,191	143,771
<i>Cinnamomum</i> spp. Schaeff.		2	23,973	26,220	996,372	1,089,782
<i>Citrus reticulata</i> Blanco	musrisrik, goligao	5	51,036	64,099	202,041	253,754
<i>Claoxylon carolinianum</i> Pax & Hoffm.	koe	4	459,919	489,578	27,830	30,439
<i>Cocos nucifera</i> L.	niu, koanu, nu, lu	55	739,566	218,516	14,372,677	4,904,53
<i>Commersonia bartramia</i> (L.) Merr.	acarido, kahil, gagu, wapof, oun, tupuchol	32	2,410,929	1,788,203	703,963	542,480
<i>Cyathea ponapeana</i> (Hosok.) Glassman	kattar, po	32	795,537	510,393	1,789,392	1,027,413
<i>Cyathea</i> spp. Sm.		98	2,804,841	831,970	4,366,251	1,377,995
<i>Cycas</i> spp. L.		3	53,431	51,088	172,062	164,514
<i>Cynometra ramiflora</i> L.	kameu	1	11,986	13,110	1,141,934	1,248,991
<i>Dendrocnide harveyi</i> (Seem.) Chew		5	701,203	670,443	123,334	117,924
<i>Diospyros ferrea</i> (Willd.) Bakh.	aringal	1	115,917	153,932		
<i>Elaeocarpus carolinensis</i> Koidz.	syatak, nanek	31	883,929	363,601	13,110,429	5,921,034
<i>Elaeocarpus kusanoi</i> Kaneh.	maratte, opop	5	471,906	502,683	96,089	73,820
<i>Eugenia</i> spp. L.		5	519,874	407,975	503,111	305,334
<i>Eugenia stelechantha</i> (Diels) Kaneh.	kirekinwel, kahkarak, fukunnes, attieu	35	6,395,722	2,207,462	1,909,369	1,774,315
<i>Exorrhiza ponapensis</i> (Becc.) Burret	kotop	290	5,147,637	1,948,624	67,694,269	25,387,057
<i>Fagraea berteriana</i> (Gilg & Bened.) Fosb.	sair, seir	3	35,959	39,330	140,943	154,156
<i>Ficus prolixa</i> Forst. f.	aoa, konya, giliau, aow, au	27	668,597	421,068	41,649,426	22,661,059
<i>Ficus</i> spp. L.		6	484,337	460,650	205,222	221,093

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees in the Federated States of Micronesia (continued)

Scientific name	Common names	Number measured	Estimated number (≥ 1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥ 5 inches diameter)	Standard error for estimated volume (±)
<i>Ficus tinctoria</i> Forst. f.	ahwahn, neen, shara, guwan, wach'guy, auwon	14	754,712	391,199	2,140,139	1,708,633
<i>Garcinia ponapensis</i> Laut.	konpuil	1	19,161	16,400	110,053	94,198
<i>Garcinia rumiyo</i> Fosb.	rumiyo	4	143,833	175,965	107,363	89,524
<i>Glochidion</i> spp. J.R. & G. Forst.		21	1,575,214	853,365	1,018,690	463,092
<i>Heritiera littoralis</i> Dry.	marapinset, lum, rung, zwobott	5	95,804	82,001	5,336,822	4,567,946
<i>Heterospathe elata</i> (Becc.) Becc.	buag bbuag	11	125,012	145,484	412,692	480,272
<i>Hibiscus tiliaceus</i> L.	hau, kalau, lo, hulifui, gaal, sinifo	263	14,039,298	4,215,739	16,173,212	3,320,774
<i>Horsfieldia numu</i> Kanehira		77	1,698,764	496,994	27,800,080	11,156,776
<i>Inocarpus fagifer</i> (Park.) Fosb.	marrup, clark, buoy, anilla, kurrak	9	144,941	102,316	11,059,267	9,182,993
<i>Lumnitzera littorea</i> (Jack) Voigt	weingal, oi, wei, wei, achoro	10	484,723	418,671	251,344	220,690
<i>Macaranga carolinensis</i> Volk.	apwid, lo-lep, bith, aput	36	2,966,667	1,282,088	979,942	496,943
<i>Macaranga</i> spp.		1	9,306	12,357	22,481	29,854
<i>Mangifera indica</i> L.	kangit, mango, manga, manko	27	700,408	355,544	10,961,411	5,755,859
<i>Morinda citrifolia</i> L.	weipwul, nonu, hi, lel, mangalueg, nen, nopur	6	197,874	167,431	467,478	439,133
<i>Morinda</i> spp. L.		1	115,917	153,932		
<i>Musa nana</i> Lour.	tama	1	11,365	13,226		
<i>Musa</i> spp.		186	5,042,577	1,956,899		
<i>Myristica insularis</i> Kaneh.	karara	43	1,086,235	411,630	19,402,716	7,996,061
<i>Neubergia celebica</i> (Koord.) Leenhouts	toa	11	392,362	240,448	813,126	750,430
<i>Palaquium karrak</i> Kanehira		1	11,986	13,110	2,658,754	2,908,014
<i>Pandanus cominsii</i> Hemsl.	matal	19	3,015,649	1,052,041		
<i>Pandanus dubius</i> Spr.	pakoa, kipar-n-ai, meu yok, poak	1	17,810	17,029	48,912	46,767
<i>Pandanus</i> spp.		18	687,860	447,576	718,380	493,207
<i>Pandanus tectorius</i> Park.	hara, fach, choi,	15	608,153	531,836	326,277	308,701
<i>Pangium edule</i> Reinw. ex Bl.	durien, rowal,	8	329,103	253,349	549,840	465,047
<i>Parinari laurina</i> A. Gray	ais, aset, adidi, gritin, ais	17	811,308	540,527	7,145,580	6,285,489
<i>Pittosporum</i> spp.		3	43,134	30,927	1,304,043	1,106,261
<i>Ponapea hosinoi</i> Kaneh.	kattai	7	221,229	241,969	353,596	386,746
<i>Ponapea ledermanniana</i> (Becc.) Engl.	kattai	1	11,986	13,110	225,861	247,036
<i>Premna obtusifolia</i> R. Br.	sobuk, orr, varovaro, fienkek, yar, umukau, nior	15	726,977	320,508	652,354	277,952
<i>Premna</i> spp.		3	447,933	359,280		
<i>Psychotria</i> spp.		3	143,033	167,159	135,466	110,093
<i>Pterocarpus indicus</i> Willd.	lach	19	785,158	749,182	4,672,783	3,122,428
<i>Ptychococcus ledermanninus</i> (Becc.) Moore & Fosb.		2	35,621	21,985	101,340	63,308
<i>Rhizophora apiculata</i> Bl.	aak, akapa, sakasrik	45	837,690	436,295	22,669,970	15,876,614
<i>Rhizophora mucronata</i> Lam.	akelel, karak, chia, roway, chia	45	862,236	465,366	15,250,735	7,354,870
<i>Rhizophora</i> spp.		7	108,338	106,919	326,644	322,368
<i>Rhizophora stylosa</i> Griff.		28	536,502	459,208	2,817,206	2,411,331

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees in the Federated States of Micronesia (continued)

Scientific name	Common names	Number measured	Estimated number (≥ 1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥ 5 inches diameter)	Standard error for estimated volume (±)
<i>Rhus taitensis</i> Guill.	g'lad, garahde	6	693,553	460,097	37,777	43,963
<i>Scyphiphora hydrophyllacea</i> Gaertn.	gause	13	1,449,774	1,687,179	93,584	108,908
<i>Semecarpus venenosus</i> Volk.	changath changad	25	339,250	246,982	1,890,877	1,209,349
<i>Sonneratia alba</i> J.E. Sm.	kwat, kotoh, folofol, abruk, sales	33	798,105	370,042	79,820,773	31,200,032
<i>Spathodea campanulata</i> Beauv.	rarningobchey	64	2,964,321	3,080,768	5,488,522	3,733,399
<i>Sterculia palauensis</i> Kaneh.		6	334,485	286,296	699,181	598,450
<i>Swietenia macrophylla</i> King		1	19,161	16,400	170,104	145,597
<i>Swietenia mahogoni</i> (L.) Jacq.	moakumi, mahogany	3	294,501	342,726	98,140	114,211
<i>Swietenia</i> spp. Jacq.		1	11,365	13,226	77,665	90,383
<i>Syzygium carolinense</i> (Koidz.) Hosokawa		9	746,546	350,374	826,586	511,372
<i>Thespesia populnea</i> (L.) Sol. ex Correa	miro, pone, panu, bangbeng, pona, okuran, likokon	1	15,477	15,274	35,660	35,193
<i>Timonius</i> spp. DC.		4	262,981	308,580	907,972	922,882
<i>Toona ciliata</i> Roem.		2	38,322	32,801	1,035,450	886,273
<i>Trichospermum ikutai</i> Kaneh.	wapof	4	37,222	30,269	273,212	266,689
Unknown		36	2,918,095	1,389,279	11,523,242	4,866,782
Unknown 0		3	57,482	49,201	1,441,593	1,233,903
Unknown 14		1	115,917	153,932		
Unknown 20		2	125,222	166,290	38,188	50,712
Unknown 5		1	141,568	164,750		
<i>Xylocarpus granatum</i> Koen.	brok, pwulok, ploek brok, tui, yamgur, punopun	48	918,673	419,361	34,716,711	15,217,940
Total		2,324	94,125,367	7,945,163	577,122,816	68,712,655

work in American Samoa, Guam, Palau, and the Northern Mariana Islands. The current survey mapped roads as urban land. Although the differences in interpretation methods and canopy cover thresholds between 1986/1987 and 2006 must be considered, trends suggest some conversions to urban land.

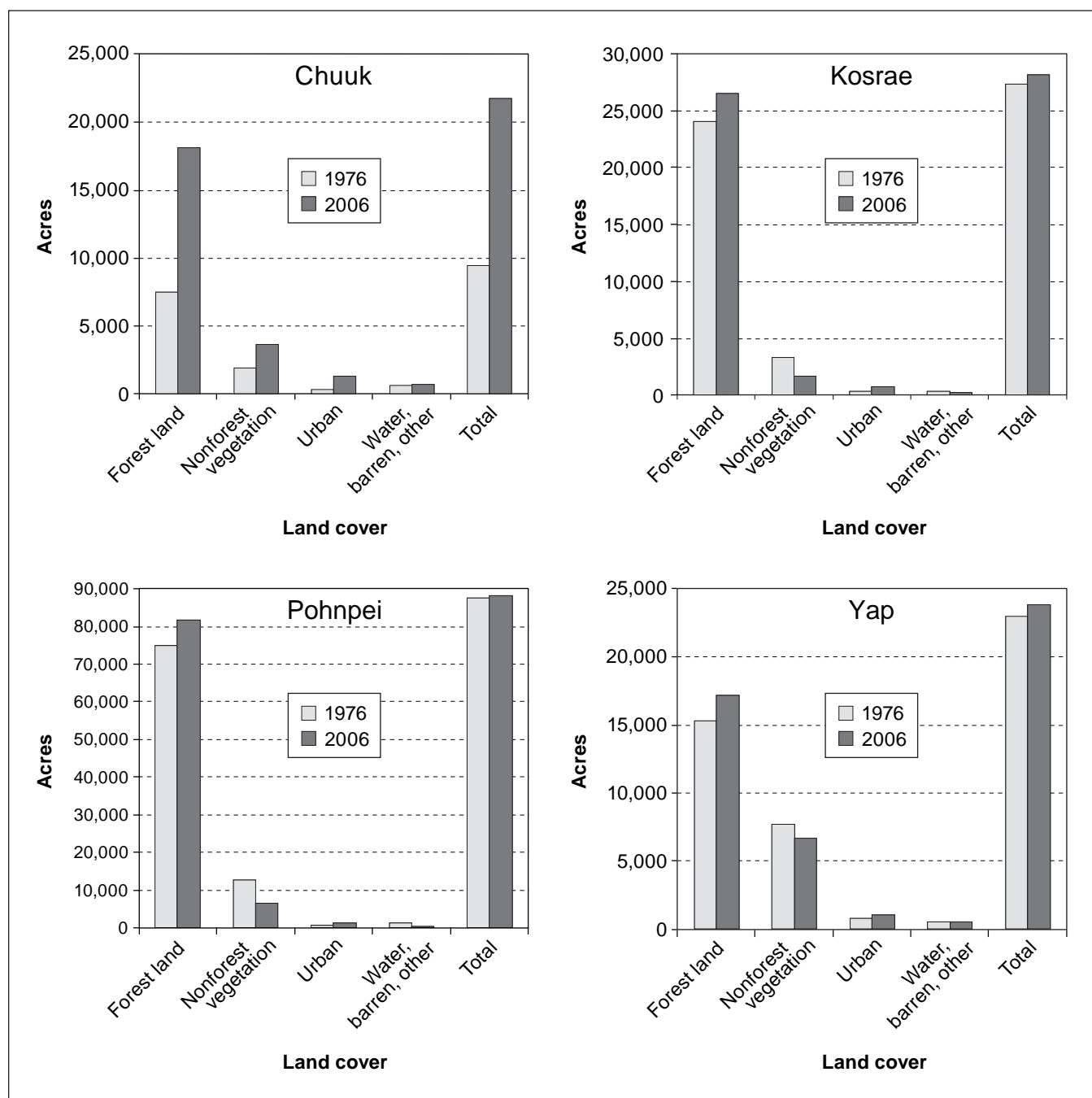


Figure 7—Slight increases in urban lands are evident throughout the Federated States of Micronesia over the 30-year period between 1976 and 2006. However, making direct comparisons among the area of forested and nonforested land between inventories is complicated because of slightly different forest land definitions that were based on different tree cover percentages at each point in time.

Table 2—Estimated area by land cover by island in the Federated States of Micronesia, 1976^a and 2006^b

	1976						2006				
	Chuuk	Kosrae	Pohnpei	Yap	Total		Chuuk	Kosrae	Pohnpei	Yap	Total
Land cover: ^c	<i>Acres</i>					Land cover: ^c	<i>Acres</i>				
Upland forest	1,547	14,470	41,869	6,260	64,146	Upland forest	4,145	18,231	48,300	7,731	78,407
Palm forest	5		4,261		4,266	Palm forest	195		4,526		4,721
Swamp forest		1,282	1,040	384	2,706	Swamp forest		1,128	244	62	1,433
Mangrove	730	3,608	13,668	2,810	20,816	Mangrove forest	3,180	3,452	13,982	2,636	23,249
Agroforest	5,229	4,535	14,057	5,790	29,611	Agroforest	10,614	3,686	14,608	6,748	35,655
Dwarf forest		171	3		174						
Atoll forest			13		13						
Plantation forest	2		15		17						
Coconut plantation			307	390	697						
Forested subtotal	7,514	24,066	74,926	15,244	121,749	Forested subtotal	18,134	26,496	81,659	17,176	143,466
Nonforest vegetation:						Nonforest vegetation:					
Grassland or savanna	400	41	3,590	4,980	9,011	Savanna or other shrub/grass	684	15	2,440	4,094	7,233
Secondary vegetation	610	2,640	6,768	1,357	11,375	Disturbed vegetation	771	650	2,214	984	4,619
Cropland	5	5	189	109	307	Cropland	147	4	29	14	195
Urban land	316	291	591	754	1,952	Urban builtup	774	313	972	721	2,780
Unclassified	12	10	930	17	969	Urban cultivated	527	438	440	299	1,705
Strand	10				10						
Barren	13	6	5	18	41	Barren	43	40	14	184	280
Marsh	555	63	429	394	1,440	Water	140	56	80	22	299
Water	8	244	55	86	393	Marsh	549	151	330	310	1,341
Nonforest subtotal	1,929	3,300	12,556	7,713	25,499	Nonforest subtotal	3,636	1,667	6,519	6,629	18,451
Total	9,443	27,366	87,482	22,957	147,248	Total	21,770	28,163	88,179	23,805	161,917

^a Figures for maps derived from 1976 aerial photography differ slightly from those published by Falanruw et. al (1987a, 1987b), Whitesell et al. (1986), and MacLean et al. (1986). Figures here were derived by scanning the historical maps and aggregating area totals with a geographic information system.

^b Figures for 2006 were summarized from the work of Liu and Fischer (2006), aggregating area totals with a geographic information system.

^c Note that classification schemes differ slightly from the 1986/1987 to 2006 map summaries. Additionally, the area surveyed, the imagery, and the methodology differ such that detailed change detection is not possible across land cover maps.

Productivity and Drought Resilience

Site productivity estimates are difficult to obtain in tropical environments because of a lack of consistent annual tree rings. The standard premise for site productivity hinges on determining how height or diameter changes with respect to tree age under particular site conditions; depending on site quality, a given tree species is expected to grow to a certain diameter or height given a certain age. Remeasurement of individual trees at the next inventory cycle will provide better estimates of site productivity by using growth over the specific period. For the present work, we estimated productivity as an additive index based on a site's potential moisture accumulation owing to local topography (TRMI) (Parker 1982). The topographic relative moisture index may have utility in very wet environments as a predictor of resilience to occasional drought, because TRMI predicts moisture accumulation (and likely sediment/soil accumulation as well) based on topography. By using TRMI in this context, we classified about 46 percent of the forested lands in the FSM as highly drought resilient (fig. 8). Given the prevalence of steep slopes throughout Pohnpei, Chuuk, and especially Kosrae, water tends to run off and the potential for moisture accumulation lies in flat lands.

In a region of high precipitation, such as the FSM, the TRMI estimate of productivity may be less reliable than productivity estimates based on detailed soil sampling and mapping. For example, differences among coarse upland and clay lowland soils are dramatic with respect to soil organic matter and water holding capacity.

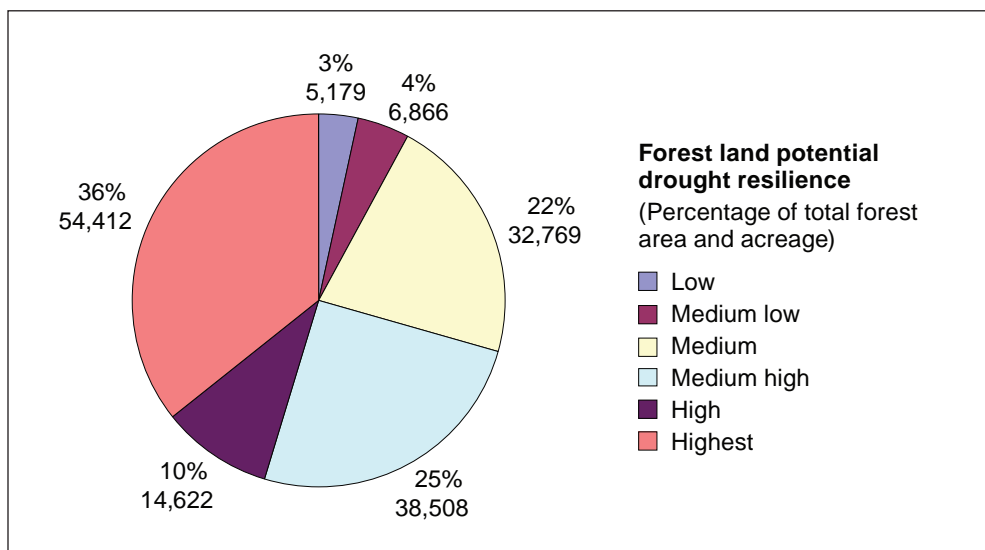


Figure 8—A topographic relative moisture index was used to predict drought resilience in the perhumid climate of the Federated States of Micronesia. Owing to the steep topography on Pohnpei, Kosrae, and Chuuk, water runs off quickly.

Forest Structure

In the FSM, we estimated stand size class on forested field plots to capture the predominant diameter of live trees in forest stands. The dominant size class (64 percent of acreage) tends to be medium sized, in the 5- to 10.9-inch diameter category (fig. 9, table 3). About 31 percent of acreage is made up of stands in the 11- to 19.9-inch category, and only about 2 percent of acreage is dominated by very large trees in the 20- to 39.9-inch category. The smallest diameter class (less than 5 inches) represented about 3 percent of the forested acreage.

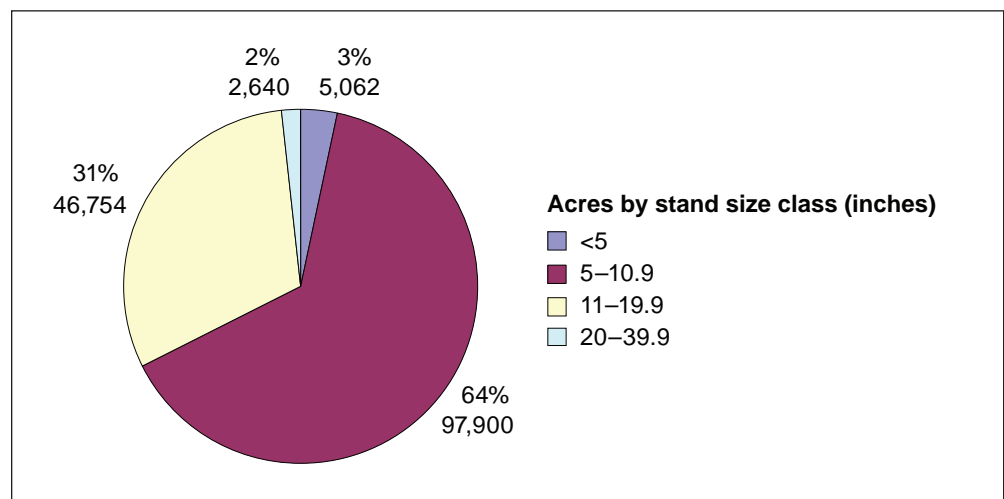


Figure 9—The stands that characterize the Federated States of Micronesia’s forests tend to be composed of larger diameter trees in the 5- to 10.9- and 11- to 19.9-inch categories.

The diameter distribution for trees in the FSM shows a “reverse-J” distribution for tree diameters, demonstrating that regeneration is abundant (fig. 10). Larger diameter classes are also well represented in these forests. Gap-phase replacement is typical for these forests, where one large tree dies, falls, and creates a gap that is quickly filled with new seedlings. As expected for most forests throughout succession, many small trees die before they grow into the larger diameter classes. For trees at least 5 inches in diameter, tree heights are predominantly in the 20- to 39-foot height classes (fig. 11). The tallest tree on an FIA plot was found on Pohnpei, a *Xylocarpus granatum* that measured 29.8 inches in diameter and about 155 feet tall. The largest diameter tree also was found on Pohnpei, a *Sonneratia alba* measuring 79.3 inches in diameter and 141 feet tall.

Wood volume (fig. 12, tables 1, 4, and 5), biomass (fig. 13, table 6), and carbon storage (table 7) tend to be concentrated in the larger diameter classes in the FSM. This pattern is typical where there exists a wide variety of tree size classes, especially larger ones.

Table 3—Estimated number of live trees on forest land by species and diameter class

Species	Diameter class (inches)														All classes
	< 5.0	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9	29.0+	
	<i>Number of trees</i>														
<i>Adenanthera pavonina</i>	800,232	155,627	85,832	35,621	17,810	77,404		41,783	35,621	28,018		17,810	10,207	33,287	1,339,253
<i>Aglaiia ponapensis</i>	2,209,153	71,918	74,281	11,986	35,959		11,986							11,986	2,427,270
<i>Aidia cochinchinensis</i>	141,568	31,147	19,161	11,986											203,862
<i>Allophylus timorensis</i>								11,365							11,365
<i>Antidesma kusaiense</i>	443,721	35,621													479,342
<i>Antidesma</i> spp.	221,861														221,861
<i>Araucaria</i> spp.			35,959												35,959
<i>Areca catechu</i>	707,840	204,566													912,405
<i>Artocarpus altilis</i>	1,679,535	111,136	94,309	133,594	66,417	30,954	53,147	42,318	20,414	61,575	30,954			30,622	2,354,974
<i>Averrhoa bilimbi</i>	141,568	34,094	11,365												187,027
<i>Barringtonia asiatica</i>	298,622	23,973		11,986											334,581
<i>Barringtonia racemosa</i>	1,199,593	168,499	23,973		23,973	11,986									1,428,024
<i>Bruguiera gymnorrhiza</i>	1,282,315	191,608	136,537	107,169	214,337	76,643	95,804	38,322			38,322				2,181,056
<i>Calophyllum inophyllum</i>		9,306		20,670		11,365						9,306		22,730	73,376
<i>Campnosperma brevipetiolata</i>	1,011,783	96,353	35,959	92,091	17,810	23,973	96,903	41,783	59,594	35,959	11,986	91,079	11,986	47,945	1,675,205
<i>Cananga odorata</i>	4,211,048	560,522	340,746	113,537	23,973		15,477	19,161	11,986						5,296,449
<i>Carica papaya</i>			10,207												10,207
<i>Cerbera manghas</i>		17,810													17,810
<i>Cinnamomum carolinense</i>			31,147												31,147
<i>Cinnamomum</i> spp.					11,986					11,986					23,973
<i>Citrus reticulata</i>		20,414	30,622												51,036
<i>Claoxylon carolinianum</i>	447,933	11,986													459,919
<i>Cocos nucifera</i>			26,842	339,544	305,511	67,670									739,566
<i>Commersonia bartramia</i>	2,237,738	142,593	21,292			9,306									2,410,929
<i>Cyathea ponapeana</i>	447,933	131,850	131,850	71,918	11,986										795,537
<i>Cyathea</i> spp.	1,595,089	829,320	303,028	59,594	17,810										2,804,841
<i>Cycas</i> spp.		17,810	35,621												53,431
<i>Cynometra ramiflora</i>											11,986				11,986
<i>Dendrocnide harveyi</i>	665,582	35,621													701,203
<i>Diospyros ferrea</i>	115,917														115,917
<i>Elaeocarpus carolinensis</i>	520,483	171,178	35,959	34,180		28,018	11,986		10,207	23,973	11,986	11,986	23,973		883,929
<i>Elaeocarpus kusanoi</i>	447,933	23,973													471,906
<i>Eugenia</i> spp.	477,362		11,365	31,147											519,874
<i>Eugenia stelechantha</i>	6,288,859	53,431	17,810			17,810		17,810							6,395,722
<i>Exorrhiza ponapensis</i>	686,614	637,379	1,033,622	1,931,210	749,894	74,281	34,638								5,147,637
<i>Fagraea berteriana</i>		11,986	23,973												35,959
<i>Ficus prolixa</i>	221,861	86,719	51,098	48,764	51,098	35,621		71,242	15,477		17,810	17,810	17,810	33,287	668,597
<i>Ficus</i> spp.	463,667		11,365	9,306											484,337

Table 3—Estimated number of live trees on forest land by species and diameter class (continued)

Species	Diameter class (inches)														All classes
	< 5.0	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9	29.0+	
	<i>Number of trees</i>														
<i>Scyphiphora hydrophyllacea</i>	1,415,679	11,365	22,730												1,449,774
<i>Semecarpus venenosus</i>	115,917	55,833	120,972	37,222		9,306									339,250
<i>Sonneratia alba</i>	238,681			19,161	38,322	29,368	19,161	95,804	19,161	106,011	38,322	10,207	10,207	173,701	798,105
<i>Spathodea campanulata</i>	2,388,976	251,713	179,795	95,891	35,959							11,986			2,964,321
<i>Sterculia palauensis</i>	238,681	57,482	19,161	19,161											334,485
<i>Swietenia macrophylla</i>			19,161												19,161
<i>Swietenia mahogoni</i>	283,136			11,365											294,501
<i>Swietenia</i> spp.			11,365												11,365
<i>Syzygium carolinense</i>	686,614	11,986	11,986	23,973			11,986								746,546
<i>Thespesia populnea</i>		15,477													15,477
<i>Timonius</i> spp.	231,833	19,161											11,986		262,981
<i>Toona ciliata</i>				19,161	19,161										38,322
<i>Trichospermum ikutai</i>		9,306	9,306	9,306	9,306										37,222
Unknown	2,677,156	58,514	15,477	15,477	27,463	30,954		15,477	15,477	19,161	11,986	15,477		15,477	2,918,095
Unknown 0					19,161	19,161	19,161								57,482
Unknown 14	115,917														115,917
Unknown 20	115,917	9,306													125,222
Unknown 5	141,568														141,568
<i>Xylocarpus granatum</i>	141,568	111,050	72,844	68,732	110,737	30,526	134,126	114,965		19,161	38,322		19,161	57,482	918,673
Total	66,890,074	9,309,950	5,803,396	4,757,044	2,814,143	1,146,061	837,507	680,344	286,971	408,377	317,892	263,433	115,538	494,636	94,125,367

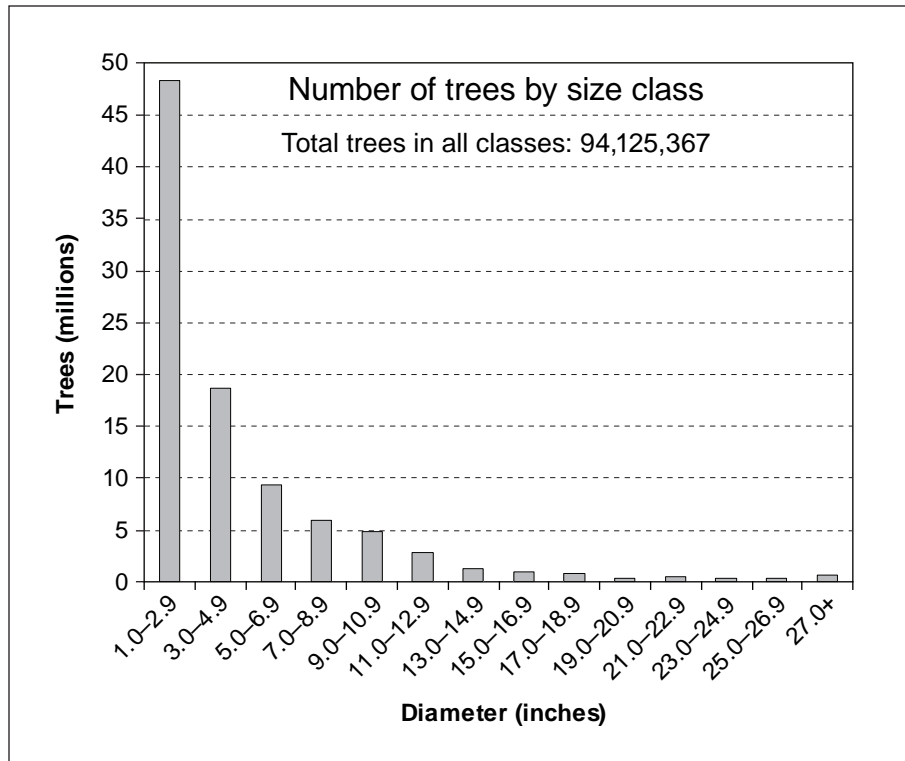


Figure 10—Small trees are abundant in the Federated States of Micronesia, indicating disturbance and regeneration also are abundant. There are many larger trees as well.

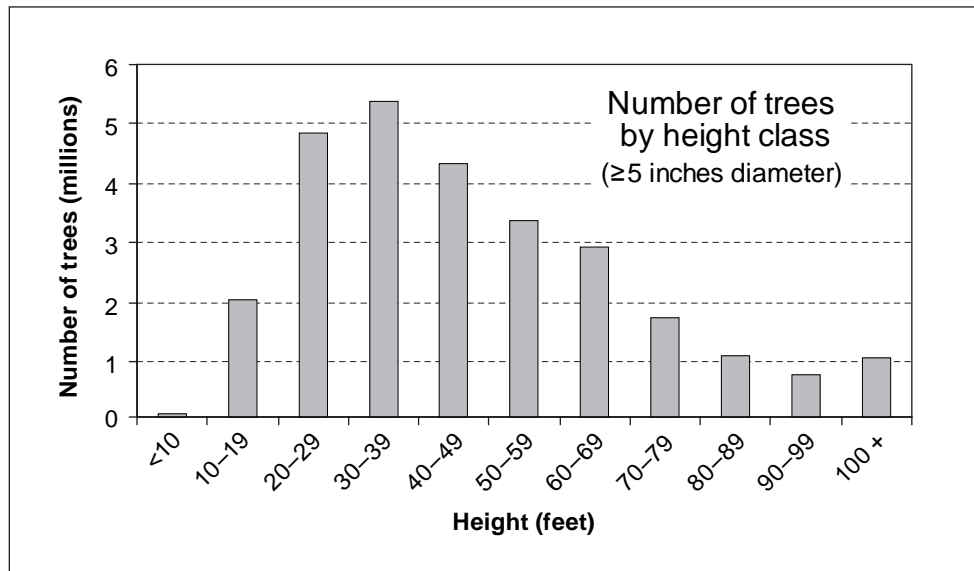


Figure 11—For trees greater than or equal to 5 inches in diameter, the most common heights attained range from 20 to 39 feet tall.

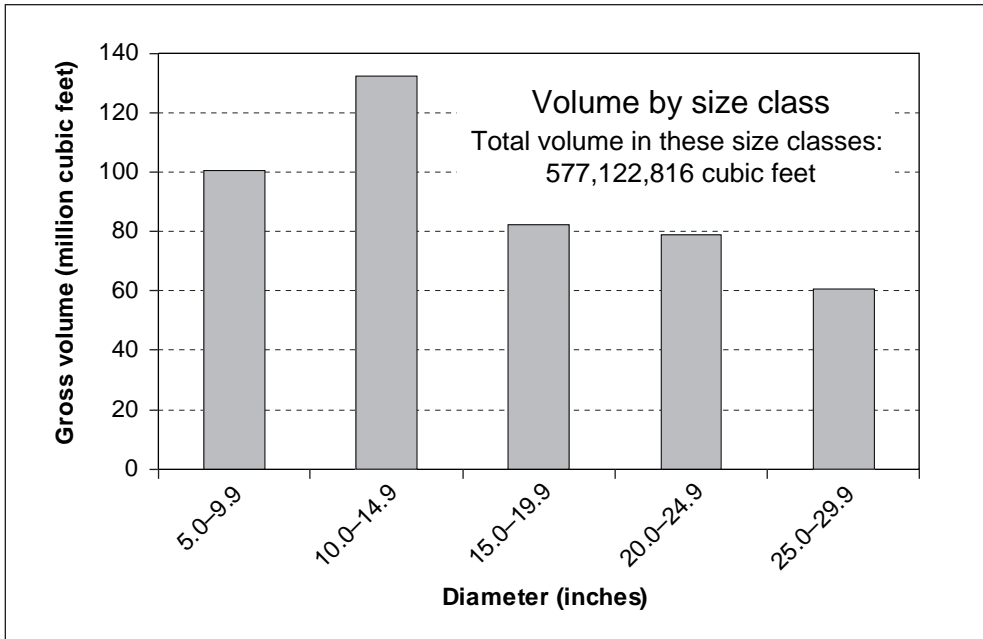


Figure 12—The gross volume of wood is concentrated in the 10- to 14.9-inch diameter class.

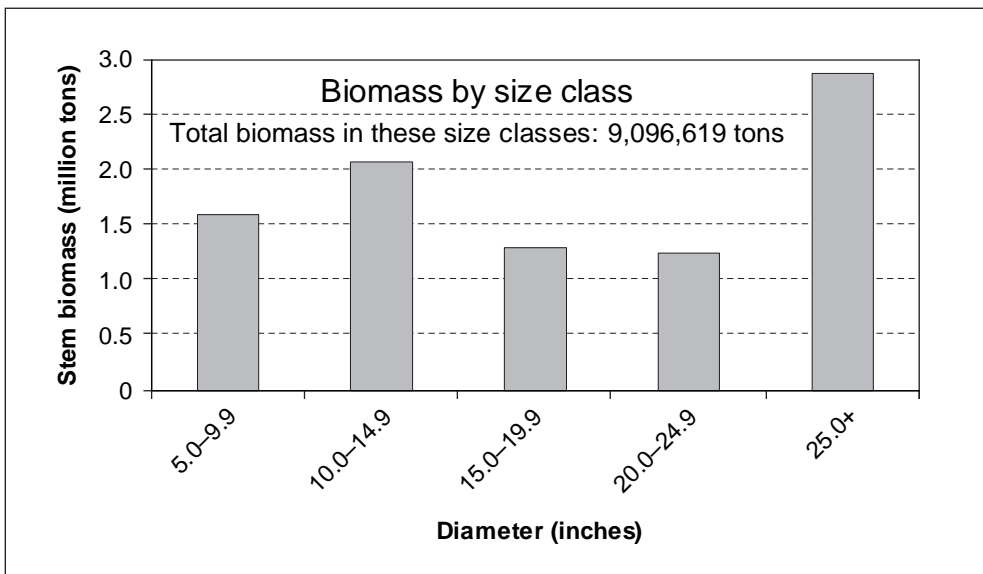


Figure 13—Biomass is concentrated in the larger diameter size classes.

Table 4—Estimated volume of live trees on forest land by diameter class

	Diameter class (inches)					All sizes
	< 5	5-9.9	10-14.9	15-19.9	≥ 20	
Gross volume	32,260,970	100,432,285	132,052,385	82,265,889	262,372,257	609,383,786
Net volume (≥ 5 in)		100,426,463	131,980,850	82,093,165	257,138,855	571,639,334

Cubic feet

Table 5—Estimated gross volume of live trees ≥5 inches diameter at breast height on forest land by species and diameter class

Species	Diameter class (inches)												All classes	
	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9		29.0+
	<i>Cubic feet</i>													
<i>Adenanthera pavonina</i>	790,088	723,575	453,178	387,196	2,244,925		1,756,090	3,082,844	2,239,815		2,013,048	1,155,580	11,013,154	25,859,494
<i>Aglaia ponapensis</i>	228,291	500,193	180,617	479,714		569,899							2,157,312	4,116,025
<i>Aidia cochinchinensis</i>	97,551	115,132	149,745											362,429
<i>Allophylus timorensis</i>							499,009							499,009
<i>Antidesma kusaiense</i>	132,130													132,130
<i>Araucaria</i> spp.		234,005												234,005
<i>Areca catechu</i>	860,963													860,963
<i>Artocarpus altilis</i>	351,320	692,658	1,539,366	1,331,617	755,047	1,965,223	1,536,856	1,566,930	4,257,927	2,628,820			3,599,269	20,225,035
<i>Averrhoa bilimbi</i>	81,941	43,744												125,685
<i>Barringtonia asiatica</i>	89,251		79,127											168,378
<i>Barringtonia racemosa</i>	565,853	133,382		388,225	366,438									1,453,897
<i>Bruguiera gymnorrhiza</i>	656,435	1,041,852	1,234,122	4,087,098	2,037,541	3,823,503	1,428,656			2,820,561				17,129,767
<i>Calophyllum inophyllum</i>	22,794		216,250		189,671						901,810		4,588,807	5,919,333
<i>Camptosperma brevipetiolata</i>	425,879	275,074	1,562,787	299,552	761,776	4,713,459	2,117,733	3,549,930	3,510,941	1,793,098	9,691,386	2,465,074	14,462,378	45,629,068
<i>Cananga odorata</i>	2,611,914	2,506,452	1,202,161	345,652		543,819	920,705	538,426						8,669,129
<i>Carica papaya</i>		49,418												49,418
<i>Cerbera manghas</i>	82,349													82,349
<i>Cinnamomum carolinense</i>		212,191												212,191
<i>Cinnamomum</i> spp.				237,276					759,096					996,372
<i>Citrus reticulata</i>	51,529	150,512												202,041
<i>Claoxylon carolinianum</i>	27,830													27,830
<i>Cocos nucifera</i>		242,480	5,110,511	6,982,698	2,036,988									14,372,677
<i>Commersonia bartramia</i>	431,030	136,573			136,360									703,963
<i>Cyathea ponapeana</i>	449,668	740,538	509,629	89,557										1,789,392
<i>Cyathea</i> spp.	2,409,614	1,384,397	413,236	159,004										4,366,251
<i>Cycas</i> spp.	27,752	144,310												172,062
<i>Cynometra ramiflora</i>										1,141,934				1,141,934
<i>Dendrocnide harveyi</i>	123,334													123,334
<i>Elaeocarpus carolinensis</i>	737,769	332,388	401,405		1,409,660	598,859		416,146	2,284,462	1,392,541	1,536,173	4,001,025		13,110,429
<i>Elaeocarpus kusanoi</i>	96,089													96,089
<i>Eugenia</i> spp.		64,178	438,933											503,111
<i>Eugenia stelechantha</i>	219,022	131,510			423,761		1,135,076							1,909,369
<i>Exorrhiza ponapensis</i>	2,119,988	9,192,001	32,580,935	19,169,244	2,699,948	1,932,152								67,694,269
<i>Fagraea berteriana</i>	28,822	112,120												140,943
<i>Ficus prolixa</i>	359,338	1,110,342	1,012,019	2,043,402	1,798,955		7,997,862	620,514		3,467,839	4,771,774	5,272,670	13,194,710	41,649,426
<i>Ficus</i> spp.		43,065	162,157											205,222
<i>Ficus tinctoria</i>	269,710	106,340					1,764,089							2,140,139
<i>Garcinia ponapensis</i>	110,053													110,053
<i>Garcinia rumiyo</i>	107,363													107,363
<i>Glochidion</i> spp.	212,681	359,030	202,774	244,205										1,018,690
<i>Heritiera littoralis</i>			528,104				978,781				3,829,937			5,336,822
<i>Heterospatha elata</i>	412,692													412,692
<i>Hibiscus tiliaceus</i>	5,256,002	4,446,041	3,510,745	933,290	1,335,883	691,252								16,173,212
<i>Horsfieldia nunu</i>	583,276	1,980,150	1,372,039	4,432,305	2,181,441	4,066,197	3,099,435	1,394,196		3,101,835		1,211,308	4,377,898	27,800,080
<i>Inocarpus fagifer</i>		149,694	112,559	166,394	581,364	795,349				1,362,823			7,891,085	11,059,267

Table 5—Estimated gross volume of live trees ≥5 inches diameter at breast height on forest land by species and diameter class (continued)

Species	Diameter class (inches)												All classes	
	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9		29.0+
	<i>Cubic feet</i>													
<i>Lumnitzera littorea</i>	190,583	60,761												251,344
<i>Macaranga carolinensis</i>	528,290	451,652												979,942
<i>Macaranga</i> spp.	22,481													22,481
<i>Mangifera indica</i>	256,641	381,193	604,431	537,183	332,447	921,133	1,454,163	561,119	2,407,716	1,743,678	1,761,705			10,961,411
<i>Morinda citrifolia</i>	71,944	58,673				336,860								467,478
<i>Myristica insularis</i>	303,840	1,085,245	539,997	1,400,895	948,348	617,829	639,621	3,213,394	4,307,696	2,578,780	3,767,072			19,402,716
<i>Neubergia celebica</i>	208,511	251,879	82,568	270,169										813,126
<i>Palaquium karrak</i>												2,658,754		2,658,754
<i>Pandanus dubius</i>	48,912													48,912
<i>Pandanus</i> spp.	556,632	161,748												718,380
<i>Pandanus tectorius</i>	148,274	178,003												326,277
<i>Pangium edule</i>	65,416		62,105	300,445		121,874								549,840
<i>Parinari laurina</i>	102,827	116,846	777,791	745,328		674,747	2,050,507		2,677,534					7,145,580
<i>Pittosporum</i> spp.	46,077				325,131					932,835				1,304,043
<i>Ponapea hosinoi</i>	258,666	94,930												353,596
<i>Ponapea ledermanniana</i>				225,861										225,861
<i>Premna obtusifolia</i>	132,669	211,245	308,440											652,354
<i>Psychotria</i> spp.	69,209	66,257												135,466
<i>Pterocarpus indicus</i>	95,502	95,870	475,110	394,429	1,634,443	217,360		1,760,069						4,672,783
<i>Ptychococcus ledermanninus</i>	101,340													101,340
<i>Rhizophora apiculata</i>	795,752	1,448,387	1,804,800	7,246,822	5,798,818	4,375,628	1,199,763							22,669,970
<i>Rhizophora mucronata</i>	989,570	2,132,237	3,946,112	3,513,946	4,668,870									15,250,735
<i>Rhizophora</i> spp.	326,644													326,644
<i>Rhizophora stylosa</i>	1,192,604	544,585	705,546	374,470										2,817,206
<i>Rhus taitensis</i>	37,777													37,777
<i>Scyphiphora hydrophyllacea</i>	20,869	72,714												93,584
<i>Semecarpus venenosus</i>	186,905	939,635	551,407		212,931									1,890,877
<i>Sonneratia alba</i>			211,033	846,138	625,201	753,483	5,251,190	885,859	7,980,738	6,100,484	951,781	1,583,310	54,631,557	79,820,773
<i>Spathodea campanulata</i>	954,101	1,390,610	1,079,957	619,166						1,444,688				5,488,522
<i>Sterculia palauensis</i>	263,379	122,830	312,972											699,181
<i>Swietenia macrophylla</i>		170,104												170,104
<i>Swietenia mahogoni</i>			98,140											98,140
<i>Swietenia</i> spp.		77,665												77,665
<i>Syzygium carolinense</i>	29,257	85,432	321,407			390,491								826,586
<i>Thespesia populnea</i>	35,660													35,660
<i>Timonius</i> spp.	65,766											842,206		907,972
<i>Toona ciliata</i>			463,771	571,680										1,035,450
<i>Trichospermum ikutai</i>	28,010	38,339	95,065	111,797										273,212
Unknown	213,046	125,767	134,333	361,218	1,186,474		1,055,855	790,758	2,593,415	1,276,253	1,948,780		1,837,344	11,523,242
Unknown 0				359,354	563,401	518,837								1,441,593
Unknown 20	38,188													38,188
<i>Xylocarpus granatum</i>	380,634	354,801	746,614	2,732,423	680,045	4,995,571	5,768,626		2,161,994	2,864,206		2,616,430	11,415,367	34,716,711
Total	29,796,297	38,070,754	66,293,998	62,387,756	35,935,865	33,623,526	40,654,019	18,380,187	35,181,336	33,205,687	32,618,154	19,147,603	131,827,634	577,122,816

Table 6—Estimated aboveground dry stem biomass of live trees ≥5 inches diameter at breast height on forest land by species and diameter class

State	Species	Diameter class (inches)												All classes	
		5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9		29.0+
		<i>Tons</i>													
Chuuk	<i>Adenanthera pavonina</i>	3,015												55,021	58,037
	<i>Artocarpus altilis</i>	2,750	3,080	11,595	4,868	11,784	19,720	18,356		35,842	41,029				149,025
	<i>Cananga odorata</i>	3,395	8,930	6,680			8,488								27,493
	<i>Cocos nucifera</i>			53,607	56,402	9,816									121,828
	<i>Exorrhiza ponapensis</i>		1,450				14,121								15,571
	<i>Ficus prolixa</i>	1,004	1,047	4,779	5,899			9,685						129,344	151,757
	<i>Glochidion</i> spp.	2,908	3,746		3,811										10,466
	<i>Hibiscus tiliaceus</i>		1,782												1,782
	<i>Lumnitzera littorea</i>	1,120													1,120
	<i>Macaranga carolinensis</i>	4,322	1,098												5,420
	<i>Mangifera indica</i>	3,279	2,789	7,297	8,384	5,189	7,762	22,696		37,578	27,214	27,496			149,684
	<i>Morinda citrifolia</i>		916												916
	<i>Premna obtusifolia</i>	463													463
	<i>Rhizophora</i> spp.	5,098													5,098
	<i>Thespesia populnea</i>	557													557
	Unknown		1,963	2,097	2,434	18,518		16,479	12,342			30,416		28,676	112,925
	<i>Xylocarpus granatum</i>	2,339	2,230	1,348											5,917
	Chuuk subtotal	30,251	31,033	87,402	81,799	45,307	50,091	57,531	22,026	73,420	68,244	57,911		213,041	818,058
Kosrae	<i>Adenanthera pavonina</i>	9,316	9,826	7,073	6,043	22,095		9,637	48,115	34,958		31,419	18,036	116,867	313,384
	<i>Antidesma kusaiense</i>	2,062													2,062
	<i>Artocarpus altilis</i>	580	3,786	3,549	6,641		5,060		24,456	30,614				56,176	130,861
	<i>Barringtonia racemosa</i>	2,900													2,900
	<i>Bruguiera gymnorrhiza</i>		693												693
	<i>Campnosperma brevipetiolata</i>	773		4,643	4,675		9,042	12,252	25,214						56,600
	<i>Cananga odorata</i>		3,541												3,541
	<i>Carica papaya</i>		771												771
	<i>Cerbera manghas</i>	1,285													1,285
	<i>Citrus reticulata</i>	804	2,349												3,153
	<i>Cocos nucifera</i>			11,948	10,019	18,276									40,242
	<i>Cyathea</i> spp.	12,138	6,528	4,064	2,482										25,211
	<i>Cycas</i> spp.	433	2,252												2,685
	<i>Dendrocide harveyi</i>	1,925													1,925
	<i>Elaeocarpus carolinensis</i>	5,431		2,080		22,001			6,495						36,007
	<i>Eugenia stelechantha</i>	3,418	2,053			6,614			17,716						29,800
	<i>Ficus prolixa</i>	4,605	16,283	11,016	25,993	28,077		124,827			54,124	74,475	82,293	76,593	498,286
	<i>Ficus tinctoria</i>							21,476							21,476
	<i>Hibiscus tiliaceus</i>	15,806	13,082	1,431		2,840									33,159
	<i>Horsfieldia nunu</i>	9,103	30,905	21,414	69,177	34,047	63,463	48,374	21,760		48,412		18,905	68,328	433,890
	<i>Mangifera indica</i>		969	2,137											3,105
	<i>Morinda citrifolia</i>	1,123						5,258							6,380
	<i>Neubergia celebica</i>	3,254	3,931	1,289	4,217										12,691
	<i>Pandanus dubius</i>	763													763
	<i>Pandanus</i> spp.	4,554													4,554
	<i>Parinari laurina</i>	2,183	2,480	4,118	15,820		14,322	43,524		56,834					139,282
	<i>Premna obtusifolia</i>		3,297												3,297
	<i>Psychotria</i> spp.	1,080													1,080
	<i>Ptychococcus ledermanninus</i>	1,582													1,582
	<i>Rhizophora apiculata</i>			2,607											2,607
	<i>Sonneratia alba</i>					3,921				14,843		14,855	24,712	48,224	106,555
	Kosrae subtotal	85,118	102,746	77,368	145,067	137,871	97,145	277,806	126,040	137,248	102,536	120,749	143,946	366,187	1,919,829

Table 6—Estimated aboveground dry stem biomass of live trees ≥5 inches diameter at breast height on forest land by species and diameter class (continued)

State	Species	Diameter class (inches)													All classes
		5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9	29.0+	
		<i>Tons</i>													
Pohnpei	<i>Adenanthera pavonina</i>		1,468			12,943		17,771							32,182
	<i>Aglaia ponapensis</i>	3,563	7,807	2,819	7,487		8,895							33,670	64,241
	<i>Aidia cochinchinensis</i>	1,523	1,797	2,337											5,657
	<i>Araucaria</i> spp.		3,652												3,652
	<i>Artocarpus altilis</i>	1,661	2,972	5,074	7,005		5,892								22,604
	<i>Barringtonia asiatica</i>	1,393		1,235											2,628
	<i>Barringtonia racemosa</i>	5,579	2,082		6,059	5,719									19,439
	<i>Bruguiera gymnorrhiza</i>	10,245	14,255	18,137	60,324	31,801	59,675	22,298		44,022					260,756
	<i>Campnosperma brevipetiolata</i>	4,994	4,293	19,748		11,889	64,523	20,800	30,192	54,797	27,986	151,258	38,474	225,722	654,676
	<i>Cananga odorata</i>	37,370	26,648	12,083	5,395			14,370	8,403						104,270
	<i>Cinnamomum carolinense</i>		3,312												3,312
	<i>Cinnamomum</i> spp.				3,185				10,189						13,374
	<i>Claoxylon carolinianum</i>	434													434
	<i>Cocos nucifera</i>			10,042	25,251										35,293
	<i>Commersonia bartramia</i>	5,534	987												6,521
	<i>Cyathea ponapeana</i>	7,018	11,558	7,954	1,398										27,928
	<i>Cyathea</i> spp.	25,470	15,079	2,386											42,935
	<i>Cynometra ramiflora</i>										17,823				17,823
	<i>Elaeocarpus carolinensis</i>	6,084	5,188	4,185			9,347			35,655	21,734	23,976	62,446		168,614
	<i>Elaeocarpus kusanoi</i>	1,500													1,500
	<i>Eugenia</i> spp.			8,906											8,906
	<i>Exorrhiza ponapensis</i>	33,088	142,014	508,507	299,184	42,139	16,035								1,040,967
	<i>Fagraea berteriana</i>	450	1,750												2,200
	<i>Ficus tinctoria</i>	2,981	520												3,502
	<i>Garcinia ponapensis</i>	1,718													1,718
	<i>Glochidion</i> spp.			1,300											1,300
	<i>Heritiera littoralis</i>			8,242				15,276				59,776			83,294
	<i>Hibiscus tiliaceus</i>	58,211	59,517	53,486	11,502	20,929	12,299								215,944
	<i>Inocarpus fagifer</i>		1,389			9,074	12,413				21,270			123,160	167,306
	<i>Macaranga carolinensis</i>	1,722	4,266												5,988
	<i>Mangifera indica</i>		2,192				6,615		8,758						17,564
	<i>Myristica insularis</i>	4,742	16,938	8,428	21,864	14,801	9,643	9,983	50,153	67,232	40,248	58,795			302,828
	<i>Palaquium karrak</i>													41,497	41,497
	<i>Pangium edule</i>	678			4,689										5,367
	<i>Parinari laurina</i>			12,391											12,391
	<i>Pittosporum</i> spp.	719				5,074					14,559				20,353
	<i>Ponapea hosinoi</i>	4,037	1,482												5,519
	<i>Ponapea ledermanniana</i>				3,525										3,525
	<i>Premna obtusifolia</i>			3,408											3,408
	<i>Pterocarpus indicus</i>	1,550	1,556	7,712	4,288	19,412			19,579						54,097
	<i>Rhizophora apiculata</i>	11,586	22,606	25,562	113,105	90,505	68,293	18,725							350,382
	<i>Rhizophora mucronata</i>	15,445	33,279	61,589	54,844	72,869									238,026
	<i>Rhizophora stylosa</i>	18,614	8,500	11,012	5,845										43,970
	<i>Sonneratia alba</i>			3,294	13,206	5,836	11,760	81,958	13,826	109,717	95,213			804,438	1,139,248
	<i>Spathodea campanulata</i>	14,891	21,704	16,855	9,664						22,548				85,662
	<i>Sterculia palauensis</i>	4,111	1,917	4,885											10,912
	<i>Swietenia macrophylla</i>		2,230												2,230
	<i>Syzygium carolinense</i>	457	1,333	5,016			6,095								12,901
	<i>Timonius</i> spp.	1,026											13,145		14,171
	<i>Toona ciliata</i>			7,238	8,922										16,161

Table 6—Estimated aboveground dry stem biomass of live trees ≥5 inches diameter at breast height on forest land by species and diameter class (continued)

State	Species	Diameter class (inches)												All classes	
		5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9		29.0+
		<i>Tons</i>													
	Unknown	674			3,203					40,477	19,919				64,273
	Unknown 0				5,609	8,793	8,098								22,500
	<i>Xylocarpus granatum</i>	1,267	1,572	6,568	36,332	7,892	77,968	90,034		33,743	44,703		40,836	178,165	519,082
	Pohnpei subtotal	290,335	425,861	840,398	711,886	359,678	377,550	291,216	130,911	351,810	347,478	316,352	154,900	1,406,651	6,005,026
Yap	<i>Allophylus timorensis</i>							7,788							7,788
	<i>Areca catechu</i>	13,437													13,437
	<i>Artocarpus altilis</i>	493	973	3,808	2,269			5,631							13,173
	<i>Averrhoa bilimbi</i>	1,279	683												1,962
	<i>Barringtonia racemosa</i>	353													353
	<i>Bruguiera gymnorrhiza</i>		1,314	1,125	3,465										5,904
	<i>Calophyllum inophyllum</i>	406		3,848		3,375					16,046		81,647		105,320
	<i>Camposperma brevipedunculata</i>	879													879
	<i>Cocos nucifera</i>		1,782	4,166	17,311	3,700									26,958
	<i>Commersonia bartramia</i>	1,194	1,144			2,128									4,466
	<i>Eugenia</i> spp.		1,302												1,302
	<i>Ficus</i> spp.		430	1,620											2,050
	<i>Ficus tinctoria</i>	302	774												1,076
	<i>Garcinia rumiyo</i>	2,514													2,514
	<i>Glochidion</i> spp.	411	1,857	1,865											4,133
	<i>Heterospathe elata</i>	6,441													6,441
	<i>Hibiscus tiliaceus</i>	19,501	4,726	7,548	5,104										36,878
	<i>Inocarpus fagifer</i>		947	1,757	2,597										5,301
	<i>Lumnitzera littorea</i>	1,855	948												2,803
	<i>Macaranga carolinensis</i>	2,201	1,685												3,886
	<i>Macaranga</i> spp.	351													351
	<i>Mangifera indica</i>	726													726
	<i>Pandanus</i> spp.	4,134	2,524												6,658
	<i>Pandanus tectorius</i>	2,314	2,778												5,092
	<i>Pangium edule</i>	343		969			1,902								3,215
	<i>Premna obtusifolia</i>	1,608		1,406											3,014
	<i>Psychotria</i> spp.		1,034												1,034
	<i>Pterocarpus indicus</i>				2,115	7,118	3,528		8,990						21,751
	<i>Rhizophora apiculata</i>	833													833
	<i>Rhus taitensis</i>	590													590
	<i>Scyphiphora hydrophyllacea</i>	326	1,135												1,461
	<i>Semecarpus venenosus</i>	2,917	14,665	8,606		3,323									29,512
	<i>Swietenia mahogoni</i>			1,869											1,869
	<i>Swietenia</i> spp.		1,212												1,212
	<i>Trichospermum ikutai</i>	437	598	1,484	1,745										4,264
	Unknown	2,652													2,652
	Unknown 20	596													596
	<i>Xylocarpus granatum</i>	2,334	1,736	3,737	6,314	2,722									16,842
	Yap subtotal	71,426	44,248	43,807	40,919	22,367	5,430	13,419	8,990			16,046		81,647	348,298
All FSM total		477,129	603,889	1,048,975	979,672	565,223	530,217	639,972	287,968	562,478	518,258	511,058	298,846	2,067,527	9,091,211

FSM = Federated States of Micronesia.

Table 7—Estimated carbon mass of live trees ≥5 inches diameter at breast height on forest land by species and diameter class

Species	Diameter class (inches)													All classes
	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9	29.0+	
	<i>Tons</i>													
<i>Adenanthera pavonina</i>	6,166	5,647	3,536	3,022	17,519		13,704	24,058	17,479		15,709	9,018	85,944	201,801
<i>Aglaia ponapensis</i>	1,782	3,903	1,409	3,744		4,447							16,835	32,120
<i>Aidia cochinchinensis</i>	761	898	1,169											2,828
<i>Allophylus timorensis</i>							3,894							3,894
<i>Antidesma kusaiense</i>	1,031													1,031
<i>Araucaria</i> spp.		1,826												1,826
<i>Areca catechu</i>	6,719													6,719
<i>Artocarpus altilis</i>	2,742	5,405	12,013	10,392	5,892	15,336	11,993	12,228	33,228	20,515			28,088	157,831
<i>Averrhoa bilimbi</i>	639	341												981
<i>Barringtonia asiatica</i>	696		617											1,314
<i>Barringtonia racemosa</i>	4,416	1,041		3,030	2,860									11,346
<i>Bruguiera gymnorrhiza</i>	5,123	8,130	9,631	31,895	15,900	29,838	11,149			22,011				133,676
<i>Calophyllum inophyllum</i>	203		1,924		1,687						8,023		40,823	52,660
<i>Campnosperma brevipetiolata</i>	3,323	2,147	12,196	2,338	5,945	36,783	16,526	27,703	27,399	13,993	75,629	19,237	112,861	356,078
<i>Cananga odorata</i>	20,383	19,560	9,381	2,697		4,244	7,185	4,202						67,652
<i>Carica papaya</i>		386												386
<i>Cerbera manghas</i>	643													643
<i>Cinnamomum carolinense</i>		1,656												1,656
<i>Cinnamomum</i> spp.				1,592					5,094					6,687
<i>Citrus reticulata</i>	402	1,175												1,577
<i>Claoxylon carolinianum</i>	217													217
<i>Cocos nucifera</i>		1,892	39,881	54,491	15,896									112,161
<i>Commersonia bartramia</i>	3,364	1,066			1,064									5,494
<i>Cyathea ponapeana</i>	3,509	5,779	3,977	699										13,964
<i>Cyathea</i> spp.	18,804	10,803	3,225	1,241										34,073
<i>Cycas</i> spp.	217	1,126												1,343
<i>Cynometra ramiflora</i>										8,911				8,911
<i>Dendrocnide harveyi</i>	962													962
<i>Elaeocarpus carolinensis</i>	5,757	2,594	3,132		11,001	4,673		3,248	17,827	10,867	11,988	31,223		102,311
<i>Elaeocarpus kusanoi</i>	750													750
<i>Eugenia</i> spp.		651	4,453											5,104
<i>Eugenia stelechantha</i>	1,709	1,026			3,307		8,858							14,900
<i>Exorrhiza ponapensis</i>	16,544	71,732	254,253	149,592	21,070	15,078								528,269
<i>Fagraea berteriana</i>	225	875												1,100
<i>Ficus prolixa</i>	2,804	8,665	7,898	15,946	14,039		62,413	4,842		27,062	37,238	41,147	102,968	325,022
<i>Ficus</i> spp.		215	810											1,025
<i>Ficus tinctoria</i>	1,642	647					10,738							13,027
<i>Garcinia ponapensis</i>	859													859
<i>Garcinia rumiyo</i>	1,257													1,257
<i>Glochidion</i> spp.	1,660	2,802	1,582	1,906										7,950
<i>Heritiera littoralis</i>			4,121				7,638				29,888			41,647
<i>Heterospathe elata</i>	3,221													3,221
<i>Hibiscus tiliaceus</i>	46,759	39,553	31,233	8,303	11,884	6,150								143,881
<i>Horsfieldia nunu</i>	4,552	15,453	10,707	34,589	17,023	31,732	24,187	10,880		24,206		9,453	34,164	216,945
<i>Inocarpus fagifer</i>		1,168	878	1,299	4,537	6,207				10,635			61,580	86,304
<i>Lumnitzera littorea</i>	1,487	474												1,961
<i>Macaranga carolinensis</i>	4,123	3,525												7,647

Table 7—Estimated carbon mass of live trees ≥5 inches diameter at breast height on forest land by species and diameter class (continued)

Species	Diameter class (inches)													All classes
	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–22.9	23.0–24.9	25.0–26.9	27.0–28.9	29.0+	
	<i>Tons</i>													
<i>Macaranga</i> spp.	175													175
<i>Mangifera indica</i>	2,003	2,975	4,717	4,192	2,594	7,188	11,348	4,379	18,789	13,607	13,748			85,540
<i>Morinda citrifolia</i>	561	458				2,629								3,648
<i>Myristica insularis</i>	2,371	8,469	4,214	10,932	7,401	4,821	4,991	25,077	33,616	20,124	29,397			151,414
<i>Neubergia celebica</i>	1,627	1,966	644	2,108										6,345
<i>Palaquium karrak</i>													20,748	20,748
<i>Pandanus dubius</i>	382													382
<i>Pandanus</i> spp.	4,344	1,262												5,606
<i>Pandanus tectorius</i>	1,157	1,389												2,546
<i>Pangium edule</i>	510		485	2,345		951								4,291
<i>Parinari laurina</i>	1,091	1,240	8,255	7,910		7,161	21,762		28,417					75,837
<i>Pittosporum</i> spp.	360				2,537						7,280			10,176
<i>Ponapea hosinoi</i>	2,019	741												2,759
<i>Ponapea ledermanniana</i>				1,763										1,763
<i>Premna obtusifolia</i>	1,035	1,649	2,407											5,091
<i>Psychotria</i> spp.	540	517												1,057
<i>Pterocarpus indicus</i>	775	778	3,856	3,201	13,265	1,764		14,285						37,924
<i>Ptychococcus ledermanninus</i>	791													791
<i>Rhizophora apiculata</i>	6,210	11,303	14,084	56,552	45,253	34,146	9,363							176,911
<i>Rhizophora mucronata</i>	7,722	16,639	30,794	27,422	36,435									119,013
<i>Rhizophora</i> spp.	2,549													2,549
<i>Rhizophora stylosa</i>	9,307	4,250	5,506	2,922										21,985
<i>Rhus taitensis</i>	295													295
<i>Scyphiphora hydrophyllacea</i>	163	567												730
<i>Semecarpus venenosus</i>	1,459	7,333	4,303		1,662									14,756
<i>Sonneratia alba</i>			1,647	6,603	4,879	5,880	40,979	6,913	62,280	47,607	7,427	12,356	426,331	622,901
<i>Spathodea campanulata</i>	7,446	10,852	8,428	4,832							11,274			42,831
<i>Sterculia palauensis</i>	2,055	959	2,442											5,456
<i>Swietenia macrophylla</i>		1,115												1,115
<i>Swietenia mahogoni</i>			934											934
<i>Swietenia</i> spp.		606												606
<i>Syzygium carolinense</i>	228	667	2,508			3,047								6,450
<i>Thespesia populnea</i>	278													278
<i>Timonius</i> spp.	513											6,572		7,086
<i>Toona ciliata</i>			3,619	4,461										8,080
<i>Trichospermum ikutai</i>	219	299	742	872										2,132
Unknown	1,663	981	1,048	2,819	9,259		8,240	6,171	20,238	9,960	15,208		14,338	89,925
Unknown 0				2,804	4,397	4,049								11,250
Unknown 20	298													298
<i>Xylocarpus granatum</i>	2,970	2,769	5,826	21,323	5,307	38,984	45,017		16,872	22,352		20,418	89,083	270,921
<i>Total</i>	238,565	301,945	524,488	489,836	282,611	265,108	319,986	143,984	281,239	259,129	255,529	149,423	1,033,763	4,545,605

Number of Canopy and Understory Species

In addition to counting and measuring overstory trees, understory vegetation cover and layer heights were estimated for shrubs, forbs, vines, and grasses on FIA subplots where a species occupied at least 3 percent cover on that subplot (table 8). Tree seedlings that are less than or equal to 1 inch in diameter are also estimated as understory vegetation cover (table 9). Special interest species (e.g., rare, endangered, medicinal, or invasive) identified by island foresters were also noted when found. However, if a species covered less than 3 percent of a subplot and was not listed as special interest, it was not enumerated.

For the 2005–2006 inventory, 96 tree species and 206 understory species were measured on FIA plots. On a per-plot basis (approximately one-sixth acre), the mean number of tree species found was 7 (fig. 14).

Table 8—Average understory vegetation cover^a on Forest Inventory and Analysis field subplots by species

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Abrus precatorius</i> L.	80.0	1	
<i>Abutilon</i> sp. P. Mill.	9.7	3	5.5
<i>Acalypha lanceolata</i> Willd.	8.7	15	8.1
<i>Achyranthes bidentata</i> Blume	45.0	2	49.5
<i>Ageratum conyzoides</i> L.	1.0	1	
<i>Allamanda cathartica</i> L.	3.0	1	
<i>Allophylus timorensis</i> (DC.) Blume	6.0	2	5.7
<i>Alocasia macrorrhizos</i> (L.) G. Don	5.8	4	2.5
<i>Alpinia carolinensis</i> Koidz.	3.0	1	
<i>Alpinia purpurata</i> (Vieill.) K. Schum.	9.0	2	8.5
<i>Ananas comosus</i> (L.) Merr.	1.0	2	0.0
<i>Angiopteris evecta</i> (J.R. Forst.) Hoffman	9.4	14	6.8
<i>Angiopteris</i> sp. Hoffmann	9.0	1	
<i>Asplenium laserpitifolium</i> Lamarck	4.9	7	3.6
<i>Asplenium nidus</i> L.	4.3	61	5.0
<i>Asplenium pellucidum</i> Lam.	1.5	2	0.7
<i>Asplenium polyodon</i> G. Forst.	2.0	2	1.4
<i>Asplenium scolopendrium</i> L.	4.0	2	0.0
<i>Asplenium scolopendropsis</i> F. Muell.	3.0	1	
<i>Asplenium</i> sp. L.	5.5	24	4.3
<i>Asplenium tenerum</i> Forst. f.	3.0	1	
<i>Astronidium kusaianum</i> Hosokowa	3.0	1	
<i>Astronidium ponapense</i> (Kanehira) Markgraf	3.0	1	
<i>Bambusa</i> sp. Schreb.	7.2	10	9.6
<i>Bambusa vulgaris</i> Schrad. ex J.C. Wendl.	28.8	4	34.7
<i>Blechnum</i> sp. Linnaeus	5.0	1	
<i>Blechnum orientale</i> L.	1.0	2	0.0
<i>Blechnum pyramidatum</i> (Lam.) Urb.	9.3	8	7.7
<i>Bolbitis heteroclita</i> (Presl) in C. Ch.	20.1	8	14.8
<i>Bolbitis</i> sp. Schott.	3.0	1	

Table 8—Average understory vegetation cover^a on Forest Inventory and Analysis field subplots by species (continued)

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Bothriochloa bladhii</i> (Retz.) S.T. Blake	35.0	1	
<i>Caesalpinia bonduc</i> (L.) Roxb.	2.7	3	1.5
<i>Cassytha filiformis</i> L.	33.0	5	25.6
<i>Cayratia</i> sp. Juss.	2.3	3	1.5
<i>Cayratia trifolia</i> (L.) Domin	3.0	1	
<i>Centotheca lappacea</i> (L.) Desv.	6.1	8	7.8
<i>Chromolaena odorata</i> (L.) King & H.E. Robins.	11.5	24	18.3
<i>Clerodendrum buchananii</i> (Roxb.) Walp.	1.0	1	
<i>Clerodendrum inerme</i> (L.) Gaertn.	5.0	1	
<i>Codiaeum</i> sp. Juss.	1.0	1	
<i>Codiaeum variegatum</i> (L.) A. Juss.	1.0	2	0.0
<i>Colocasia esculenta</i> (L.) Schott	12.3	7	21.3
<i>Cordyline fruticosa</i> (L.) A. Chev	1.7	10	0.8
<i>Costus speciosus</i> Smith	12.7	31	17.4
<i>Crotalaria pallida</i> Aiton	1.0	2	0.0
<i>Curcuma australasica</i> Hook. f.	5.0	2	2.8
<i>Cyathula prostrata</i> (L.) Blume	10.0	1	
<i>Cyperus</i> sp. L.	2.5	12	2.9
<i>Cyrtococcum accrescens</i> (Trin.) Straph.	6.2	11	5.6
<i>Cyrtosperma chamissonis</i> (Schott) Merrill	3.7	6	2.7
<i>Davallia pectinata</i> J. Sm.	3.0	1	
<i>Davallia solida</i> (Forster fil.) Swartz. Schrad	1.8	6	1.0
<i>Davallia</i> sp. Sm.	1.0	1	
<i>Decaspermum fruticosum</i> J.R. Forst.	5.3	9	8.0
<i>Dendrobium</i> sp. Sw.	15.6	5	24.9
<i>Derris elliptica</i> (Wallich) Benth.	5.5	82	4.8
<i>Derris trifoliata</i> Lour.	6.4	37	8.0
<i>Desmodium</i> sp. Desv.	2.0	1	
<i>Desmodium triflorum</i> (L.) DC.	6.5	2	2.1
<i>Dieffenbachia seguine</i> (Jacq.) Schott	10.0	1	
<i>Digitaria ciliaris</i> (Retz.) Koel.	1.0	1	
<i>Dioscorea bulbifera</i> L.	9.9	16	10.2
<i>Dioscorea</i> sp. L.	9.3	12	10.2
<i>Diospyros sandwicensis</i> (A. DC.) Fosberg	1.0	1	
<i>Diplazium</i> sp. Sw.	8.0	5	5.2
<i>Elatostema</i> sp. J.R. & G. Forst	6.7	3	3.2
<i>Elephantopus mollis</i> Kunth	4.0	2	4.2
<i>Eleusine indica</i> (Linnaeus) Gaertn.	5.0	1	
<i>Eleutheranther ruderalis</i> (Sw.) Schultz-Bip.	5.0	1	
<i>Embelia palauensis</i> Mez	1.0	1	
<i>Entada phaseoloides</i> (L.) Merr.	2.0	2	1.4
<i>Eragrostis</i> sp. von Wolf	40.0	1	
<i>Eurya japonica</i> Thunb.	1.0	1	
<i>Eurya japonica</i> var. <i>nitida</i> Thunb. (Korth.) Dyer	2.0	2	1.4
<i>Fimbristylis dichotoma</i> (L.) Vahl	1.0	1	
<i>Fimbristylis ferruginea</i> (L.) Vahl	1.0	2	0.0
<i>Fimbristylis globulosa</i> (Retz.) Kunth	1.0	2	0.0
<i>Flacourtia rukam</i> Zoll. & Moritzi	5.0	1	
<i>Flagellaria indica</i> Linnaeus	8.3	8	10.5

Table 8—Average understory vegetation cover^a on Forest Inventory and Analysis field subplots by species (continued)

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Flagellaria</i> sp. L.	6.3	20	5.4
<i>Freycinetia ponapensis</i> Martelli	6.1	44	4.0
<i>Geophila repens</i> (Linnaeus) I.M. Johnston	7.0	1	
<i>Gleichenia linearis</i> (Luers.) Fosberg	35.8	8	27.2
<i>Gynochthodes ovalifolia</i> (Val.) Kaneh.	2.5	2	0.7
<i>Haplopteris elongata</i> (Sw.) E. H. Crane	1.0	1	
<i>Hedychium coronarium</i> J. Koenig	3.0	1	
<i>Hedyotis cornifolia</i> Kaneh.	35.0	1	
<i>Hedyotis</i> sp. L.	1.7	3	1.2
<i>Helicteres angustifolia</i> L.	1.0	1	
<i>Hibiscus rosa-sinensis</i> L.	1.7	3	0.6
<i>Histiopteris incisa</i> (Thunb.) J. Sm.	4.5	2	5.0
<i>Hoya schneei</i> Schltr.	6.3	24	6.2
<i>Hoya</i> sp. R. Br.	3.0	3	2.0
<i>Hymenophyllum</i> sp. Sm.	9.2	5	10.6
<i>Hypolytrum nemorum</i> sensu Parham, non Spreng.	6.1	12	8.9
<i>Hypolytrum</i> sp. Pers.	1.0	1	
<i>Hyptis capitata</i> Jacq.	6.7	10	5.8
<i>Ipomea</i> sp. L.	10.8	5	16.8
<i>Ipomoea littoralis</i> Blume	4.3	3	1.5
<i>Ischaemum polystachyum</i> J. S. Presl.	46.0	7	35.7
<i>Ischaemum</i> sp. L.	10.4	12	12.7
<i>Ixora casei</i> Hance	6.0	19	5.0
<i>Ixora trianthia</i> Volkens	4.0	1	
<i>Lantana camara</i> L.	3.0	1	
<i>Leea sambucina</i> (L.) Willd.	6.3	7	4.7
<i>Lindsaea decomposita</i> Holtum, Fl. Malaya	3.0	1	
<i>Linsaea</i> sp. Dry. ex Sm.	1.0	1	
<i>Ludwigia octovalis</i> (Jacquin) Raven, Kew	3.0	1	
<i>Luffa cylindrica</i> (Linnaeus) Roem. Syn. Pepon.	5.0	1	
<i>Lycopodiella cernua</i> (L.) Pic. Serm. var. <i>cernua</i>	15.0	1	
<i>Lycopodiella cernua</i> (L.) Pic. Serm. var. <i>curvata</i> (Sw.) Kartesz & Gandhi	45.0	2	21.2
<i>Lycopodium</i> sp. L.	3.7	3	0.6
<i>Lygodium scandens</i> (L.) Sw.	3.0	1	
<i>Lygodium</i> sp. Sw.	3.0	1	
<i>Macropiper puberlum</i> Benth.	1.0	1	
<i>Maesa caroninensis</i> Mez	2.7	3	1.5
<i>Manihot esculenta</i> Crantz	8.0	15	10.0
<i>Mapania pandanophylla</i> Aubl.	3.0	1	
<i>Melastoma malabathricum</i> L.	5.1	12	6.2
<i>Merremia peltata</i> (L.) Merrill	18.9	79	22.3
<i>Merremia</i> sp. Dennst. ex Endl.	10.0	3	5.0
<i>Microgramma lycopodioides</i> (L.) Copeland	10.0	2	0.0
<i>Microlepia speluncae</i> (L.) T. Moore	6.5	2	5.0
<i>Microsorium scolopendria</i> (Burm. f.)	5.9	7	4.3
<i>Microstegium glabratum</i> (Brongn.) A. Camus	1.8	4	1.0
<i>Mucuna platyphylla</i> A. Gray	8.0	1	

Table 8—Average understory vegetation cover^a on Forest Inventory and Analysis field subplots by species (continued)

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Mussaenda frondosa</i> L.	1.0	2	0.0
<i>Myrtella bennigseniana</i> (Volkens) Diels	20.0	1	
<i>Nepenthes mirabilis</i> Druce	4.7	10	4.0
<i>Nephrolepis acutifolia</i> (Desv.) Christ	5.0	1	
<i>Nephrolepis biserrata</i> (Sw.) Schott	35.0	2	28.3
<i>Nephrolepis hirsutula</i> (J.R. Forst.) K. Presl	18.3	3	11.6
<i>Nephrolepis obliterated</i> (R. Br.) J. Sm.	27.4	28	28.3
<i>Nephrolepis saligna</i> Carr.	9.1	22	9.1
<i>Nephrolepis</i> sp. Schott	9.7	29	11.1
<i>Nothocnide repanda</i> (Blume) Blume	4.3	4	4.0
<i>Nypa fruticans</i> Wurmb, Verh. Batav. Gen.	1.0	1	
<i>Oplismenus compositus</i> (Linnaeus) Beauv.	3.0	1	
<i>Oplismenus hirtellus</i> (L.) Beauv. var. <i>setarius</i> (Lam.) F.M. Bailey	16.5	4	16.7
<i>Oplismenus</i> sp. Beauv.	6.3	8	6.1
<i>Pachygone ledermannii</i> Deils	2.5	2	0.7
<i>Paspalum conjugatum</i> Berg.	5.9	7	5.7
<i>Paspalum orbiculare</i> L.	4.0	4	4.1
<i>Passiflora foetida</i> L.	3.0	1	
<i>Passiflora</i> sp. L.	10.0	1	
<i>Pennisetum polystachyon</i> (L.) J.A. Schultes	12.0	3	15.7
<i>Pennisetum</i> sp. L.C. Rich ex Pers.	8.0	1	
<i>Phragmites karka</i> (Retz.) Trin. ex Steud.	5.0	1	
<i>Phymatosorus grossus</i> (Langsd. & Fisch.) Brownlie	7.0	1	
<i>Piper betel</i> L.	1.0	1	
<i>Piper methysticum</i> G. Forst.	6.1	8	3.8
<i>Piper ponapensis</i> C. de Candolle	8.2	89	7.9
<i>Piper</i> sp. L.	19.1	7	27.9
<i>Polygala paniculata</i> L.	1.5	2	0.7
<i>Polypodium cyathoides</i> Sw.	2.0	1	
<i>Polypodium punctatum</i> (Raddi) Hook.	3.0	1	
<i>Polypodium</i> sp. L.	2.8	5	1.5
<i>Polyscias grandifolia</i> Volk.	4.3	4	3.8
<i>Polyscias</i> sp. J.R. Forst. & G. Forst.	1.0	1	
<i>Polyscias subcapitata</i> Kanehira	5.5	8	4.4
<i>Procris pedunculata</i> (J.R. Forst.) Wedd.	4.7	26	2.9
<i>Psychotria hombroniana</i> (Baill.) Fosberg	3.0	3	2.0
<i>Pteris plumula</i> Desv auct. Non Retz.	3.8	6	1.3
<i>Pteris spinescens</i> C. Presl	5.0	6	2.8
<i>Pteris tripartita</i> Sw.	3.0	1	
<i>Puera</i> sp. DC.	3.5	2	0.7
<i>Pueraria phaseoloides</i> (Roxb.) Benth	3.0	1	
<i>Rubus moluccanus</i> L.	13.6	7	13.1

Table 8—Average understory vegetation cover^a on Forest Inventory and Analysis field subplots by species (continued)

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Rumohra aristata</i> (Forst.) Ching	3.0	1	
<i>Sacciolepis indica</i> (L.) Chase	18.7	3	17.0
<i>Salacia chinensis</i> L.	10.3	3	12.7
<i>Salacia naumanni</i> Engl.	20.0	2	14.1
<i>Scaevola sericea</i> Vahl var. <i>taccada</i> (Gaertn.) Thieret & B. Lipscomb	8.8	4	5.4
<i>Schizaea dichotoma</i> (L.) Sm.	1.5	2	0.7
<i>Scirpodendron ghaeri</i> Merrill	3.0	1	
<i>Scleria lithosperma</i> L. (Sw.)	8.6	16	11.6
<i>Scleria</i> sp. Berg.	5.2	5	5.9
<i>Selaginella</i> sp. Beauv.	7.0	1	
<i>Sida</i> sp. L.	1.0	2	0.0
<i>Sphagneticola trilobata</i> (L.) Pruski	4.0	2	1.4
<i>Stachytarpheta jamaicensis</i> (L.) Vahl	3.0	1	
<i>Syngium stelechanthum</i> (Diels) Glassman	5.0	1	
<i>Tabernaemontana</i> sp. L.	4.0	1	
<i>Tacca leontopetaloides</i> (L.) Kuntze	1.5	2	0.7
<i>Tectaria grandifolia</i> (Presl) Copel.	10.1	12	7.5
<i>Tectaria</i> sp. Cav.	7.3	17	11.2
<i>Thelypteris heterocarpa</i> (Blume) Morton	13.4	7	9.5
<i>Thelypteris maemonensis</i> (W.H. Wagner & Grether) Stone	21.3	3	15.8
<i>Thelypteris</i> sp. Schmidel	12.3	40	12.9
<i>Thelypteris truncata</i> (Poir.) K. Iwats.	6.0	3	3.6
<i>Trichomanes</i> sp. L.	1.0	1	
<i>Triphasia trifolia</i> (Burm. f.) P. Wilson	2.0	4	2.0
Unknown annual grass 1	1.0	1	
Unknown fern 0	0.0	11	0.0
Unknown forb	0.0	60	0.0
Unknown grass 1	10.5	27	23.6
Unknown perennial grass 1	3.3	4	3.3
Unknown perennial grass 1a	1.0	2	0.0
Unknown perennial grass 2	2.0	1	
Unknown perennial grass 2a	1.3	3	0.6
Unknown sedge	0.0	1	
Unknown shrub	0.0	32	0.0
Unknown sp.	4.2	20	2.9
Unknown vine	5.0	1	
<i>Vigna marina</i> (Burm.) Merrill	10.0	1	
<i>Wollastonia biflora</i> (L.) DC.	4.7	3	1.5

^a Percentage cover of "1" indicates cover less than or equal to 1 percent. Cover estimates are averaged among subplots where each species was found. In total, 252 subplots were surveyed for vegetation cover. The number of subplots where a species was found and the standard deviation for cover estimates provide an idea of spatial variability for each species across the island group. Understory vegetation includes the epiphytes and climbing vines.

Table 9—Average understory tree cover^a on Forest Inventory and Analysis field subplots by species

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Acacia</i> spp.	2.0	1	
<i>Adenanthera pavonina</i>	6.2	17	7.1
<i>Aglaiia ponapensis</i>	9.3	74	10.0
<i>Aidia cochinchinensis</i>	6.7	11	9.8
<i>Albizia lebbbeck</i>	2.0	1	
<i>Angiopteris evecta</i>	2.5	2	0.7
<i>Annona muricata</i>	1.0	1	
<i>Antidesma kusaiense</i>	3.5	6	0.8
<i>Antidesma sphaerocarpum</i>	1.5	2	0.7
<i>Antidesma</i> spp.	3.0	1	
<i>Areca catechu</i>	3.4	5	1.5
<i>Artocarpus altilis</i>	1.4	12	0.7
<i>Averrhoa bilimbi</i>	1.0	1	
<i>Barringtonia racemosa</i>	5.3	12	4.8
<i>Bruguiera gymnorrhiza</i>	1.8	21	1.3
<i>Calophyllum inophyllum</i>	4.7	3	4.7
<i>Camptosperma brevipetiolata</i>	2.1	10	1.4
<i>Cananga odorata</i>	1.9	10	0.7
<i>Carica papaya</i>	1.0	1	
<i>Cerbera manghas</i>	1.0	1	
<i>Cinnamomum carolinense</i>	2.0	1	
<i>Cinnamomum</i> spp.	3.0	1	
<i>Claoxylon carolinianum</i>	2.8	4	0.5
<i>Cocos nucifera</i>	2.5	37	2.0
<i>Commersonia bartramia</i>	5.4	5	2.3
<i>Crateva religiosa</i>	1.3	4	0.5
<i>Cyathea ponapeana</i>	4.7	13	3.1
<i>Cyathea</i> spp.	7.6	33	5.9
<i>Cynometra ramiflora</i>	4.0	1	
<i>Dendrocnide harveyi</i>	3.0	2	2.8
<i>Diospyros elliptica</i>	4.0	2	1.4
<i>Discocalyx ponapensis</i>	2.5	2	0.7
<i>Elaeocarpus carolinensis</i>	2.4	5	1.5
<i>Eucalyptus</i> spp.	5.0	1	
<i>Eugenia stelechantha</i>	4.4	35	3.0
<i>Exorrhiza ponapensis</i>	7.9	25	6.3
<i>Ficus</i> spp.	4.6	5	3.6
<i>Ficus tinctoria</i>	2.3	15	1.4
<i>Ficus virens</i>	3.0	1	
<i>Garcinia rumiyo</i>	2.8	4	2.4
<i>Garcinia</i> spp.	3.0	1	
<i>Glochidion ramiflorum</i>	3.5	8	2.8
<i>Glochidion</i> spp.	3.1	8	2.0
<i>Heritiera littoralis</i>	7.0	4	9.0
<i>Heterospathe elata</i>	42.5	2	10.6
<i>Hibiscus tiliaceus</i>	4.4	34	4.9
<i>Horsfieldia nunu</i>	2.7	19	1.7
<i>Inocarpus fagifer</i>	7.0	5	7.4
<i>Leucaena leucocephala</i>	6.0	1	
<i>Macaranga carolinensis</i>	4.5	37	4.2

Table 9—Average understory tree cover^a on Forest Inventory and Analysis field subplots by species (continued)

Scientific name	Cover	Number of subplots	Standard deviation across subplots where species was found
	<i>Percent</i>		
<i>Mangifera indica</i>	2.8	12	1.9
<i>Melochia aristata</i>	1.0	2	0.0
<i>Meryta senffiana</i>	1.0	1	
<i>Metroxylon amicarum</i>	5.5	2	6.4
<i>Morinda citrifolia</i>	2.2	43	2.0
<i>Morinda</i> spp.	10.0	1	
<i>Musa</i> spp.	3.5	24	2.7
<i>Mussaenda frondosa</i>	1.0	1	
<i>Myristica hypargyrea</i>	1.0	2	0.0
<i>Myristica insularis</i>	5.5	15	4.7
<i>Neubergia celebica</i>	4.8	4	3.5
<i>Pandanus cominsii</i>	14.0	72	15.2
<i>Pandanus dubius</i>	4.0	1	
<i>Pandanus ponapensis</i>	5.0	2	0.0
<i>Pandanus</i> spp.	11.7	24	13.8
<i>Pandanus tectorius</i>	4.7	12	4.2
<i>Pangium edule</i>	2.0	2	1.4
<i>Parinari laurina</i>	29.2	9	26.1
<i>Pemphis acidula</i>	1.0	1	
<i>Pipturus argenteus</i>	6.5	2	4.9
<i>Pisonia grandis</i>	1.0	2	0.0
<i>Ponapea hosinoi</i>	7.5	2	6.4
<i>Premna obtusifolia</i>	3.0	13	3.0
<i>Premna</i> spp.	2.0	2	0.0
<i>Psychotria</i> spp.	3.6	7	1.7
<i>Pterocarpus indicus</i>	4.3	3	2.3
<i>Rhizophora apiculata</i>	2.1	13	1.7
<i>Rhizophora mucronata</i>	1.3	3	0.6
<i>Rhizophora</i> spp.	1.5	2	0.7
<i>Rhizophora stylosa</i>	4.0	2	2.8
<i>Rhus taitensis</i>	2.1	10	1.1
<i>Scyphiphora hydrophyllacea</i>	7.7	3	10.7
<i>Semecarpus venenosus</i>	2.9	9	2.1
<i>Sonneratia alba</i>	1.3	4	0.5
<i>Spathodea campanulata</i>	12.3	7	13.8
<i>Swietenia macrophylla</i>	7.0	2	4.2
<i>Swietenia mahogoni</i>	4.0	1	
<i>Syzygium carolinense</i>	1.0	3	0.0
<i>Syzygium samarangense</i>	1.0	1	
<i>Terminalia catappa</i>	1.0	1	
<i>Timonius</i> spp.	2.8	4	1.7
<i>Trichospermum ikutai</i>	4.0	2	4.2
Unknown 0	1.0	1	
Unknown 14	13.5	2	9.2
Unknown 3	5.0	1	
<i>Xylocarpus granatum</i>	2.1	21	1.9

^a Percentage cover of "1" indicates cover less than or equal to 1 percent. Cover estimates are averaged among subplots where each species was found. A total of 252 subplots were surveyed for vegetation cover. The number of subplots where a species was found and the standard deviation for cover estimates provide an idea of spatial variability for each species across the island group.

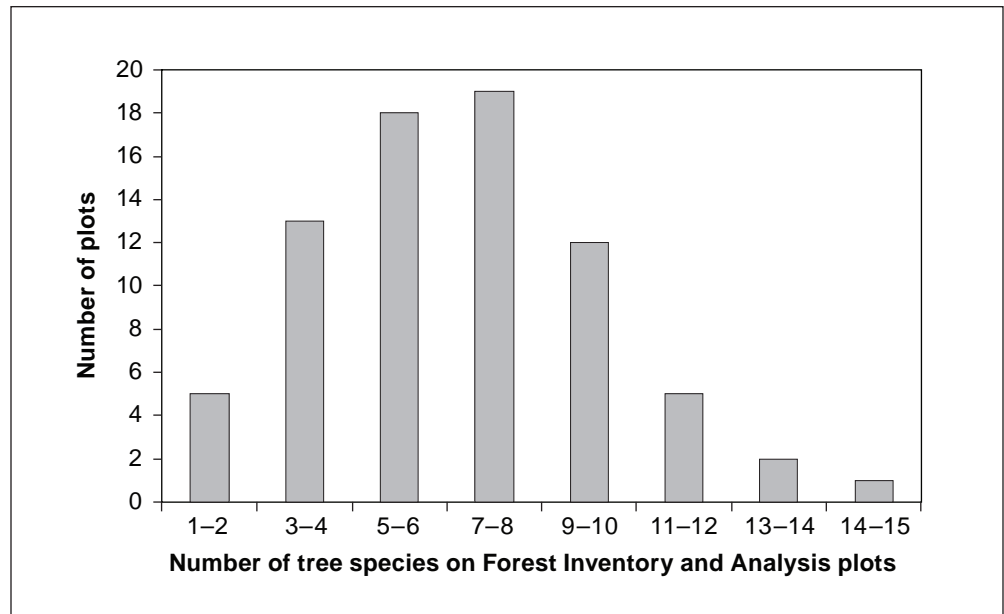


Figure 14—For the 2005–2006 inventory, the average number of tree species found per one-sixth-acre plot was seven.

Tree Damage and Mortality

We estimated about 11 percent of the individual trees (≥ 5 inches diameter at breast height) in the FSM show some sign of damage (table 10). The most prevalent damage types are lost apical dominance (damage to the primary growing leader), vines in crowns, and conks (shelf fungus indicating rot) (fig. 15). Of the damaged trees, the prevalence of lost apical dominance was high (34 percent) often indicating damage to the central growing leader from insects, disease, or physical damage. Vines in the crowns were also common (27 percent of damages), although their effect on their supporting tree hosts was not quantified. Effects ranged from some additional weight to instances of strangulation or smothering. For the identifiable damaging agents, damage by other vegetation, damage from humans (silvicultural/cutting), and weather ranked as the most prevalent primary damage agents (fig. 16).

About 1.5 percent of the trees sampled during the inventory were dead. The most prevalent identifiable dead trees were *Cyathea* spp. (16.6 percent of total dead), *Hibiscus tiliaceus* (10 percent), and *Cyathea ponapeana* (8 percent) (fig. 17).

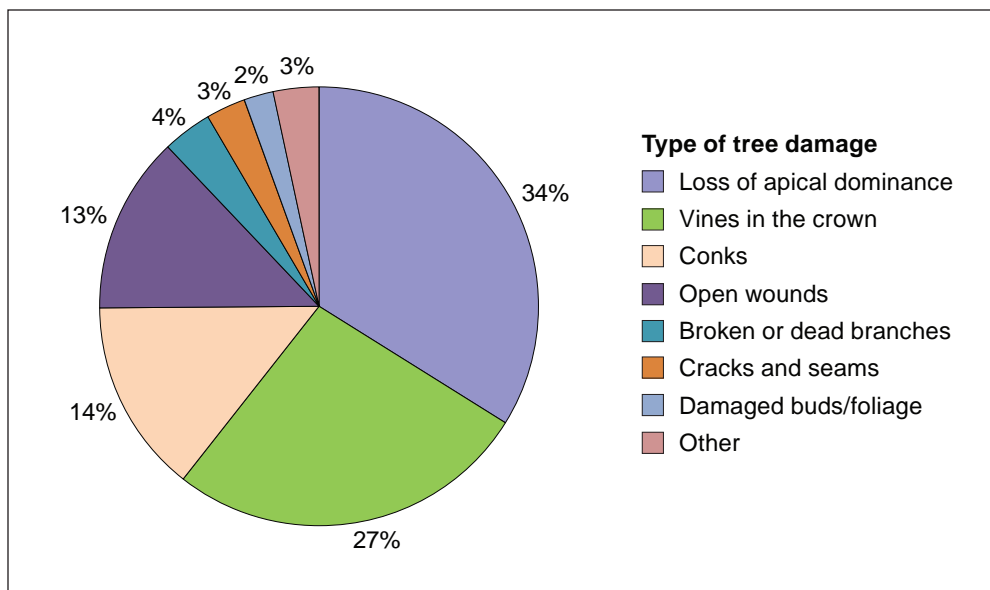


Figure 15—Loss of apical dominance is very common in the Federated States of Micronesia. Damage from vines also was prevalent (recorded when the vines occupied 20 percent or more of the crown). Conks (fruiting shelf fungi indicating rot) were also common damages.

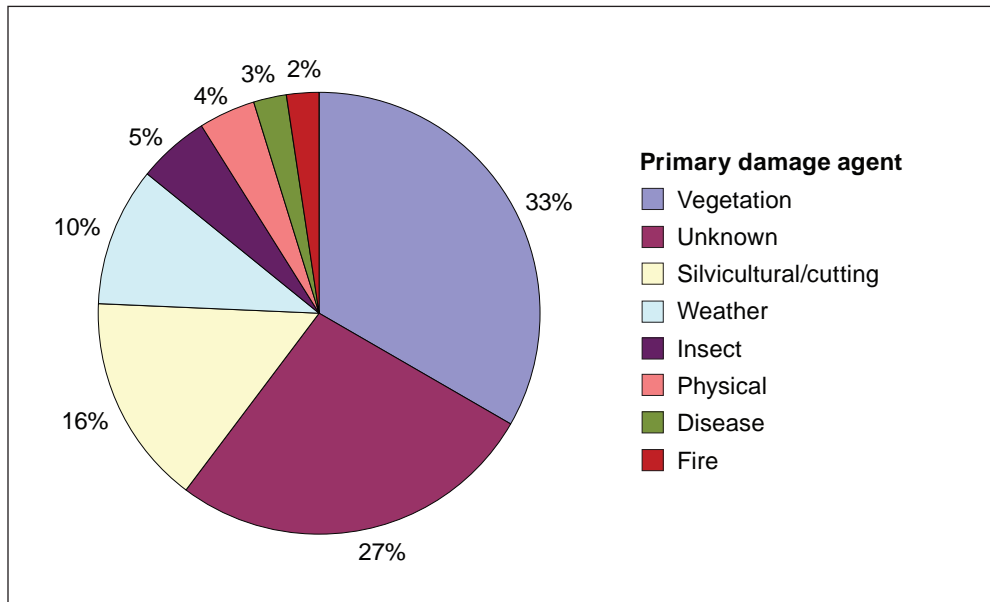


Figure 16—Disturbance from other vegetation and damage from humans were the most common identifiable damaging agents for trees.

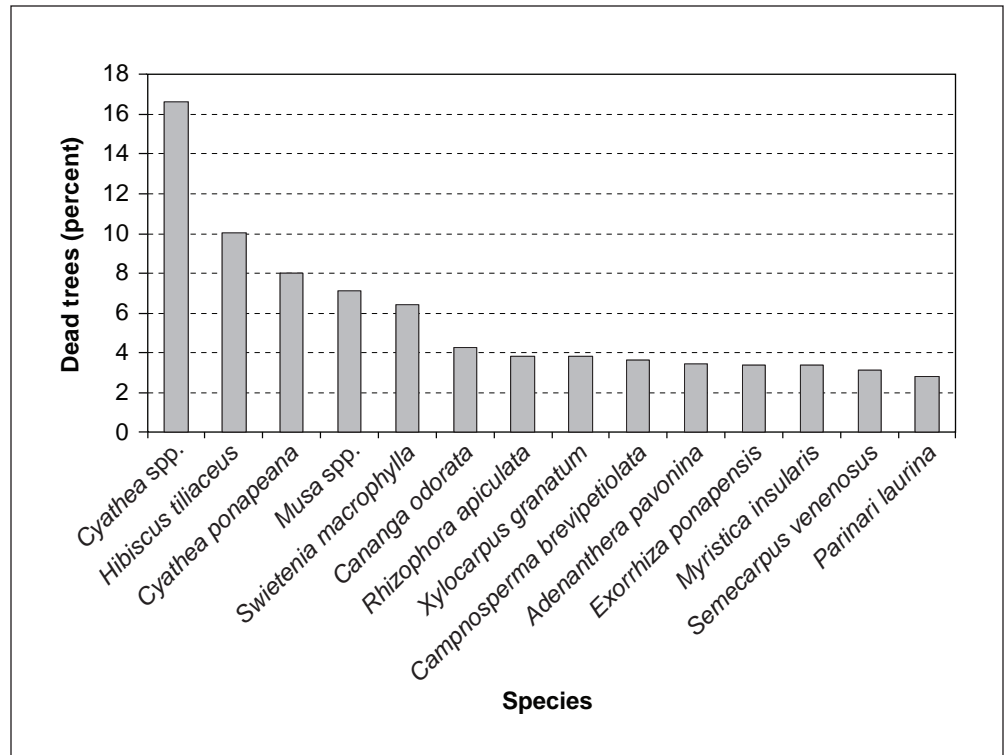


Figure 17—Dead trees were fairly abundant in the Federated States of Micronesia. *Cyathea* spp., *Hibiscus tiliaceus*, and *Cyathea ponapeana* were the most common dead trees of those species identified.

Epiphytes

In the moist environment of the tropics, many plant species are found growing on longer lived trees. These epiphytes use the trees primarily for support, but they also use space, moisture, and nutrients that might otherwise be used by the tree. When the epiphytes accumulate over many years, their weight can be excessive, leading to the breakage of branches and occasionally snapping the stems of trees. In the FSM, we rated epiphytic loading on trees as a summation of loading on the bole, branches, and canopy. We estimate that about 55 percent of the trees (≥ 5 inches diameter at breast height) in the FSM had few to no epiphytes, and 45 percent of the trees had moderate to high amounts of epiphytes (table 11).

Table 10—Number of trees by primary damage type and species for all trees

Species	No damage	Broken bole	Broken or dead	Broken roots	Conks	Cracks/seams	Damaged foliage/shoots	Loss of apical dominance	Open wounds	Vines in crown	Other	All damages
	<i>Number of trees</i>											
<i>Adenanthera pavonina</i>	1,031,561		28,018		239,671	11,986				28,018		1,339,253
<i>Aglaiia ponapensis</i>	2,415,284						11,986					2,427,270
<i>Aidia cochinchinensis</i>	203,862											203,862
<i>Allophylus timorensis</i>	11,365											11,365
<i>Antidesma kusaiense</i>	479,342											479,342
<i>Antidesma</i> spp.	221,861											221,861
<i>Araucaria</i> spp.	23,973	11,986										35,959
<i>Areca catechu</i>	912,405											912,405
<i>Artocarpus altilis</i>	1,976,825				30,954		15,477	252,569		79,150		2,354,974
<i>Averrhoa bilimbi</i>	187,027											187,027
<i>Barringtonia asiatica</i>	334,581											334,581
<i>Barringtonia racemosa</i>	1,404,051	11,986	11,986									1,428,023
<i>Bruguiera gymnorrhiza</i>	2,161,895							19,161				2,181,056
<i>Calophyllum inophyllum</i>	41,341						22,730	9,306				73,376
<i>Camposperma brevipetiolata</i>	1,567,666		23,973		23,973				11,986	47,607		1,675,205
<i>Cananga odorata</i>	4,614,388				223,744	11,986		11,986	208,267	226,078		5,296,449
<i>Carica papaya</i>	10,207											10,207
<i>Cerbera manghas</i>	17,810											17,810
<i>Cinnamomum carolinense</i>	11,986								19,161			31,147
<i>Cinnamomum</i> spp.	23,973											23,973
<i>Citrus reticulata</i>	40,829							10,207				51,036
<i>Claoxylon carolinianum</i>	459,919											459,919
<i>Cocos nucifera</i>	630,735								30,622	78,210		739,566
<i>Commersonia bartramia</i>	2,410,929											2,410,929
<i>Cyathea ponapeana</i>	795,537											795,537
<i>Cyathea</i> spp.	2,794,633									10,207		2,804,841
<i>Cycas</i> spp.	53,431											53,431
<i>Cynometra ramiflora</i>	11,986											11,986
<i>Dendrocnide harveyi</i>	683,392									17,810		701,203
<i>Diospyros ferrea</i>	115,917											115,917
<i>Elaeocarpus carolinensis</i>	843,925		10,207							29,797		883,929
<i>Elaeocarpus kusanoi</i>	471,906											471,906
<i>Eugenia</i> spp.	508,509									11,365		519,874
<i>Eugenia stelechantha</i>	6,173,861							221,861				6,395,722
<i>Exorrhiza ponapensis</i>	5,070,993								76,643			5,147,637
<i>Fagraea berteriana</i>	11,986	11,986					11,986					35,959
<i>Ficus prolixa</i>	313,588		17,810					275,292		61,907		668,597
<i>Ficus</i> spp.	484,337											484,337
<i>Ficus tinctoria</i>	745,406								9,306			754,712
<i>Garcinia ponapensis</i>	19,161											19,161
<i>Garcinia rumiyo</i>	143,833											143,833
<i>Glochidion</i> spp.	1,418,169						141,568		15,477			1,575,214
<i>Heritiera littoralis</i>	95,804											95,804

Table 10—Number of trees by primary damage type and species for all trees (continued)

Species	No damage	Broken bole	Broken or dead	Broken roots	Conks	Cracks/seams	Damaged foliage/shoots	Loss of apical dominance	Open wounds	Vines in crown	Other	All damages
	<i>Number of trees</i>											
<i>Heterospathe elata</i>	125,012											125,012
<i>Hibiscus tiliaceus</i>	9,466,076	31,147	119,777		697,610	33,287	31,147	2,062,869	861,003	736,383		14,039,298
<i>Horsfieldia nunu</i>	1,275,780		10,207	17,810	56,035	10,207		71,242	17,810	239,671		1,698,764
<i>Inocarpus fagifer</i>	133,576									11,365		144,941
<i>Lumnitzera littorea</i>	435,152		15,477						11,365			484,723
<i>Macaranga carolinensis</i>	2,343,652				9,306		23,973			589,736		2,966,667
<i>Macaranga</i> spp.	9,306											9,306
<i>Mangifera indica</i>	504,667		15,477					164,788			15,477	700,408
<i>Morinda citrifolia</i>	187,666									10,207		197,874
<i>Morinda</i> spp.	115,917											115,917
<i>Musa nana</i>	11,365											11,365
<i>Musa</i> spp.	4,208,217				19,161			10,207		626,807	178,185	5,042,577
<i>Myristica insularis</i>	1,086,235											1,086,235
<i>Neubergia celebica</i>	356,741									35,621		392,362
<i>Palaquium karrak</i>	11,986											11,986
<i>Pandanus cominsii</i>	3,015,649											3,015,649
<i>Pandanus dubius</i>	17,810											17,810
<i>Pandanus</i> spp.	659,944		18,611			9,306						687,860
<i>Pandanus tectorius</i>	435,412	11,365			34,094		11,365	115,917				608,153
<i>Pangium edule</i>	329,103											329,103
<i>Parinari laurina</i>	793,497							17,810				811,308
<i>Pittosporum</i> spp.	43,133											43,133
<i>Ponapea hosinoi</i>	221,229											221,229
<i>Ponapea ledermanniana</i>	11,986											11,986
<i>Premna obtusifolia</i>	684,735	9,306	10,207		11,365			11,365				726,977
<i>Premna</i> spp.	447,933											447,933
<i>Psychotria</i> spp.	143,033											143,033
<i>Pterocarpus indicus</i>	785,158											785,158
<i>Ptychococcus ledermanninus</i>	35,621											35,621
<i>Rhizophora apiculata</i>	826,325								11,365			837,690
<i>Rhizophora mucronata</i>	862,236											862,236
<i>Rhizophora</i> spp.	108,338											108,338
<i>Rhizophora stylosa</i>	459,859		76,643									536,502
<i>Rhus taitensis</i>	693,553											693,553
<i>Scyphiphora hydrophyllacea</i>	1,415,679						11,365		22,730			1,449,774
<i>Semecarpus venenosus</i>	274,111	9,306						9,306	46,528			339,250
<i>Sonneratia alba</i>	672,933				106,011			19,161				798,105
<i>Spathodea campanulata</i>	2,581,794	11,986			11,986			322,595	35,959			2,964,320
<i>Sterculia palauensis</i>	334,485											334,485
<i>Swietenia macrophylla</i>	19,161											19,161
<i>Swietenia mahogoni</i>	294,501											294,501
<i>Swietenia</i> spp.										11,365		11,365

Table 10—Number of trees by primary damage type and species for all trees (continued)

Species	No damage	Broken bole	Broken or dead	Broken roots	Conks	Cracks/seams	Damaged foliage/shoots	Loss of apical dominance	Open wounds	Vines in crown	Other	All damages
	<i>Number of trees</i>											
<i>Syzygium carolinense</i>	746,546											746,546
<i>Thespesia populnea</i>	15,477											15,477
<i>Timonius</i> spp.	243,820					19,161						262,981
<i>Toona ciliata</i>	38,322											38,322
<i>Trichospermum ikutai</i>	27,917										9,306	37,222
Unknown	2,874,152		15,477		19,161			9,306				2,918,095
Unknown 0	57,482											57,482
Unknown 14	115,917											115,917
Unknown 20	125,222											125,222
Unknown 5						141,568						141,568
<i>Xylocarpus granatum</i>	822,984	19,161	15,477		49,686				11,365			918,673
Total	83,456,594	128,229	389,347	27,116	1,523,451	309,802	232,025	3,614,946	1,389,585	2,851,304	202,967	94,125,367

Table 11—Estimated number of live trees ≥ 5 inches diameter at breast height on forest land by epiphyte loading (amounts of nontree vegetation in the canopy and branches) and species

Species	Epiphyte loadings				
	None	Low	Moderate	High	All loadings
			<i>Number of trees</i>		
<i>Adenanthera pavonina</i>	53,431	189,807	234,478	61,305	539,022
<i>Aglaia ponapensis</i>		11,986	98,253	107,877	218,117
<i>Aidia cochinchinensis</i>			43,134	19,161	62,294
<i>Allophylus timorensis</i>		11,365			11,365
<i>Antidesma kusaiense</i>		17,810	17,810		35,621
<i>Araucaria</i> spp.		11,986	11,986	11,986	35,959
<i>Areca catechu</i>	170,471	34,094			204,566
<i>Artocarpus altilis</i>	121,685	249,366	176,202	128,186	675,439
<i>Averrhoa bilimbi</i>	34,094	11,365			45,459
<i>Barringtonia asiatica</i>				35,959	35,959
<i>Barringtonia racemosa</i>	41,986	56,373	82,125	47,945	228,431
<i>Bruguiera gymnorrhiza</i>	508,388	191,608	176,016	22,730	898,741
<i>Calophyllum inophyllum</i>	9,306	29,976	11,365	22,730	73,376
<i>Camposperma brevipetiolata</i>	39,102	45,265	320,168	258,888	663,423
<i>Cananga odorata</i>	207,258	370,909	357,573	149,660	1,085,401
<i>Carica papaya</i>	10,207				10,207
<i>Cerbera manghas</i>	17,810				17,810
<i>Cinnamomum carolinense</i>				31,147	31,147
<i>Cinnamomum</i> spp.			11,986	11,986	23,973
<i>Citrus reticulata</i>		51,036			51,036
<i>Claoxylon carolinianum</i>				11,986	11,986
<i>Cocos nucifera</i>	227,340	244,556	158,820	108,850	739,566
<i>Commersonia bartramia</i>	71,918	56,629	32,657	11,986	173,190
<i>Cyathea ponapeana</i>	47,945	23,973	71,918	203,768	347,604
<i>Cyathea</i> spp.	17,810	315,688	668,778	207,475	1,209,752
<i>Cycas</i> spp.		35,621	17,810		53,431
<i>Cynometra ramiflora</i>		11,986			11,986
<i>Dendrocnide harveyi</i>		17,810		17,810	35,621
<i>Elaeocarpus carolinensis</i>	41,783	57,815	77,742	186,106	363,446
<i>Elaeocarpus kusanoi</i>		11,986	11,986		23,973
<i>Eugenia</i> spp.	19,161			23,351	42,512
<i>Eugenia stelechantha</i>		71,242	17,810	17,810	106,863
<i>Exorrhiza ponapensis</i>	346,109	1,546,325	1,758,589	810,000	4,461,023
<i>Fagraea berteriana</i>			11,986	23,973	35,959
<i>Ficus prolixa</i>		71,242	306,586	68,908	446,737
<i>Ficus</i> spp.	11,365			9,306	20,670
<i>Ficus tinctoria</i>		33,278	53,770	21,292	108,340
<i>Garcinia ponapensis</i>	19,161				19,161
<i>Garcinia rumiyo</i>	27,917				27,917
<i>Glochidion</i> spp.	15,477	65,041	51,624	11,986	144,128
<i>Heritiera littoralis</i>			38,322	57,482	95,804
<i>Heterospatha elata</i>	79,553	45,459			125,012
<i>Hibiscus tiliaceus</i>	262,995	845,490	762,305	691,109	2,561,899
<i>Horsfieldia nunu</i>	56,035	572,956	343,607	155,295	1,127,894
<i>Inocarpus fagifer</i>		56,933	68,847	19,161	144,941
<i>Lumnitzera littorea</i>	87,777	11,365			99,142
<i>Macaranga carolinensis</i>	32,657	9,306	128,580	63,422	233,964
<i>Macaranga</i> spp.			9,306		9,306
<i>Mangifera indica</i>	56,638	200,313	101,357		358,307
<i>Morinda citrifolia</i>	25,684	10,207	10,207	10,207	56,306

Table 11—Estimated number of live trees ≥ 5 inches diameter at breast height on forest land by epiphyte loading (amounts of nontree vegetation in the canopy and branches) and species (continued)

Species	Epiphyte loadings				All loadings
	None	Low	Moderate	High	
	<i>Number of trees</i>				
<i>Musa nana</i>	11,365				11,365
<i>Musa</i> spp.	1,530,285	343,051	226,286	92,597	2,192,218
<i>Myristica insularis</i>		86,267	246,902	155,823	488,991
<i>Neubergia celebica</i>			117,070	53,431	170,502
<i>Palaquium karrak</i>				11,986	11,986
<i>Pandanus dubius</i>		17,810			17,810
<i>Pandanus</i> spp.	74,444	9,306	58,350	18,611	160,711
<i>Pandanus tectorius</i>	107,470	11,365			118,835
<i>Pangium edule</i>	18,611	21,292	11,986	11,986	63,876
<i>Parinari laurina</i>	124,673	77,404		11,986	214,064
<i>Pittosporum</i> spp.		11,986	19,161	11,986	43,134
<i>Ponapea hosinoi</i>		11,986	23,973	35,959	71,918
<i>Ponapea ledermanniana</i>			11,986		11,986
<i>Premna obtusifolia</i>	11,365	29,976	57,183	11,986	110,510
<i>Psychotria</i> spp.		17,810	9,306		27,116
<i>Pterocarpus indicus</i>		55,120	68,919	63,876	187,915
<i>Ptychococcus ledermanninus</i>			35,621		35,621
<i>Rhizophora apiculata</i>	711,360	95,804	19,161	11,365	837,690
<i>Rhizophora mucronata</i>	728,110	114,965	19,161		862,236
<i>Rhizophora</i> spp.	108,338				108,338
<i>Rhizophora stylosa</i>	536,502				536,502
<i>Rhus taitensis</i>	11,365				11,365
<i>Scyphiphora hydrophyllacea</i>	34,094				34,094
<i>Semecarpus venenosus</i>	46,528	65,139	65,139	46,528	223,333
<i>Sonneratia alba</i>	201,815	166,001	95,804	95,804	559,424
<i>Spathodea campanulata</i>		323,632	203,768	47,945	575,345
<i>Sterculia palauensis</i>		76,643	19,161		95,804
<i>Swietenia macrophylla</i>		19,161			19,161
<i>Swietenia mahogoni</i>	11,365				11,365
<i>Swietenia</i> spp.			11,365		11,365
<i>Syzygium carolinense</i>	11,986		47,945		59,932
<i>Thespesia populnea</i>	15,477				15,477
<i>Timonius</i> spp.			31,147		31,147
<i>Toona ciliata</i>		19,161	19,161		38,322
<i>Trichospermum ikutai</i>	27,917		9,306		37,222
Unknown	55,736	49,565	101,550	34,088	240,939
Unknown 0			19,161	38,322	57,482
Unknown 20		9,306			9,306
<i>Xylocarpus granatum</i>	629,363		22,730	125,012	777,105
Total	7,669,235	7,230,917	7,815,005	4,520,136	27,235,293

Forest Dynamics

The forests of the FSM are generally dense forests with larger trees, reflected in high basal area and wood volume on a per-acre basis (table 12). Gap-phase dynamics typically characterize tropical forests where little human intervention occurs (Brokaw 1985). Species die and are replaced on an individual basis as the forest renews itself. In more heavily disturbed areas, cohorts of regeneration, maturity, and senescence are common. Forest structure and species composition change through time as a result of forest succession and disturbance dynamics. The forests of the FSM have been strongly influenced by a long history of shifting human settlement and disturbance, both human caused and climatic. Human populations have fluctuated, and resulting land use has changed. Within the last century, the most important land use changes have involved the conversion of forests to agricultural and urban uses, and disturbance by military actions, especially on Chuuk.

Table 12—Estimated number of trees per acre, basal area per acre, net and gross volume per acre, and standard errors (SE) for trees ≥5 inches, 2005–2006

	Chuuk	SE	Kosrae	SE	Pohnpei	SE	Yap	SE	Total	SE
Trees per acre	137	21	166	29	208	18	123	20	179	12
Basal area (ft ² per acre)	98	21	142	38	158	16	51	12	132	12
Net volume (ft ³ per acre)	2,411	813	4,357	1,397	4,582	552	1,026	334	3,752	417
Gross volume (ft ³ per acre)	2,423	815	4,358	1,398	4,645	564	1,027	334	3,788	422

Much of the flat land on Chuuk had been planted with coconut (*Cocos nucifera* L.) and sweet potato (*Ipomoea batatas* (L.) Lam.) prior to and during World War II and now supports agroforest (Mueller-Dombois and Fosberg 1998). Yap has had a long history of agroforestry use in the form of tree gardens that supported formerly extensive human populations (Mueller-Dombois and Fosberg 1998). Much of the native vegetation there has been altered. Pohnpei’s intact upland forest is currently threatened by commercial introductions of kava. A “Grow Low” campaign sponsored by the Conservation Society of Pohnpei and The Nature Conservancy seeks to conserve intact upland forests by promoting the cultivation of agricultural crops at lower elevations. The interpretation of 1975 aerial photography showed Pohnpei to be about 16 percent agroforest, but that percentage was adjusted upward to 33 percent using the proportion of field plots found to be agroforest in 1983 (MacLean et al. 1986). From the mapping work in 2005–2006, Pohnpei’s agroforest was

estimated to be about 16 percent of total land cover (table 2). Using the 2006 inventory plots, the inventory-based estimate for agroforest area would be only about 9 percent of total land cover. However, the standard error of the field-plot estimate is about 45 percent of the estimate meaning the percentage of agroforest is 9 percent, plus or minus 4.5 percent. On Kosrae, the abundance of precipitation and the difficulty in access to the steep topography has permitted the persistence of dense upland rain forest with tremendous epiphyte growth. In the lowlands, the landscape has been modified to provide food and fiber via agroforest. However, as sea levels rise, Kosrae is faced with the possibility of substantial loss of flat, lowland areas owing to tidal surges and inundation. Food and water security have become important concerns for low-lying Pacific islands and atolls that are facing the loss of arable lands, both through urbanization and inundation from rising sea levels.

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Metric Equivalentents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	.305	Meters
Miles	1.609	Kilometers
Acres	.405	Hectares
Square miles	2.59	Square kilometers
Cubic feet	.028	Cubic meters
Tons	907	Kilograms
Tons per acre	2.24	Tonnes or megagrams per hectare
Cubic feet per acre	.07	Cubic meters per hectare
Trees per acre	2.471	Trees per hectare
Degrees Fahrenheit	$(^{\circ}\text{F} - 32)/1.8$	Degrees Celsius

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