Palau's Forest Resources, 2003

Joseph A. Donnegan, Sarah L. Butler,
Olaf Kuegler, Brent J. Stroud,
Bruce A. Hiserote, and Kashgar Rengulbai

Resource Bulletin
PNW-RB-252
January 2007

USDA United States Department of Agriculture

Forest Service

PNW Pacific Northwest Research Station

Authors

Joseph A. Donnegan is an ecologist, **Sarah L. Butler** is an ecologist, **Olaf Kuegler** is a statistician, and **Bruce A. Hiserote** is an information management specialist, Forestry Sciences Laboratory, 620 SW Main Street, Suite 400, Portland, OR 97205-3028. **Brent J. Stroud** was the quality assurance technician for the Portland Forestry Sciences Laboratory, but now works for Interior West Forest Inventory and Analysis. **Kashgar Rengulbai** was a forester on Palau.

Abstract

Donnegan, Joseph A.; Butler, Sarah L.; Kuegler, Olaf; Stroud, Brent J.; Hiserote, Bruce A.; Rengulbai, Kashgar. 2007. Palau's forest resources, 2003. Resour. Bull. PNW-RB-252. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 52 p.

The Forest Inventory and Analysis Program collected, analyzed, and summarized field data on 54 forested plots on the islands in the Republic of Palau. 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 Palau's forest resources and a comparison to 1987 data.

Keywords: Palau, biomass, damage, FIA, forest inventory, volume, land cover.

Summary

The Forest Inventory and Analysis (FIA) Program conducted a systematic inventory of the forests of Palau in 2003 to estimate forest area, tree stem volume, biomass, carbon storage, tree damages, and the percentage cover of understory vegetation species. Fifty-four permanent field plots were installed, 11 in limestone forest and 43 in volcanic forest. Land cover was mapped into five broad classes, forest, nonforest vegetation, urban, barren, and inland water, by using recently acquired high-resolution satellite imagery. Soil survey information was used to classify forest into limestone and volcanic types. Our estimates for this inventory are derived from a sample based on 110,028 acres in Palau, with about 16 percent of the land classified as limestone forest and 67 percent classified as volcanic forest. About 2 percent of the landscape was classified as urban land, the majority on Koror and Babeldaob. We estimated gross tree stem volume to be about 302 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 4.7 million tons. Approximately 13 percent of the trees sampled in the inventory had some form of damage. The growth of damaging vines in the crowns of trees was the most prevalent damage type, with conks and lost apical dominance following in prevalence. The most frequently identified damaging agents were other vegetation, disease, and weather. Palau's forests are relatively dense and have high species diversity. A total of 128 tree species and 132 understory species were measured on FIA plots. The average number of tree species per sixth-acre plot was 12 in volcanic forest and 10 in limestone forest. Palauan foresters and ecologists were especially helpful with species identification in the field.

Introduction

This summary of forest resources on the islands of Palau (fig. 1) was based on a forest inventory conducted in 2003 by the USDA Forest Service, Pacific Northwest Forest Inventory and Analysis (FIA) Program in cooperation with Pacific Island foresters. The inventory is a subset of the national FIA effort and was designed to help answer local and national questions about the status and trends in tropical forested ecosystems and to share forestry skills among cultures and agencies. The fieldwork for this inventory was conducted by a multinational crew including foresters from Palau, American Samoa, and mainland U.S. foresters and ecologists.

This systematic, sample-based field inventory on Palau is an update to prior inventory work (Cole et al. 1987, MacLean et al. 1988) estimating forest type area, tree size distribution, and stem volume. New information is included for all forests on biomass, and damages for living and dead trees. The inventory was designed to provide resource managers with information about the current situation so they can better manage their forested and nonforested lands, and manage or mitigate any changes in the resource. Empirically based knowledge of the status and trends in forest vegetation can help managers plan sustainable land use practices, plan sustainable supplies of wood, control invasive species, control erosion, and manage disturbances such as fire and animal damage.

Objectives

- Estimate the current area of forest land by forest type group and stand size class.
- Estimate the volume, biomass, and carbon storage for tree species by 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.

Methods

Site Description

Palau is well known for its tremendous diversity and concentration of both terrestrial and marine life along the network of coral reefs and the chain of more than 300 raised limestone and volcanic islands. The chain of islands runs from the northeast to southwest for a distance of about 125 miles, approximately 470 miles east of the Philippines. The islands range in size from the relatively large, volcanic island

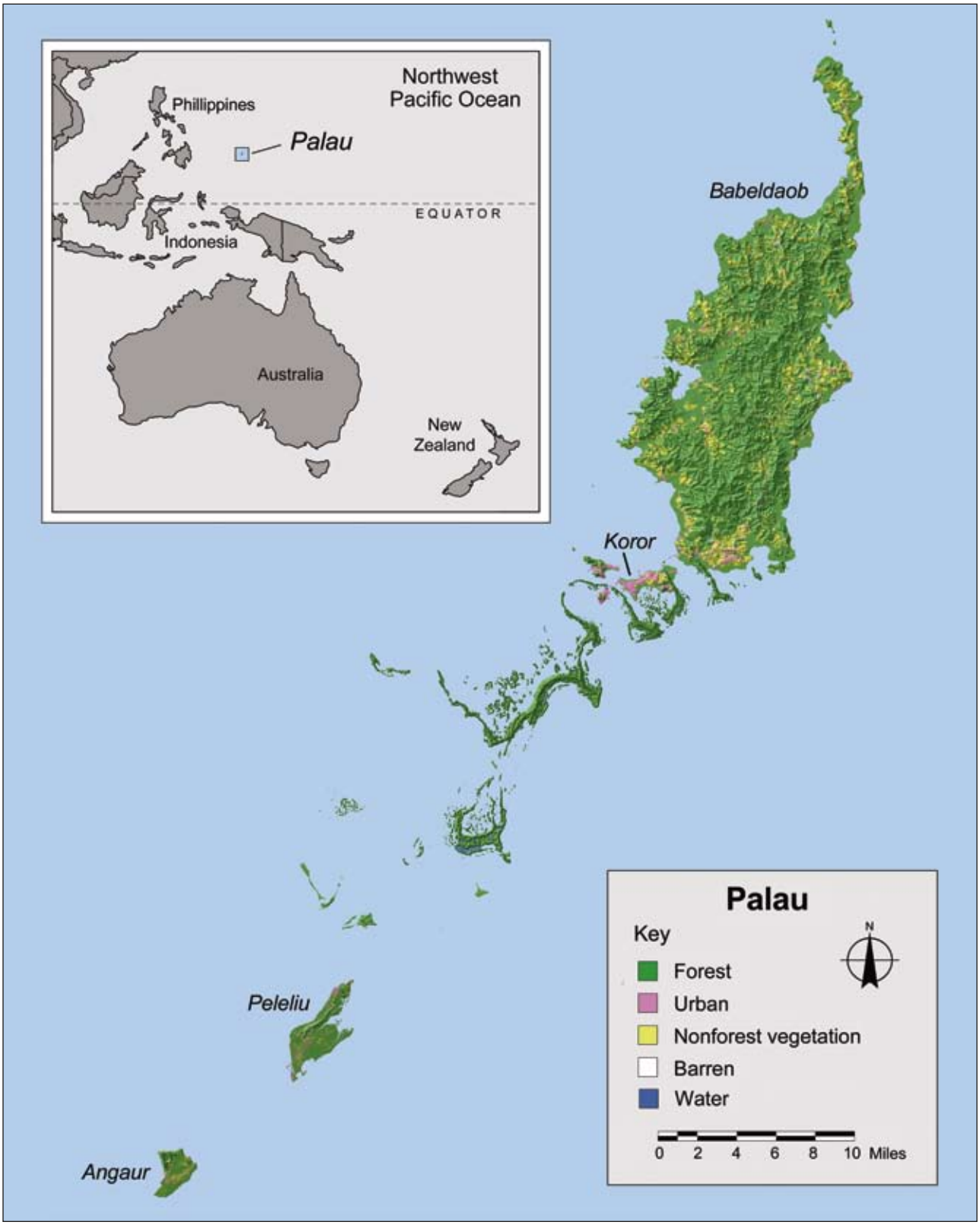

Figure 1—The Republic of Palau is in the North Pacific Ocean approximately 470 miles east of the Phillipines. Land cover was mapped from 2005 QuickBird satellite data.

of Babeldaob, at about 92,000 acres, to coral rocks topped with trees, only a few yards across. The tremendous marine diversity is supported by the convergence of oceanic currents and the filtering and nutrient effects of the dense terrestrial forests. The topography of the four volcanic islands is marked by steep slopes and rolling hills, with mangroves often found on coastal flats. The limestone coral islands or "Rock Islands" support a diversity of tree species on often surprisingly shallow soils deposited in the recesses of the rugged karstic topography. The highest point in Palau is the approximately 700-foot-tall Mount Ngerchelchuus on Babeldaob (Palau Conservation Society).

The climate of Palau is hot and humid with little annual variation in the mean maximum temperature of 87.9 °F and the mean minimum of 75.6 °F (fig. 2). Total annual precipitation averages 147.3 inches. In the wettest months, June and July, monthly precipitation averages 17.04 inches, whereas during the driest months, February, March, and April, monthly precipitation averages 8.84 inches (data from Western Regional Climate Center 2004). During an El Niño year (warm phase of the Southern Oscillation), rainfall tends to be above average for that summer and below average in the following autumn and winter months (Climate Prediction Center 2005).

Palau borders the typhoon belt in the western tropical Pacific and is subject to occasional typhoon damage. Prior to European contact, extensive terracing was practiced on Babeldaob in upland areas. Paleoenvironmental evidence suggests terracing may have contributed to landcover change from forest to savanna and fernland, and accelerated erosion as much as 2,500 years before present (Athens and Ward 2002). Additional recent disturbances have included mining of bauxite, military action during World War II (which denuded much of Peleliu and Angaur), and conversion of forest for agriculture. Forest was cleared during the recent construction of a new capitol on Babeldaob and a road to encircle the island. Barren volcanic soils pose high risk of erosion with frequent, intense rainfall and are often a corridor for colonization by invasive species.

Vegetation Types

The flora of Palau shares many common elements with that of east-Asian and Indo-Malesian floras (Mueller-Dombois and Fosberg 1998). Species composition in Palau is distinctive depending on the parent material the soil is derived from, with volcanic soils found in the north (Babeldaob, Arakabesang, Malakal, and Oreor), and limestone soils on Peleliu, Angaur, and the Rock Islands to the south. Where volcanic soils are deposited along coastal flats, mangrove and freshwater swamps are common. The volcanic islands also support a shrubby, strand vegetation, a

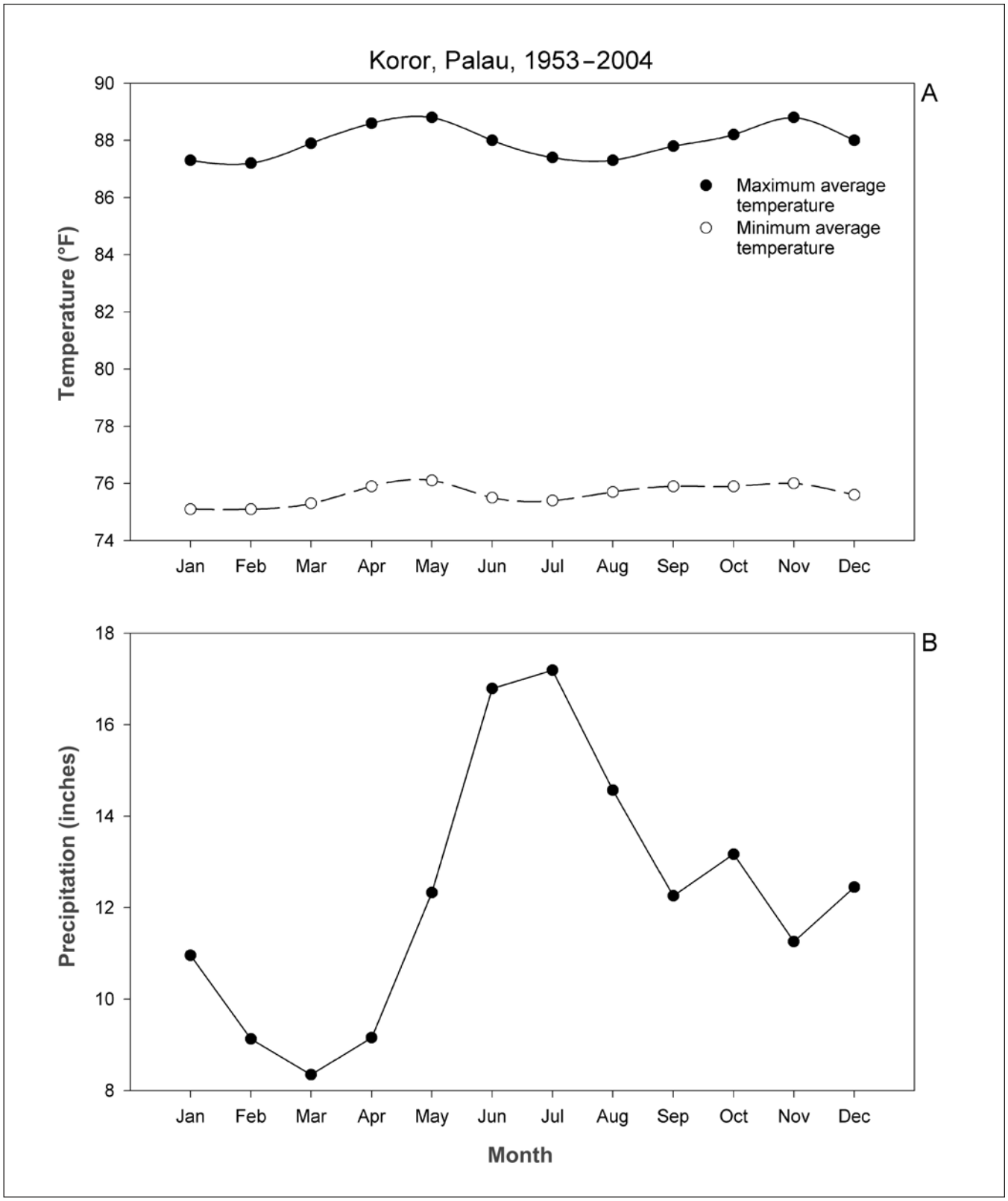

Figure 2—(A) The annual maximum and minimum temperatures in Palau do not fluctuate markedly. However, (B) precipitation is highly variable throughout the year with a distinct summer wet season and a dry early spring (Western Regional Climate Center 2004).

closed-canopy interior volcanic forest, ravine and riparian forest, and savanna and fernland on degraded soils (Mueller-Dombois and Fosberg 1998). The southern, raised limestone islands support evergreen, closed-canopy forest that is generally quite species rich and variable from island to island (Cole et al. 1987). Note that the current report does not describe the vegetation of the Southwest Islands of Palau, approximately 400 miles southwest of Babeldaob. Additionally, the FIA inventory does not provide sufficient plot density to reliably classify vegetation types in these highly diverse tropical forests, but provides plot-level data to help refine remotely sensed estimates of forest type acreage and developmental stage. Some of the species named in the following vegetation descriptions (from Cole et al. 1987, and Mueller-Dombois and Fosberg 1998) were not identified on the 2003 sample of FIA field plots, either owing to their absence, their understory cover not meeting the 3 percent threshold, or possible misidentification. The FIA and local island staff were trained by regional botanical experts, and when species could not be identified in the field, they were sent for expert identification. However, misidentification in the field remains a possibility.

Volcanic Forest Types

Mangrove—

Mangroves play a vital role in buffering the effects of storms and waves along coastal areas. They also provide habitat for marine life and filter runoff exiting terrestrial ecosystems. The filtration that mangroves provide helps to sustain coral reef and fish habitat by trapping sediment. The mangroves of Palau are a particularly species-rich mangrove type that extends along a narrow strip of the tidal zone. The species found here include *Rhizophora mucronata, Rhizophora apiculata, Bruguiera gymnorrhiza, Ceriops tagal, Sonneratia alba, Avicennia marina, Lumnitzera littorea, Xylocarpus granatum, Scyphiphora hydrophyllacea, Dalbergia candenatensis, Derris trifoliata, Nypa fruticans, Acrostichum aureum,* and *Nephrolepis acutifolia* (see table 1 for common and scientific names with authorities). Mangroves are very dense forest types where left undisturbed.

Swamp forest—

This forest type tends to occur slightly inland of mangrove in areas of fresh or slightly brackish water. *Horsfieldia amklaal, Cynometra ramiflora, Barringtonia racemosa, Campnosperma brevipetiolata,* and *Heritiera littoralis* are often found in the intact freshwater swamps, whereas *Hibiscus tiliaceus* is found in disturbed areas.

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees on Palau

Scientific name	Common name	Number measured	Estimated number (≥1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥5 inches diameter)	Standard error for estimated volume (±)
Aglaia palauensis Kaneh.	meseoes	23	847,803	431,384	1,783,505	1,359,572
Allophylus ternatus (Forst.) Radlk.	chebeludes	3	36,989	37,027	206,199	206,415
Allophylus timorensis (DC.) Bl.	ebeludes, chebeludes	1	12,330	12,342	29,280	29,311
Alphitonia carolinensis Hosok.	elebiob, elebiong	50	1,531,290	803,629	4,434,129	1,662,961
Annona reticulata L.	ngel ra ngebard	1	12,330	12,342	62,771	62,836
Areca catechu L.	buuch, betel nut	6	73,977	74,055	292,165	292,472
Artocarpus mariannensis Trec.	ebiei, wild breadfuit	4	48,518	35,710	5,140,163	4,028,666
Astronidium palauense (Kaneh.) Mgf.	meskui	32	1,641,189	590,773	1,169,439	460,600
Avicennia marina (Bl.) Bakh.	dadaiit	2	24,659	24,685	1,422,693	1,424,186
Badusa palauensis Valeton	ralm	29	897,973	582,173	3,048,028	2,276,642
Barringtonia racemosa (L.) Spreng.	koranges	51	3,407,461	2,020,608	2,986,606	1,838,290
Bruguiera gymnorrhiza (L.) Lam.	kadeges, denges, adeges	43	1,095,193	671,454	5,542,897	2,800,425
Buchanania palawensis Lauterb.	geloagl	10	405,607	253,723	1,308,999	1,155,922
Calophyllum inophyllum L.	laurel	34	1,184,578	579,030	5,436,901	3,643,184
Calophyllum pelewense P. F. Stevens	chesemoroch	20	608,511	363,048	1,040,719	654,142
Calophyllum soulattri Burm. f.	olebtaches, chesemoroch	6	356,489	332,521	480,790	342,400
Calophyllum sp. L.		6	61,247	45,601	1,910,972	1,635,495
Campnosperma brevipetiolata Volk.	kelela charm, kiu	72	1,133,048	372,006	22,836,047	6,496,431
Canarium hirsutum Willd.	mesechaues	11	553,209	439,687	1,072,970	1,081,278
Casearia cauliflora Volk.	kevert	1	12,330	12,342	157,802	157,967
Casearia sp. Jacq.		7	84,906	93,158	626,648	687,549
Casuarina equisetifolia L.	ngas, ironwood	6	24,259	17,855	1,436,905	1,536,233
Cerbera floribunda K. Schum.	emeridech	2	24,659	17,251	281,010	234,815
Cerbera manghas L.	emeridech	19	362,987	187,580	2,378,467	906,798
Cocos nucifera L.	lius, coconut	26	318,967	175,394	8,416,588	4,303,993
Commersonia bartramia (L.) Merr.	aspitan, eremallueang	7	165,915	153,955	29,882	29,913
Cordia micronesica Kaneh. & Hatus.		1	12,330	12,342	312,315	312,643
Cyathea lunulata (Forst. f.) Copel.	eluu, tree fern	46	634,436	212,213	1,985,641	633,206
Diospyros ferrea (Willd.) Bakh.		10	393,478	357,921	384,300	270,515
Diospyros sp. L.		10	544,171	302,309	717,026	458,131
Dodonaea viscosa (L.) Jacq.		6	73,177	34,397	1,642,371	831,416
Dracaena multiflora L.		14	878,093	397,272	459,125	279,546
Drypetes nitida Kaneh.	keuelt	4	187,882	180,779	373,021	309,627
Dysoxylum sp. Blume		13	1,572,844	901,519	64,752	64,820

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees on Palau (continued)

Scientific name	Common name	Number measured	Estimated number (≥1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥5 inches diameter)	Standard error for estimated volume (±)
Elaeocarpus graeffei Seem.		1	12,330	12,342	64,508	64,575
Elaeocarpus joga Merr.	dekemerír	49	1,419,038	530,051	6,648,512	2,094,414
Erythrina fusca Lour.	roro	1	12,129	13,308	600,183	658,512
Eugenia cumini (L.) Druce	mesekerrak, java plum	23	974,799	753,514	1,960,664	1,472,100
Eugenia javanica Lam.	rebotel	20	381,553	251,122	4,324,582	2,660,022
Eugenia reinwardtiana (Bl.) DC.	kesiil	65	3,017,755	1,068,888	6,011,868	3,482,031
Eugenia sp. L.		7	648,639	313,824	130,011	76,791
Evodia sp.		1	153,586	153,747	—	—
Fagraea ksid Gilg and Bened.	ksid	19	172,613	76,502	2,248,390	1,098,577
Ficus sp. L.		2	165,915	153,955	409,933	410,364
Ficus tinctoria Forst. f.	oseked	9	1,096,866	936,957	3,187,214	3,429,467
Flacourtia rukam Zoll. & Moritzi		21	1,388,568	780,722	751,255	355,672
Garcinia matudai Kaneh.	tilol	12	995,490	741,721	725,013	655,318
Garcinia rumiyo Fosb.	tilol	40	2,457,435	969,319	2,520,347	1,145,401
Garcinia sp. L.		30	650,797	298,347	2,603,796	1,020,943
Gironniera celtidifolia Gaudich.		3	36,989	37,027	261,379	261,653
Glochidion ramiflorum Forst.		26	1,565,282	776,102	1,201,069	508,131
Glochidion sp. J.R. & G. Forst.		3	178,245	166,261	93,117	65,804
Gmelina elliptica Sm.	kalngebard ra belau	22	825,997	495,311	4,368,123	2,646,783
Gmelina palawensis H. J. Lam.	blancheos	49	1,027,314	537,789	4,916,499	1,349,345
Gmelina sp. L.		6	73,977	51,752	1,315,262	959,938
Guettarda speciosa L.	belau	3	460,757	461,240	—	—
Gulubia palauensis (Becc.) Moore & Fosb.	chebouch, akaboek	9	97,036	106,466	518,759	569,175
Hernandia sonora L.	dokou	3	36,388	39,925	360,357	395,379
Hernandia sp. L.		5	60,647	66,541	1,714,517	1,881,143
Heterospathe elata (Becc.) Becc.	demailei, ebouch	11	700,649	641,212	404,770	332,830
Hibiscus tiliaceus L.	cheramal	25	2,709,590	2,248,657	375,843	273,510
Horsfieldia amklaal Kaneh.	emeklachel, eumail	25	1,003,150	563,395	5,112,032	4,154,971
Horsfieldia novo-guineensis Warb.	ersachel	24	1,002,188	567,747	10,735,352	9,640,055
Horsfieldia palauensis Kaneh.	ersachel	101	3,852,198	1,132,578	13,722,763	5,211,646
Horsfieldia sp. Wild.		5	626,672	614,824	42,993	43,038
Inocarpus fagifer (Park.) Fosb.	keam, boui	1	12,330	12,342	29,390	29,421
Intsia bijuga (Colebr.) O. Ktze.	dort	20	381,553	267,583	8,903,896	6,152,703
Lumnitzera littorea (Jack) Voigt	ngemoel, mekekad	1	12,330	12,342	127,232	127,365

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees on Palau (continued)

Scientific name	Common name	Number measured	Estimated number (≥1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥5 inches diameter)	Standard error for estimated volume (±)
Macaranga carolinensis Volk.	bedel	49	5,074,421	1,760,927	671,260	357,840
Manilkara udoido Kaneh.	udeuid	29	283,579	173,439	2,085,556	1,209,721
Manilkara zapota (L.) P. v. Roy.	sapodilla	6	73,977	62,652	1,296,562	1,181,412
Morinda citrifolia L.	ngel	8	946,172	352,952	132,139	99,769
Morinda latibracteata Val.	kesengelengel, ngel	5	61,648	50,610	211,608	165,154
Morinda pedunculata Val.	kesengelengel	1	12,330	12,342	81,626	81,712
Morinda sp. L.		3	36,989	37,027	127,267	127,400
Mussaenda frondosa L.		1	153,586	153,747	—	—
Neonauclea forsteri Merrill		3	460,757	461,240	—	—
Nephelium lappaceum L.	rambutan, rambotang	1	12,330	12,342	100,828	100,934
Osmoxylon oliveri Fosberg & Sachet		3	178,245	155,148	65,896	65,965
Osmoxylon sp.		9	675,990	639,395	145,875	86,232
Pandanus aimiriikensis Mart.	ertochet	25	3,130,866	1,232,969	272,360	167,696
Pandanus dubius Spr.	beku, ongor	21	810,575	608,016	897,251	621,269
Pandanus kanehirae Mart.	buuk	6	202,904	190,886	332,031	262,594
Pandanus palawensis Mart.	ongor	1	153,586	153,747	—	—
Pandanus tectorius Park.	ongor	13	559,393	274,312	463,602	464,088
Pandanus utiyamai Kaneh.		1	12,330	12,342	1,050,209	1,051,312
Pangium edule Reinw. ex Bl.	riamel	2	24,659	24,685	237,335	237,584
Parinari corymbosum (Bl.) Miq.	bkau, apgau	63	2,008,183	672,025	21,934,439	7,016,031
Parinari laurina Gray	eritem, gritin	56	2,086,261	1,251,377	5,980,513	3,010,760
Parinari sp.		4	331,830	223,617	66,714	48,675
Pinanga insignis Becc.	ebouch, demailei	240	11,655,307	2,337,956	8,329,960	1,802,335
Pithecellobium dulce (Roxb.) Benth.	kamatsiri, opiuma	4	465,410	510,641	80,161	87,951
Pongamia pinnata (L.) Merr.	kisaks	1	151,094	165,778	—	—
Pouteria calcarea (Hosok.) Fosb.	elangel	3	36,989	37,027	160,981	161,150
Pouteria obovata (R. Br.) Baehni	elangel	37	855,954	637,145	4,146,921	1,701,642
Pouteria sp. Aubl.		1	12,330	12,342	59,315	59,377
Premna obtusifolia R. Br.	osem	9	381,148	309,108	246,764	165,406
Pterocarpus indicus Willd.	las	2	24,659	24,685	917,560	918,523
Ptychosperma palauensis (Kaneh.) Moore & Fosb.	esbuuch	8	239,892	240,144	329,740	330,086
Rhizophora apiculata Bl.	bngaol	129	3,657,133	2,280,225	8,538,981	5,332,588
Rhizophora mucronata Lam.	tebechel	31	365,084	327,871	2,265,232	1,681,146
Rhus taitensis Guill.	eues	40	714,045	251,240	5,850,777	2,434,616

Table 1—Scientific names, common names, estimated number and gross volume, and standard errors for estimated totals of species measured as trees on Palau (continued)

Scientific name	Common name	Number measured	Estimated number (≥1 inch diameter)	Standard error for estimated number (±)	Gross volume (≥5 inches diameter)	Standard error for estimated volume (±)
Rinorea carolinensis Kaneh.		1	12,129	13,308	44,758	49,108
Semecarpus venenosus Volk.	tonget	58	2,266,927	689,153	6,877,953	2,306,382
Sonneratia alba J. E. Sm.	urur	52	5,959,545	3,934,040	11,503,833	11,491,789
Stemonurus ammui (Kaneh.) Sleumer	ngmui	5	61,648	61,712	3,215,714	3,219,089
Swietenia macrophylla King	honduras mahogany	5	202,904	179,561	327,606	235,724
Swietenia mahagoni (L.) Jacq.	mahogany	8	381,148	345,648	414,720	307,348
Symplocos racemosa Roxb.		19	829,575	509,114	224,606	143,427
Tecoma stans (L.) Juss. ex HBK.		1	153,586	153,747	—	—
Terminalia catappa L.	beach almond, miich	4	49,318	38,757	805,001	657,530
Theobroma cacao L.	suklatei, cocoa	5	61,648	61,712	617,845	618,494
Timonius subauritus Fosberg & Sachet		19	1,595,842	1,090,534	925,779	614,886
Tournefortia argentea L. f.	rirs, tree heliotrope	4	48,918	36,301	327,509	270,923
Trichospermum ledermannii Burret	elsau	11	252,222	167,347	1,067,694	945,028
Vitex cofassus Reinw. ex Bl.	bars, beokel	9	110,966	111,082	5,134,682	5,140,070
Xylocarpus granatum Koen.	meduulokebong	16	338,528	292,559	1,399,499	1,140,977
Unknown 0		13	188,082	168,017	120,479	85,328
Unknown 1		6	331,630	215,243	37,791	32,354
Unknown 2		2	307,171	307,493	—	—
Unknown 3		4	24,659	17,251	228,639	188,570
Unknown 5		7	85,906	67,207	513,431	452,329
Unknown 11		1	12,330	12,342	126,165	126,298
Unknown, other		7	36,989	20,875	1,657,879	1,471,197
Total		2,248	96,594,950	6,639,026	268,511,801	26,355,589

Interior volcanic forest—
Occurring primarily on volcanic substrates, interior volcanic forest encompasses distinct subtypes of forest in undisturbed ecosystems. Moving inland from the mangroves and swamps, the dominant species include *Casuarina equisetifolia* and *Pandanus tectorius.* Farther inland, the forest grades into a mixed-forest canopy that includes *Campnosperma brevipetiolata, Horsfieldia amklaal, H. palauensis, H. novo-guineensis, Myristica insularis, Parinari laurina, Parinari corymbosum, Serianthes kanehirae, Glochidion macrosepalum, G. ramiflorum, Alphitonia carolinensis, Calophyllum inophyllum* var. *wakamatsui, C. soulattri, C. pelewense, Symplocos racemosa* var. *palauensis, Cerbera floribunda, Manilkara udoido,* and *Fagraea ksid.* The forest is dense, multilayered, and structurally complex here.

Ravine and riparian forest—
In the complex terrain of Palau's savannas, ravines often break up the open forest and grassland with narrow strips and sheltered hillsides of more dense and diverse forest vegetation occurring in relatively moist areas. *Barringtonia racemosa* and the poison tree (causes a severe skin rash) *Semecarpus venenosus* are common components of the ravine and riparian type.

Limestone forest type

On the limestone substrate of Peleliu, Angaur, and the Rock Islands, organic matter from the vegetation forms a thin layer in places over the coral rock. The limestone substrate is often steep, porous, and extremely rugged. Rock that borders the ocean is often undercut by waves and bioerosion, making access difficult. A species-rich and structurally diverse forest forms here with the dominant species *Intsia bijuga, Psychotria* spp., *Clerodendron inerme, Eugenia reinwardtiana, Morinda latibracteata, Garcinia matudai, G. rumiyo* var. *clacicola, Rinorea* sp., *Cycas circinalis, Flacourtia rukam* var. *micronesica, Aidia cochinchinensis, Meryta senfftiana, Polyscias grandifolia, Geniostoma sessile, Premna serratifolia, Cyrtandra todaiensis, Guettarda speciosa, Badusa palauensis, Psychotria hombroniana, Ixora casei,* and *Tarenna sambucina.*

Field Methods

The Palau inventory was based on the FIA inventory design that was implemented across the mainland United States beginning in 2000. Adaptations were made to the national design to include additional branching and rooting forms, using topography to define site productivity or drought resilience (in perhumid climates), additional tree crown measurements, and including special-interest species ranging from invasive plants to pathogens to culturally or economically important species

of various life forms. In the mainland FIA Program, plots are spaced within forest land on a 3.3-mile grid. With the assistance of the Government of Palau, Bureau of Agriculture, plots were spaced across all vegetation types at approximately 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. 3). 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 was 120 feet.

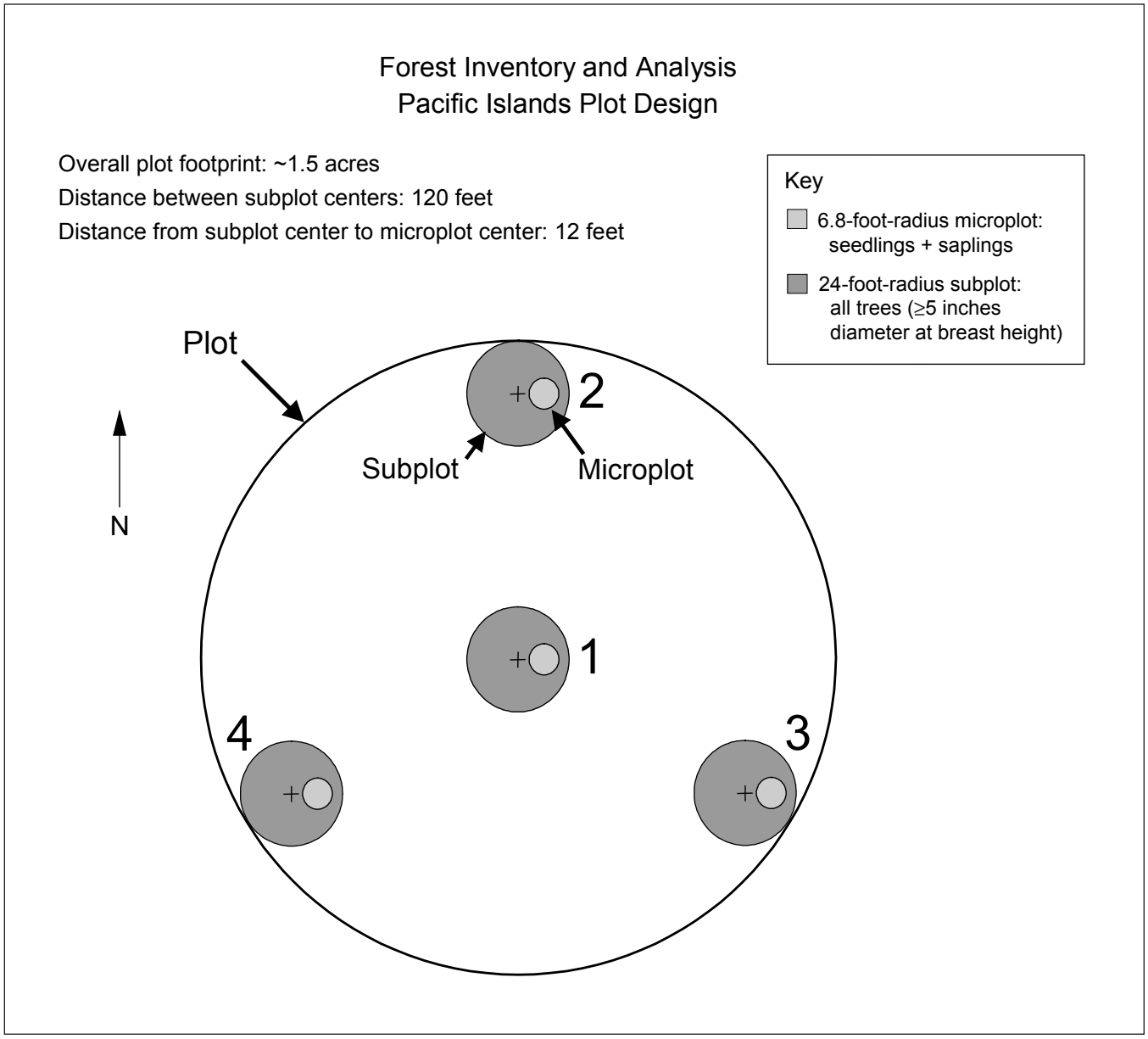

Figure 3—Forest Inventory and Analysis Pacific Islands plot design.

A variety of information was collected at the plot, subplot, and tree levels (USDA Forest Service 2003). 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 February to April 2003.

Analysis Methods

The FIA estimates of 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.

The Palau stratification for estimating numbers of trees, volume, biomass, and carbon was conducted via a classification of 2003 IKONOS satellite data. The initial land-cover classification divided the landscape into forest, urban, nonforest vegetation, barren, and water cover types. At least 10 percent cover of trees 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 cover of trees. A geographic information system (GIS) was used to sum acreage for each type. Forest was further classified into volcanic and limestone forest types by overlaying a soils layer (USDA Natural Resources Conservation Service 1983) on the land-cover-classification layer in a GIS. We used the GIS to individually sum the acreage of limestone and volcanic forest types. From this limestone/volcanic stratification, field plot condition types were expanded to the landscape level. The acreage each field plot represents was derived by dividing the total acreage of forest in each of the limestone and volcanic soil types by the number of field plots that fell within the geographic bounds of that specific type. Average stand size was expanded from the plots to the landscape level by using the same expansion factors.

Land cover was further refined into more detailed classes through an ongoing cooperative project with the USDA Forest Service, Pacific Southwest Region, Remote Sensing Laboratory. Both the 2003 IKONOS and 2005 QuickBird satellite imagery were used for the detailed mapping and served as the basis for land cover estimates.

Wood volume was estimated for individual trees by 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 (30 out of 129 species measured on Palau have known specific gravities). For species where specific gravity was not known, an average specific gravity, according to forest type, 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.

An additive combination of relative density and relative basal area (importance value) was used to classify forest types and assess the species dominance in a stand. 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 like Palau, 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.

Reliability of FIA Data

The area of forested land cover types classified from the IKONOS satellite imagery was assumed to be accurate and was used as the basis for the expansion of the numbers of trees, tree volume, and tree biomass from the plot scale 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 either volcanic or limestone forest types. Volcanic and limestone 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 on Palau lies between

275,061,708 and 329,711,230 cubic feet. There is a 68-percent chance that the true number of trees (≥1 inch diameter) on Palau lies within the range of 89,955,926 to 103,233,978. 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

Palau is currently about 82 percent forested, which includes agroforest and secondary forest vegetation (table 2). About 2 percent of the landscape was classified as urban land and about 14 percent was classified as nonforest vegetation including savanna and agricultural lands. The area for land cover estimates totaled 110,028 acres.

A prior vegetation survey (Cole et al. 1987) delineated vegetation types by using 1976 aerial photography, and estimated forest cover to be 80 percent of total land, including secondary vegetation and agroforest (table 2). Nonforest vegetation was estimated to be about 20 percent of the total land cover. Total acreage calculated from the Cole et al. (1987) maps that FIA recently scanned and digitized was 101,851 acres.

The methodology and the area sampled for land cover estimates differ from those used for prior estimates. The Cole et al. (1987) work surveyed and mapped less limestone forest and 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 national FIA standards and the recent FIA work in American Samoa and Guam. In the current survey we mapped roads as urban land.

To compare similar sample areas on Palau, we summarized land cover area on an island-by-island basis for Babeldaob, Peleliu, Angaur, and Koror (fig. 4). Although the difference in canopy cover thresholds between 1987 and 2005 still exists, trends suggest there may be some areas of Babeldaob where nonforest vegetation has reverted to forest. On Peleliu and Koror, it appears that forest land is being converted to urban and nonforest vegetation uses. These observations are tentative pending a thorough analysis of land cover change for Palau.

Table 2—Estimated area by land cover, 1976[a] and 2005

Land cover	1976	2005
	Acres	
Limestone forest[b]	9,626	17,316
Volcanic forest	71,948	73,369
Total forest land[c]	81,574	90,685
Nonforest and other areas:		
Nonforest urban	1,550	2,433
Nonforest vegetation	18,250	15,329
Barren lands	339	1,103
Unclassified		64
Water	139	414
Total nonforest and other land	20,277	19,343
Total area in survey	101,851	110,028

[a] Figures for maps derived from 1976 aerial photography differ slightly from those published by Cole et al. (1987). Figures here were derived by scanning the historical maps and aggregating area totals with a geographic information system.
[b] The sample area for forest cover, especially limestone types, was increased between the 1976 and 2005 remotely sensed imagery.
[c] Forest land includes agroforest and secondary forest vegetation.

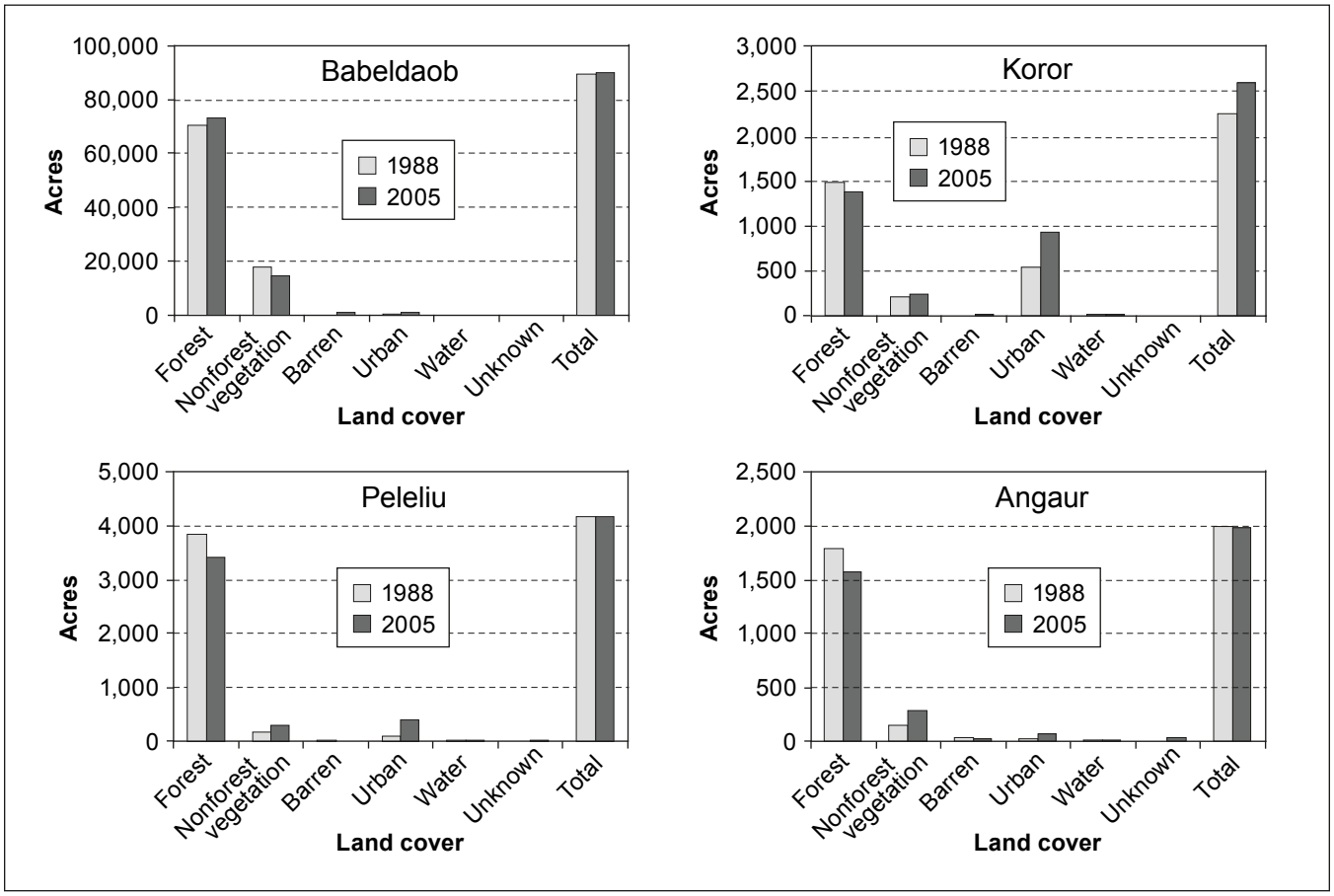

Figure 4—Forest land on Babeldaob is maturing and may be encroaching slightly on nonforest vegetation. On Peleliu, Koror, and Angaur, forest land is being lost to urban and nonforest vegetation land uses. Conversion of forest to urban land use is also expected on Babeldaob upon completion of the circumnavigating "Compact Road" in 2006, that will open areas previously inaccessible.

Productivity and Drought Resilience

Site productivity estimates are difficult to obtain in tropical environments owing to 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. 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 attempted to estimate productivity as an additive index based on a site's potential moisture accumulation owing to local topography (TRMI) (Parker 1982). However, in a region of such high precipitation, as in Palau, the TRMI estimate of productivity may be much less reliable than productivity estimates based on detailed soil mapping. For example, differences among forest, savanna, and fernland topsoils are dramatic with respect to soil organic matter, cation exchange capacity, and potential aluminum toxicity for plant growth, with a succession of soil degradation occurring from forest soils to savanna and fernland soils through processes of land clearing, repeated burning, and subsequent erosion and leaching of topsoil nutrients (Smith and Babik 1988). 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. Using TRMI in this context, we classified approximately 58 percent of the forested lands in Palau as medium high to highest drought resilience (fig. 5). This relatively high percentage owes to much of the land on Babeldaob being gently sloping volcanic soils, and thus drought resilience on these lands is expected to be relatively high. Babeldaob represents approximately 80 percent of our inventory area. On the limestone and limestone-derived soils of the Rock Islands, resilience to drought would be expected to be less based on lower moisture retaining capacities of these well-drained, often shallow soils and the complex karst topography. However, aluminum toxicity to plants is not expected on limestone-derived soils, whereas it is likely to limit plant growth in degraded volcanic-derived soils.

Forest Structure

Forest Inventory and Analysis estimates stand size class on forested field plots to capture the predominant diameter of live trees in forest stands. In Palau the dominant size class for volcanic forest types tends to be small, in the 5- to 11-inch diameter category (table 3, fig. 6). Limestone forest types tend to be dominated by slightly larger trees, in the 11- to 20-inch category (fig. 6). No plots were sampled on limestone soils that included stands in the smallest diameter category of 1 to 5 inches.

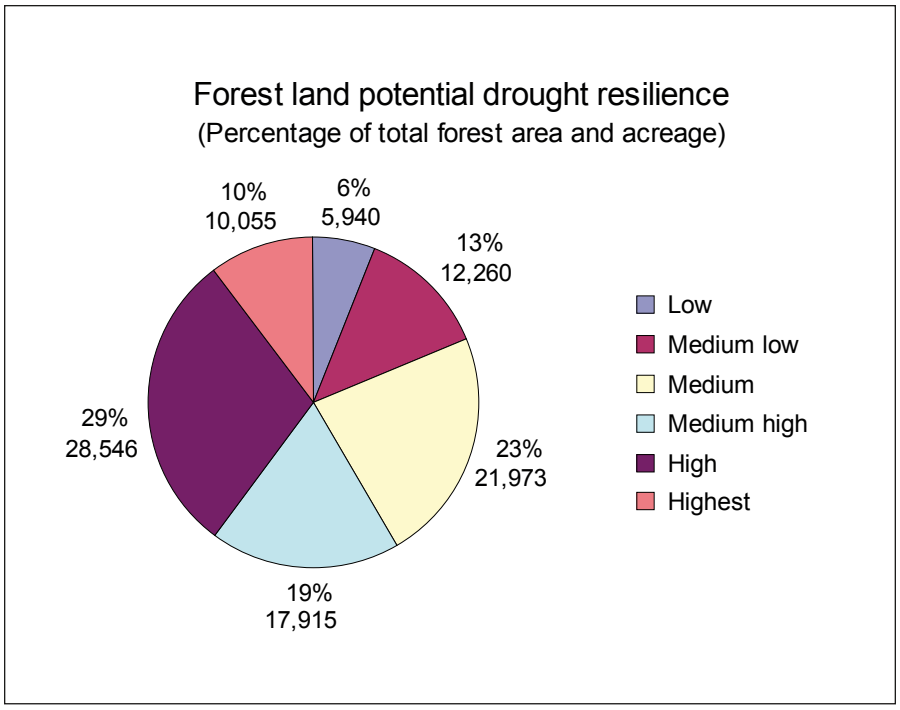

Figure 5—A topographic relative moisture index was used to predict drought resilience in the perhumid climate of Palau. On the gentle slopes and relatively deep volcanic soils of the largest island, Babeldaob (approximately 80 percent of forested acreage on Palau), drought resilience is expected to be higher than in the raised limestone Rock Islands.

The diameter distribution for trees on Palau is heavily weighted toward small-diameter trees (fig. 7). This "reverse-J" distribution of tree diameter is typical where regeneration is abundant. Through time, 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 30- to 50-foot height classes (fig. 8). The tallest tree on an FIA plot, a *Horsfieldia* sp., measured 44 inches in diameter and approximately 114 feet tall.

Wood volume (fig. 9, tables 4, 5, and 6), biomass (fig. 10, table 7), and carbon storage (table 8) follow a similar distribution as the "reverse-J" seen for the number of trees according to diameter (fig. 7). Most of the volume, biomass, and carbon is accounted for in the smaller diameter classes owing to the relatively high number of trees in those size classes. (*Text continues on page 33.)*

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

Species	Diameter class (inches) ≤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+	All classes
							Number of trees								
Aglaia palauensis	614,342	122,495	36,989	49,318	—	—	24,659	—	—	—	—	—	—	—	847,803
Allophylus ternatus	—	—	36,989	—	—	—	—	—	—	—	—	—	—	—	36,989
Allophylus timorensis	—	12,330	—	—	—	—	—	—	—	—	—	—	—	—	12,330
Alphitonia carolinensis	1,075,099	197,272	135,625	36,989	61,648	—	24,659	—	—	—	—	—	—	—	1,531,290
Annona reticulata	—	12,330	—	—	—	—	—	—	—	—	—	—	—	—	12,330
Areca catechu	—	61,648	12,330	—	—	—	—	—	—	—	—	—	—	—	73,977
Artocarpus mariannensis	—	—	—	—	—	12,129	—	—	12,129	—	12,129	12,129	—	—	48,518
Astronidium palauense	1,382,270	184,943	36,989	36,989	—	—	—	—	—	—	—	—	—	—	1,641,189
Avicennia marina	—	—	—	12,330	—	—	—	—	—	—	—	12,330	—	—	24,659
Badusa palauensis	606,866	121,295	24,259	84,906	24,259	24,259	12,129	—	—	—	—	—	—	—	897,973
Barringtonia racemosa	3,064,235	135,224	86,106	61,047	48,718	12,129	—	—	—	—	—	—	—	—	3,407,461
Bruguiera gymnorrhiza	614,342	135,625	172,613	86,307	24,659	49,318	—	—	—	—	—	—	—	12,330	1,095,193
Buchanania palawensis	307,171	73,777	—	12,330	—	—	—	—	—	12,330	—	—	—	—	405,607
Calophyllum inophyllum	916,529	36,588	61,247	36,588	48,518	12,129	24,259	—	36,588	—	12,129	—	—	—	1,184,578
Calophyllum pelewense	460,757	61,447	61,648	—	24,659	—	—	—	—	—	—	—	—	—	608,511
Calophyllum soulattri	307,171	12,330	12,330	—	24,659	—	—	—	—	—	—	—	—	—	356,489
Calophyllum sp.	—	—	24,459	12,129	—	—	—	12,330	—	12,330	—	—	—	—	61,247
Campnosperma brevipetiolata	307,171	123,095	98,636	86,307	147,954	98,636	86,307	73,977	36,989	36,989	36,989	—	—	—	1,133,048
Canarium hirsutum	455,773	36,588	24,459	12,129	12,129	—	—	12,129	—	—	—	—	—	—	553,209
Casearia cauliflora	—	—	12,330	—	—	—	—	—	—	—	—	—	—	—	12,330
Casearia sp.	—	60,647	12,129	12,129	—	—	—	—	—	—	—	—	—	—	84,906
Casuarina equisetifolia	—	12,129	—	—	—	—	—	—	—	—	—	12,129	—	—	24,259
Cerbera floribunda	—	12,330	—	—	12,330	—	—	—	—	—	—	—	—	—	24,659
Cerbera manghas	153,586	61,447	36,989	61,648	24,659	12,330	12,330	—	—	—	—	—	—	—	362,987
Cocos nucifera	—	—	—	85,706	171,813	49,118	—	12,330	—	—	—	—	—	—	318,967
Commersonia bartramia	153,586	12,330	—	—	—	—	—	—	—	—	—	—	—	—	165,915
Cordia micronesica	—	—	—	—	—	12,330	—	—	—	—	—	—	—	—	12,330
Cyathea lunulata	153,586	258,920	147,954	49,318	24,659	—	—	—	—	—	—	—	—	—	634,436
Diospyros ferrea	307,171	49,318	36,989	—	—	—	—	—	—	—	—	—	—	—	393,478
Diospyros sp.	458,265	49,118	24,459	—	12,330	—	—	—	—	—	—	—	—	—	544,171
Dodonaea viscosa	—	12,330	12,129	12,129	—	—	24,259	—	—	12,330	—	—	—	—	73,177
Dracaena multiflora	767,928	73,377	24,459	—	12,330	—	—	—	—	—	—	—	—	—	878,093
Drypetes nitida	151,094	12,330	12,129	—	—	12,330	—	—	—	—	—	—	—	—	187,882
Dysoxylum sp.	1,535,855	36,989	—	—	—	—	—	—	—	—	—	—	—	—	1,572,844
Elaeocarpus graeffei	—	12,330	—	—	—	—	—	—	—	—	—	—	—	—	12,330
Elaeocarpus joga	916,529	159,083	171,813	12,330	86,106	36,388	36,788	—	—	—	—	—	—	—	1,419,038
Erythrina fusca	—	—	—	—	—	—	—	12,129	—	—	—	—	—	—	12,129
Eugenia cumini	755,468	109,765	48,718	12,129	24,459	12,129	12,129	—	—	—	—	—	—	—	974,799
Eugenia javanica	151,094	36,388	48,518	60,647	12,129	12,129	24,259	12,129	12,129	—	—	12,129	—	—	381,553
Eugenia reinwardtiana	2,434,941	255,319	145,554	97,036	48,518	12,129	12,129	12,129	—	—	—	—	—	—	3,017,755
Eugenia sp.	611,850	36,788	—	—	—	—	—	—	—	—	—	—	—	—	648,639
Evodia sp.	153,586	—	—	—	—	—	—	—	—	—	—	—	—	—	153,586

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+	
	Number of trees														
Fagraea ksid	—	49,318	—	61,648	24,659	12,330	24,659	—	—	—	—	—	—	—	172,613
Ficus tinctoria	1,072,607	—	12,129	—	—	—	—	—	—	—	—	—	—	12,129	1,096,866
Flacourtia rukam	1,228,684	110,565	36,989	—	12,330	—	—	—	—	—	—	—	—	—	1,388,568
Garcinia matudai	921,513	36,989	12,330	12,330	—	12,330	—	—	—	—	—	—	—	—	995,490
Garcinia rumiyo	2,150,197	135,425	85,706	49,118	36,989	—	—	—	—	—	—	—	—	—	2,457,435
Garcinia sp.	307,171	221,131	49,118	48,718	24,659	—	—	—	—	—	—	—	—	—	650,797
Gironniera celtidifolia	—	24,659	12,330	—	—	—	—	—	—	—	—	—	—	—	36,989
Glochidion ramiflorum	1,369,810	85,506	85,506	12,129	12,330	—	—	—	—	—	—	—	—	—	1,565,282
Glochidion sp.	153,586	24,659	—	—	—	—	—	—	—	—	—	—	—	—	178,245
Gmelina elliptica	606,866	60,847	24,259	24,259	24,259	24,259	24,459	12,129	12,330	—	—	—	12,330	—	825,997
Gmelina palawensis	460,757	234,261	135,625	86,106	49,118	36,989	—	24,459	—	—	—	—	—	—	1,027,314
Gmelina sp.	—	—	24,659	12,330	12,330	12,330	—	12,330	—	—	—	—	—	—	73,977
Guettarda speciosa	460,757	—	—	—	—	—	—	—	—	—	—	—	—	—	460,757
Gulubia palauensis	—	97,036	—	—	—	—	—	—	—	—	—	—	—	—	97,036
Hernandia sonora	—	12,129	12,129	—	12,129	—	—	—	—	—	—	—	—	—	36,388
Hernandia sp.	—	24,259	—	12,129	12,129	—	—	—	—	—	12,129	—	—	—	60,647
Heterospathe elata	614,342	61,648	24,659	—	—	—	—	—	—	—	—	—	—	—	700,649
Hibiscus tiliaceus	2,610,954	49,318	49,318	—	—	—	—	—	—	—	—	—	—	—	2,709,590
Horsfieldia amklaal	757,960	146,954	36,788	—	12,330	36,788	—	—	—	—	—	—	—	12,330	1,003,150
Horsfieldia novo–guineensis	767,928	86,307	36,989	49,318	—	12,330	12,330	12,330	12,330	—	—	—	—	12,330	1,002,188
Horsfieldia palauensis	2,895,698	478,850	208,201	159,283	48,918	12,129	—	—	12,129	—	—	—	12,330	24,659	3,852,198
Horsfieldia sp.	614,342	12,330	—	—	—	—	—	—	—	—	—	—	—	—	626,672
Inocarpus fagifer	—	12,330	—	—	—	—	—	—	—	—	—	—	—	—	12,330
Intsia bijuga	151,094	12,129	48,518	24,259	12,129	24,259	24,259	24,259	12,129	12,129	12,129	—	12,129	12,129	381,553
Lumnitzera littorea	—	—	—	12,330	—	—	—	—	—	—	—	—	—	—	12,330
Macaranga carolinensis	4,914,737	110,565	36,989	12,129	—	—	—	—	—	—	—	—	—	—	5,074,420
Manilkara udoido	—	197,272	36,989	12,330	—	12,330	12,330	12,330	—	—	—	—	—	—	283,579
Manilkara zapota	—	24,659	—	12,330	12,330	—	—	—	12,330	12,330	—	—	—	—	73,977
Morinda citrifolia	921,513	—	24,659	—	—	—	—	—	—	—	—	—	—	—	946,172
Morinda latibracteata	—	61,648	—	—	—	—	—	—	—	—	—	—	—	—	61,648
Morinda pedunculata	—	12,330	—	—	—	—	—	—	—	—	—	—	—	—	12,330
Morinda sp.	—	36,989	—	—	—	—	—	—	—	—	—	—	—	—	36,989
Mussaenda frondosa	153,586	—	—	—	—	—	—	—	—	—	—	—	—	—	153,586
Neonauclea forsteri	460,757	—	—	—	—	—	—	—	—	—	—	—	—	—	460,757
Nephelium lappaceum	—	—	12,330	—	—	—	—	—	—	—	—	—	—	—	12,330
Osmoxylon oliveri	153,586	24,659	—	—	—	—	—	—	—	—	—	—	—	—	178,245
Osmoxylon sp.	614,342	61,648	—	—	—	—	—	—	—	—	—	—	—	—	675,990
Pandanus aimiriikensis	3,069,219	36,989	12,330	12,330	—	—	—	—	—	—	—	—	—	—	3,130,866
Pandanus dubius	604,374	181,942	24,259	—	—	—	—	—	—	—	—	—	—	—	810,575
Pandanus kanehirae	153,586	—	49,318	—	—	—	—	—	—	—	—	—	—	—	202,904
Pandanus palawensis	153,586	—	—	—	—	—	—	—	—	—	—	—	—	—	153,586
Pandanus tectorius	460,757	73,977	24,659	—	—	—	—	—	—	—	—	—	—	—	559,393
Pandamus utiyamai	—	—	—	—	—	—	—	—	—	—	—	12,330	—	—	12,330

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

Species	Diameter class (inches) ≤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+	All classes
							Number of trees								
Pangium edule	—	—	12,330	12,330	—	—	—	—	—	—	—	—	—	—	24,659
Parinari corymbosum	1,379,778	184,743	73,777	36,989	61,648	86,307	12,330	12,330	12,330	24,659	12,330	49,318	12,330	49,318	2,008,182
Parinari laurina	1,520,904	282,778	86,106	98,436	48,918	—	36,989	—	—	—	12,129	—	—	—	2,086,261
Parinari sp.	307,171	24,659	—	—	—	—	—	—	—	—	—	—	—	—	331,830
Pinanga insignis	9,522,303	2,083,686	36,989	12,330	—	—	—	—	—	—	—	—	—	—	11,655,307
Pithecellobium dulce	453,281	—	12,129	—	—	—	—	—	—	—	—	—	—	—	465,410
Pongamia pinnata	151,094	—	—	—	—	—	—	—	—	—	—	—	—	—	151,094
Pouteria calcarea	—	36,989	—	—	—	—	—	—	—	—	—	—	—	—	36,989
Pouteria obovata	453,281	134,424	134,224	73,177	36,388	—	—	12,129	12,330	—	—	—	—	—	855,954
Pouteria sp.	—	—	12,330	—	—	—	—	—	—	—	—	—	—	—	12,330
Premna obtusifolia	307,171	49,318	24,659	—	—	—	—	—	—	—	—	—	—	—	381,148
Pterocarpus indicus	—	—	—	—	—	—	12,330	—	—	12,330	—	—	—	—	24,659
Ptychosperma palauensis	153,586	86,307	—	—	—	—	—	—	—	—	—	—	—	—	239,892
Rhizophora apiculata	2,288,831	782,687	401,472	110,565	36,788	36,788	—	—	—	—	—	—	—	—	3,657,133
Rhizophora mucronata	—	242,589	85,506	12,330	24,659	—	—	—	—	—	—	—	—	—	365,084
Rhus taitensis	307,171	86,307	98,636	61,648	61,648	61,648	24,659	12,330	—	—	—	—	—	—	714,045
Rinorea carolinensis	—	—	12,129	—	—	—	—	—	—	—	—	—	—	—	12,129
Semecarpus venenosus	1,689,441	271,049	135,224	73,177	49,118	12,129	12,129	—	—	—	—	12,330	—	12,330	2,266,927
Sonneratia alba	5,836,250	12,330	24,659	—	12,330	—	12,330	—	—	—	—	—	24,659	36,989	5,959,545
Stemonurus ammui	—	—	12,330	—	—	—	12,330	12,330	24,659	—	—	—	—	—	61,648
Swietenia macrophylla	153,586	36,989	—	12,330	—	—	—	—	—	—	—	—	—	—	202,904
Swietenia mahagoni	307,171	49,318	12,330	12,330	—	—	—	—	—	—	—	—	—	—	381,148
Symplocos racemosa	767,928	49,318	12,330	—	—	—	—	—	—	—	—	—	—	—	829,575
Tecoma stans	153,586	—	—	—	—	—	—	—	—	—	—	—	—	—	153,586
Terminalia catappa	—	—	12,330	24,659	12,330	—	—	—	—	—	—	—	—	—	49,318
Theobroma cacao	—	12,330	24,659	—	24,659	—	—	—	—	—	—	—	—	—	61,648
Timonius subauritus	1,510,936	36,388	24,259	12,129	—	—	12,129	—	—	—	—	—	—	—	1,595,842
Tournefortia argentea	—	12,129	12,129	12,330	—	12,330	—	—	—	—	—	—	—	—	48,918
Trichospermum ledermannii	153,586	36,989	24,659	24,659	12,330	—	—	—	—	—	—	—	—	—	252,222
Vitex cofassus	—	—	12,330	—	—	12,330	24,659	12,330	—	24,659	12,330	12,330	—	—	110,966
Xylocarpus granatum	153,586	61,648	24,659	36,989	12,330	36,989	—	12,330	—	—	—	—	—	—	338,528
Unknown 0	151,094	36,989	—	—	—	—	—	—	—	—	—	—	—	—	188,082
Unknown 1	307,171	12,129	12,330	—	—	—	—	—	—	—	—	—	—	—	331,630
Unknown 2	307,171	—	—	—	—	—	—	—	—	—	—	—	—	—	307,171
Unknown 3	—	12,330	—	—	12,330	—	—	—	—	—	—	—	—	—	24,659
Unknown 5	—	24,259	36,989	24,659	—	—	—	—	—	—	—	—	—	—	85,906
Unknown 11	—	—	—	12,330	—	—	—	—	—	—	—	—	—	—	12,330
Unknown, other	—	12,330	—	12,330	—	—	—	—	—	—	—	—	—	12,330	36,989
Total	76,110,228	10,058,255	4,047,132	2,219,238	1,558,645	822,076	551,827	318,767	220,731	160,084	122,295	135,024	73,777	196,872	96,594,950

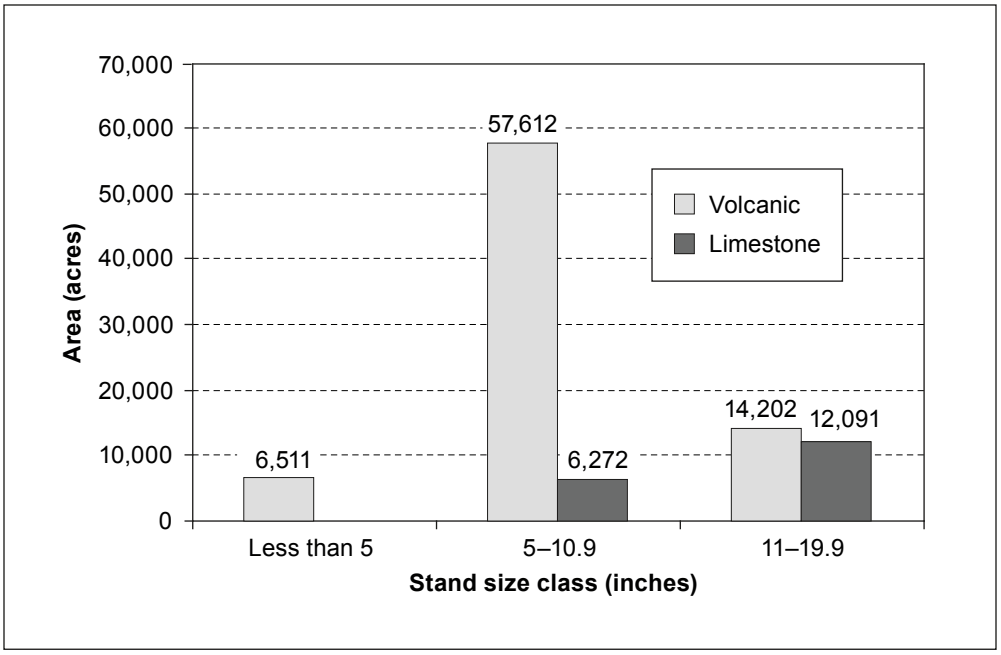

Figure 6—The trees that characterize volcanic forests tend to be somewhat small, in the 5- to 11-inch category. Forested stands on limestone soils tend to be characterized by larger trees in the 11- to 20-inch category.

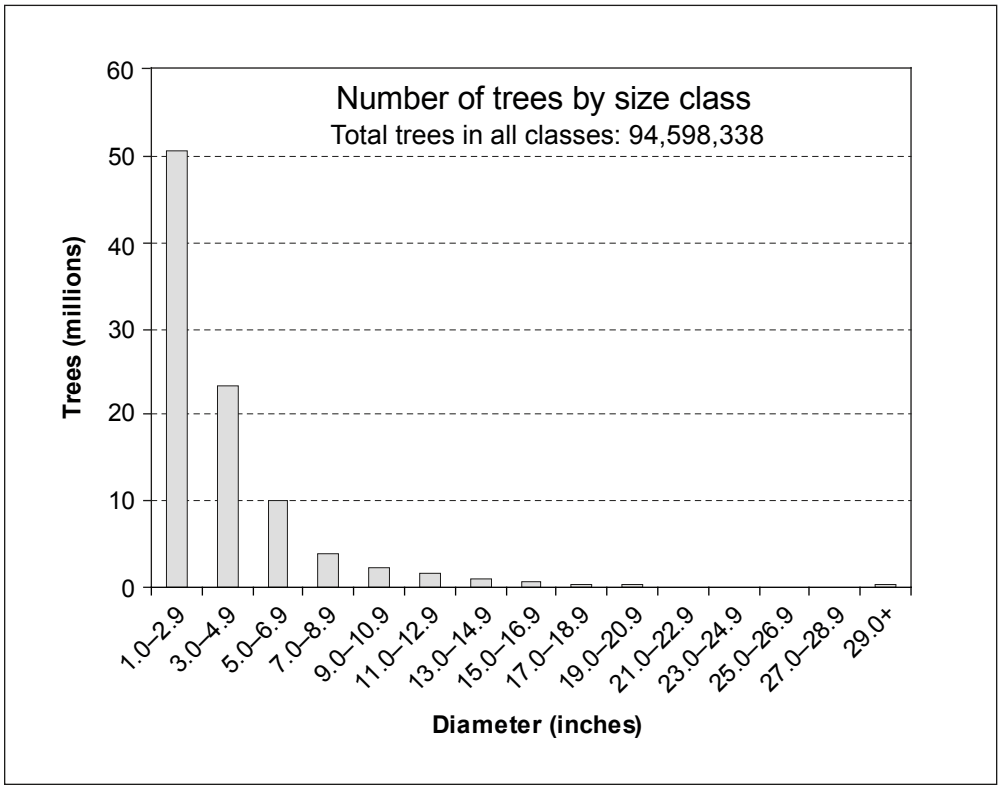

Figure 7—Small trees are very common in Palau, indicating regeneration is abundant.

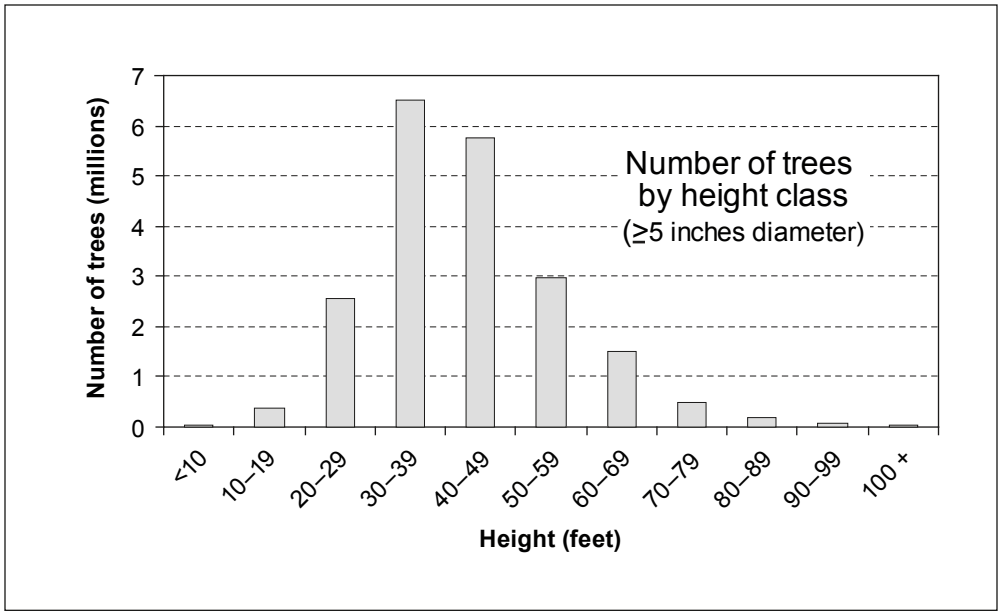

Figure 8—For trees greater than or equal to 5 inches in diameter, the most common heights attained range from 30 to 50 feet tall.

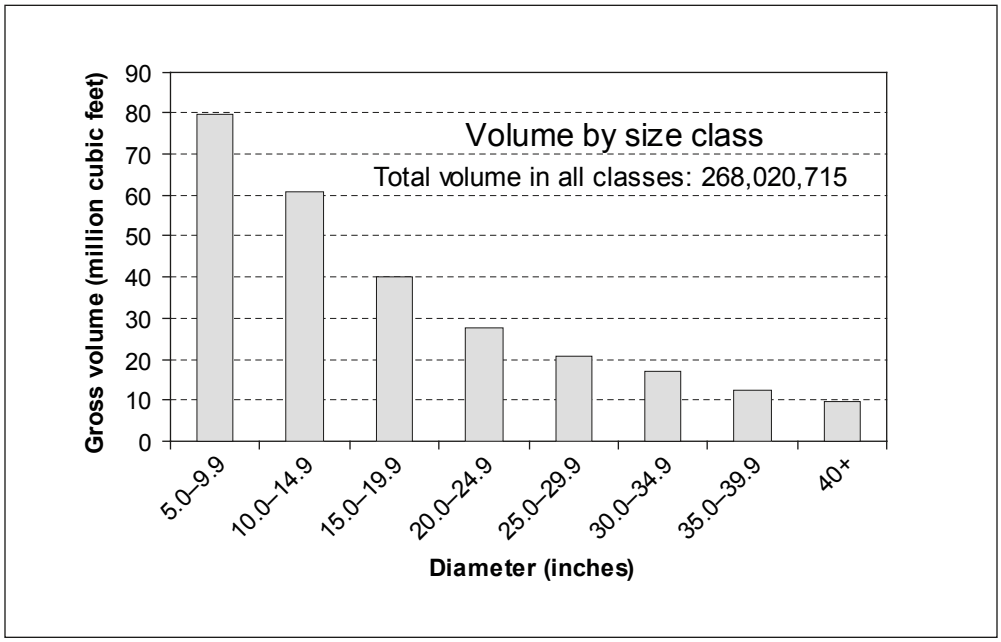

Figure 9—As with numbers of trees, gross volume of wood tends to be concentrated in the smaller diameter classes. However, many larger diameter trees contribute to the substantial volume in those size classes.

Table 4—Estimated gross volume of all live trees on forest land by forest-type group and diameter class

	Diameter class (inches)				
Forest-type group	**Less than 5**	**5–10.9**	**11–19.9**	**20+**	**All sizes**
			Cubic feet		
Limestone forest	6,248,751	28,309,959	28,665,545	19,013,470	82,237,724
Volcanic/ravine forest	28,116,999	62,596,123	60,913,733	68,521,890	220,148,745
Total	34,365,749	90,906,081	89,579,278	87,535,360	302,386,469

Table 5—Estimated net volume of all live trees ≥5 inches in diameter on forest land by forest-type group and diameter class

	Diameter class (inches)			
Forest-type group	**5–10.9**	**11–19.9**	**20+**	**All sizes**
		Cubic feet		
Limestone forest	28,285,444	28,570,500	18,577,815	75,433,759
Volcanic/ravine forest	62,311,497	60,297,635	67,289,502	189,898,634
Total	90,596,941	88,868,135	85,867,317	265,332,393

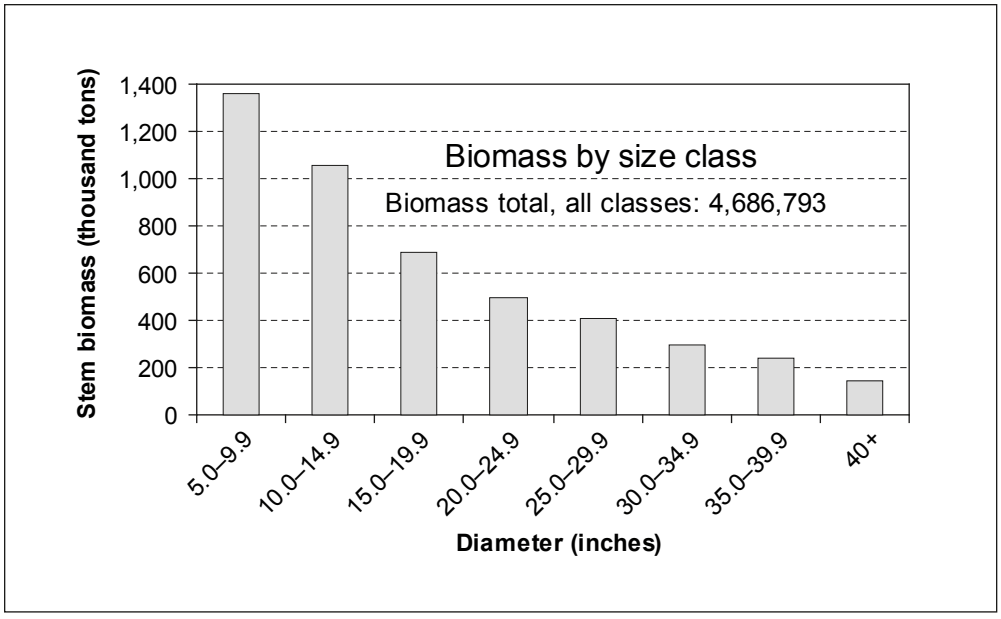

Figure 10—Biomass is also concentrated in the smaller size classes.

Table 6—Estimated gross volume of all live trees on forest land by species and diameter class

Species	Diameter class (inches) 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+	All classes
							Cubic feet							
Aglaia palauensis	358,196	217,203	448,937	—	—	759,169	—	—	—	—	—	—	—	1,783,505
Allophylus ternatus	—	206,199	—	—	—	—	—	—	—	—	—	—	—	206,199
Allophylus timorensis	29,280	—	—	—	—	—	—	—	—	—	—	—	—	29,280
Alphitonia carolinensis	735,731	1,129,350	467,218	1,269,881	—	834,761	—	—	—	—	—	—	—	4,436,940
Annona reticulata	62,771	—	—	—	—	—	—	—	—	—	—	—	—	62,771
Areca catechu	211,184	80,981	—	—	—	—	—	—	—	—	—	—	—	292,165
Artocarpus mariannensis	—	—	—	—	440,417	—	—	635,097	—	1,278,815	2,134,102	—	—	4,488,431
Astronidium palauense	577,119	208,231	364,270	—	—	—	—	—	—	—	—	—	—	1,149,620
Avicennia marina	—	—	114,276	—	—	—	—	—	—	—	1,308,417	—	—	1,422,693
Badusa palauensis	453,193	211,682	816,673	379,532	578,607	608,341	—	—	—	—	—	—	—	3,048,028
Barringtonia racemosa	452,159	527,080	711,656	1,053,700	229,549	—	—	—	—	—	—	—	—	2,974,144
Bruguiera gymnorrhiza	524,400	1,038,683	871,613	397,703	852,655	—	—	—	—	—	—	—	1,857,843	5,542,897
Buchanania palawensis	243,769	—	140,678	—	—	—	—	—	924,553	—	—	—	—	1,308,999
Calophyllum inophyllum	188,139	500,540	392,480	704,449	194,770	748,863	—	1,760,060	—	947,598	—	—	—	5,436,901
Calophyllum pelewense	204,921	498,086	—	337,712	—	—	—	—	—	—	—	—	—	1,040,719
Calophyllum soulattri	63,170	79,559	—	338,061	—	—	—	—	—	—	—	—	—	480,790
Calophyllum sp.	—	164,982	192,860	—	—	—	309,745	—	1,243,385	—	—	—	—	1,910,972
Campnosperma brevipetiolata	410,952	750,845	973,757	2,465,508	2,491,979	3,277,299	4,050,260	1,937,832	3,038,783	3,494,230	—	—	—	22,891,446
Canarium hirsutum	116,651	119,701	142,942	195,799	—	—	497,877	—	—	—	—	—	—	1,072,970
Casearia cauliflora	—	157,802	—	—	—	—	—	—	—	—	—	—	—	157,802
Casearia sp.	300,526	118,182	207,941	—	—	—	—	—	—	—	—	—	—	626,648
Casuarina equisetifolia	33,773	—	—	—	—	—	—	—	—	—	1,403,132	—	—	1,436,905
Cerbera floribunda	50,830	—	—	143,752	—	—	—	—	—	—	—	—	—	194,582
Cerbera manghas	261,427	272,907	719,166	529,306	267,966	294,836	—	—	—	—	—	—	—	2,345,608
Cocos nucifera	—	—	1,364,708	4,923,463	1,481,204	—	647,213	—	—	—	—	—	—	8,416,588
Commersonia bartramia	29,882	—	—	—	—	—	—	—	—	—	—	—	—	29,882
Cordia micronesica	—	—	—	—	312,315	—	—	—	—	—	—	—	—	312,315
Cyathea lunulata	683,380	708,128	306,007	277,547	—	—	—	—	—	—	—	—	—	1,975,061
Diospyros ferrea	128,287	256,014	—	—	—	—	—	—	—	—	—	—	—	384,300
Diospyros sp.	187,930	277,568	—	251,528	—	—	—	—	—	—	—	—	—	717,026
Dodonaea viscosa	34,597	67,158	163,789	—	—	846,599	—	—	530,228	—	—	—	—	1,642,371
Dracaena multiflora	204,143	115,524	—	147,157	—	—	—	—	—	—	—	—	—	466,823
Drypetes nitida	47,105	74,774	—	—	251,142	—	—	—	—	—	—	—	—	373,021
Dysoxylum sp.	64,752	—	—	—	—	—	—	—	—	—	—	—	—	64,752
Elaeocarpus graeffei	64,508	—	—	—	—	—	—	—	—	—	—	—	—	64,508
Elaeocarpus joga	662,676	1,399,992	95,607	1,623,421	1,376,416	1,568,153	—	—	—	—	—	—	—	6,726,266
Erythrina fusca	—	—	—	—	—	—	600,183	—	—	—	—	—	—	600,183
Eugenia cumini	383,104	338,074	160,248	380,749	298,384	400,104	—	—	—	—	—	—	—	1,960,664
Eugenia javanica	127,922	369,502	677,261	190,441	297,325	740,797	497,380	426,207	—	—	1,092,791	—	—	4,419,626
Eugenia reinwardtiana	1,003,419	1,093,777	1,425,442	930,288	382,084	560,575	616,284	—	—	—	—	—	—	6,011,868
Eugenia sp.	130,011	—	—	—	—	—	—	—	—	—	—	—	—	130,011
Fagraea ksid	161,826	—	499,547	481,374	277,505	822,261	—	—	—	—	—	—	—	2,242,513
Ficus sp.	—	—	—	—	—	—	—	409,933	—	—	—	—	—	409,933
Ficus tinctoria	—	56,385	—	—	—	—	—	—	—	—	—	—	2,606,279	2,662,664

Table 6—Estimated gross volume of all live trees 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+	
	Cubic feet													
Flacourtia rukam	399,756	205,465	—	146,034	—	—	—	—	—	—	—	—	—	751,255
Garcinia matudai	181,521	80,400	155,242	—	307,851	—	—	—	—	—	—	—	—	725,013
Garcinia rumiyo	547,736	734,850	507,022	730,739	—	—	—	—	—	—	—	—	—	2,520,347
Garcinia sp.	937,863	459,661	605,835	579,278	—	—	—	—	—	—	—	—	—	2,582,637
Gironniera celtidifolia	89,179	172,200	—	—	—	—	—	—	—	—	—	—	—	261,379
Glochidion ramiflorum	296,385	533,580	139,993	231,111	—	—	—	—	—	—	—	—	—	1,201,069
Glochidion sp.	93,117	—	—	—	—	—	—	—	—	—	—	—	—	93,117
Gmelina elliptica	218,166	159,556	363,533	401,804	534,904	701,063	694,331	513,192	—	—	—	897,498	—	4,484,048
Gmelina palawensis	860,819	888,819	771,909	732,695	1,121,009	—	673,159	—	—	—	—	—	—	5,048,410
Gmelina sp.	—	275,888	190,681	268,382	159,607	—	420,704	—	—	—	—	—	—	1,315,262
Gulubia palauensis	518,759	—	—	—	—	—	—	—	—	—	—	—	—	518,759
Hernandia sonora	48,678	93,646	—	227,398	—	—	—	—	—	—	—	—	—	369,722
Hernandia sp.	72,835	—	120,735	144,215	—	—	—	—	—	1,376,732	—	—	—	1,714,517
Heterospathe elata	223,139	181,631	—	—	—	—	—	—	—	—	—	—	—	404,770
Hibiscus tiliaceus	157,229	191,147	—	—	—	—	—	—	—	—	—	—	—	348,375
Horsfieldia amklaal	604,676	248,982	—	270,510	1,020,728	—	—	—	—	—	—	—	2,995,219	5,140,116
Horsfieldia novo-guineensis	303,272	254,896	744,724	—	344,493	396,646	806,216	930,642	—	—	—	—	6,929,268	10,710,158
Horsfieldia palauensis	1,795,603	1,549,305	1,962,502	870,606	242,883	—	—	856,766	—	—	—	1,138,744	5,239,828	13,656,236
Horsfieldia sp.	61,419	—	—	—	—	—	—	—	—	—	—	—	—	61,419
Inocarpus fagifer	29,390	—	—	—	—	—	—	—	—	—	—	—	—	29,390
Intsia bijuga	60,415	420,363	256,073	176,722	609,515	1,153,528	1,228,373	633,825	742,335	1,089,139	—	1,507,134	1,462,131	9,339,552
Lumnitzera littorea	—	—	127,232	—	—	—	—	—	—	—	—	—	—	127,232
Macaranga carolinensis	328,807	186,047	167,974	—	—	—	—	—	—	—	—	—	—	682,828
Manilkara udoido	753,108	207,350	226,930	—	225,960	288,213	383,995	—	—	—	—	—	—	2,085,556
Manilkara zapota	95,965	—	119,687	177,080	—	—	—	328,616	575,215	—	—	—	—	1,296,562
Morinda citrifolia	—	142,104	—	—	—	—	—	—	—	—	—	—	—	142,104
Morinda latibracteata	211,608	—	—	—	—	—	—	—	—	—	—	—	—	211,608
Morinda pedunculata	81,626	—	—	—	—	—	—	—	—	—	—	—	—	81,626
Morinda sp.	127,267	—	—	—	—	—	—	—	—	—	—	—	—	127,267
Nephelium lappaceum	—	100,828	—	—	—	—	—	—	—	—	—	—	—	100,828
Osmoxylon oliveri	65,896	—	—	—	—	—	—	—	—	—	—	—	—	65,896
Osmoxylon sp.	145,875	—	—	—	—	—	—	—	—	—	—	—	—	145,875
Pandanus aimiriikensis	136,228	51,506	84,627	—	—	—	—	—	—	—	—	—	—	272,360
Pandanus dubius	677,136	220,116	—	—	—	—	—	—	—	—	—	—	—	897,251
Pandanus kanehirae	—	332,031	—	—	—	—	—	—	—	—	—	—	—	332,031
Pandanus tectorius	261,072	188,207	—	—	—	—	—	—	—	—	—	—	—	449,279
Pandanus utiyamai	—	—	—	—	—	—	—	—	—	—	1,050,209	—	—	1,050,209
Pangium edule	—	73,623	163,712	—	—	—	—	—	—	—	—	—	—	237,335
Parinari corymbosum	689,431	506,454	431,678	1,097,576	1,990,397	421,904	852,296	607,489	1,822,127	1,386,894	3,444,684	1,289,904	7,877,115	22,417,949
Parinari laurina	1,056,482	521,650	925,184	962,513	—	1,115,534	—	—	—	1,399,150	—	—	—	5,980,513
Parinari sp.	66,714	—	—	—	—	—	—	—	—	—	—	—	—	66,714
Pinanga insignis	7,832,438	303,291	133,263	—	—	—	—	—	—	—	—	—	—	8,268,992
Pithecellobium dulce	—	80,161	—	—	—	—	—	—	—	—	—	—	—	80,161
Pouteria calcarea	160,981	—	—	—	—	—	—	—	—	—	—	—	—	160,981

Table 6—Estimated gross volume of all live trees 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+	
	Cubic feet													
Pouteria obovata	541,147	1,054,853	864,486	712,852	—	—	595,227	392,699	—	—	—	—	—	4,161,263
Pouteria sp.	—	59,315	—	—	—	—	—	—	—	—	—	—	—	59,315
Premna obtusifolia	127,669	119,095	—	—	—	—	—	—	—	—	—	—	—	246,764
Pterocarpus indicus	—	—	—	—	—	229,537	—	—	488,213	—	—	—	—	717,750
Ptychosperma palauensis	314,678	—	—	—	—	—	—	—	—	—	—	—	—	314,678
Rhizophora apiculata	3,089,759	2,545,438	1,320,834	612,144	882,643	—	—	—	—	—	—	—	—	8,450,819
Rhizophora mucronata	815,800	758,392	183,142	507,898	—	—	—	—	—	—	—	—	—	2,265,232
Rhus taitensis	288,555	725,964	586,929	1,176,660	1,461,139	495,846	560,851	—	—	—	—	—	—	5,295,943
Rinorea carolinensis	—	44,758	—	—	—	—	—	—	—	—	—	—	—	44,758
Semecarpus venenosus	1,155,137	852,343	954,517	891,534	312,069	526,363	—	—	—	—	1,367,032	—	1,364,929	7,423,924
Sonneratia alba	23,568	169,976	—	149,403	—	538,634	—	—	—	—	—	2,270,776	8,351,476	11,503,833
Stemonurus ammui	—	70,618	—	—	—	633,032	808,378	1,703,686	—	—	—	—	—	3,215,714
Swietenia macrophylla	175,805	—	151,802	—	—	—	—	—	—	—	—	—	—	327,606
Swietenia mahagoni	179,811	71,296	163,613	—	—	—	—	—	—	—	—	—	—	414,720
Symplocos racemosa	128,478	96,128	—	—	—	—	—	—	—	—	—	—	—	224,606
Terminalia catappa	—	165,490	340,579	298,932	—	—	—	—	—	—	—	—	—	805,001
Theobroma cacao	30,258	187,894	—	399,693	—	—	—	—	—	—	—	—	—	617,845
Timonius subauritus	168,555	187,252	131,543	—	—	438,429	—	—	—	—	—	—	—	925,779
Tournefortia argentea	22,145	44,889	116,849	—	143,626	—	—	—	—	—	—	—	—	327,509
Trichospermum ledermannii	129,573	288,139	387,762	262,220	—	—	—	—	—	—	—	—	—	1,067,694
Vitex cofassus	—	91,031	—	—	319,190	714,086	435,761	—	1,255,579	1,024,803	924,646	—	—	4,765,096
Xylocarpus granatum	178,267	113,859	368,179	178,624	554,708	—	239,527	—	—	—	—	—	—	1,633,164
Unknown 0	120,479	—	—	—	—	—	—	—	—	—	—	—	—	120,479
Unknown 1	35,180	48,232	—	—	—	—	—	—	—	—	—	—	—	83,412
Unknown 3	44,577	—	—	184,062	—	—	—	—	—	—	—	—	—	228,639
Unknown 5	67,712	235,500	210,219	—	—	—	—	—	—	—	—	—	—	513,431
Unknown 11	—	—	126,165	—	—	—	—	—	—	—	—	—	—	126,165
Unknown, other	50,997	—	140,256	—	—	—	—	—	—	—	—	—	1,440,229	1,631,482
Total	37,070,470	28,333,126	25,502,485	29,412,054	19,963,042	19,114,573	14,917,757	11,136,046	10,620,417	11,997,362	12,725,013	7,104,057	40,124,318	268,020,719

Table 7—Estimated aboveground dry stem weight of all live trees 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+	
	Tons													
Aglaia palauensis	5,722	3,470	7,172	—	—	12,128	—	—	—	—	—	—	—	28,491
Allophylus ternatus	—	3,294	—	—	—	—	—	—	—	—	—	—	—	3,294
Allophylus timorensis	468	—	—	—	—	—	—	—	—	—	—	—	—	468
Alphitonia carolinensis	11,753	18,041	7,464	20,286	—	13,335	—	—	—	—	—	—	—	70,880
Annona reticulata	1,003	—	—	—	—	—	—	—	—	—	—	—	—	1,003
Areca catechu	3,374	1,294	—	—	—	—	—	—	—	—	—	—	—	4,667
Artocarpus mariannensis	—	—	—	—	7,036	—	—	10,146	—	20,429	34,092	—	—	71,703
Astronidium palauense	9,219	3,326	5,819	—	—	—	—	—	—	—	—	—	—	18,365
Avicennia marina	—	—	1,826	—	—	—	—	—	—	—	20,902	—	—	22,728
Badusa palauensis	7,240	3,382	13,046	6,063	9,243	9,718	—	—	—	—	—	—	—	48,692
Barringtonia racemosa	7,223	8,420	11,369	16,833	3,667	—	—	—	—	—	—	—	—	47,512
Bruguiera gymnorrhiza	8,377	16,593	13,924	6,353	13,621	—	—	—	—	—	—	—	29,679	88,548
Buchanania palawensis	3,894	—	2,247	—	—	—	—	—	14,770	—	—	—	—	20,911
Calophyllum inophyllum	3,426	9,115	7,147	12,828	3,547	13,637	—	32,051	—	17,256	—	—	—	99,006
Calophyllum pelewense	3,274	7,957	—	5,395	—	—	—	—	—	—	—	—	—	16,625
Calophyllum soulattri	1,009	1,271	—	5,401	—	—	—	—	—	—	—	—	—	7,681
Calophyllum sp.	—	3,426	4,005	—	—	—	6,432	—	25,819	—	—	—	—	39,681
Campnosperma brevipetiolata	6,565	11,995	15,556	39,386	39,809	52,355	64,703	30,957	48,545	55,820	—	—	—	365,691
Canarium hirsutum	1,491	1,530	1,827	2,502	—	—	6,363	—	—	—	—	—	—	13,713
Casearia cauliflora	—	2,521	—	—	—	—	—	—	—	—	—	—	—	2,521
Casearia sp.	5,953	2,341	4,119	—	—	—	—	—	—	—	—	—	—	12,414
Casuarina equisetifolia	896	—	—	—	—	—	—	—	—	—	37,211	—	—	38,107
Cerbera floribunda	812	—	—	2,296	—	—	—	—	—	—	—	—	—	3,108
Cerbera manghas	4,176	4,360	11,489	8,456	4,281	4,710	—	—	—	—	—	—	—	37,471
Cocos nucifera	—	—	21,801	78,652	23,662	—	10,339	—	—	—	—	—	—	134,455
Commersonia bartramia	477	—	—	—	—	—	—	—	—	—	—	—	—	477
Cordia micronesica	—	—	—	—	5,287	—	—	—	—	—	—	—	—	5,287
Cyathea lunulata	10,917	11,312	4,888	4,434	—	—	—	—	—	—	—	—	—	31,552
Diospyros ferrea	2,869	5,726	—	—	—	—	—	—	—	—	—	—	—	8,595
Diospyros sp.	4,203	6,208	—	5,625	—	—	—	—	—	—	—	—	—	16,036
Dodonaea viscosa	553	1,073	2,617	—	—	13,524	—	—	8,470	—	—	—	—	26,237
Dracaena multiflora	3,261	1,845	—	2,351	—	—	—	—	—	—	—	—	—	7,458
Drypetes nitida	753	1,195	—	—	4,012	—	—	—	—	—	—	—	—	5,959
Dysoxylum sp.	1,034	—	—	—	—	—	—	—	—	—	—	—	—	1,034
Elaeocarpus graeffei	1,031	—	—	—	—	—	—	—	—	—	—	—	—	1,031
Elaeocarpus joga	10,586	22,365	1,527	25,934	21,988	25,051	—	—	—	—	—	—	—	107,452
Erythrina fusca	—	—	—	—	—	—	4,792	—	—	—	—	—	—	4,792
Eugenia cumini	7,955	7,020	3,328	7,906	6,196	8,308	—	—	—	—	—	—	—	40,713
Eugenia javanica	2,656	7,673	14,063	3,955	6,174	15,383	10,328	8,850	—	—	22,692	—	—	91,774
Eugenia reinwardtiana	20,836	22,712	29,599	19,317	7,934	11,640	12,797	—	—	—	—	—	—	124,836
Eugenia sp.	2,700	—	—	—	—	—	—	—	—	—	—	—	—	2,700
Fagraea ksid	3,775	—	11,652	11,228	6,473	19,179	—	—	—	—	—	—	—	52,307
Ficus sp.	—	—	—	—	—	—	—	4,190	—	—	—	—	—	4,190
Ficus tinctoria	—	703	—	—	—	—	—	—	—	—	—	—	32,474	33,177

Table 7—Estimated aboveground dry stem weight of all live trees 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+	
	Tons													
Flacourtia rukam	6,386	3,282	—	2,333	—	—	—	—	—	—	—	—	—	12,001
Garcinia matudai	4,349	1,926	3,720	—	7,376	—	—	—	—	—	—	—	—	17,371
Garcinia rumiyo	13,124	17,607	12,148	17,509	—	—	—	—	—	—	—	—	—	60,388
Garcinia sp.	22,471	11,013	14,516	13,880	—	—	—	—	—	—	—	—	—	61,880
Gironniera celtidifolia	1,425	2,751	—	—	—	—	—	—	—	—	—	—	—	4,176
Glochidion ramiflorum	4,735	8,524	2,236	3,692	—	—	—	—	—	—	—	—	—	19,187
Glochidion sp.	1,488	—	—	—	—	—	—	—	—	—	—	—	—	1,488
Gmelina elliptica	3,485	2,549	5,807	6,419	8,545	11,199	11,092	8,198	—	—	—	14,338	—	71,633
Gmelina palawensis	13,752	14,199	12,331	11,705	17,908	—	10,754	—	—	—	—	—	—	80,648
Gmelina sp.	—	4,407	3,046	4,287	2,550	—	6,721	—	—	—	—	—	—	21,011
Gulubia palauensis	8,287	—	—	—	—	—	—	—	—	—	—	—	—	8,287
Hernandia sonora	451	868	—	2,107	—	—	—	—	—	—	—	—	—	3,425
Hernandia sp.	1,164	—	1,929	2,304	—	—	—	—	—	21,993	—	—	—	27,389
Heterospathe elata	3,565	2,902	—	—	—	—	—	—	—	—	—	—	—	6,466
Hibiscus tiliaceus	2,863	3,481	—	—	—	—	—	—	—	—	—	—	—	6,344
Horsfieldia amklaal	9,660	3,977	—	4,321	16,306	—	—	—	—	—	—	—	47,849	82,113
Horsfieldia novo-guineensis	4,845	4,072	11,897	—	5,503	6,336	12,879	14,867	—	—	—	—	110,695	171,095
Horsfieldia palauensis	28,685	24,750	31,351	13,908	3,880	—	—	13,687	—	—	—	18,191	83,706	218,158
Horsfieldia sp.	981	—	—	—	—	—	—	—	—	—	—	—	—	981
Inocarpus fagifer	470	—	—	—	—	—	—	—	—	—	—	—	—	470
Intsia bijuga	1,177	8,193	4,991	3,444	11,879	22,482	23,941	12,353	14,468	21,227	—	29,374	28,497	182,028
Lumnitzera littorea	—	—	2,033	—	—	—	—	—	—	—	—	—	—	2,033
Macaranga carolinensis	5,253	2,972	2,683	—	—	—	—	—	—	—	—	—	—	10,908
Manilkara udoido	12,031	3,312	3,625	—	3,610	4,604	6,134	—	—	—	—	—	—	33,317
Manilkara zapota	1,533	—	1,912	2,829	—	—	—	5,250	9,189	—	—	—	—	20,713
Morinda citrifolia	—	2,270	—	—	—	—	—	—	—	—	—	—	—	2,270
Morinda latibracteata	3,380	—	—	—	—	—	—	—	—	—	—	—	—	3,380
Morinda pedunculata	1,304	—	—	—	—	—	—	—	—	—	—	—	—	1,304
Morinda sp.	2,033	—	—	—	—	—	—	—	—	—	—	—	—	2,033
Nephelium lappaceum	—	1,611	—	—	—	—	—	—	—	—	—	—	—	1,611
Osmoxylon oliveri	1,053	—	—	—	—	—	—	—	—	—	—	—	—	1,053
Osmoxylon sp.	2,330	—	—	—	—	—	—	—	—	—	—	—	—	2,330
Pandanus aimiriikensis	2,176	823	1,352	—	—	—	—	—	—	—	—	—	—	4,351
Pandanus dubius	10,817	3,516	—	—	—	—	—	—	—	—	—	—	—	14,334
Pandanus kanehirae	—	5,304	—	—	—	—	—	—	—	—	—	—	—	5,304
Pandanus tectorius	4,171	3,007	—	—	—	—	—	—	—	—	—	—	—	7,177
Pandanus utiyamai	—	—	—	—	—	—	—	—	—	—	16,777	—	—	16,777
Pangium edule	—	1,176	2,615	—	—	—	—	—	—	—	—	—	—	3,791
Parinari corymbosum	16,739	12,297	10,481	26,649	48,327	10,244	20,694	14,750	44,241	33,674	83,637	31,319	191,256	544,308
Parinari laurina	22,952	11,333	20,100	20,911	—	24,235	—	—	—	30,397	—	—	—	129,927
Parinari sp.	1,449	—	—	—	—	—	—	—	—	—	—	—	—	1,449
Pinanga insignis	125,123	4,845	2,129	—	—	—	—	—	—	—	—	—	—	132,097
Pithecellobium dulce	—	1,281	—	—	—	—	—	—	—	—	—	—	—	1,281
Pouteria calcarea	2,572	—	—	—	—	—	—	—	—	—	—	—	—	2,572

Table 7—Estimated aboveground dry stem weight of all live trees 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+	
	Tons													
Pouteria obovata	8,645	16,851	13,810	11,388	—	—	9,509	6,273	—	—	—	—	—	66,476
Pouteria sp.	—	1,384	—	—	—	—	—	—	—	—	—	—	—	1,384
Premna obtusifolia	2,040	1,903	—	—	—	—	—	—	—	—	—	—	—	3,942
Pterocarpus indicus	—	—	—	—	—	3,814	—	—	8,112	—	—	—	—	11,925
Ptychosperma palauensis	5,027	—	—	—	—	—	—	—	—	—	—	—	—	5,027
Rhizophora apiculata	49,359	40,663	21,100	9,779	14,100	—	—	—	—	—	—	—	—	135,002
Rhizophora mucronata	13,032	12,115	2,926	8,114	—	—	—	—	—	—	—	—	—	36,187
Rhus taitensis	4,610	11,597	9,376	18,797	23,342	7,921	8,960	—	—	—	—	—	—	84,603
Rinorea carolinensis	—	715	—	—	—	—	—	—	—	—	—	—	—	715
Semecarpus venenosus	18,453	13,616	15,248	14,242	4,985	8,409	—	—	—	—	21,838	—	21,805	118,597
Sonneratia alba	376	2,715	—	2,387	—	8,605	—	—	—	—	—	36,276	133,415	183,774
Stemonurus ammui	—	1,128	—	—	—	10,113	12,914	27,216	—	—	—	—	—	51,371
Swietenia macrophylla	2,358	—	2,036	—	—	—	—	—	—	—	—	—	—	4,395
Swietenia mahagoni	3,505	1,390	3,189	—	—	—	—	—	—	—	—	—	—	8,083
Symplocos racemosa	2,052	1,536	—	—	—	—	—	—	—	—	—	—	—	3,588
Terminalia catappa	—	3,119	6,420	5,635	—	—	—	—	—	—	—	—	—	15,174
Theobroma cacao	483	3,002	—	6,385	—	—	—	—	—	—	—	—	—	9,870
Timonius subauritus	2,693	2,991	2,101	—	—	7,004	—	—	—	—	—	—	—	14,789
Tournefortia argentea	354	717	1,867	—	2,294	—	—	—	—	—	—	—	—	5,232
Trichospermum ledermannii	2,070	4,603	6,195	4,189	—	—	—	—	—	—	—	—	—	17,056
Vitex cofassus	—	1,454	—	—	5,099	11,408	6,961	—	20,058	16,371	14,771	—	—	76,122
Xylocarpus granatum	2,848	1,819	5,882	2,854	8,861	—	3,826	—	—	—	—	—	—	26,090
Unknown 0	1,925	—	—	—	—	—	—	—	—	—	—	—	—	1,925
Unknown 1	562	771	—	—	—	—	—	—	—	—	—	—	—	1,333
Unknown 3	712	—	—	2,940	—	—	—	—	—	—	—	—	—	3,653
Unknown 5	1,082	3,762	3,358	—	—	—	—	—	—	—	—	—	—	8,202
Unknown 11	—	—	2,015	—	—	—	—	—	—	—	—	—	—	2,015
Unknown, other	815	—	2,241	—	—	—	—	—	—	—	—	—	23,008	26,063
Total	630,759	486,266	445,152	508,209	347,497	335,342	250,139	188,788	193,672	217,167	251,921	129,498	702,384	4,686,793

Table 8—Estimated carbon mass of all live trees 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+	
	Tons													
Aglaia palauensis	2,804	1,700	3,514	—	—	5,943	—	—	—	—	—	—	—	13,961
Allophylus ternatus	—	1,614	—	—	—	—	—	—	—	—	—	—	—	1,614
Allophylus timorensis	229	—	—	—	—	—	—	—	—	—	—	—	—	229
Alphitonia carolinensis	5,759	8,840	3,657	9,940	—	6,534	—	—	—	—	—	—	—	34,731
Annona reticulata	491	—	—	—	—	—	—	—	—	—	—	—	—	491
Areca catechu	1,653	634	—	—	—	—	—	—	—	—	—	—	—	2,287
Artocarpus mariannensis	—	—	—	—	3,447	—	—	4,971	—	10,010	16,705	—	—	35,134
Astronidium palauense	4,518	1,630	2,851	—	—	—	—	—	—	—	—	—	—	8,999
Avicennia marina	—	—	895	—	—	—	—	—	—	—	10,242	—	—	11,136
Badusa palauensis	3,547	1,657	6,393	2,971	4,529	4,762	—	—	—	—	—	—	—	23,859
Barringtonia racemosa	3,539	4,126	5,571	8,248	1,797	—	—	—	—	—	—	—	—	23,281
Bruguiera gymnorrhiza	4,105	8,131	6,823	3,113	6,674	—	—	—	—	—	—	—	14,543	43,388
Buchanania palawensis	1,908	—	1,101	—	—	—	—	—	7,237	—	—	—	—	10,247
Calophyllum inophyllum	1,679	4,466	3,502	6,286	1,738	6,682	—	15,705	—	8,455	—	—	—	48,513
Calophyllum pelewense	1,604	3,899	—	2,644	—	—	—	—	—	—	—	—	—	8,146
Calophyllum soulattri	494	623	—	2,646	—	—	—	—	—	—	—	—	—	3,764
Calophyllum sp.	—	1,679	1,962	—	—	—	3,152	—	12,651	—	—	—	—	19,444
Campnosperma brevipetiolata	3,217	5,877	7,622	19,299	19,507	25,654	31,704	15,169	23,787	27,352	—	—	—	179,189
Canarium hirsutum	730	750	895	1,226	—	—	3,118	—	—	—	—	—	—	6,719
Casearia cauliflora	—	1,235	—	—	—	—	—	—	—	—	—	—	—	1,235
Casearia sp.	2,917	1,147	2,018	—	—	—	—	—	—	—	—	—	—	6,083
Casuarina equisetifolia	439	—	—	—	—	—	—	—	—	—	18,233	—	—	18,672
Cerbera floribunda	398	—	—	1,125	—	—	—	—	—	—	—	—	—	1,523
Cerbera manghas	2,046	2,136	5,629	4,143	2,098	2,308	—	—	—	—	—	—	—	18,361
Cocos nucifera	—	—	10,683	38,540	11,595	—	5,066	—	—	—	—	—	—	65,883
Commersonia bartramia	234	—	—	—	—	—	—	—	—	—	—	—	—	234
Cordia micronesica	—	—	—	—	2,591	—	—	—	—	—	—	—	—	2,591
Cyathea lunulata	5,349	5,543	2,395	2,173	—	—	—	—	—	—	—	—	—	15,460
Diospyros ferrea	1,406	2,806	—	—	—	—	—	—	—	—	—	—	—	4,211
Diospyros sp.	2,060	3,042	—	2,756	—	—	—	—	—	—	—	—	—	7,858
Dodonaea viscosa	271	526	1,282	—	—	6,627	—	—	4,150	—	—	—	—	12,856
Dracaena multiflora	1,598	904	—	1,152	—	—	—	—	—	—	—	—	—	3,654
Drypetes nitida	369	585	—	—	1,966	—	—	—	—	—	—	—	—	2,920
Dysoxylum sp.	507	—	—	—	—	—	—	—	—	—	—	—	—	507
Elaeocarpus graeffei	505	—	—	—	—	—	—	—	—	—	—	—	—	505
Elaeocarpus joga	5,187	10,959	748	12,708	10,774	12,275	—	—	—	—	—	—	—	52,652
Erythrina fusca	—	—	—	—	—	—	2,348	—	—	—	—	—	—	2,348
Eugenia cumini	3,898	3,440	1,631	3,874	3,036	4,071	—	—	—	—	—	—	—	19,949
Eugenia javanica	1,302	3,760	6,891	1,938	3,025	7,538	5,061	4,337	—	—	11,119	—	—	44,969
Eugenia reinwardtiana	10,210	11,129	14,504	9,466	3,888	5,704	6,271	—	—	—	—	—	—	61,170
Eugenia sp.	1,323	—	—	—	—	—	—	—	—	—	—	—	—	1,323
Fagraea ksid	1,850	—	5,709	5,502	3,172	9,398	—	—	—	—	—	—	—	25,630
Ficus sp.	—	—	—	—	—	—	—	2,053	—	—	—	—	—	2,053
Ficus tinctoria	—	344	—	—	—	—	—	—	—	—	—	—	15,912	16,257

Table 8—Estimated carbon mass of all live trees 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+	
	Tons													
Flacourtia rukam	3,129	1,608	—	1,143	—	—	—	—	—	—	—	—	—	5,881
Garcinia matudai	2,131	944	1,823	—	3,614	—	—	—	—	—	—	—	—	8,512
Garcinia rumiyo	6,431	8,627	5,953	8,579	—	—	—	—	—	—	—	—	—	29,590
Garcinia sp.	11,011	5,397	7,113	6,801	—	—	—	—	—	—	—	—	—	30,321
Gironniera celtidifolia	698	1,348	—	—	—	—	—	—	—	—	—	—	—	2,046
Glochidion ramiflorum	2,320	4,177	1,096	1,809	—	—	—	—	—	—	—	—	—	9,402
Glochidion sp.	729	—	—	—	—	—	—	—	—	—	—	—	—	729
Gmelina elliptica	1,708	1,249	2,846	3,145	4,187	5,488	5,435	4,017	—	—	—	7,025	—	35,100
Gmelina palawensis	6,738	6,957	6,042	5,735	8,775	—	5,269	—	—	—	—	—	—	39,518
Gmelina sp.	—	2,160	1,493	2,101	1,249	—	3,293	—	—	—	—	—	—	10,296
Gulubia palauensis	4,061	—	—	—	—	—	—	—	—	—	—	—	—	4,061
Hernandia sonora	221	425	—	1,032	—	—	—	—	—	—	—	—	—	1,678
Hernandia sp.	570	—	945	1,129	—	—	—	—	—	10,777	—	—	—	13,421
Heterospathe elata	1,747	1,422	—	—	—	—	—	—	—	—	—	—	—	3,168
Hibiscus tiliaceus	1,403	1,706	—	—	—	—	—	—	—	—	—	—	—	3,109
Horsfieldia amklaal	4,733	1,949	—	2,117	7,990	—	—	—	—	—	—	—	23,446	40,236
Horsfieldia novo-guineensis	2,374	1,995	5,830	—	2,697	3,105	6,311	7,285	—	—	—	—	54,241	83,836
Horsfieldia palauensis	14,056	12,128	15,362	6,815	1,901	—	—	6,707	—	—	—	8,914	41,016	106,898
Horsfieldia sp.	481	—	—	—	—	—	—	—	—	—	—	—	—	481
Inocarpus fagifer	230	—	—	—	—	—	—	—	—	—	—	—	—	230
Intsia bijuga	577	4,015	2,446	1,688	5,821	11,016	11,731	6,053	7,089	10,401	—	14,393	13,964	89,194
Lumnitzera littorea	—	—	996	—	—	—	—	—	—	—	—	—	—	996
Macaranga carolinensis	2,574	1,456	1,315	—	—	—	—	—	—	—	—	—	—	5,345
Manilkara udoido	5,895	1,623	1,776	—	1,769	2,256	3,006	—	—	—	—	—	—	16,325
Manilkara zapota	751	—	937	1,386	—	—	—	2,572	4,503	—	—	—	—	10,149
Morinda citrifolia	—	1,112	—	—	—	—	—	—	—	—	—	—	—	1,112
Morinda latibracteata	1,656	—	—	—	—	—	—	—	—	—	—	—	—	1,656
Morinda pedunculata	639	—	—	—	—	—	—	—	—	—	—	—	—	639
Morinda sp.	996	—	—	—	—	—	—	—	—	—	—	—	—	996
Nephelium lappaceum	—	789	—	—	—	—	—	—	—	—	—	—	—	789
Osmoxylon oliveri	516	—	—	—	—	—	—	—	—	—	—	—	—	516
Osmoxylon sp.	1,142	—	—	—	—	—	—	—	—	—	—	—	—	1,142
Pandanus aimiriikensis	1,066	403	662	—	—	—	—	—	—	—	—	—	—	2,132
Pandanus dubius	5,300	1,723	—	—	—	—	—	—	—	—	—	—	—	7,023
Pandanus kanehirae	—	2,599	—	—	—	—	—	—	—	—	—	—	—	2,599
Pandanus tectorius	2,044	1,473	—	—	—	—	—	—	—	—	—	—	—	3,517
Pandanus utiyamai	—	—	—	—	—	—	—	—	—	—	8,221	—	—	8,221
Pangium edule	—	576	1,282	—	—	—	—	—	—	—	—	—	—	1,858
Parinari corymbosum	8,202	6,025	5,136	13,058	23,680	5,019	10,140	7,227	21,678	16,500	40,982	15,346	93,716	266,711
Parinari laurina	11,247	5,553	9,849	10,246	—	11,875	—	—	—	14,894	—	—	—	63,664
Parinari sp.	710	—	—	—	—	—	—	—	—	—	—	—	—	710
Pinanga insignis	61,310	2,374	1,043	—	—	—	—	—	—	—	—	—	—	64,728
Pithecellobium dulce	—	627	—	—	—	—	—	—	—	—	—	—	—	627
Pouteria calcarea	1,260	—	—	—	—	—	—	—	—	—	—	—	—	1,260

Table 8—Estimated carbon mass of all live trees 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+	
							Tons							
Pouteria obovata	4,236	8,257	6,767	5,580	—	—	4,659	3,074	—	—	—	—	—	32,573
Pouteria sp.	—	678	—	—	—	—	—	—	—	—	—	—	—	678
Premna obtusifolia	999	932	—	—	—	—	—	—	—	—	—	—	—	1,932
Pterocarpus indicus	—	—	—	—	—	1,869	—	—	3,975	—	—	—	—	5,843
Ptychosperma palauensis	2,463	—	—	—	—	—	—	—	—	—	—	—	—	2,463
Rhizophora apiculata	24,186	19,925	10,339	4,792	6,909	—	—	—	—	—	—	—	—	66,151
Rhizophora mucronata	6,386	5,937	1,434	3,976	—	—	—	—	—	—	—	—	—	17,732
Rhus taitensis	2,259	5,683	4,594	9,211	11,437	3,881	4,390	—	—	—	—	—	—	41,455
Rinorea carolinensis	—	350	—	—	—	—	—	—	—	—	—	—	—	350
Semecarpus venenosus	9,042	6,672	7,472	6,979	2,443	4,120	—	—	—	—	10,701	—	10,684	58,113
Sonneratia alba	184	1,331	—	1,169	—	4,216	—	—	—	—	—	17,775	65,373	90,049
Stemonurus ammui	—	553	—	—	—	4,955	6,328	13,336	—	—	—	—	—	25,172
Swietenia macrophylla	1,156	—	998	—	—	—	—	—	—	—	—	—	—	2,153
Swietenia mahagoni	1,717	681	1,563	—	—	—	—	—	—	—	—	—	—	3,961
Symplocos racemosa	1,006	752	—	—	—	—	—	—	—	—	—	—	—	1,758
Terminalia catappa	—	1,529	3,146	2,761	—	—	—	—	—	—	—	—	—	7,435
Theobroma cacao	237	1,471	—	3,129	—	—	—	—	—	—	—	—	—	4,836
Timonius subauritus	1,319	1,466	1,030	—	—	3,432	—	—	—	—	—	—	—	7,247
Tournefortia argentea	173	351	915	—	1,124	—	—	—	—	—	—	—	—	2,564
Trichospermum ledermannii	1,014	2,255	3,035	2,053	—	—	—	—	—	—	—	—	—	8,358
Vitex cofassus	—	713	—	—	2,499	5,590	3,411	—	9,828	8,022	7,238	—	—	37,300
Xylocarpus granatum	1,395	891	2,882	1,398	4,342	—	1,875	—	—	—	—	—	—	12,784
Unknown 0	943	—	—	—	—	—	—	—	—	—	—	—	—	943
Unknown 1	275	378	—	—	—	—	—	—	—	—	—	—	—	653
Unknown 3	—	—	988	—	—	—	—	—	—	—	—	—	—	988
Unknown 5	349	—	—	1,441	—	—	—	—	—	—	—	—	—	1,790
Unknown 11	530	1,843	1,646	—	—	—	—	—	—	—	—	—	—	4,019
Unknown, other	399	—	1,098	—	—	—	—	—	—	—	—	—	11,274	12,771
Total	309,072	238,270	218,124	249,022	170,274	164,318	122,568	92,506	94,899	106,412	123,441	63,454	344,168	2,296,529

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 9). Tree seedlings that are less than or equal to 1 inch in diameter are also estimated as understory vegetation cover (table 10). 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 it was not listed as special interest, it was not enumerated.

Table 9—Average nontree understory cover[a] on FIA field subplots by species and forest type

	Forest type					
	Volcanic			Limestone		
Scientific name	Cover	Number of subplots	Standard deviation	Cover	Number of subplots	Standard deviation
	Percent			*Percent*		
Achyranthes aspera L.	2.0	1	—	—	—	—
Adiantum philippense L.	4.8	4	4.1	—	—	—
Alpinia carolinensis Koidz.	9.6	14	17.6	—	—	—
Alpinia pubiflora K.Schum.	5.0	3	4.4	—	—	—
Alpinia purpurata (Vieill.) K. Schum.	3.3	3	3.2	—	—	—
Alpinia sp. Roxb.	3.2	13	3.0	—	—	—
Angiopteris evecta (J.R. Forst.) Hoffman	3.7	3	2.5	—	—	—
Antrophyum plantagineum (Cav.) Kaulf.	—	—	—	1.0	2	0.0
Asplenium nidus L.	1.6	65	1.02	1.4	23	0.7
Asplenium pellucidum Lam.	—	—	—	2.0	1	—
Asplenium polyodon G. Forst.	1.0	1	—	2.1	10	2.1
Bambusa vulgaris Schrad. ex J.C. Wendl.	2.0	1	—	—	—	—
Blechnum orientale L.	4.6	16	6.1	—	—	—
Bolbitis sp. Schott.	3.3	3	4.0	—	—	—
Caesalpinia major (Medik.) Dandy & Exell	1.0	1	—	—	—	—
Caesalpinia sp. L.	2.0	1	—	—	—	—
Calamus sp. L.	1.0	1	—	5.0	2	4.2
Cassytha filiformis L.	6.0	3	7.8	—	—	—
Centotheca lappacea (L.) Desv.	1.3	3	0.6	—	—	—
Cheilanthes tenuifolia (Burmann) Swartz	1.0	1	—	—	—	—
Clerodendrum sp. L.	1.0	2	0.0	—	—	—
Clidemia hirta (L.) D. Don	1.3	4	0.5	—	—	—
Clidemia sp. D. Don	1.0	1	—	—	—	—
Combined ferns	1.0	2	0.0	—	—	—
Costus speciosus Smith	2.2	5	1.1	—	—	—
Cyperus sp. L.	50.0	1	—	—	—	—
Cyrtosperma chamissonis (Schott) Merrill	8.3	3	10.1	—	—	—
Dalbergia palauensis Hosokawa	3.0	1	—	—	—	—
Davallia solida (Forster fil.) Swartz. Schrad	1.7	3	1.2	1.5	4	0.6
Davallia sp. Sm.	3.0	5	1.9	—	—	—
Decaspermum raymundii Diels	2.0	1	—	—	—	—
Decaspermum sp. J. R. Forst. & G. Forst.	2.0	2	1.4	—	—	—
Derris sp. Lour.	35.0	4	12.9	—	—	—
Derris trifoliata Lour.	19.0	5	13.4	—	—	—

Table 9—Average nontree understory cover[a] on FIA field subplots by species and forest type (continued)

Scientific name	Forest type					
	Volcanic			Limestone		
	Cover	Number of subplots	Standard deviation	Cover	Number of subplots	Standard deviation
	Percent			*Percent*		
Dianella sp. Lam.	1.7	3	1.2	—	—	—
Dioscorea alata L.	5.0	4	1.6	—	—	—
Dioscorea bulbifera L.	1.5	2	0.7	—	—	—
Dioscorea sp. L.	3.0	1	—	—	—	—
Donax cannaeformis (Forst. f.) K. Schum.	11.0	9	11.9	—	—	—
Donax sp. Lour.	24.0	3	23.3	—	—	—
Eriachne pallescens R. Br.	45.0	4	5.8	—	—	—
Eurya japonica (Korth.) This.-Dyer	7.8	10	9.9	—	—	—
Eustachys petraea (Sw.) Desv.	4.7	3	0.6	—	—	—
Ficus sp. L.	1.5	4	1.0	—	—	—
Ficus tinctoria Forst. f.	6.5	2	2.1	—	—	—
Flagellaria gigantea Hook f.	1.0	1	—	—	—	—
Freycinetia villalobosii Martelli	23.8	6	29.3	—	—	—
Gleichenia linearis (Luers.) Fosberg	47.1	20	38.3	—	—	—
Gliricidia sp. (Blank)	15.0	1	—	—	—	—
Hanguana malayana Merrill	19.0	4	14.5	—	—	—
Hedyotis cornifolia Kaneh.	2.0	7	1.2	—	—	—
Hedyotis korrorensis (Valeton) Hosok.	1.0	1	—	—	—	—
Hedyotis sp. L.	3.6	5	3.7	—	—	—
Heterogonium pinnatum (Copel.) Holtt.	2.0	1	—	—	—	—
Hippobroma longiflora (L.) G. Don	1.0	1	—	—	—	—
Hyptis capitata Jacq.	1.5	2	0.7	—	—	—
Ipomea sp. L.	—	—	—	1.0	1	—
Ischaemum polystachyum J. S. Presl	17.7	3	19.7	—	—	—
Ixora casei Hance	4.7	3	2.9	—	—	—
Ixora sp. L.	2.8	37	3.1	5.0	1	—
Lantana camara L.	2.5	2	0.7	—	—	—
Lindsaea obtusa J. Sm. Hook.	1.1	14	0.3	2.0	1	—
Lycopodium cernuum L.	10.9	11	9.0	—	—	—
Lycopodium phlegmaria L.	1.0	1	—	—	—	—
Lygodium auriculatum (Willd.) Alston	1.7	9	0.9	—	—	—
Lygodium circinnatum (Burm. f.) Sw.	6.6	5	3.2	—	—	—
Machaerina mariscoides (Gaud.) J. Kern	5.3	19	7.3	—	—	—
Macrothelypteris torresiana (Gaud.)	2.5	2	0.7	—	—	—
Medinilla blumeana Mansfeld	1.0	2	0.0	—	—	—
Melastoma malabathricum L.	1.5	16	0.9	—	—	—
Merremia peltata (L.) Merrill	25.3	19	28.8	5.0	1	—
Merremia sp. Dennst. Ex Endl.	1.5	2	0.7	—	—	—
Microsorum scolopendria (Burm. f.)	2.2	5	1.6	2.7	19	3.3
Mimosa pudica L.	2.0	1	—	—	—	—
Mussaenda frondosa L.	2.0	1	—	—	—	—
Nepenthes mirabilis Druce	1.2	25	0.4	—	—	—
Nephrolepis acutifolia (Desv.) J. Christ	2.0	1	—	—	—	—
Nephrolepis biserrata (Sw.) Schott	2.0	4	0.8	24.7	13	30.2
Nephrolepis hirsutula (J.R. Forst.) K. Presl	9.9	7	15.8	—	—	—
Pandanus aimiriikensis Martelli	10.7	9	24.2	—	—	—
Pandanus sp. L. f.	4.6	68	5.9	2.0	1	—
Paspalum conjugatum Berg.	11.4	5	8.3	—	—	—
Pennisetum polystachyon (L.) J.A. Schultes	1.0	1	—	—	—	—
Phaleria nisidai Kaheh.	2.0	1	—	—	—	—
Phragmites karka (Retz.) Trin. ex Steud.	25.3	3	22.4	—	—	—

Table 9—Average nontree understory cover[a] on FIA field subplots by species and forest type (continued)

Scientific name	Forest type					
	Volcanic			Limestone		
	Cover	Number of subplots	Standard deviation	Cover	Number of subplots	Standard deviation
	Percent			*Percent*		
Phyllanthus sp. L.	1.3	3	0.6	—	—	—
Piper fragile Benth.	1.0	1	—	—	—	—
Piper sp. L.	1.0	1	—	5.5	6	5.9
Pityrogramma calomelanos (L.) Link	1.0	2	0.0	—	—	—
Polypodium punctatum (Raddi) Hook.	1.0	2	0.0	—	—	
Polyscias grandifolia Volk.	22.5	4	19.4	—	—	—
Portulaca oleracea L.	25.0	3	13.2	—	—	—
Pteris ensiformis Burm. f.	2.0	1	—	—	—	—
Pteris plumula Desv auct. Non Retz.	2.0	1	—	—	—	—
Pteris tripartita Sw.	1.6	8	0.7	—	—	—
Pteris vittata L.	1.0	2	0.0	—	—	—
Rhaphidophora carolinensis (Volk.) Fosberg	2.0	2	1.4	—	—	—
Rhaphidophora sp. Hassk.	1.5	4	1.0	—	—	—
Rhaphidophora versteegii Engl. & K. Krause	2.5	23	2.7	2.5	11	1.3
Rhynchospora sp. Vahl	25.0	1	—	—	—	—
Scaevola sericea Vahl var. *taccada* (Gaertn.) Thieret & B. Lipscomb	5.0	1	—	—	—	—
Schefflera odorata Merr. & Rolfe	17.3	3	14.2	—	—	—
Schefflera sp. J.R. & G. Forst.	1.0	2	0.0	2.0	2	0.0
Schizaea dichotoma (L.) Sm.	1.2	20	0.5	—	—	—
Scleria levis Willd.	3.0	8	2.1	—	—	—
Spathoglottis carolinensis Schlecht.	1.7	3	0.6	—	—	—
Thelypteris forsteri Morton	6.0	1	—	—	—	—
Thelypteris parasitica (L.) Reed.	2.0	3	1.0	—	—	—
Thelypteris sp. Schmidel	3.0	1	—	—	—	—
Thelypteris unita (L.) C.V. Morton	6.2	24	14.2	1.0	1	—
Vernonia sp. Schreb.	2.0	3	1.0	—	—	—
Vitex sp. L.	—	—	—	5.6	7	10.8
Vitex trifolia L.	25.0	1	—	—	—	—
Wikstroemia elliptica Merr.	2.4	5	1.7	—	—	—
Unknown annual grass 1	4.3	4	4.3	—	—	—
Unknown fern 0	1.0	1	—	—	—	—
Unknown fern 1	12.8	6	28.0	1.5	4	0.6
Unknown fern 2	8.0	4	9.1	2.0	2	0.0
Unknown fern 3	1.0	1	—	—	—	—
Unknown fern 4	1.0	2	0.0	—	—	—
Unknown forb 1	3.6	11	2.7	3.0	1	—
Unknown forb 2	3.3	3	1.5	2.0	2	1.4
Unknown grass 1	1.0	1	—	—	—	—
Unknown orchid 0	2.8	5	4.0	1.0	1	—
Unknown perennial grass 1	13.6	13	18.8	—	—	—
Unknown perennial grass 1a	1.0	1	—	—	—	—
Unknown perennial grass 2	45.5	2	62.9	—	—	—
Unknown shrub 0	3.1	7	5.2	1.6	11	0.7
Unknown shrub 2	5.0	1	—	—	—	—
Unknown vine 1	2.8	9	4.6	2.0	5	0.7
Unknown vine 2	3.0	1	—	1.0	1	—
Unknown vine 3	25.0	1	—	—	—	—

[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 188 subplots was 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.

Table 10—Average understory tree cover[a] on FIA field subplots by species and forest type

Scientific name	Forest type					
	Volcanic			Limestone		
	Cover	Number of subplots	Standard deviation	Cover	Number of subplots	Standard deviation
	Percent			*Percent*		
Aglaia palauensis Kaneh.	2.4	21	1.6	2.3	4	0.5
Aidia cochinchinensis Lour.	—	—	—	1.5	2	0.7
Allophylus ternatus (Forst.) Radlk.	2.0	1	—	—	—	—
Alphitonia carolinensis Hosok.	3.3	6	2.7	—	—	—
Alphitonia zizyphoides A. Gray	2.0	1	—	—	—	—
Areca catechu L.	3.0	3	2.0	—	—	—
Astronidium palauense (Kaneh.) Mgf.	1.4	11	0.7	—	—	—
Astronidium sp. A. Gray	1.0	1	—	—	—	—
Badusa palauensis Valeton	2.0	1	—	2.8	4	0.5
Barringtonia asiatica (L.) Kurz	—	—	—	1.0	1	—
Barringtonia racemosa (L.) Spreng.	5.9	7	6.5	3.0	1	—
Bruguiera gymnorrhiza (L.) Lam.	1.6	15	1.4	—	—	—
Buchanania engleriana Volk.	1.0	1	—	—	—	—
Buchanania palawensis Lauterb.	3.0	1	—	—	—	—
Buchanania sp. Spreng.	5.5	2	3.5	—	—	—
Calophyllum inophyllum L.	1.5	2	0.7	2.2	5	0.8
Calophyllum pelewense P. F. Stevens	2.3	4	1.5	—	—	—
Campnosperma brevipetiolata Volk.	2.8	9	2.9	—	—	—
Canarium hirsutum Willd.	7.0	2	1.4	—	—	—
Casuarina equisetifolia L.	—	—	—	2.0	1	—
Cerbera manghas L.	2.8	4	1.7	—	—	—
Cerbera sp. L.	1.0	1	—	—	—	—
Cocos nucifera L.	3.8	9	4.3	34.0	3	29.5
Commersonia bartramia (L.) Merr.	1.0	1	—	—	—	—
Cyathea lunulata (Forst. f.) Copel.	4.3	4	3.9	—	—	—
Diospyros discolor Willd.	2.5	2	0.7	—	—	—
Diospyros ferrea (Willd.) Bakh.	2.5	2	0.7	—	—	—
Diospyros sp. L.	2.5	2	0.7	—	—	—
Dracaena multiflora Tentative	—	—	—	3.0	1	—
Drypetes nitida Kaneh.	—	—	—	3.0	1	—
Dysoxylum sp. Blume	2.4	7	1.0	—	—	—
Elaeocarpus joga Merr.	2.2	5	1.3	8.0	1	—
Elaeocarpus sp. L.	1.0	1	—	—	—	—
Elattostachys falcata (Seem.) Radik.	1.0	1	—	—	—	—
Eugenia cumini (L.) Druce	2.0	1	—	4.8	4	2.8
Eugenia javanica Lam.	—	—	—	1.8	8	0.7
Eugenia reinwardtiana (Bl.) DC.	6.6	7	8.4	4.3	9	2.8
Eugenia sp. L.	1.9	8	1.0	3.3	3	1.5
Evodia sp. Lam.	2.0	1	—	—	—	—
Fagraea ksid Gilg and Bened.	1.0	1	—	—	—	—
Ficus sp. L.	2.3	3	0.6	—	—	—
Ficus tinctoria Forst. f.	5.3	19	4.4	2.4	7	1.3
Flacourtia rukam Zoll. & Moritzi	2.8	5	1.5	—	—	—
Garcinia matudai Kaneh.	6.8	4	9.0	—	—	—
Garcinia rumiyo Fosb.	8.2	19	12.5	—	—	—

Table 10—Average understory tree cover[a] on FIA field subplots by species and forest type (continued)

Scientific name	Forest type					
	Volcanic			Limestone		
	Cover	Number of subplots	Standard deviation	Cover	Number of subplots	Standard deviation
	Percent			*Percent*		
Garcinia sp. L.	4.3	4	3.9	7.8	5	6.9
Glochidion ramiflorum Forst.	3.0	4	1.4	2.0	2	—
Glochidion sp. J.R. & G. Forst.	—	—	—	1.0	1	—
Gmelina elliptica Sm.	—	—	—	2.0	1	—
Gmelina palawensis H. J. Lam.	1.5	2	0.7	—	—	—
Gulubia palauensis (Becc.) Moore & Fosb.	9.3	3	5.1	2.0	1	—
Heterospathe elata (Becc.) Becc.	4.2	6	2.0	2.0	1	—
Hibiscus tiliaceus L.	5.0	8	5.1	—	—	—
Horsfieldia amklaal Kaneh.	3.0	2	—	2.5	2	0.7
Horsfieldia novo-guineensis Warb.	4.5	15	3.1	—	—	—
Horsfieldia palauensis Kaneh.	4.3	45	10.6	2.2	10	0.8
Horsfieldia sp. Wild.	2.5	2	0.7	—	—	—
Inocarpus fagifer (Park.) Fosb.	2.0	2	1.4	—	—	—
Macaranga carolinensis Volk.	3.1	17	3.0	5.5	2	3.5
Manilkara udoido Kaneh.	2.0	5	1.4	—	—	—
Manilkara zapota (L.) P. v. Roy.	1.7	3	0.6	—	—	—
Melochia aristata A. Gray	2.0	1	—	—	—	—
Morinda citrifolia L.	1.5	4	0.6	—	—	—
Morinda pedunculata Val.	21.5	2	26.2	—	—	—
Myristica sp. Gronov.	2.0	1	—	—	—	—
Neonauclea forsteri Merrill	4.0	1	—	—	—	—
Omalanthus sp. A.Juss.	11.5	4	12.3	—	—	—
Ormosia calavensis Azaola ex Blanco	2.0	1	—	—	—	—
Osmoxylon oliveri Fosberg & Sachet	5.0	4	5.0	—	—	—
Osmoxylon pachyphyllum (Kanehira) F.R. Fosberg & M.-H. Sachet	3.0	1	—	—	—	—
Osmoxylon sp. Miq.	3.0	10	3.3	1.0	1	—
Pandanus aimiriikensis Mart.	3.5	10	2.8	27.0	3	37.5
Pandanus dubius Spr.	—	—	—	2.5	6	1.6
Pandanus kanehirae Mart.	1.5	2	0.7	—	—	—
Pandanus peliliuensis Kaneh.	—	—	—	1.5	2	0.7
Pandanus tectorius Park.	3.1	8	2.4	—	—	—
Parinari corymbosum (Bl.) Miq.	8.0	4	11.4	—	—	—
Parinari laurina Gray	30.8	12	27.5	2.0	1	—
Parkia parvifoliola Hosok.	1.0	1	—	—	—	—
Pinanga insignis Becc.	19.9	103	20.6	1.5	4	0.6
Pithecellobium dulce (Roxb.) Benth.	—	—	—	1.8	4	0.5
Polyscias nodosa (Bl.) Seem.	—	—	—	3.0	1	—
Pongamia pinnata (L.) Merr.	—	—	—	2.0	1	—
Pouteria calcarea (Hosok.) Fosb.	—	—	—	1.0	1	—
Pouteria obovata (R. Br.) Baehni	1.5	2	0.7	1.6	7	0.5
Premna obtusifolia R. Br.	5.0	1	—	—	—	—
Rhizophora apiculata Bl.	13.9	15	23.9	1.0	4	—
Rhizophora mucronata Lam.	1.5	2	0.7	—	—	—
Rhus taitensis Guill.	1.9	8	1.4	2.0	1	—

Table 10—Average understory tree cover[a] on FIA field subplots by species and forest type (continued)

Scientific name	Forest type					
	Volcanic			Limestone		
	Cover	Number of subplots	Standard deviation	Cover	Number of subplots	Standard deviation
	Percent			*Percent*		
Semecarpus venenosus Volk.	2.2	31	1.6	3.0	1	—
Sonneratia alba J. E. Sm.	2.8	8	3.1	—	—	—
Stemonurus ammui (Kaneh.) Sleumer	40.0	1	—	—	—	—
Swietenia mahagoni (L.) Jacq.	6.0	2	2.8	—	—	—
Symplocos racemosa Roxb.	2.3	6	0.8	—	—	—
Tecoma stans (L.) Juss. ex HBK.	3.0	1	—	—	—	—
Terminalia catappa L.	3.0	1	—	—	—	—
Terminalia sp. L.	20.0	1	—	—	—	—
Timonius subauritus Fosberg & Sachet	—	—	—	8.5	2	9.2
Trichospermum ledermannii Burret	1.0	2	—	—	—	—
Xylocarpus granatum Koen.	1.6	8	1.4	—	—	—
Unknown 0	1.3	4	0.5	—	—	—
Unknown 1	2.0	1	—	—	—	—
Unknown 20	2.0	1	—	—	—	—

[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 188 subplots was 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.

For the 2003 inventory, 128 tree species and 132 understory species were measured on FIA plots. The volcanic forest area sampled was about four times the area sampled for the limestone forest. Because we expect the number of species counted to increase with increasing area, it is not surprising that over twice the number of tree species and over four times the number of understory species were found in volcanic forest compared to limestone forest (fig. 11). On a per-plot basis (approximately one-sixth acre), the mean number of tree species found on volcanic plots was 12, with an average of 10 tree species found per limestone plot (fig. 12). The one limestone plot where only two species occurred (fig. 12) was a mangrove plot where 90 trees (≥5 inches) were measured, 65 *Rhizophora apiculata* and 25 *R. mucronata*. The area of mangrove forest could not be accurately delineated from limestone forest with this small sample, thus separate expansion factors were not calculated for mangrove species. Mangrove species numbers may be falsely high owing to this expansion. However, because mangrove species tend to dominate the extensive mangroves on Palau, and only five partial plots contained mangrove species, the estimate may be reasonable. Additional mapping data are forthcoming and will help refine our estimate for mangrove species. The urgent need to better understand mangroves as buffers to coastal disturbance (storms, typhoons, and tsunami) suggests the need for a separate, detailed mangrove inventory.

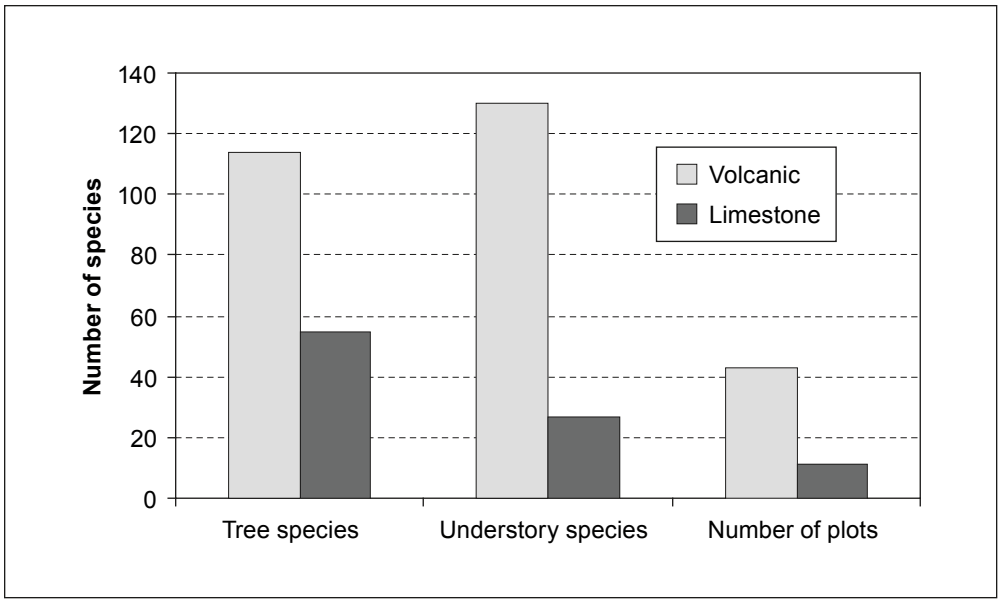

Figure 11—One hundred and twenty-eight tree species and 132 understory species were measured on 54 forested plots in Palau.

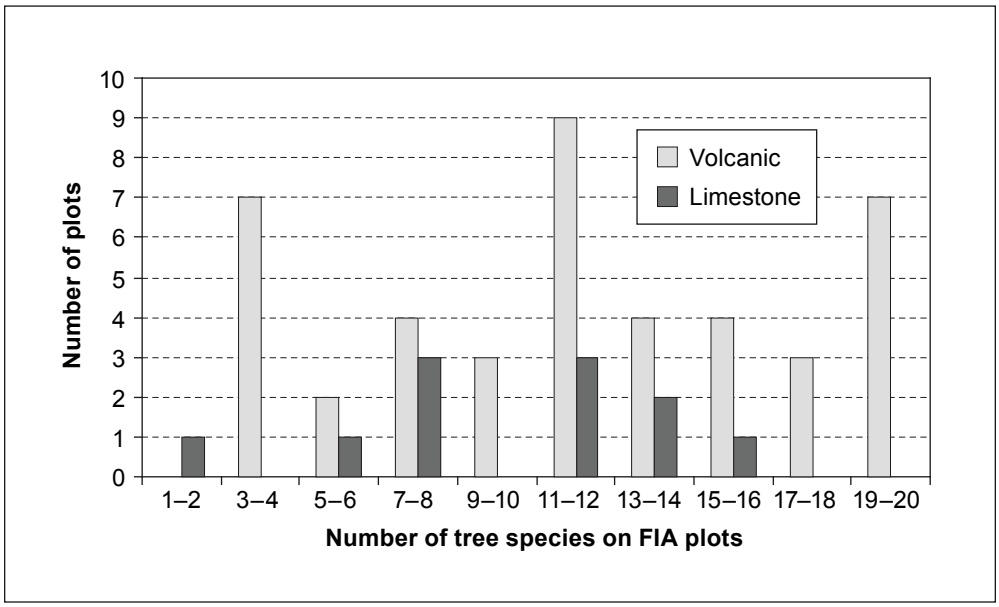

Figure 12—The average number of tree species found per sixth-acre plot was 12 for volcanic forests and 10 for limestone forests.

Tree Damage and Mortality

Approximately 13 percent of the individual trees on Palau show some sign of damage (table 11). The most prevalent damage types are vines in crowns, conks (shelf fungus indicating rot), and lost apical dominance (damage to the primary growing leader) (fig. 13). The prevalence of vines in tree crowns was high, 41 percent. Although the vines are common, their effect on their supporting tree hosts was not quantified. Effects ranged from some additional weight to rare instances of strangulation. For the identifiable damaging agents, damage by other vegetation, disease, and weather ranked as the most prevalent primary damage agents (fig. 14).

Less than 5 percent of the trees sampled during the inventory were dead (fig. 15). Of those dead, nearly one-fourth could not be identified to species level. The most prevalent, identifiable dead trees were *Cyathea lunulata* (7.3 percent of total dead)*, Calophyllum inophyllum, Calophyllum pelewense,* and *Pinanga insignis* (each accounting for 6.1 percent of total dead).

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 the stems of trees. In Palau we rated epiphytic loading on trees as a summation of loading on the bole, branches, and canopy. We estimate that about 65 percent of the trees in Palau had few to no epiphytes, and 45 percent of the trees had moderate to high amounts of epiphytes (table 12).

Forest Dynamics—

Forest structure and species composition change through time as a result of forest succession and disturbance dynamics. The forests of Palau have been strongly influenced by a long history of disturbance, both human-caused and climatic disturbance. Human populations and land use on Palau have changed, resulting in differing influences on forest vegetation. Within the last century, the most important land use changes have involved the conversion of forest to agriculture and its subsequent abandonment and reversion to grassland, and eventually forest. Endress and Chinea (2001) documented the abandonment of agricultural lands and reversion to forest by comparing 1947 and 1992 aerial photography for approximately 20,500 acres in the Ngeremeduu Bay drainage area on Babeldaob. These authors noted the most dramatic change occurred during the period 1947 to 1976, using the Cole et al. (1987) map as an intermediate comparison point. (*Text continues on page 49.)*

Table 11—Number of trees by primary damage type and species for all trees (≥5 inches diameter at breast height; includes dead trees)

Species	No damage	Broken bole	Broken branches	Broken roots	Canker/ gall	Conks	Cracks/ seams	Discolored foliage	Excessive branching	Lost apical dominance	Open wound	Vines in crown	All damages
						Number of trees							
Aglaia palauensis	171,813	—	—	—	—	—	—	—	—	12,330	—	49,318	61,648
Allophylus ternatus	36,989	—	—	—	—	—	—	—	—	—	—	—	—
Allophylus timorensis	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Alphitonia carolinensis	456,192	—	—	—	—	12,330	—	—	—	—	12,330	12,330	36,989
Annona reticulata	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Areca catechu	73,977	—	—	—	—	—	—	—	—	—	—	—	—
Artocarpus mariannensis	48,518	—	—	—	—	—	—	—	—	—	—	—	—
Astronidium palauense	258,920	—	—	—	—	12,330	—	—	—	12,330	—	—	24,659
Avicennia marina	12,330	—	—	—	—	12,330	—	—	—	—	—	—	12,330
Badusa palauensis	254,719	—	12,129	—	—	12,129	—	—	—	12,129	—	12,129	48,518
Barringtonia racemosa	330,896	—	—	—	—	12,129	—	—	—	—	—	36,989	49,118
Bruguiera gymnorrhiza	468,521	—	—	—	12,330	—	—	—	—	—	—	—	12,330
Buchanania palawensis	98,436	—	—	—	—	—	—	—	—	—	—	—	—
Calophyllum inophyllum	293,308	—	12,129	—	—	—	—	—	—	—	24,259	—	36,388
Calophyllum pelewense	197,072	—	—	—	—	12,330	—	—	—	—	—	—	12,330
Calophyllum soulattri	49,318	—	—	—	—	—	—	—	—	—	—	—	—
Calophyllum sp.	36,588	24,659	—	—	—	—	—	—	—	—	—	12,129	36,788
Campnosperma brevipetiolata	714,911	—	24,659	12,330	—	24,659	—	—	—	—	—	61,648	123,295
Canarium hirsutum	72,777	—	—	—	—	—	—	—	—	—	12,330	12,330	24,659
Casearia cauliflora	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Casearia sp.	84,906	—	—	—	—	—	—	—	—	—	—	—	—
Casuarina equisetifolia	60,647	—	12,129	—	—	—	—	—	—	—	—	—	12,129
Cerbera floribunda	24,659	—	—	—	—	—	—	—	—	—	—	—	—
Cerbera manghas	135,425	—	—	—	—	—	—	—	—	—	12,330	61,648	73,977
Cocos nucifera	306,637	—	—	—	—	—	—	—	—	—	—	12,330	12,330
Commersonia bartramia	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Cordia micronesica	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Cyathea lunulata	542,498	—	12,330	—	—	—	—	—	—	—	—	—	12,330
Diospyros ferrea	98,636	—	—	—	—	—	—	—	—	—	—	—	—
Diospyros sp.	73,577	—	—	—	—	—	—	—	—	12,330	—	—	12,330
Dodonaea viscosa	73,177	—	—	—	—	—	—	—	—	—	—	—	—
Dracaena multiflora	98,036	—	—	—	—	12,129	—	—	—	—	—	—	12,129
Drypetes nitida	36,788	—	—	—	—	—	—	—	—	—	—	—	—
Dysoxylum sp.	36,989	—	—	—	—	—	—	—	—	—	—	—	—
Elaeocarpus graeffei	—	—	—	—	—	—	—	—	—	—	—	12,330	12,330
Elaeocarpus joga	453,391	—	—	—	—	24,659	—	—	—	12,330	12,330	24,459	73,777

Table 11—Number of trees by primary damage type and species for all trees (≥5 inches diameter at breast height; includes dead trees) (continued)

Species	No damage	Broken bole	Broken branches	Broken roots	Canker/ gall	Conks	Cracks/ seams	Discolored foliage	Excessive branching	Lost apical dominance	Open wound	Vines in crown	All damages
						Number of trees							
Erythrina fusca	12,129	—	—	—	—	—	—	—	—	—	—	—	—
Eugenia cumini	207,201	—	—	—	—	—	—	—	—	—	—	12,129	12,129
Eugenia javanica	181,942	—	—	—	—	24,259	—	—	—	—	24,259	—	48,518
Eugenia reinwardtiana	570,685	—	—	—	—	—	—	—	—	—	24,259	—	24,259
Eugenia sp.	36,788	—	—	—	—	—	—	—	—	—	—	—	—
Fagraea ksid	110,966	—	12,330	—	—	12,330	—	—	—	—	—	36,989	61,648
Ficus sp.	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Ficus tinctoria	24,259	—	—	—	—	—	—	—	—	—	—	—	—
Flacourtia rukam	135,425	—	—	—	—	—	12,129	12,330	—	—	—	—	24,459
Garcinia matudai	49,318	—	—	—	—	—	—	—	—	24,659	—	—	24,659
Garcinia rumiyo	294,908	—	—	—	—	12,330	—	—	—	—	—	12,330	24,659
Garcinia sp.	343,626	—	—	—	—	—	—	—	—	—	—	—	—
Gironniera celtidifolia	36,989	—	—	—	—	—	—	—	—	—	—	—	—
Glochidion ramiflorum	134,224	—	12,129	—	—	12,330	—	—	—	—	—	36,788	61,247
Glochidion sp.	—	—	—	—	—	—	—	—	—	12,330	—	12,330	24,659
Gmelina elliptica	182,342	—	12,129	—	—	24,659	—	—	—	—	—	—	36,788
Gmelina palawensis	431,133	—	—	—	—	61,648	—	—	—	36,989	36,788	—	135,425
Gmelina sp.	36,989	—	—	—	—	—	—	—	—	—	12,330	24,659	36,989
Gulubia palauensis	109,165	—	—	—	—	—	—	—	—	—	—	—	—
Hernandia sonora	12,129	—	—	—	—	12,129	—	—	—	—	—	12,129	24,259
Hernandia sp.	36,388	—	—	—	—	12,129	—	—	—	—	12,129	—	24,259
Heterospathe elata	73,977	—	—	—	—	—	—	—	—	—	—	12,330	12,330
Hibiscus tiliaceus	49,318	—	—	—	—	—	—	—	—	12,330	—	36,989	49,318
Horsfieldia amklaal	220,531	—	—	—	—	12,330	—	—	—	12,330	—	—	24,659
Horsfieldia novo-guineensis	221,931	—	—	—	—	12,330	—	—	—	—	—	—	12,330
Horsfieldia palauensis	845,935	—	24,459	—	—	36,588	—	—	—	24,659	12,330	49,118	147,154
Horsfieldia sp.	—	—	—	—	—	12,330	—	—	—	—	—	—	12,330
Inocarpus fagifer	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Intsia bijuga	181,942	—	—	—	—	36,388	—	—	—	—	12,129	—	48,518
Lumnitzera littorea	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Macaranga carolinensis	122,695	—	—	—	—	12,330	—	—	—	—	—	36,989	49,318
Manilkara udoido	234,261	—	—	12,330	—	—	—	—	—	—	—	36,989	49,318
Manilkara zapota	49,318	—	—	—	—	—	—	—	—	12,330	—	12,330	24,659
Morinda citrifolia	—	—	—	—	—	12,330	—	—	—	—	—	12,330	24,659
Morinda latibracteata	24,659	—	—	—	—	12,330	—	—	—	—	—	24,659	36,989

Table 11—Number of trees by primary damage type and species for all trees (≥5 inches diameter at breast height; includes dead trees) (continued)

Species	No damage	Broken bole	Broken branches	Broken roots	Canker/ gall	Conks	Cracks/ seams	Discolored foliage	Excessive branching	Lost apical dominance	Open wound	Vines in crown	All damages
						Number of trees							
Morinda sp.	12,330	—	—	—	—	—	—	—	—	12,330	12,330	—	24,659
Morinda pedunculata	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Nephelium lappaceum	—	—	—	—	—	—	—	—	—	—	—	12,330	12,330
Osmoxylon oliveri	24,659	—	—	—	—	—	—	—	—	—	—	—	—
Osmoxylon sp.	24,659	—	—	—	—	—	—	—	—	—	—	36,989	36,989
Pandanus aimiriikensis	61,648	—	—	—	—	—	—	—	—	—	—	—	—
Pandanus dubius	145,554	—	—	48,518	—	—	—	—	—	12,129	—	—	60,647
Pandanus kanehirae	61,648	—	—	—	—	—	—	—	—	—	—	—	—
Pandanus tectorius	86,307	—	—	12,330	—	—	—	—	—	—	—	—	12,330
Pandanus utiyamai	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Pangium edule	12,330	—	—	—	—	—	—	—	—	—	—	12,330	12,330
Parinari corymbosum	554,428	—	12,330	—	—	49,318	—	—	12,330	12,330	12,330	12,330	110,966
Parinari laurina	516,039	—	—	—	—	24,659	—	—	—	—	—	24,659	49,318
Parinari sp.	24,659	—	—	—	—	—	—	—	—	—	—	—	—
Pinanga insignis	2,071,357	—	—	—	—	—	—	—	—	—	—	123,295	123,295
Pithecellobium dulce	12,129	—	—	—	—	—	—	—	—	—	—	—	—
Pouteria calcarea	36,989	—	—	—	—	—	—	—	—	—	—	—	—
Pouteria obovata	353,555	—	—	—	—	24,659	—	—	—	—	—	24,459	49,118
Pouteria sp.	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Premna obtusifolia	36,989	—	—	—	—	—	—	—	—	—	—	49,318	49,318
Pterocarpus indicus	24,659	—	—	—	—	—	—	—	—	—	—	—	—
Ptychosperma palauensis	86,307	—	—	—	—	—	—	—	—	—	—	—	—
Rhizophora apiculata	1,343,843	—	12,129	—	—	12,129	—	—	—	12,129	12,330	—	48,718
Rhizophora mucronata	377,214	—	—	—	—	—	—	—	—	—	—	—	—
Rhus taitensis	357,556	—	12,330	12,330	—	12,330	—	—	—	12,330	12,330	12,330	73,977
Rinorea carolinensis	12,129	—	—	—	—	—	—	—	—	—	—	—	—
Semecarpus venenosus	528,168	—	—	—	—	12,330	—	—	—	12,330	—	24,659	49,318
Sonneratia alba	172,613	—	—	—	—	—	—	—	—	—	—	—	—
Stemonurus ammui	61,648	—	—	—	—	—	—	—	—	—	—	—	—
Swietenia macrophylla	49,318	—	—	—	—	—	—	—	—	—	—	—	—
Swietenia mahagoni	36,989	—	—	—	—	—	—	—	—	—	—	36,989	36,989
Symplocos racemosa	36,989	—	12,330	—	—	—	—	—	—	12,330	—	—	24,659
Terminalia catappa	12,330	—	—	—	—	—	—	—	—	—	—	36,989	36,989
Theobroma cacao	24,659	—	—	—	—	24,659	—	—	—	12,330	—	—	36,989
Timonius subauritus	84,906	—	—	—	—	—	—	—	—	—	—	24,259	24,259

Table 11—Number of trees by primary damage type and species for all trees (≥5 inches diameter at breast height; includes dead trees) (continued)

Species	No damage	Broken bole	Broken branches	Broken roots	Canker/ gall	Conks	Cracks/ seams	Discolored foliage	Excessive branching	Lost apical dominance	Open wound	Vines in crown	All damages
						Number of trees							
Tournefortia argentea	36,588	—	—	—	—	12,330	—	—	—	—	—	—	12,330
Trichospermum ledermanni	98,636	—	—	—	—	—	—	—	—	—	—	—	—
Vitex cofassus	61,648	—	—	—	—	—	—	—	—	—	12,330	36,989	49,318
Xylocarpus granatum	147,954	—	—	—	—	24,659	—	—	—	—	12,330	—	36,989
Unknown	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Unknown 0	134,824	—	12,330	—	—	—	—	—	—	—	—	—	12,330
Unknown 1	24,659	—	—	—	—	24,459	—	—	—	—	—	—	24,459
Unknown 3	49,318	—	—	—	—	—	—	—	—	—	—	—	—
Unknown 5	85,906	—	—	—	—	—	—	—	—	—	—	—	—
Unknown 10	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Unknown 11	12,330	—	—	—	—	—	—	—	—	—	—	—	—
Unknown 30	12,129	—	—	—	—	—	—	—	—	—	—	—	—
Unknown, other	73,977	—	—	—	—	12,330	—	—	—	—	—	—	12,330
Total	18,714,675	24,659	195,872	97,836	12,330	687,652	12,129	12,330	12,330	295,308	281,778	1,144,644	2,776,866

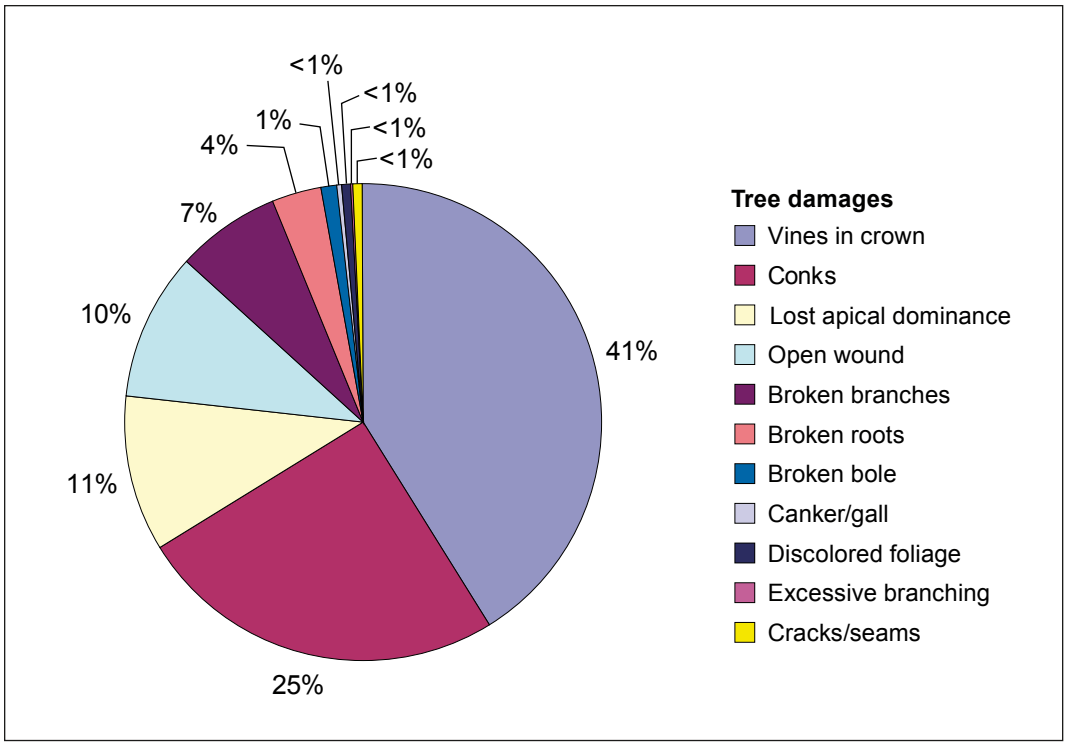

Figure 13—Vines in the crowns of trees are very common in Palau. Damage from vines was recorded when the vines occupied 20 percent or more of the crown. Rot, indicated by the fruiting shelf fungi (conks) was also a common damage.

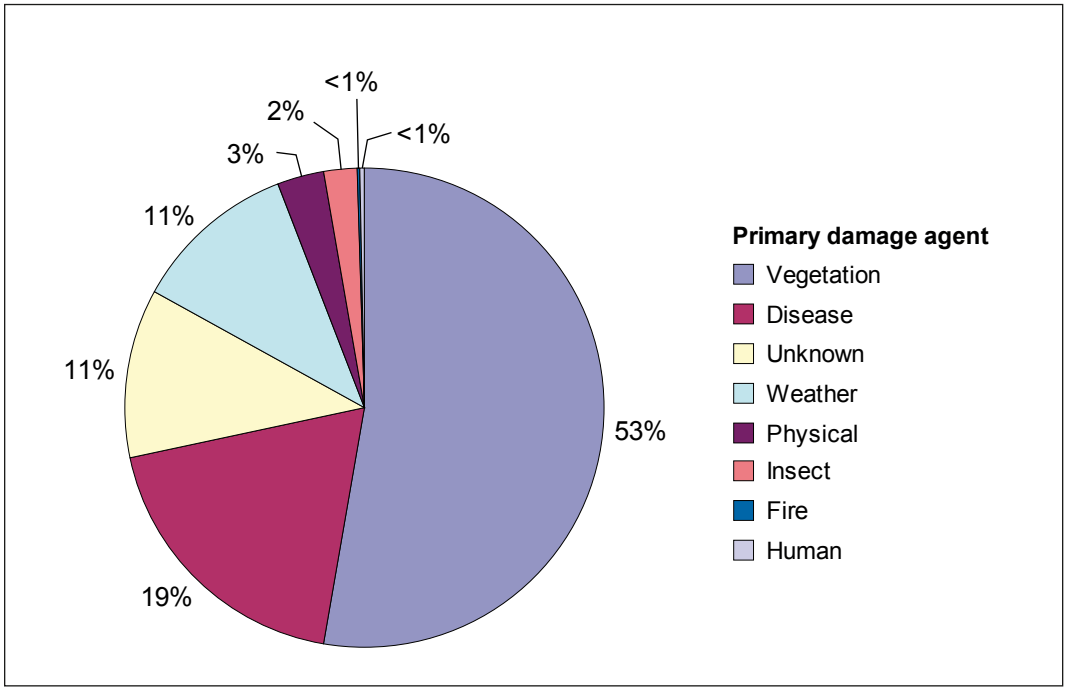

Figure 14—Disturbance by other vegetation and disease were the most common identifiable damaging agents for trees.

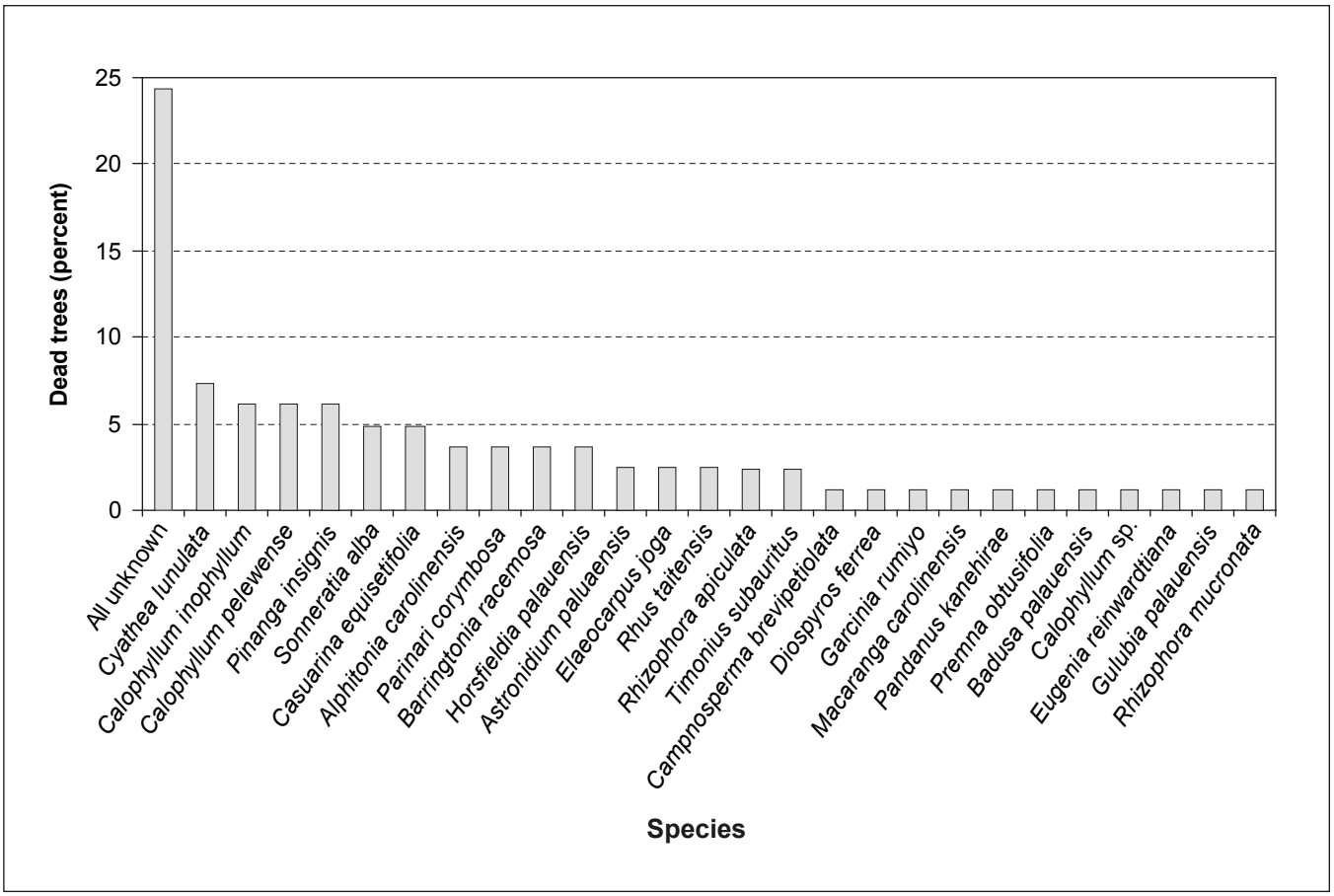

Figure 15—Identifying dead trees proved to be difficult in Palau. Nearly one-fourth of those dead could not be identified.

Table 12—Estimated number of trees on forest land by epiphyte loading (amounts of nontree vegetation in the canopy and branches) and species (includes dead trees)

Species	Epiphyte loadings				All loadings
	None	Low	Moderate	High	
			Number of trees		
Aglaia palauensis	36,388	123,095	61,648	12,330	197,072
Allophylus ternatus	—	12,330	12,330	12,330	36,989
Allophylus timorensis	—	—	12,330	—	12,330
Alphitonia carolinensis	135,625	160,284	110,966	86,307	357,556
Annona reticulata	—	—	12,330	—	12,330
Areca catechu	—	36,989	12,330	24,659	73,977
Artocarpus mariannensis	24,259	—	24,259	—	24,259
Astronidium palauense	12,330	135,625	73,977	61,648	271,249
Avicennia marina	—	12,330	12,330	—	24,659
Badusa palauensis	97,036	145,554	36,388	24,259	206,201
Barringtonia racemosa	97,436	134,624	110,966	36,989	282,578
Bruguiera gymnorrhiza	184,943	234,261	36,989	24,659	295,908
Buchanania palawensis	—	49,118	24,659	24,659	98,436
Calophyllum inophyllum	60,647	146,154	73,577	49,318	269,049

Table 12—Estimated number of trees on forest land by epiphyte loading (amounts of nontree vegetation in the canopy and branches) and species (includes dead trees) (continued)

Species	Epiphyte loadings				All loadings
	None	Low	Moderate	High	
			Number of trees		
Calophyllum pelewense	24,659	86,106	36,989	61,648	184,743
Calophyllum soulattri	36,989	12,330	—	—	12,330
Calophyllum sp.	—	48,918	24,459	—	73,377
Campnosperma brevipetiolata	61,447	332,897	271,249	172,613	776,759
Canarium hirsutum	36,588	12,129	36,388	12,330	60,847
Casearia cauliflora	—	12,330	—	—	12,330
Casearia sp.	—	84,906	—	—	84,906
Casuarina equisetifolia	12,129	—	60,647	—	60,647
Cerbera floribunda	—	24,659	—	—	24,659
Cerbera manghas	12,330	98,436	61,648	36,989	197,072
Cocos nucifera	12,330	159,083	110,565	36,989	306,637
Commersonia bartramia	—	12,330	—	—	12,330
Cordia micronesica	—	—	—	12,330	12,330
Cyathea lunulata	49,318	98,636	234,261	172,613	505,510
Diospyros ferrea	—	49,318	49,318	—	98,636
Diospyros sp.	36,588	49,318	—	—	49,318
Dodonaea viscosa	12,129	48,718	—	12,330	61,047
Dracaena multiflora	73,377	24,459	12,330	—	36,788
Drypetes nitida	24,659	12,129	—	—	12,129
Dysoxylum sp.	36,989	—	—	—	—
Elaeocarpus graeffei	—	—	12,330	—	12,330
Elaeocarpus joga	85,706	269,649	122,695	49,118	441,462
Erythrina fusca	12,129	—	—	—	—
Eugenia cumini	36,388	97,836	72,977	12,129	182,942
Eugenia javanica	24,259	121,295	84,906	—	206,201
Eugenia reinwardtiana	218,330	340,025	36,588	—	376,613
Eugenia sp.	—	—	24,459	12,330	36,788
Fagraea ksid	24,659	24,659	123,295	—	147,954
Ficus sp.	—	—	12,330	—	12,330
Ficus tinctoria	—	12,129	12,129	—	24,259
Flacourtia rukam	—	85,906	49,318	24,659	159,883
Garcinia matudai	12,330	36,989	12,330	12,330	61,648
Garcinia rumiyo	36,989	85,706	122,895	73,977	282,578
Garcinia sp.	48,718	233,260	36,989	24,659	294,908
Gironniera celtidifolia	—	24,659	12,330	—	36,989
Glochidion ramiflorum	24,659	85,306	73,377	12,129	170,813
Glochidion sp.	12,330	—	—	12,330	12,330
Gmelina elliptica	72,777	72,777	61,247	12,330	146,354
Gmelina palawensis	184,943	221,331	110,966	49,318	381,615
Gmelina sp.	—	36,989	12,330	24,659	73,977
Gulubia palauensis	109,165	—	—	—	—
Hernandia sonora	—	—	36,388	—	36,388
Hernandia sp.	—	60,647	—	—	60,647
Heterospathe elata	—	73,977	12,330	—	86,307

Table 12—Estimated number of trees on forest land by epiphyte loading (amounts of nontree vegetation in the canopy and branches) and species (includes dead trees) (continued)

Species	Epiphyte loadings				All loadings
	None	Low	Moderate	High	
			Number of trees		
Hibiscus tiliaceus	—	49,318	—	49,318	98,636
Horsfieldia amklaal	12,330	159,083	49,118	24,659	232,860
Horsfieldia novo-guineensis	—	86,307	98,636	49,318	234,261
Horsfieldia palauensis	182,742	355,755	282,178	172,413	810,347
Horsfieldia sp.	—	12,330	—	—	12,330
Inocarpus fagifer	—	12,330	—	—	12,330
Intsia bijuga	145,554	84,906	—	—	84,906
Lumnitzera littorea	—	12,330	—	—	12,330
Macaranga carolinensis	12,330	110,565	36,788	12,330	159,683
Manilkara udoido	98,636	110,966	36,989	36,989	184,943
Manilkara zapota	—	36,989	24,659	12,330	73,977
Morinda citrifolia	—	—	24,659	—	24,659
Morinda latibracteata	—	—	36,989	24,659	61,648
Morinda pedunculata	—	—	—	12,330	12,330
Morinda sp.	24,659	12,330	—	—	12,330
Nephelium lappaceum	—	—	—	12,330	12,330
Osmoxylon oliveri	—	24,659	—	—	24,659
Osmoxylon sp.	—	—	24,659	36,989	61,648
Pandanus aimiriikensis	—	36,989	24,659	—	61,648
Pandanus dubius	109,165	84,906	12,129	—	97,036
Pandanus kanehirae	12,330	24,659	24,659	—	49,318
Pandanus tectorius	49,318	36,989	12,330	—	49,318
Pandanus utiyamai	—	—	—	12,330	12,330
Pangium edule	—	—	12,330	12,330	24,659
Parinari corymbosum	73,577	197,272	172,613	221,931	591,816
Parinari laurina	49,118	269,649	123,295	123,295	516,239
Parinari sp.	12,330	12,330	—	—	12,330
Pinanga insignis	110,966	1,269,939	505,510	308,238	2,083,686
Pithecellobium dulce	12,129	—	—	—	—
Pouteria calcarea	—	24,659	12,330	—	36,989
Pouteria obovata	60,647	134,824	109,365	97,836	342,025
Pouteria sp.	—	12,330	—	—	12,330
Premna obtusifolia	—	12,330	36,989	36,989	86,307
Pterocarpus indicus	—	—	—	24,659	24,659
Ptychosperma palauensis	—	24,659	61,648	—	86,307
Rhizophora apiculata	1,145,970	246,590	—	—	246,590
Rhizophora mucronata	303,236	24,659	49,318	—	73,977
Rhus taitensis	110,966	234,261	61,648	24,659	320,567
Rinorea carolinensis	12,129	—	—	—	—
Semecarpus venenosus	73,377	294,708	135,425	73,977	504,109
Sonneratia alba	135,625	36,989	—	—	36,989
Stemonurus ammui	—	12,330	—	49,318	61,648
Swietenia macrophylla	24,659	24,659	—	—	24,659
Swietenia mahagoni	—	36,989	24,659	12,330	73,977

Table 12—Estimated number of trees on forest land by epiphyte loading (amounts of nontree vegetation in the canopy and branches) and species (includes dead trees) (continued)

Species	Epiphyte loadings				All loadings
	None	Low	Moderate	High	
			Number of trees		
Symplocos racemosa	49,318	12,330	—	—	12,330
Terminalia catappa	12,330	12,330	—	24,659	36,989
Theobroma cacao	12,330	12,330	36,989	—	49,318
Timonius subauritus	24,259	36,388	48,518	—	84,906
Tournefortia argentea	24,259	12,330	12,330	—	24,659
Trichospermum ledermannii	—	73,977	24,659	—	98,636
Vitex cofassus	—	24,659	24,659	61,648	110,966
Xylocarpus granatum	110,966	73,977	—	—	73,977
Unknown	12,330	—	—	—	—
Unknown 0	73,177	36,989	12,330	24,659	73,977
Unknown 1	24,459	—	12,330	12,330	24,659
Unknown 3	24,659	12,330	12,330	—	24,659
Unknown 5	24,259	61,648	—	—	61,648
Unknown 10	—	—	12,330	—	12,330
Unknown 11	—	—	12,330	—	12,330
Unknown 30	—	12,129	—	—	12,129
Unknown, other	36,989	—	36,989	12,330	49,318
Total	5,182,700	8,742,199	4,794,504	2,772,138	16,308,841

Comparing the inventory data from the present study to data from the MacLean et al. (1988) timber inventory suggests that the trend of forest recovery and maturation continues on Palau. With the exceptions of forest loss owing to roads and urban uses, forests appear to be maturing. On average, trees have been getting larger (fig. 16), and as they increased in size, some trees died during the "thinning phase" (Oliver and Larson 1996) of forest succession. We found fewer stems per acre, and greater basal area and volume per acre on forested field plots compared to the MacLean et al. (1988) data (table 13). The MacLean et al. (1988) work was restricted to forested lands on Babeldaob, whereas the current inventory included additional forest types in limestone forest and the Rock Islands. Although our current sample of plots in limestone forest was relatively small (11 out of 54 plots total), the 2003 data suggest much higher net wood volume in limestone (4,107 cubic feet per acre) than in volcanic forests (2,424 cubic feet per acre). Much of the limestone forest is in difficult terrain where access and human populations are limited. The limestone forests were probably less impacted by agricultural development and thus are likely to be in a later phase of maturity than their volcanic counterparts. Soil fertility may also play a role in wood volume differences owing to less aluminum toxicity in limestone versus the volcanic-derived soils.

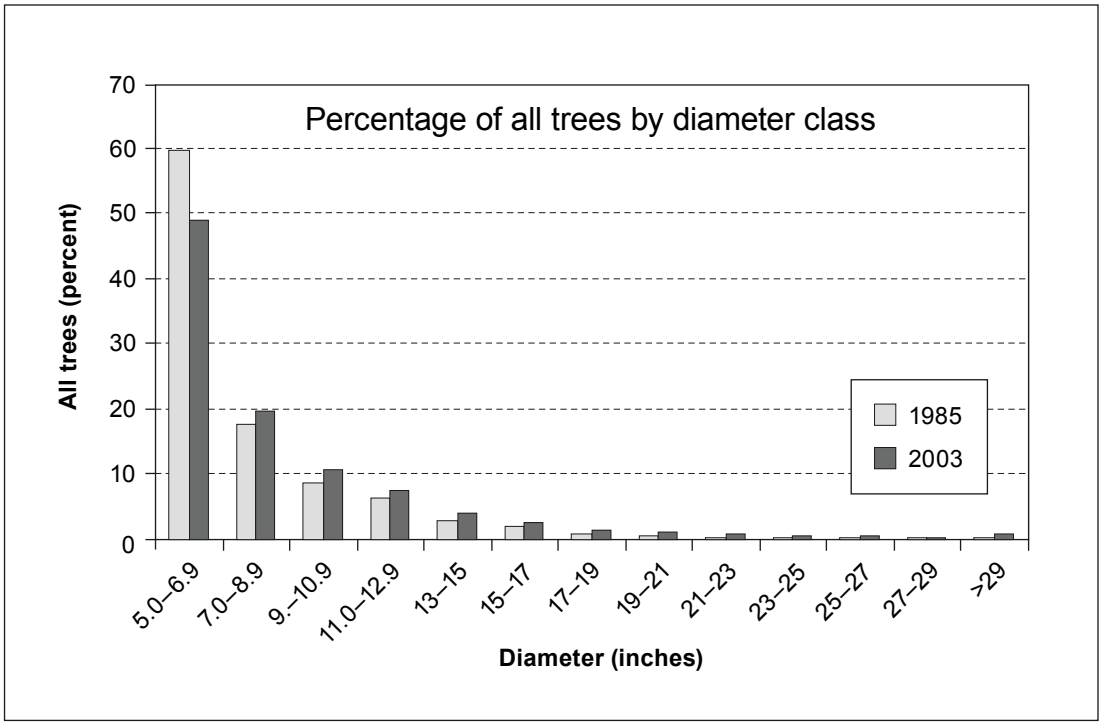

Figure 16—The diameter distribution for the percentage of total trees measured on field plots appears to have changed between the 1985 and 2003 inventories. Trees measured in the latest inventory were, on average, larger than those measured in 1985, contributing to higher basal area and volume per acre values.

Table 13—Estimated number of trees per acre, basal area per acre, net volume per acre, and standard errors (SE) for 1985 and 2003

	1985	SE	2003	SE
Trees per acre	1,282	102	856	68
Basal area (ft^2 per acre)	136	—	146	—
Volume (ft^3 per acre)	1,740	188	2,744	296

Acknowledgments

The FIA Pacific Island inventories are the result of cooperative effort between a number of groups and agencies. The USDA Forest Service, State and Private Forestry in the Pacific Southwest Region has been a strong supporter of natural resource assessments in the Pacific Islands. Many thanks to the Pacific Islands Imagery Consortium partners for sharing costs on imagery and interpretation. Thanks to Margie Falanruw with the Institute of Pacific Islands Forestry, Lynn Raulerson at University of Guam, and Agnes Rinehart for species identification and training; Lisa Fischer and Zhafeng Liu (Leo) at the Remote Sensing Lab in the Pacific Southwest Region and Julie Anderson with PNW-FIA for imagery interpretation and mapping support; Pua Michael, Larry Mamis, Pamela Skilang, Dale Baer, Falaniko Mika, Ritofu Lotovale for field assistance and logistical support. We also thank Dale Weyermann, John Chase, Chuck Veneklase, and Ron Wanek with FIA for GIS, programming, and technical support. Tom Cole, Robin DeMeo, Bob Gavenda, and Tarita Holm offered very helpful comments on prior drafts.

Metric Equivalents

When you know:	Multiply by:	To find:
Inches	2.54	Centimeters
Feet	.305	Meters
Miles	1.609	Kilometers
Acres	.405	Hectares
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	(F - 32)/1.8	Degrees Celsius

Literature Cited

Athens, J.S.; Ward, J.V. 2002. Holocene paleoenvironmental investigations on Ngerekebesang, Koror, south Babeldaob, and Peleliu islands. Honolulu, HI: International Archaeological Research Institute, Inc.

Climate Prediction Center. 2005. Composite rainfall of ENSO (El Niño/Southern Oscillation) for Pacific Island stations. http://www.cpc.ncep.noaa.gov/pacdir/ENSO11.shtml. (April 1).

Cochran, W.G. 1977. Sampling techniques. New York: John Wiley & Sons. 428 p.

Cole, T.G.; Falanruw, M.C.; MacLean, C.D.; Whitesell, C.D.; Ambacher, A.H. 1987. Vegetation survey of the Republic of Palau. Resour. Bull. PSW-RB-22. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 13 p.

Endress, B.A.; Chinea, J.D. 2001. Landscape patterns of tropical forest recovery in the Republic of Palau. Biotropica. 33: 555–565.

MacLean, C.D.; Cole, T.G.; Whitesell, C.D.; McDuffie, K.E. 1988. Timber resources of Babelthuap, Republic of Palau. Resour. Bull. PSW-RB-23. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 8 p.

Mueller-Dombois, D.; Fosberg, F.R. 1998. Vegetation of the tropical Pacific Islands. New York: Springer-Verlag. 733 p.

Oliver, C.D.; Larson, B.C. 1996. Forest stand dynamics. New York: Wiley. 520 p.

Parker, A.J. 1982. The topographic relative moisture index: an approach to soil-moisture assessment in mountain terrain. Physical Geography. 3: 160-168.

Smith, C.W.; Babik, N.R. 1988. Properties and management considerations of some acid soils on the islands of Palau. In: Demeterio, J.L.; DeGuzman, B., eds. Management and utilization of acid soils of Oceania. Guam: University of Guam: 39–61.

U.S. Department of Agriculture, Forest Service [USDA FS]. 2003. Field instructions for the inventory of the Pacific Islands. Portland, OR: Pacific Northwest Research Station, Forestry Sciences Laboratory, Forest Inventory and Analysis. 256 p.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1983. Soil survey of Islands of Palau, Republic of Palau. Washington, DC: Soil Conservation Service. 120 p., 72 plates.

Western Regional Climate Center. 2004. Koror, Palau, period of record monthly climate summary, 1953-2004. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?pikoro. (September 12).

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw/
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 SW First Avenue
P.O. Box 3890
Portland, OR 97208-3890