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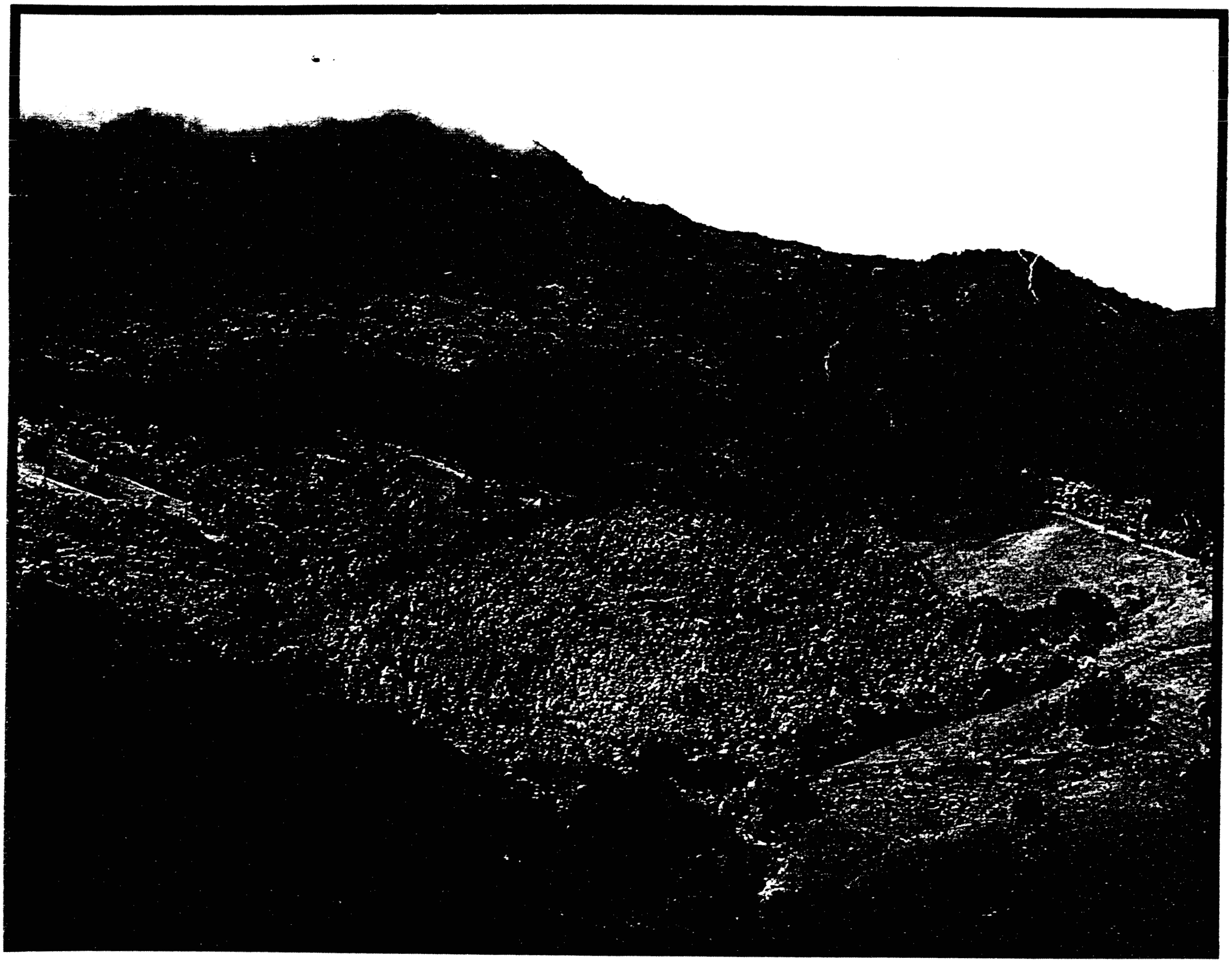
The Forest Resources of Puerto Rico

Richard A. Birdsey and Peter L. Weaver



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Cover:
Young secondary forest in the vicinity of the Luquillo Mountains.

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Teak planted along a roadside in the Rio Abajo forest.

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HIGHLIGHTS

In the spring of 1980 a forest inventory of Puerto Rico was initiated by the Southern Forest Experiment Station. The primary objective of this first survey was to assess the timber production potential of young secondary forests. The partitioning of the island into commercial and noncommercial survey regions and the concentration of fieldwork in potential commercial forests were major features of the survey.

Forest area, timber volume, and species composition data were obtained by a sampling method involving a forest-nonforest classification on aerial photographs and on-the-ground measurements of trees at sample locations. The sample locations were at the intersections of a grid of lines spaced 3 kilometers apart. In the commercial survey region, 10,925 photographic classifications were made, 437 ground locations were visited, and 4,506 sample trees were selected. Field crews identified 189 tree species.

Puerto Rico's forest area has increased dramatically in the last 30 years, to 279,000 hectares. These young forests result from migration of the rural population away from marginally productive pasture and cropland. More than half of the forest land in Puerto Rico serves important nontimber needs, including watershed protection, wildlife habitat, and recreation. About 130,000 hectares of forest land were classified as timberland, characterized by low volumes and stocking levels due to past land abuse and unfavorable site characteristics.

Much timberland occurs in rugged mountain regions with poor soils and high rainfall. Physical factors, especially steep slopes, can result in serious erosion if forest cover is removed. Deep volcanic soils in the dissected interior uplands, the favored coffee production area, support nearly half of the stocked timberland.

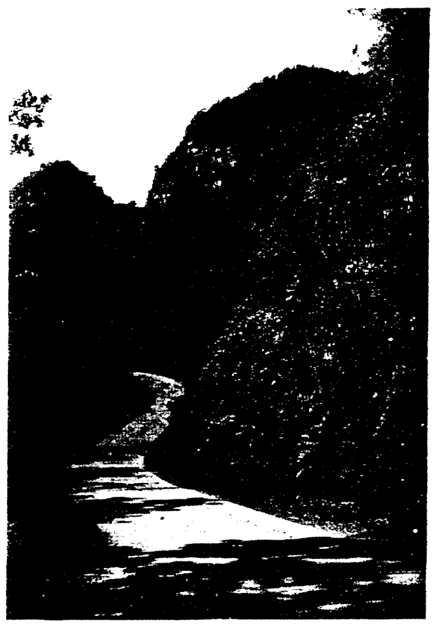
Current species composition of timberland reflects prior land use. Most of the common species tallied were once used for coffee shade, fruit production, or ornament. Coffee shade forests generally contain fewer species than abandoned pasture or farmland and fewer small trees. Secondary forests have good management prospects because of potential timber species in the smaller diameter classes. The large timber species common in the mature forest are generally absent.

Of the trees tallied, about half were classed as growing stock. In both coffee shade and other secondary forests, stands develop with many poor quality, open-grown trees.

The highest timber volumes per hectare grow in deep volcanic soils. Sixty percent of the timber volume is in 10 species. Because of poor site quality, timber volume is generally less than 50 cubic meters per hectare. Sawtimber volume, averaging 4 cubic meters per hectare, is less than one-tenth the timber volume.

Management opportunities are not clear-cut because of the diverse forest stands. Well-stocked poletimber stands offer the best opportunity for timber stand improvement, while nonstocked timberland and poorly stocked sapling-seedling stands could be planted with fast growing species. Enrichment planting of secondary forests and better management of coffee shade are alternatives for large areas of timberland.

The data gathered in the survey can provide guidelines for an applied research program on secondary tropical forest management in Puerto Rico. The survey methods will also contribute to a developing body of knowledge on tropical forest inventory techniques, and should be valid for other tropical regions.



Limestone hills near Arecibo.

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THE FOREST ENVIRONMENT

Major Forest Influences

Puerto Rico is the eastern-most and smallest of the Greater Antilles and is situated between 18°31′ and 17°55′ N latitude and 65°37′ and 67°17′ W longitude. The main island, about 160 kilometers long and 55 kilometers wide, occupies about 8,900 square kilometers including the offshore islands of Vieques, Culebra and Mona. The small mountainous island, lying directly in the path of the easterly tradewinds, shows a remarkable diversity in its physical environment (Pico 1974). The interrelations of local geology, physiography, climate, and soils influence the structure and composition of the forests. Nearly all forest areas have also been heavily influenced by man.

Geology and Physiography—The geologic history of Puerto Rico began more than 100 million years ago during the Cretaceous period. A geosyncline elongated through the Antillean region, and active volcanism occurred until near the end of the Middle Eocene epoch, giving rise to predominantly submarine accumulations of volcanic rocks (Beinroth 1969). Limestones originated along with tuffaceous shales at this time.

Extensive faulting and folding then occurred, accompanied by the emerging plutonic rocks which are now found in the vicinity of San Lorenzo and Utuado. The serpentine found in southwestern Puerto Rico probably intruded during the Cretaceous period. Later during the Middle Oligocene to Middle Miocene epochs, younger Tertiary limestones were formed. Slight uplift and tilting followed, about 15 million years ago.

The main island surface has several distinct regions (fig. 1). The Central Cordillera varies from 600–1340 meters elevation and runs from east to west, forming the principal hydrologic divide. It is located about 15 kilometers from the south coast and 40 kilometers from the north coast because of differential erosion. The Luquillo Mountains rise to 1074 meters in the northeastern part of the island, and the Cayey Mountains, an extension of the Cordillera, rise to 900 meters in the southeastern part. The latter two are separated by the Caguas Valley. Foothills surround the mountains and merge into coastal lowlands. Forty-five percent of the land surface is above the 150 meter contour and half of that area has slopes greater than 45 percent. A quarter of the land surface is above the 300 meter contour, and 60 percent of that area has slopes greater than 45 percent (Wadsworth 1949).

Climate—Daily and annual temperature fluctuations are minor because of the influence of the surrounding ocean, yet, because of rugged terrain, sizeable geographic variations occur in rainfall, temper-

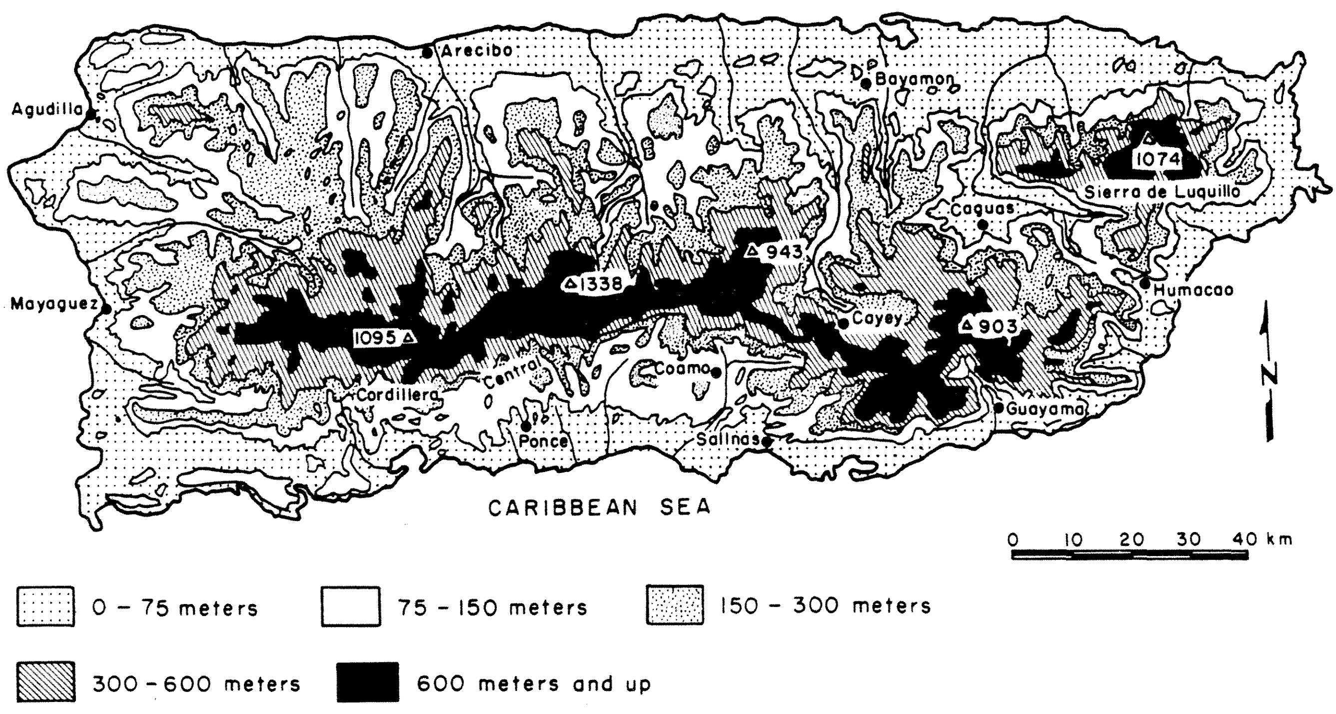


Figure 1.—*Major physiographic features of Puerto Rico (adapted from Hunt 1967).*

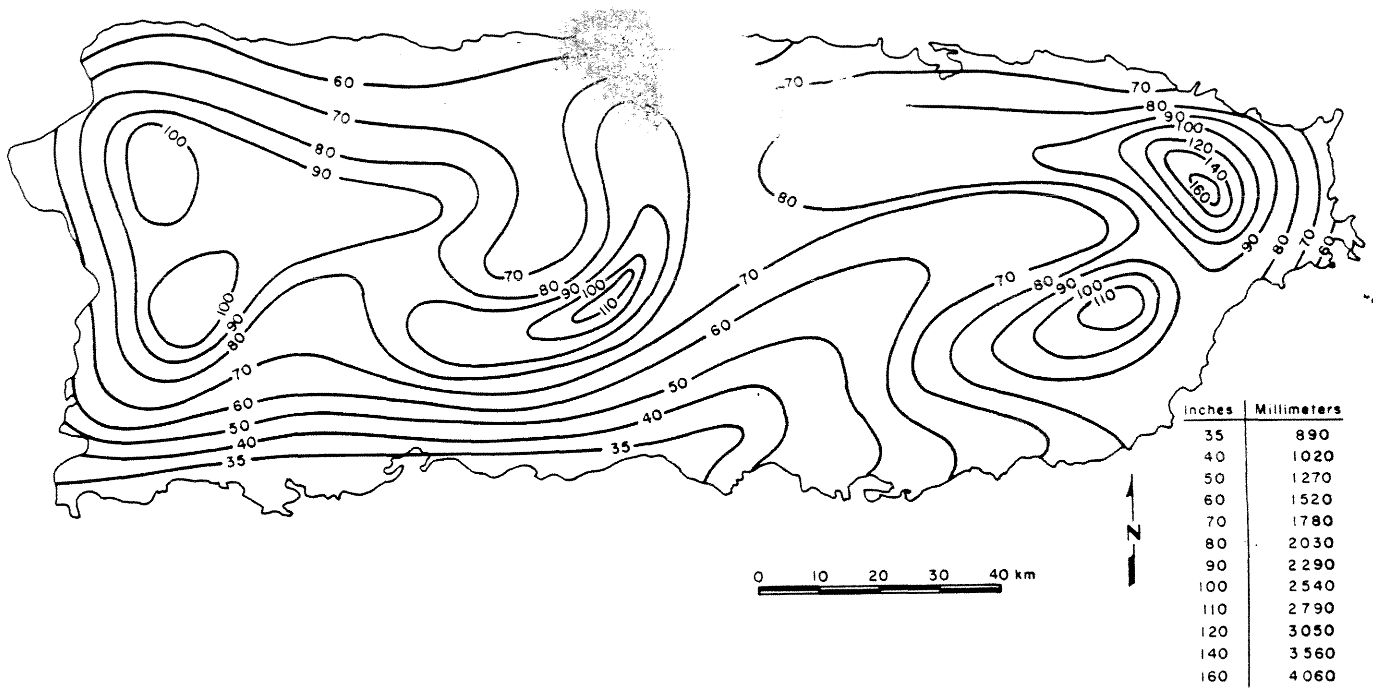


Figure 2.—*Mean annual precipitation for Puerto Rico (Commonwealth of Puerto Rico 1979).*

ature, wind speed and direction over relatively short distances (Calvesbert 1970).

The island receives an average of 1800 millimeters per year of rainfall, mostly orographic. Coastal areas receive from 750 millimeters per year in the southwest, or leeward part of the island, to 1500–2000 millimeters per year in the northeast, east and southeast, or windward part of the island. Areas of heavy rainfall, in excess of 2500 millimeters per year, include the summits of Luquillo, Carite, Toro Negro and Maricao forests (figure 2). A relatively dry season occurs over most of the island from mid-December through the end of March.

The lowest mean annual temperature is 18 degrees centigrade at Pico del Este and Cerro Maravilla and the highest, 27 degrees centigrade at Guayama on the South coast. The highest temperature ever recorded was 39° centigrade at San Lorenzo in August 1906; the lowest 4 degrees centigrade at Aibonito in March 1911.

Seasonal variation in cloudiness at stations on the north coast shows a maximum during May-June and September-October, with the lowest daily average during March. Convective buildups cause somewhat higher daytime cloudiness in the interior (Briscoe 1966).

The easterly trades are one of the most constant wind regimes, generally blowing from the ENE through ESE. The highest mean wind speeds occur during July and the lightest during October and November. Factors which interrupt trade wind flow include frontal passages, easterly waves and tropical disturbances.

Puerto Rico also experiences occasional hurricanes, most of which pass through the Caribbean in August and September. In 1898, 1928, 1932, and 1956, storms passed over the island. During the 1928 storm, known locally as San Felipe, San Juan experienced winds around 260 kilometers per hour. Storms of this magnitude cause destruction of roadside trees and changes in forest composition and growth rates (Wadsworth 1959a, Crow 1980).

Soils—Differences in rainfall patterns, as well as geologic and geomorphologic condition in Puerto Rico, have given rise to a wide variety of soils. Initially classified according to environmental and external factors such as climate and topography (Roberts et al. 1942), soils were recently reclassified in terms of soil morphology and composition (Beinroth 1971; Lugo-Lopez and Rivera 1977). Under the new system, 9 of the 10 possible soil orders were recognized in Puerto Rico, although 6 of these together occupy only 15 percent of the island (fig. 3).

The most extensive soils are Inceptisols, occupying about 37 percent of Puerto Rico. This order is concentrated in the eastern half of the island, generally on slopes ranging from 20 to 60 percent. Erosion, particularly in cultivated areas, prevents the development of mature profiles.

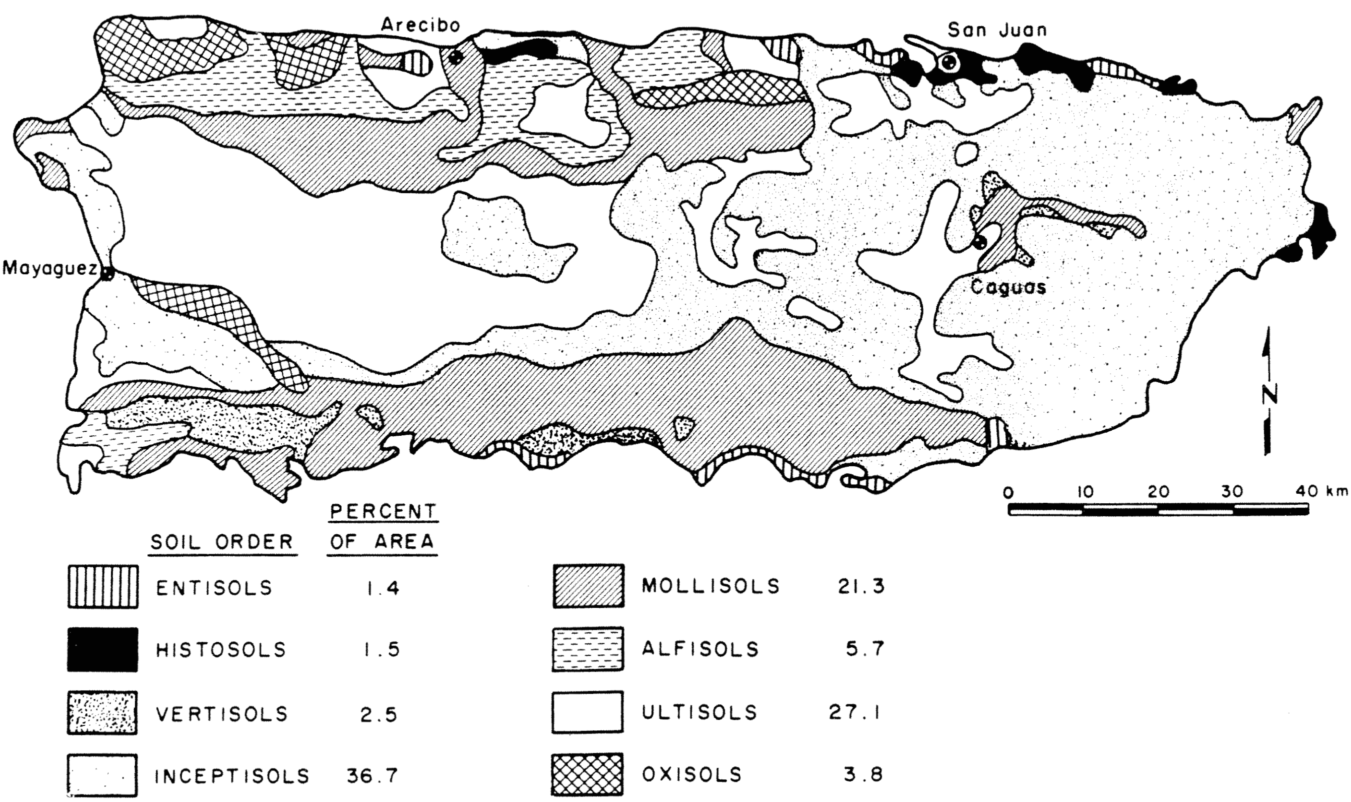
Next in areal importance, occupying about 27 percent of the island, are Ultisols, concentrated in the humid volcanic uplands of the Western Cordillera. They are re-

Intense storms cause erosion and modify the forest. This landslide occurred in the Luquillo Mountains during the passing of hurricanes David and Frederick, 1979.

stricted to humid climates, where they either occupy old surfaces or evolve in highly weathered alluvial sediments.

Mollisols, occupying 21 percent of the island, occur in 3 areas: tertiary limestones near Lares, southern foothills in the rainshadow of the Cordillera, and scattered alluvial fans and floodplains. Mollisols have a dark colored surface horizon of considerable thickness, high in base saturation and organic matter.

For the purposes of plantation establishment, 19 soil associations were recognized on the island (Zambrana 1978). Tree species for wood production, windbreaks, shade and ornamentals were suggested according to soil association. For the purposes of this inventory, only four classes of soils were distinguished: deep volcanic soils, shallow volcanic soils, granitic soils, and limestone soils. More detailed studies of vegetation on the island need a more refined soil classification system.



Figur... neralized soil map of Puerto Rico (Beinroth 1971).

Population and Land Use—Taino Indians, island occupants at the time of the 16th century conquest, either died or were driven away (Puerto Rico Public Affairs Administration 1979). Since then there has been a steady immigration of people from all over the world. Recently, Cubans and Dominicans have arrived, as well as a continual migration of Puerto Ricans back and forth from the U.S. mainland. The island's population reached 1 million at the turn of the 20th century, passed 2 million about 1945, and currently stands at over 3 million, or about 400 people per square kilometer (over 1000 per square mile).

During the 1920's and 1930's, two hurricanes and the depression brought a large part of the predominantly rural population to the brink of starvation. At that time, sugar was the dominant cash crop and accounted for two-thirds of the island's exports (Barton 1959). The decision in the 1940's to invest in other income-generating and financially self-supporting programs, including public utitilities and an industrial development company, paved the way for expansion of the island's industry.

Land clearing for agriculture resulted in the deforestation of all but 3400 hectares, including some 2200 hectares in the Luquillo Mountains and lesser areas in Carite, Toro Negro, Guilarte, Maricao and a few scattered peaks in private ownership (Wadsworth 1950). Only in these isolated areas can remnants of the island's climax vegetation be found. The remaining forested areas are secondary, arising from abandoned coffee shade, pastures or croplands.

In the comprehensive 1972 land use survey conducted by the Department of Natural Resources (table I), over 50 percent of the island is classified in agricultural uses, about 30 percent in forests including public and private, about 5 percent water resources, and some 7 percent as urban and rural residential areas. The agricultural classification includes coffee shade.

Table I.—*Summary of land use in Puerto Rico, 1972*[1]

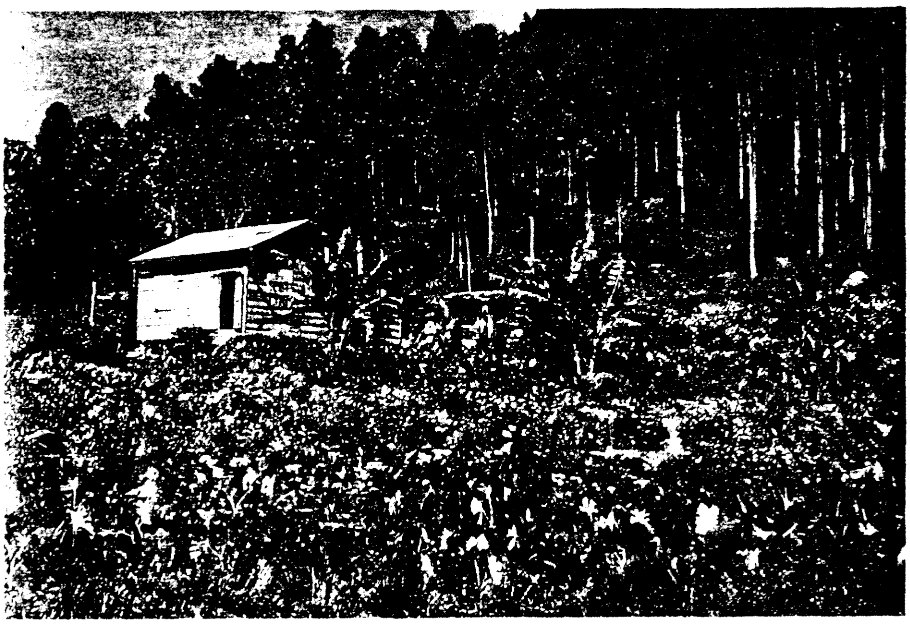
Land use	Area	Explanation
	hectares	
Agriculture	476,000	Mixed agriculture, monoculture, inactive areas
Forests	284,800	Dense forest, secondary forest, public forest
Water resources	44,700	Canals, protected coastal waters, lagoons
Wetlands	9,300	Mangroves and swamps
Non-productive areas	3,100	Rocky areas, reefs, coastal sandy areas
Residential	62,900	High, medium and low density; urban and rural
Outdoor recreation	2,500	All types
Public use	17,200	All types
Commercial use	3,500	Hotels and commercial centers
Industrial use	3,600	Light and heavy industry; industrial parks
Mining	1,700	Sand and gravel extraction; salt and minerals
Communications	400	Generating plants, substations; antennae
Transportation	2,900	Airports; port facilities; roads
	912,600[2]	

[1] Data summarized from Department of Natural Resources Inventory, 1972.
[2] Does not agree with total used elsewhere due to inclusion of coastal waters, reefs, etc.

Description of the Forests

Many descriptions of Puerto Rico's forests are available (Gleason and Cook 1926; Cook and Gleason 1928; Beard 1944, 1955; Stehle 1945; Ewel and Whitmore 1973). Some emphasize the forest formations in the Luquillo Mountains (Wadsworth 1951; Dansereau 1966).

Vegetation Classification and Forest Associations—The most recent classification of the vegetation of Puerto Rico (Ewel and Whitmore 1973) uses the Life Zone system (Holdridge 1947, 1967), which, among other benefits, provides a means of comparison among tropic-



Forestry and agriculture in the Toro Negro Forest Reserve during the mid-1960's (photo by Wadsworth).

al forests based on climatic data. The Subtropical Moist Forest occupies the largest area, covering over 58 percent of the island (fig. 4). Next in importance is the Subtropical Wet Forest covering about 23 percent, and the Subtropical Dry Forest occupying about 18 percent of the island. The last three Life Zones occurring on the island account for a little over 1 percent of the land area.

The *Subtropical Dry Forest* receives from 600-1100 millimeters of rainfall per year and is characterized by deciduous vegetation. Leaves are often small and succulent or coriaceous, and spines or thorns are common. Tree heights on zonal soils do not exceed 15 meters and the crowns are typically broad and flattened with sparse foilage. Coppicing is common. Growth rates are slow in woody species, and the wood usually hard and durable. Extensive areas of Subtropical Dry Forest overlie limestone, and some low alluvial areas contain saline soils. Mangroves are found in coastal bays and inlets.

The *Subtropical Moist Forest* receives from 1000–2200 millimeters of annual rainfall, and is characterized on zonal soils by trees up to 20 meters tall with rounded crowns. Many of the woody species are deciduous during the dry season, and epiphytes are common. Grasses, both in natural and improved pastures, form the dominant landscape in the Life Zone today. The limestone hills on the north coast have a catena of associations which correspond to a moisture gradient—moist on the gentle north slopes, more humid still on the steep southwest slopes, and xeric on the summits. Stem density is greater in this association, and stem size smaller. The serpentine-derived soils, found in southwestern Puerto Rico, support a unique vegetation which contains a number of endemics. Trees are commonly slender and under 12 meters tall. Most of the species are sclerophyllous and evergreen, and species diversity is high (Tschirley et al. 1970). Mangroves are also found along the coast where they appear to grow taller than in the Subtropical Dry Forest. Just inland from the mangroves are alluvial soils that once supported an impressive forest. Remnants of swamp forests dominated by *Pterocarpus officinalis* are evident today near Humacao, Dorado, Vacia Talega, and La Boquilla north of Mayaguez.

Subtropical Dry Forest in the vicinity of the Guanica Forest Reserve (photo by Wadsworth).

The *Subtropical Wet Forest* receives from 2000–4000 millimeters of annual rainfall, and soil moisture drops below field capacity for only 3 months during the year. Runoff is substantial. On zonal soils, the forest is impressive, containing more than 150 species of trees and forming a dark canopy at about 20 meters. The abundant moisture is evident in the character of the vegetation; epiphytic ferns, bromeliads and orchids are common. Serpentine areas are also found, and in contrast to those in Subtropical Moist Forest, the vegetation is greener, denser, more lush, and contains more epiphytes. Where limestone is the parent material for soils, the vegetation is more xerophytic than the zonal soil areas.

The *Subtropical Rain Forest* receives more than 3800 millimeters of rainfall per year, which leaves the soil at the field capacity throughout the year. Runoff is produced every month. The species in this Life Zone are the same, gener-

Aerial photograph of limestone hills near Ciales (photo by Puerto Rico Department of Public Works).

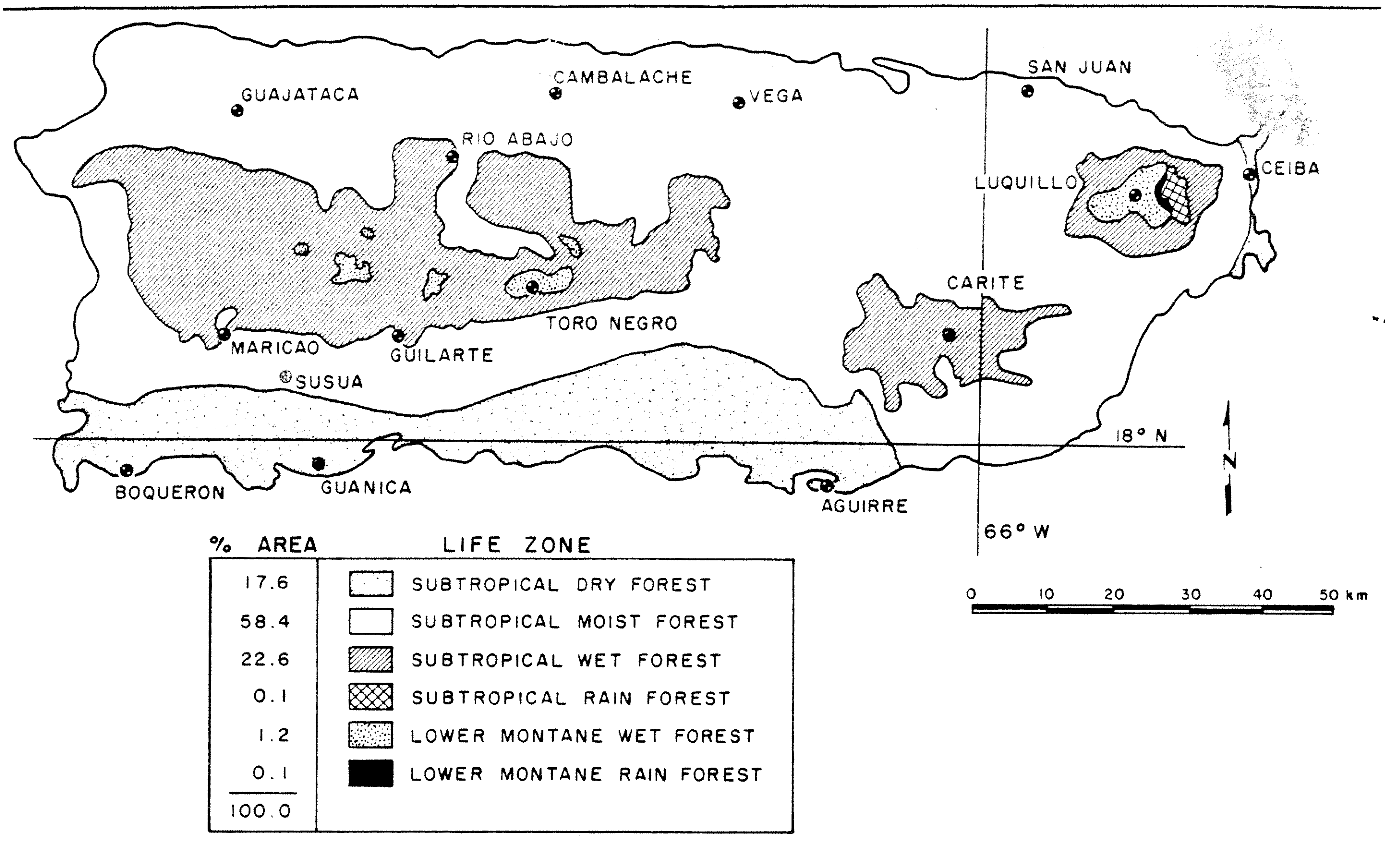


Figure 4.—*Life Zones of Puerto Rico and location of public forests (adapted from Ewel and Whitmore 1973).*

ally, as those in the surrounding Subtropical Wet Forest. The high frequency of palm *(Prestoea montana)* and abundance of epiphytes are the main features which distinguish this Life Zone. All vegetation is situated on clay soils.

The *Lower Montane Wet Forest* occurs in both the eastern and central part of the island, extending from about 700 meters through the summits of most peaks above 1000 meters. The mature vegetation is characterized by open-crowned trees, many with leaves grouped toward the ends of branches. The leaves are coriaceous and dark, giving the canopy a reddish cast. Three additional associations commonly appear within this Life Zone. The elfin woodland is characterized by gnarled trees less than 7 meters tall, high basal area, small diameters, high stem density, and slow growth. All trees are evergreen and sclerophyllous, with leaves grouping at branch ends. Decomposition

Typical landscape in the Subtropical Moist Forest Life Zone showing improved pasture, idle farmland, and scattered trees.

is slow, and subsurface soils are clayey and oxygen deficient. The palm brake, consisting of nearly pure stands of *Prestoea montana*, is found in this Life Zone, as well as the Subtropical Wet and Rain Forests. Finally, in the Maricao forest in the western Cordillera, serpentine soils are found. Species diversity is high and numerous endemic species occur (Weaver 1979).

The *Lower Montane Rain Forest* has vegetation similar to that of the Lower Montane Wet Forest, but epiphytes, palms and tree ferns are more abundant. The elfin woodland is the principal association, frequently found on windswept ridges. Stems are gnarled, laden with epiphytes and soil surfaces are covered with liverworts and bromeliads. Both superficial roots and aerial roots abound. Growth rates are slow.

Forest Plantations — Forest plantations have had a significant role in reforestation and research with exotic and native species. According to Forest Service records (USDA Forest Service, Annual Reports), about 11,200 hectares were planted by public agencies as of 1978, while private interests have planted about 27,000 hectares. The overall success of these plantations and the current area of plantation forests are not known. The major species planted was Caribbean pine (*Pinus caribaea* Morelet) with mahogany (*Swietenia macrophylla* King and *S. mahagoni* Jacq.), eucalyptus (*Eucalyptus robusta* J. E. Smith), and teak (*Tectona grandis* L. f.) also accounting for significant areas. Numerous other tree species, tested in a long series of adaptability trials, account for the remainder of the planted area.

Forest Resource Values

Numerous benefits and uses are derived from forested lands. Among them are production of timber; control of water quantity and quality; wildlife protection; recreation; and research opportunities. Forest survey data must address issues defined by these values.

Timber—Puerto Rico originally included more than 500 species of trees in 70 botanical families. These occurred in extensive and luxuriant forests of which only scattered relics may be found today. Data from the least disturbed of remaining stands suggest that the island contained about 195 million cubic meters of wood (Wadsworth 1950). Good timber species with large dimensions were once common stand components. Today, most of the original forest has been replaced by agricultural and other land uses, or secondary forest where agricultural activities have been abandoned. Dendrological descriptions of the species, their areas of occurrence on the island, their natural ranges within the hemisphere, and their potential uses have been documented (Little and Wadsworth 1964; Little, Woodbury, and Wadsworth 1974).

Mature Subtropical Wet Forest in the Luquillo Mountains.

Sixty species have been classified as potential native and plantation sawtimbers (Longwood 1961), many of which are found elsewhere in the Caribbean (Longwood 1962). A recent survey of native species, using size and wood characteristics as selection criteria, determined that the best use of 31 species was for cabinet woods, 87 as novelty woods, and 127 for roundwood. The remaining half of the island's tree species have little economic value except locally for fuel or fence posts. In the Subtropical Wet Forest of the Luquillo Mountains, some stands have been managed to enhance growth, improve species composition, and to increase the uniformity of tree size to sustain the yield of forest products (Munoz 1968). Nearly 70 percent of the stems tallied in a 1962 inventory were commercially important (table II). Basal area averaged about 16.5 square meters per hectare, with volume approaching 85 cubic meters per hectare, and net annual volume increment exceeding 3 cubic meters per hectare. Other studies of similar stands have shown that basal areas of about 20 square meters per hectare indicate vigorous stand conditions and satisfactory growth rates. In contrast to these managed secondary stands, basal areas in virgin Subtropical Moist Forests range from 35 to 50 square meters per hectare. Volumes range from 210–420 cubic meters per hectare, and net annual volume increments are between 1.7 and 3.5 cubic meters per hectare.

Long-term diameter increment has been summarized for variously located stands, ranging from mangrove forest on the coast through Subtropical Wet Forest and Lower Montane Rain Forest in the Luquillo Mountains to Subtropical Dry Forest in the southwest (Crow and Weaver 1977; Weaver 1979). These studies showed that significant differences in growth were found among species and crown classes, with the majority of stems paralleling growth rates in temperate zone forests. Diameter increment also varied by life zone, with the slowest rate in the Subtropical Dry Forest, and the most rapid rates in secondary Subtropical Moist Forest including mangroves and an association on zonal soils.

Mangroves—Mangroves extend to 29–30 degrees latitude in both hemispheres and cover from 60–70 percent of the shoreline within the tropics. Their best development occurs within 23 degrees of the equator along protected shores. Mangroves have provided local wood products in the past; however, the area has declined dramatically and mangroves are no longer heavily exploited for timber. Mangroves have important non-timber values and their special significance is briefly outlined here.

Mangroves provide shoreline protection by stabilizing soils against the pounding of waves and tidal

A trail through the cloud forest formation (elfin woodland) in the higher elevations of the Luquillo Mountains.

movements. They also support a myriad of fauna both as a substrate and through export of organic matter. In Puerto Rico, they protect rare and endangered bird species and serve as spawning areas for fish. Elsewhere, their high specific gravities, about 1.0, provide fuelwood with a high caloric content. Some species also yield tannins for the curing of leather.

Four species of mangroves (red, black, white, and button) may have once covered about 24,000 hectares in Puerto Rico (Wadsworth 1968). Mangrove coverage was reduced to 6400 hectares by exploitation for fuel and wood during the Spanish period, a series of destructive hurricanes from 1825–1891, reclamation of mangrove areas for agriculture during the early 20th century by the sugar industry, and extremely destructive hurricanes in 1928 and 1932 (Carrera 1975; Martinez et al. 1979). By 1959, an increase in mangrove area to about 7200 hectares was observed (Wadsworth 1959a), the result of decreased cutting for fuel and recovery after hurricane damage. In the 1960's, urban development and industrialization caused new destruction. By 1968, 13 of 62 estuarine zones had been destroyed, and mangrove coverage declined to 6600 hectares. In 1979, a study of 18 mangrove areas provided an estimate of 5970 hectares for mangrove coverage (Martinez et al. 1979).

Several different types of mangrove forest are recognized in Puerto Rico including overwash, fringe, basin, riverine and dwarf (Lugo and Snedaker 1974). All are dependent upon topographic variation and differences in flushing, and exhibit distinct species compositions, structure and patterns of productivity. Rapid diameter increments in secondary basin mangroves were observed (Weaver 1979) and annual volume production was estimated at 8.5 cubic meters per hectare (Wadsworth 1959b).

Water and Erosion Control—Steep topography, heavy rainfall and erodable soils contribute to a high erosion potential, and rapid clearing and development of land for agriculture and other uses causes major erosion and sedimentation problems. The island's high population density and agriculturally-based economy during the 19th and early 20th centuries disturbed over 99 percent of the original forests, leaving only scattered areas of climax vegetation in the Central Cordillera and Luquillo Mountains (Wadsworth 1950). Concern for watershed protection prompted incorporation of tracts into the public forests of Toro Negro,

Table II.—*Inventory of Subtropical Wet Forest in Luquillo Experiment Forest, Puerto Rico, 1962*[1]

Mensuration statistic	Wood utility class: Furniture	Novelties	Posts	Subtotal	Unusable portion	Total
No. stems/ha.						
(7.5–24.9 cm.dbh)	41	148	221	410	172	582
(25+ cm.dbh)	13	13	.....	26	41	67
Total	54	161	221	436	213	649
Basal area (m^2/ha)						
(7.5–24.9 cm.dbh)	0.87	2.55	3.47	6.89	2.75	9.64
(25+ cm.dbh)	1.79	1.19	.....	2.98	3.86	6.84
Total	2.66	3.74	3.47	9.87	6.61	16.48
Volume (m^3/ha)						
(7.5–24.9 cm.dbh)	3.71	11.31	14.49	29.51	11.91	41.42
(25+ cm.dbh)	12.49	6.49	.....	18.98	24.45	43.43
Total	16.20	17.80	14.49	48.49	36.36	84.85

[1]Adapted from Munoz 1968.

Sawn lumber of tabonuco, Dacryodes excelsa, *ready at the road for shipment near Villalba (photo by Wadsworth, 1945).*

The mangrove forest adjacent to the San Juan metropolitan region is visible in this high altitude color infrared photograph. Urban development reduces the area of this valuable resource each year (photo by NASA).

Carite, Maricao, Susua, Rio Abajo, Guajataca and Guilarte from 1935 through 1943. The first 3 of these areas, with about 2500 millimeters of annual rainfall at the summits, and the Luquillo Forest, which receives over 4000 millimeters per year at the summits (Weaver 1972), total about 35,000 hectares in these critical watershed areas. The major streams originate in the Central Cordillera, and only 7 have drainage areas in excess of 250 square kilometers (Department of Natural Resources 1974). The headwaters of these rivers supply most of the island's 25 major reservoir sites which yield water to meet domestic, industrial, and agricultural demands.

Investigations of 7 of the reservoir sites showed that from 4 to 90 percent of the storage capacities had been lost through sedimentation (Department of Natural Resources 1974), the higher figure for the Comerio and Coamo reservoirs. Another, Guayabal, lost 50 percent of its capacity from 1913 to 1958. The crest height was then raised 5 meters, but no action was taken within the watershed to curtail erosion (Bogart, Arnow and Crooks 1964). Studies conducted by the USDA Soil Conservation Service (1968) showed that 48 percent of the land had severe erosion problems and 22 percent had moderate erosion.

Production and transport of sediments is affected by intensity and duration of storms (Greer 1971). In the Tanama River, the discharge of sediments for 1 day in 1968 was 70 percent of the total for the year, due to heavy rainfall (Lugo, Quinones and Weaver, 1980). Other rivers in Puerto Rico show similar trends. Prolonged drought leading to water rationing and severe flooding are recurrent problems on the island. Sedimentation of reefs and mangroves has damaged these coastal systems.

Unpublished statistics from the Institute of Tropical Forestry indicate that 445,000 hectares on the island should remain forested. These include areas with slopes greater than 40 percent, areas which are principal sources of water, areas unsuitable for other crops, and those adjacent to reservoirs.

Rare and Endangered Plant Species—The diversity of habitats has led to the establishment or evolution of many plant species on the island. However, the limited size of the land mass combined with rampant destruction of large areas for agriculture and other uses has decreased some species to dangerous rarity. Over 500 species of endemic and non-endemic plants, many in Commonwealth and Federal Forests, have been classified as rare, endangered, or poorly distributed (USDA Soil Conservation Service and Commonwealth Department of Natural Resources 1975). According to a recent Forest Service report (Little and Woodbury 1980), 13 rare endemic tree species are classed as endangered, and 22 endemic tree species are threatened with extinction, principally because of habitat destruction and disturbance. About 100 tree species are listed as rare in Puerto Rico and the Virgin Islands,

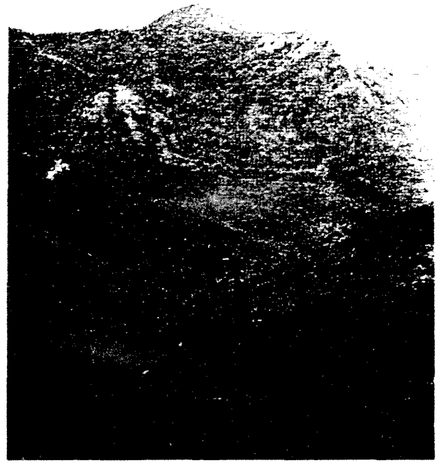
but are listed as native to other areas.

Wildlife—Puerto Rico's native wildlife species are limited. Resident native mammals include 15 species of bats (Starrett 1962), and manatees and dolphins. Pigs and goats were introduced on Mona Island where they are feral, and deer on Culebra Island. The only other mammals of note are the mongoose and two species of rats. Of an estimated 200 bird species (Bond 1971, Leopold 1963), 14 are endemic, 107 local breeders, 71 migrants, and 21 strays. About 70 species of reptiles and amphibians are native to Puerto Rico (Rivero 1978) and 33 species of fresh water fish (Erdman 1972).

The importance of the island's coastal, karst and montane forests in providing critical habitat for endemic species, as well as rare and endangered species is summarized in table III. Puerto Rico currently has 27 species listed as very endangered, 29 species as endangered, and 15 species as on the verge of being endangered (USDA Soil Conservation Service and Commonwealth Department of Natural Resources 1973). Perhaps the Puerto Rican parrot best exemplifies a species dependent upon an island forest. During the early 1900's, the species was common ranging from Arecibo to the southern part of Puerto Rico and east to the offshore island of Vieques. By 1955, the population had dwindled to about 200 birds, and by 1967 only 20 remained, all endemic to the montane forests of the Luquillo Mountains. Today, about 40 birds survive, mainly due to the efforts of the Forest Service and Fish and Wildlife Service.

Other critical wildlife areas not included within the forest system are the Roosevelt Roads Navy Base and Mona and Monito Islands. The Navy Base has mangrove forest and freshwater swamp, which serve as critical habitat for 9 endangered bird species, and offshore *Thallasia* beds where the West Indian manatee has been seen repeatedly. Approximately half of the bird species of Puerto Rico are migratory visitors or residents on the base (Weaver, Nieves and Crow 1977).

Mona Island, an elevated limestone block of 5,500 hectares, and adjacent Monito Island of 16 hectares, are located west of Puerto Rico about midway to the Dominican Republic. Most of this scrub woodland serves as a refuge for 133 species of plants and animals not found in Puerto Rico. In addition, at least another 29 species on the islands, including many sea birds, are so rare or endangered in Puerto Rico that Mona and Monito may be considered their last significant refuge (Junta de Calidad Ambiental 1973).



Watershed protection is a primary function of the Maricao Forest Reserve in the Central Cordillera.

Red Mangrove forest near Mayaguez, Puerto Rico (photo by Cintron).

Recreation — Puerto Rico's numerous beaches, coral reefs, waterfalls, canyons, scenic mountain roads, and limestone caves and cliffs, combined with year-round moderate weather, provide the basis for outdoor recreation, particularly in the well-distributed 34,000 hectares of Federal and Commonwealth forests (table III; fig. 2). Major activities include swimming, snorkeling, picnicking, boating, fishing, camping, hiking, water skiing, and driving through the forested areas. Any spot on the island is within an hour's drive of a major recreation area. Although some areas have excellent facilities, most are undeveloped (Department of Natural Resources 1974, 1976). Given the island's limited area and

high population density, the existing forest system is a vital resource for both residents and tourists (Outdoor Recreation Resources Review Commission 1962).

Overview of Research—Puerto Rico's tropical forests have been a regional focus for forestry and ecological research throughout this century. The impact of this research extends far beyond the island itself. A few projects will illustrate the breadth of this research.

The establishment of a tree nursery and the beginning of a large-scale research program of trial plantings with exotic and native tree species was begun in 1920. In 1934, a major reforestation program in public forests was initiated, and over the next 12 years, some 7,800 hectares were planted with 53 tree species, 28 of which were native. In 1939, the Tropical Forest Experiment Station (now the Institute of Tropical Forestry) was established and a site adaptability program was started in which more than 100 native species and over 350 introduced species were tested.

The mid-20's also brought American scientists into Puerto Rico to survey the natural forests (Gleason and Cook 1926; Cook and Gleason 1928). In 1939, the first of 24 volumes of the Caribbean Forester was published, covering both plantation forestry and investigation of natural forests. In 1952, the first island-wide forest inventory was undertaken by the Commonwealth Forest Service, and in 1972, the Commonwealth Department of Natural Resources initiated several research projects within the Commonwealth Forest Reserve, other forested areas, and the coastal zone.

During the 1960's, several long-term studies of the climate, wildlife and vegetation of the Luquillo Mountains were initiated. Weather phenomena were documented and compared with coastal sites in proximity to the mountains (Briscoe 1966). The dwarf forest at the summits was described in a series of articles appearing in the Journal of the Arnold Arboretum from 1968 through 1979, and the tabonuco forest at El Verde Field Station was investigated in detail (Odum and Pigeon 1970). Moreover, the colorado forest at intermediate elevations was studied in conjunction with the Puerto Rican parrot project, (Snyder 1978) which was begun in 1967.

A record of forestry research and ecological investigations was recently compiled for U.S. Forest Service personnel in Puerto Rico (Lugo 1979), and a bibliography of all forestry research on the island is anticipated.[1] Studies of plant ecology in Puerto Rico and elsewhere in the West Indies were also summarized (Rundel 1974).

[1] Mosquera and Feheley (in process).

Endangered Puerto Rican Parrot in Lower Montane Wet Forest of the Luquillo Mountains (photo by Wiley).

The Commonwealth Forest Reserves scattered throughout the island provide various recreation opportunities. This is the Maricao visitor center.

Young, managed stands in Subtropical Wet Forest (locally tabonuco forest) near the El Verde Field Station in the Luquillo Mountains (photo by Wadsworth).

Table III.—*Summary of recreation and wildlife values of island forests, Puerto Rico, 1980*

Forest	Area (ha)	Elevation (m)	Vegetation associations; unique flora	Land use and recreation	Wildlife assets
COASTAL FORESTS					
Aquirre	970	0–5	Subtropical Dry Forest — tidal flats and mangrove	Boating, fishing, picnicking; no facilities	60 bird species, 3 endemic
Boqueron	800	0–5	Subtropical Dry Forest — tidal flats and mangrove; scrub woodland	Special use permits = 94 ha; swimming, camping, hiking, picnicking, fishing, sailing, water skiing; cabins	58 fish species; 50 bird species, some endangered
Ceiba	140	0–5	Subtropical Dry Forest — salt flats and mangrove	Boating	Manatee habitat offshore
Guanica	3880	0–228	Subtropical Dry Forest — mangrove; diverse scrub woodland; Flora — 48 endangered plant species, 16 endemic to forest	Picnicking, swimming, hiking, beach facilities	Half of the island's land bird species; breeding ground for endangered whippoorwill
Pinones	610	0–1	Subtropical Moist Forest — mangrove; beach strand	Special use permits = 12 ha; swimming, picnicking, snorkeling, boating, fishing, water skiing; clandestine facilities	38 fish species; 46 bird species, some endangered; phosphorescent lagoon
KARST FORESTS					
Cambalache	370	5–50	Subtropical Moist Forest — xeric forest on pepino hill bottomlands, slopes and summits	Special use permits = 6 ha; some hiking, picnicking; no facilities	45 bird species, 8 endemic to island; endemic tree frog
Guajataca	930	150–300	Subtropical Moist Forest — associations as above	Special use permits = 3 ha; some hiking, picnicking; limited facilities	45 bird species, 8 endemic to island
Rio Abajo	2270	200–424	Most Subtropical Wet Forest Some Subtropical Moist Forest	Special use permits = 34 ha; picnicking, camping	Probably similar to above
Vega	450	5–50	Subtropical Moist Forest — associations as above	Special use permits = 56 ha; some hiking, picnicking; limited facilities	Probably similar to above
MONTANE FORESTS					
Carite	2620	250–903	Most Subtropical Wet Forest Small Lower Montane Wet Forest — (tabonuco, colorado, palm, dwarf, early secondary)	Special use permits = 42 ha; critical watershed; picnicking, hiking; recreation facilities	30 bird species, 9 endemic, 2 hawks; Lake Carite good bass lake
Maricao	4150	15–875	Most Subtropical Wet Forest Small Subtropical Moist Forest Small Lower Montane Wet Forest — associations as above; Flora — 845 species, 278 trees, with 123 endemic to island and 20 to Maricao	Special use permits = 32 ha; critical watershed; hiking, picnicking; cabins + facilities	26 bird species, 16 breeding residents, 11 species endemic to island

Table III.—*Summary of recreation and wildlife values of island forests, Puerto R[illegible]30—Continued*

Forest	Area (ha)	Elevation (m)	Vegetation: Life Zone, associations, unique flora	Land[illegible] recreation	Wildlife assets
Guilarte	1420	760–1205	Subtropical Wet Forest Lower Montane Wet Forest — associations as above	Special use permits = 75 ha; critical watershed; no facilities	Probably similar to above
Susua	1310	80–473	Subtropical Moist Forest — dry slope and gallery associations, secondary forest; Flora — numerous endemic plants	Special use permits = 12 ha; watershed importance; some recreation facilities	. . . .
Toro Negro	2730	440–1338	Subtropical Wet Forest Lower Montane Wet Forest — (tabonuco, colorado, palm, dwarf, early secondary)	Special use permits = 38 ha; critical watershed recreation facilities	Probably similar to above
Luquillo	11300	120–1060	Subtropical Moist Forest Subtropical Wet Forest Subtropical Rain Forest Lower Montane Wet Forest Lower Montane Rain Forest — associations as above	203 special use permits; critical watershed; hiking, picnicking; Visitor Information Center, good facilities	25 bird species, some endemic; endemic lizards, frogs, snakes endangered Puerto Rican Parrot

Source: Department of Natural Resources 1974, 1976; Odum and Pigeon 1970.

PREVIOUS FOREST SURVEYS AND ESTIMATES

At the beginning of the 16th century, Puerto Rico was covered with mature forests containing a great variety of species with high quality timber. The forest formations were typical of the Caribbean region at the time of discovery (Little et al. 1974, Durland 1929).

In subsequent years, European settlers gradually cut the coastal and lowland forests for pasture or cropland. Removals for timber, charcoal, and fuelwood significantly modified the forest, but land clearing for agriculture was much more destructive. By 1828 257,000 hectares of pasture and 47,000 hectares of cultivated land represented 34 percent of the total land area (Wadsworth 1950).

Most remaining mature forests were removed in the 19th century as the population increased to nearly a million. By 1899, pasture alone accounted for 55 percent of the land area (Wadsworth 1950). The best agricultural land was held by large export-oriented farms, and about 22,000 small subsistence farms were scattered on the hillsides (Hill 1899). Many small farmers were successful only by practicing a system of shifting cultivation known as "conuco". When coffee became a major crop, Puerto Rico's natural forests declined further. Coffee was

Table IV.—*Historical estimates of forest area for Puerto Rico*

Year of estimate	Forested area[1]	Coffee shade	Source of information
	hectares		
ca. 1500	850,000	0	Murphy, 1916, and Wadsworth, 1950
1828	587,000	7,000	Wadsworth, 1950
1899	182,000	77,000	Wadsworth, 1950
1912	169,000	77,000	Murphy, 1916
1916	178,000	68,000	Murphy, 1916
1931	81,000	. . . . .	Gill, 1931
1940	. . . . .	68,000	Koenig, 1953
1948	57,000	57,000	Koenig, 1953
1960	82,000	. . . . .	Englerth, 1960
1972	284,000	73,000	Department of Natural Resources, 1972

[1] Does not include non-stocked forest land.

grown under planted shade trees in the interior highlands where other cash crops proved unsuccessful.

Early in the 20th century, forests covered about 20 percent of the island, but only about one-third of this forest land could yield wood products other than charcoal or fuelwood (Murphy 1916). Later, Puerto Rico Department of Agriculture figures showed half the island to be forest, brush, swamp, and barren land, containing little timber of any value (Durland 1929). Other estimates concluded that 80 percent of about 400,000 hectares of forest land was devastated.

The rate of forest destruction declined during the first part of the 20th century. Only the most remote and marginally productive lands remained uncultivated. During the ensuing decades, pressure on land resources came from many directions: increasing population, expanding production of export crops, and fluctuating economic conditions. During periods of high unemployment people were forced to subsistence agriculture, encroaching on the remaining lands in the interior.

During the late 1940's the natural forest area of Puerto Rico declined to a minimum of 6 percent of the land area (table IV). Cropland and pasture each accounted for about 42 percent, with the remaining 10 percent in buildings, roads, and wasteland (Koenig 1953). Thus Puerto Rico became one of the most severely deforested and eroded regions in the world.

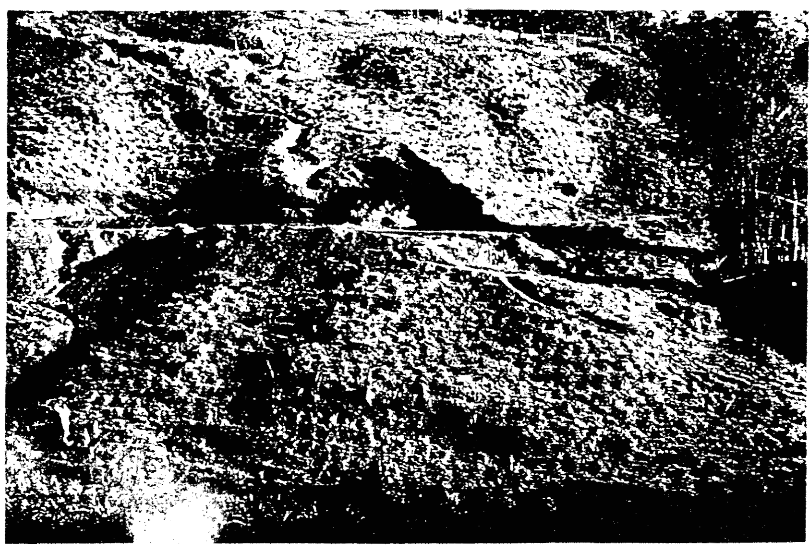
Recent statistics show that the forests have been returning in the past 30 years. Privately-owned lands have reverted to forest as small hillside farms were abandoned. These degraded lands, unsuitable for cultivation, support the potential forest resource assessed in this study.

Women carrying fuelwood from Cambalache Experimental forest, Garrochales (photo by Wadsworth, 1947).

Mouth of Rio Patillas at Patillas lake showing extensive delta due to erosion upstream (photo by Wadsworth, 1947).

Whip sawing lumber of tabonuco, Dacryodes excelsa. *Espiritu Santo Valley (photo by Wadsworth, 1947).*

Accelerated gully erosion on Maricao Forest Reserve during the late 1940's (photo by Wadsworth).



Forest removal and overgrazing result in serious erosion. Location and date of photo unknown.

Deforested hillsides during the mid-1940's in the vicinity of Mayaguez (photo by Wadsworth).

Fuelwood prepared for making charcoal, Rio Grande (photo by Wadsworth, 1947).

THE 1980 FOREST RESOURCE SURVEY

Survey Scope And Design

Although previous comprehensive assessments of Puerto Rico's forests have been attempted, the 1980 survey was the first by a Renewable Resources Evaluation Unit of the USDA Forest Service. The survey was designed to be responsive to local data needs. The primary objective was to assess the timber potential of the island. Fieldwork was concentrated in areas with commercial potential; other regions were assessed remotely or through literature research. Survey methods (see appendix) were designed to assess timber quality, volume, areal extent, and species composition. Physical site characteristics were also recorded. This information will address other current issues which include research on the management of secondary tropical forests, and monitoring secondary succession on tropical forest land. Subsequent surveys will assess changes in forest area, volume, and species composition.

The island was partitioned geographically to allow focus on regions with commercial potential. Land uses excluding intensive timber production were delineated on a base map (fig. 5). This noncommercial survey region accounts for nearly 51 percent of Puerto Rico's area (table V). These areas include the agricultural regions of the northern coast and interior valleys, and the dry southern coast. The highest mountain regions were also eliminated because of watershed values or excessive rainfall or slope. Noncommercial survey regions were eliminated sequentially, beginning with the Subtropical Dry Forest Life Zone. Subsequent categories do not include areas already eliminated in a previous category (fig. 5, table V).

The potential commercial forest region, more than 400,000 hectares, excludes environmental extremes and the better agricultural land. It is located in the dissected uplands between the fertile valleys and the highest, most rugged mountain areas. Annual rainfall varies from 1000 to 2500 millimeters. The potential commercial region encompasses only 2 of the 6 Life Zones found in Puerto Rico. Broad soil associations reflecting geologic origin (table V, fig. 6) form the basis for stratification of the data. Soils of volcanic origin divided into deep

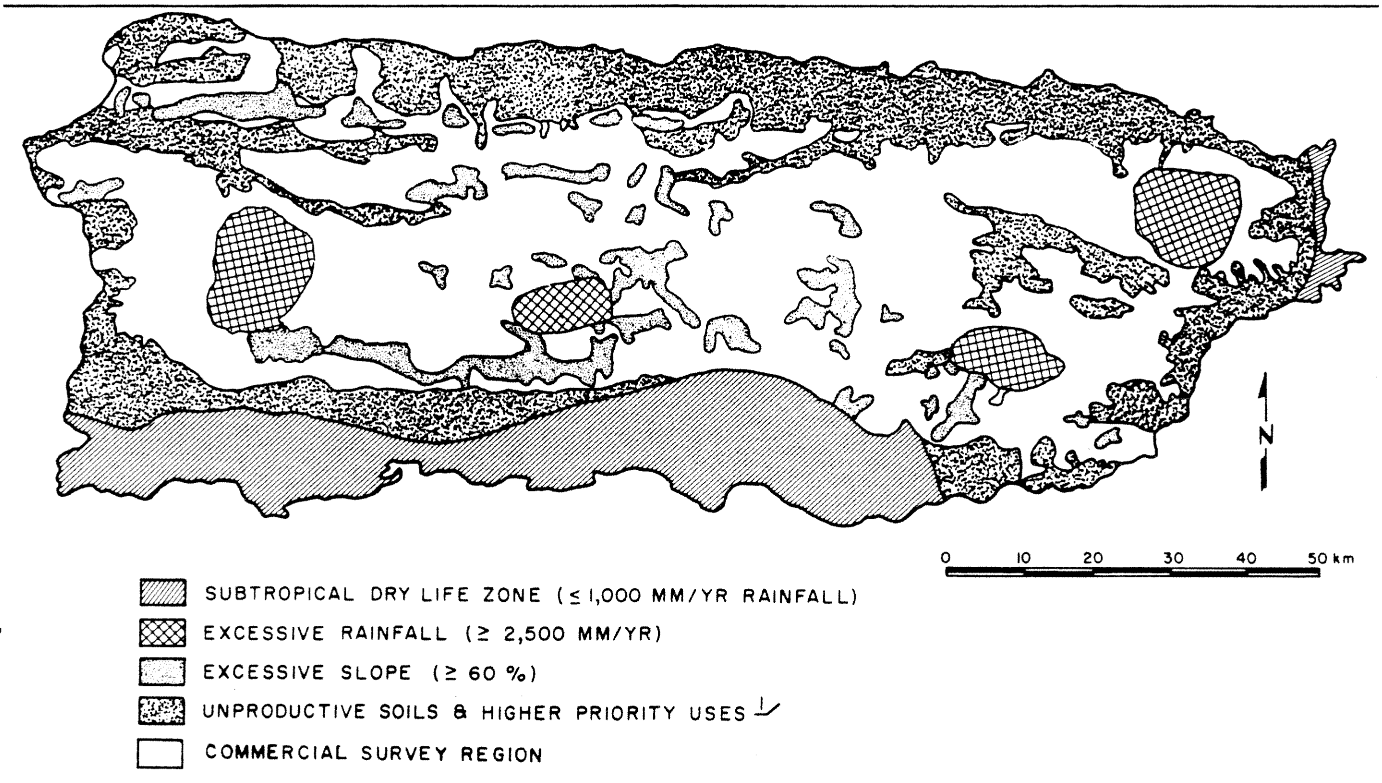


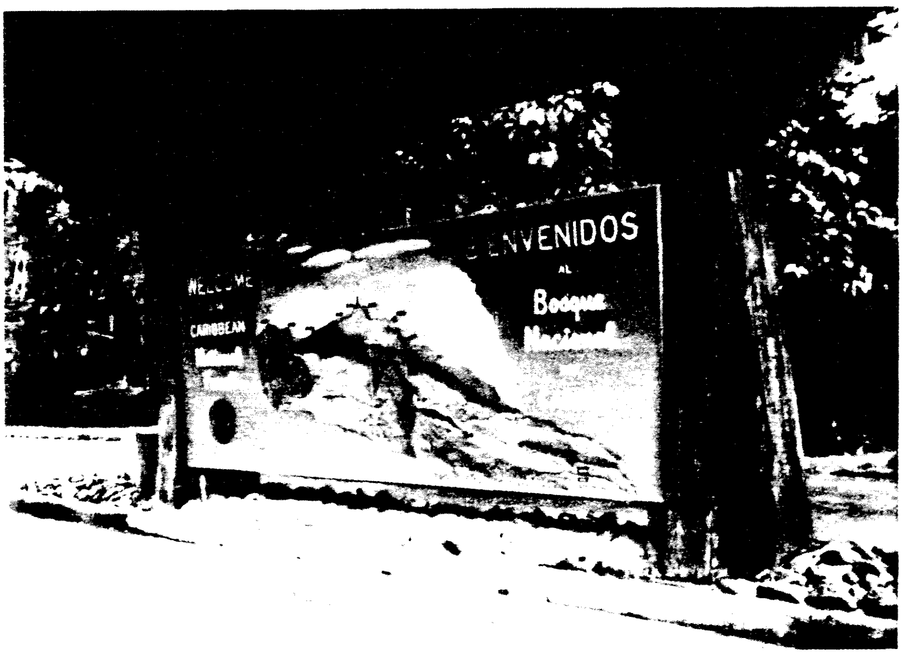
Figure 5.—*Exclusions from 1980 commercial survey region. Shaded areas were removed sequentially to determine the area for field investigation.*

[1]*Mangroves, swamps, alluvial flats, metropolitan regions.*

Table V.—*Land area by survey region, Puerto Rico, 1980*

Survey region	Area
	hectares
Commercial	
Subtropical Moist Forest Life Zone[1]	
Deep volcanic soils[2]	69,000
Shallow volcanic soils	116,700
Granite soils	33,100
Limestone soils	81,100
Total Subtropical Moist Forest Life Zone	299,900
Subtropical Wet Forest Life Zone	
Deep volcanic soils	99,600
Shallow volcanic soils	20,600
Granite soils	12,000
Limestone soils	4,500
Total Subtropical Wet Forest Life Zone	136,700
Total commercial	436,600
Noncommercial[3]	
Subtropical Dry Forest Life Zone	121,500
Critical watersheds	109,300
Unproductive soils	92,200
Alluvial and metropolitan	76,000
Mangrove and swamp	7,500
Noncontiguous Puerto Rico	47,200
Total noncommercial	453,700
Total land area	890,300

[1]Life Zones according to Holdridge (1967), determined by Ewel and Whitmore (1973).
[2]Soil groups defined and mapped by Zambrana (1978).
[3]Areas were defined sequentially in the order presented.



The unique Caribbean National Forest attracts more than a million visitors each year, and supplies most of the water used in Northeastern Puerto Rico.

and shallow clays, comprise 70 percent of the potential commercial area. The deep clays include the typical deep red latosols found in the tropics. Granitic intrusions, about 10 percent of the area, result in a sandier soil in the uplands. Limestone soil supports a unique forest vegetation and accounts for 20 percent of the potential commercial region.

Ecological Life Zone and soil group are important parameters which, along with previous land use, topography, and other site factors, determine forest resource characteristics. These classifications are interrelated. For example, coffee is generally grown in high rainfall areas (Subtropical Wet Forest) on deep volcanic clay soils. Life Zone and soil group yielded the most important prior knowledge of the survey region. Forest area statistics were compiled using this stratification rather than the county-based system used in the U.S.

Forest Ownership

The largest forested areas in public ownership are the Commonwealth forest system, the Caribbean National Forest, Mona Island, and Roosevelt Roads Navy Base. The Department of Natural Resources of Puerto Rico also holds several areas of smaller extent. The remaining forest lands, about 85 percent, are privately owned (table VI).

The Commonwealth forest system includes 14 forests scattered throughout the island. The Caribbean National Forest covers most of the Luquillo Mountains in the northeastern part of the island. Together the public forests protect valuable soil and water resources, wildlife habitat, and many rare tree species. They also provide recreation and research opportunities in all the major natural ecosystems found on the island. These areas include nearly all of the remaining virgin forests.

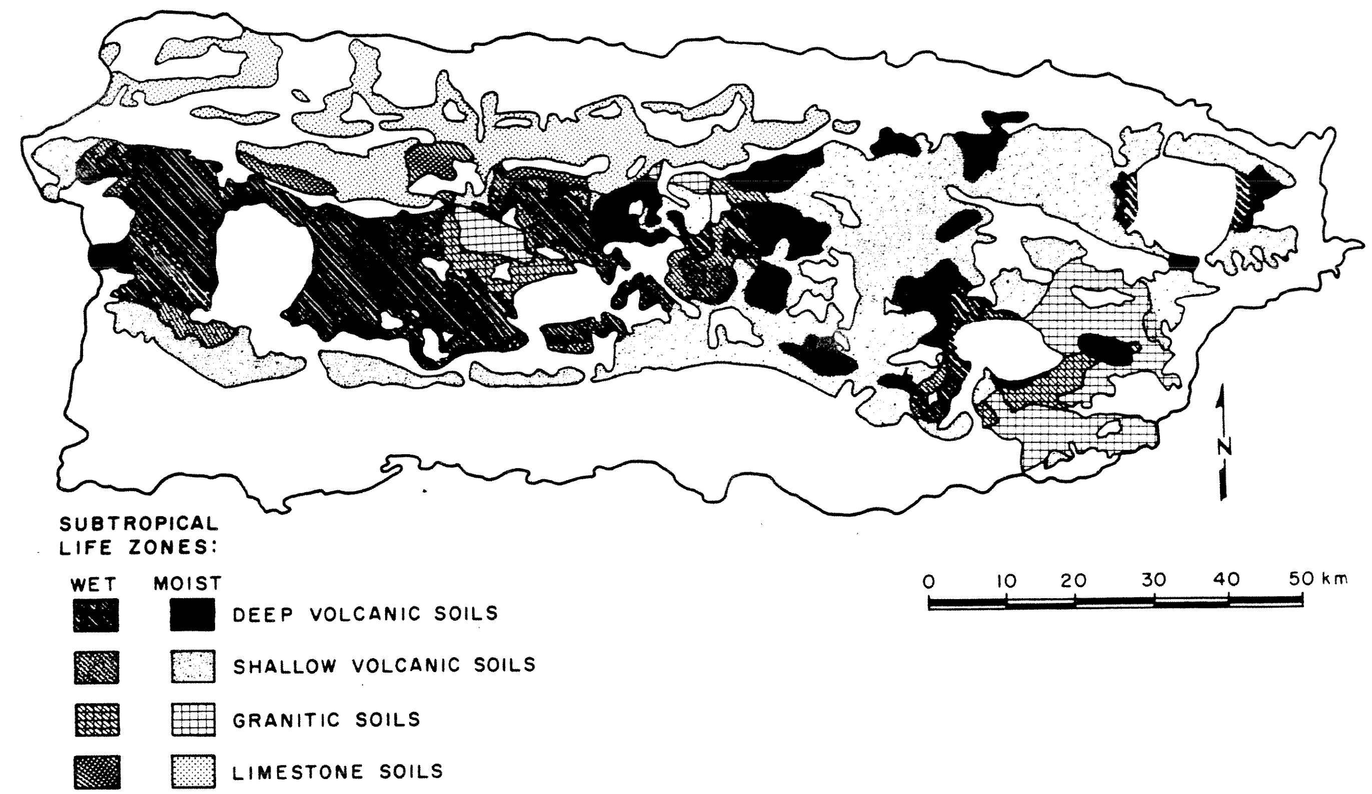


Figure 6.—*Life Zones and soil groups in the potential commercial forest region, 1980.*

Forest Area[2]

Puerto Rico's 890,000 hectares of land include 279,000 hectares of forest land.[3] Nonforest land uses account for 69 percent of the total land area. Land classed as timberland amounts to 15 percent of all land. Most of the timberland is located in the western highlands in and around coffee growing and pasture regions.

Forest Land Increasing—Long term trends (table IV) show that forest area has been increasing in the past 30 years.[4] Most of the forest land classed as timberland is composed of young forests. If these trends continue, it may be possible to develop small scale forest products industries based on managed secondary forests. Commercial timber removals have not been important recently, and the island satisfies most timber needs through imports (Wadsworth 1971).

Non-timber forest resource uses are currently more important than timber in Puerto Rico, as indicated by the large amounts of forest land in the noncommercial survey region. More than 16 percent of the land area is covered with forests whose primary use is for watershed protection, recreation, and wildlife habitat.

About one-quarter of this important noncommercial forest land is under public ownership and protection. Privately-owned noncommercial forest land includes many critical watershed and habitat areas which are best conserved under continuous vegetative cover. Most of the timberland is also privately owned. Although little is known of these owners, they ultimately will determine any future timber production on the island. Timber harvesting on noncommercial forest land could also help support small forest industries, but other values, marginal timber productivity, or ecological hazards reduce the potential contribution of this wood source.

Timberland Increases Follow Retirement of Agricultural Land—About 54 percent of Puerto Rico's timberland has resulted from abandonment of pasture and cropland. The remaining 46 percent of the timberland has been, or is currently, managed as coffee shade. Nearly 12,000 hectares of timberland are nonstocked with trees. Much of this land is covered with brush or other inhibiting vegetation.

Coffee production has been aban-

[2]Refer to appendix tables for this and all subsequent analysis. Some information screened from the data is only available through special processing.

[3]The definitions of terms are an integral part of a forest survey. Users of the data in this report are advised to study the definitions presented in the appendix.

[4]Direct comparison of forest area between this survey and previous ones is not reliable because of definition changes.

Table VI.—*Ownership of forest land in Puerto Rico, 1980*

Ownership class	Area	Source of information
	hectares	
Public:		
Commonwealth forests	22,700	Department of Natural Resources, 1976
Commonwealth islands[1]	5,500	Junta de Calidad Ambiental, 1973
Department of Natural Resources[2]	2,000	Rusanowsky, 1978
National forest	11,300	Munoz, 1968
U.S. Military	1,900	U.S. Fish and Wildlife Service, 1978
Total public	43,400	
Private:		
Total private	235,300	
All ownerships	278,700	

[1] Mona and Monito islands.
[2] Lands previously purchased by the Conservation Trust were turned over to the Department of Natural Resources in 1981.

doned on 38,000 hectares of timberland. These forests characteristically have low stocking levels and numerous large, poor quality trees. The shade trees currently used on more than 21,000 hectares of coffee land could have an important contribution to the timber resource; however, timber production as complementary to coffee production is not currently practiced.

Timberland is about evenly divided among sawtimber-size, poletimber-size, and sapling-seedling stands. More than half of the timberland classed as sawtimber has a basal area less than 15 square meters per hectare. These poorly stocked stands reflect the presence of numerous open-grown trees. Some of the older abandoned coffee shade stands have basal areas of 15 to 20 square meters per hectare.

Poletimber stands are considerably better stocked, including 29,000 hectares with 10 to 20 square meters per hectare basal area, and 10,000 hectares with more than 20 square meters per hectare. This most extensive stand-size class is a promising area for management practices which would favor the most desirable species.

Sapling-seedling stands are not common in coffee shade. In contrast, some young secondary stands are highly overstocked, especially in the limestone hills, where site conditions favor smaller tree sizes.

Low stand volumes are common in Puerto Rico's timberland. Seventy percent of the secondary forest land has less than 50 cubic meters per hectare of timber volume, significantly lower than managed secondary stands in the Luquillo Mountains. Abandoned coffee shade stand volumes are mostly in the 25–75 cubic meter range, with only small areas in high and low volume classes. Active coffee shade, if properly managed, seldom carries more than 50 cubic meters per hectare of timber volume. Only older secondary forests and a few abandoned coffee shade areas have more than 100 cubic meters of timber per hectare.

Low basal areas and timber volumes are typical in both active and abandoned coffee shade, and in the younger secondary forests. These conditions also reflect the generally poor site quality which has resulted from intensive land use.

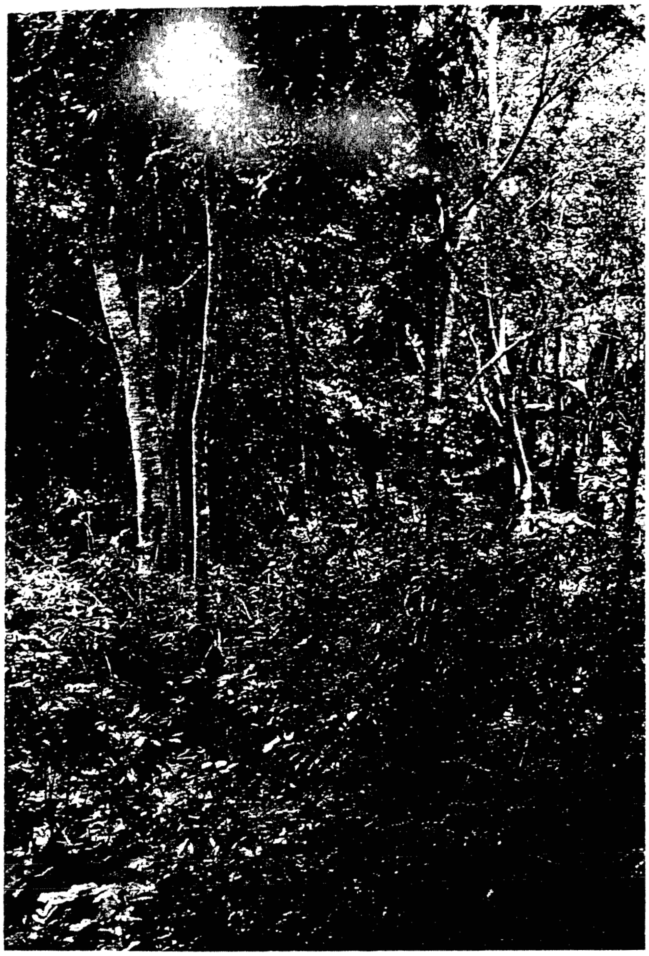
Most Timberland in Rugged Mountain Areas—Most stocked timberland occurs in areas with rough topography. About 60 percent of the area has slopes greater than 45 percent. These hillsides, subject to severe erosion in the absence of continuous vegetative cover, are made difficult to farm by the unfavorable working conditions. The land quickly becomes unproductive when cultivated.

More timberland is found on deep volcanic soils in the Subtropical Wet Forest Life Zone than in any other stratum. This is the most important coffee producing region. Two important forested soil groups in the Subtropical Moist Forest Life Zone are the shallow volcanic soils and the limestone soils. These strata include extensive pasture mixed among the forests. Timberland found on granitic soils is about evenly split between the two Life Zones included in the commercial survey area.

Timber stands on deep volcanic soils have characteristics similar to coffee shade forests: low timber volumes in sawtimber-size and poletimber-size stands, few sapling-seedling stands, and low basal areas. About two-thirds of the area was abandoned less than 30 years ago. Nearly 28,000 hectares of timberland on deep volcanic soils were classed as poletimber.

Timberland on shallow volcanic soils is stocked with sawtimber-size or sapling-seedling stands, with only a small area of poletimber. The sawtimber stands are mostly associated with coffee shade, while sapling-seedling stands tend to cover the more recently abandoned pasture and cropland.

Sapling-seedling stands dominate the timberland in the limestone hills region. Coffee shade is essentially absent. Unusual soil and topographic conditions are responsible for much of the land remaining forested with small timber, despite evenly distributed stand ages. Sample plots fall either in stands with very little slope, or stands with more than 45 percent slope. These plots correspond to the sawtimber-size and sapling-seedling stands, respectively. A narrow band of sawtimber is often found on the concave lower slopes and bottomlands of the limestone hills.



Coffee is grown under shade trees which are a potential source of timber.

Recently abandoned pasture and cropland is often rapidly overgrown with ferns or brush, delaying establishment of a forest stand.

Abandoned coffee shade results in a mixture of older shade trees and young saplings.

Granitic soils support a more uniform stand-size distribution, with a substantial area of poletimber. These young stands are principally the result of abandonment of pasture and cropland.

Dangerous precipices, steep ravines, numerous boulders and other obstacles, and a generally uneven land surface characterize the eroded slopes on all soil groups. This rugged, marginal land should be carefully managed for its timber potential. Even the partial cover provided by coffee shade may not result in sufficient protection from weather extremes, as heavy rains recurrently inflict heavy soil losses.

Species Composition

There are 547 tree species known to be native to Puerto Rico, with an additional 203 species naturalized (Little et al. 1974). This approximates the number of native and naturalized species found in the continental United States (Little 1979). Such a striking richness of tree flora within a small area is an important consideration in an assessment of Puerto Rico's forests.

Species Represent Past Human Influence—Two factors influence the current species composition of Puerto Rico's timberland. First, most of the timberland has been farmed or cleared for coffee in the recent past. Second, a wide variety of site conditions exist on the island.

Field crews tallied 189 different species and were able to identify more than 99 percent of the sample trees. Ten species account for 49 percent of the basal area (fig. 7). Many species were encountered very infrequently: 142 species together account for 16 percent of the basal area.

The current forests are substantially different from the original vegetation. Nine of the ten most common timberland species are used for coffee shade, fruit, or ornament (table VII). Four of the five

Table VII.—*The most common trees and their characteristics, Puerto Rico timberland, 1980*

Species	Used for coffee shade	Used for fruit or product	Used for ornament or shade	Used for fuel or posts only	Potential timber species[1]
Inga vera Willd.	X				X
Guarea guidonia (L.) Sleumer	X				X[2]
Cecropia peltata L.					X
Andira inermis (W. Wright) DC.	X				X[2]
Inga fagifolia (L.) Willd.	X				X[2]
Eugenia jambos L.		X	X		
Tabebuia heterophylla (DC.) Britton			X		X[2]
Spathodea campanulata Beauv.			X		
Mangifera indica L.		X	X		X
Citrus sinensis Osbeck		X	X		
Erythrina poeppigiana (Walp.) O.F. Cook	X		X		
Dendropanax arboreus (L.) Decne. and Planch.				X	X
Didymopanax morototoni (Aubl.) Decne. and Planch.					X
Coffea arabica L.		X			
Ocotea leucoxylon (Sw.) Mez				X	X
Prestoea montana (R. Grah.) Nichols.					
Calophyllum calaba L.			X		X[2]
Roystonea borinquena O.F. Cook		X	X		
Alchornea latifolia Sw.				X	X
Thouinia striata Radlk.				X	

[1]Based on past use in Puerto Rico, or use elsewhere in the tropics for products other than specialty items.
[2]Cabinet quality.

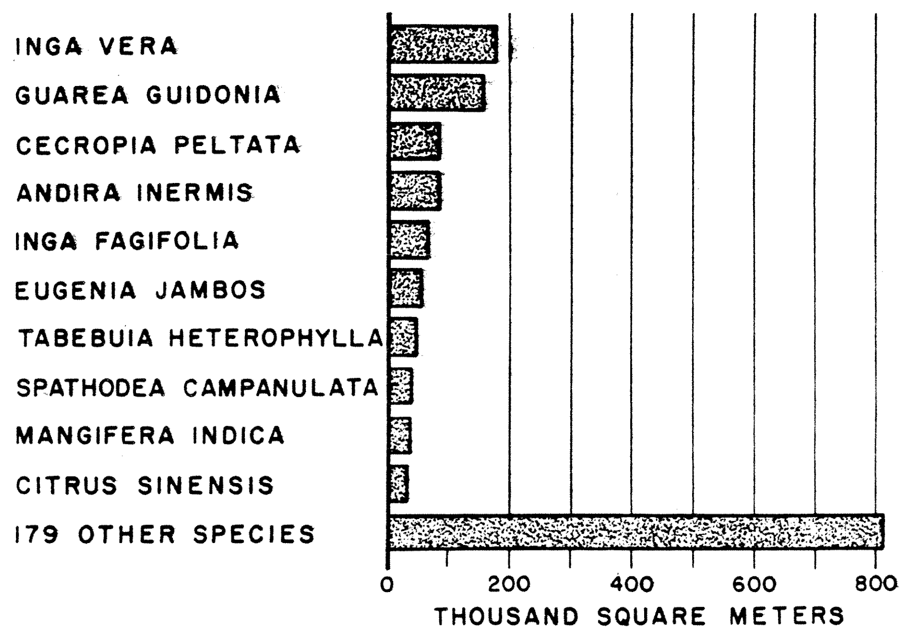


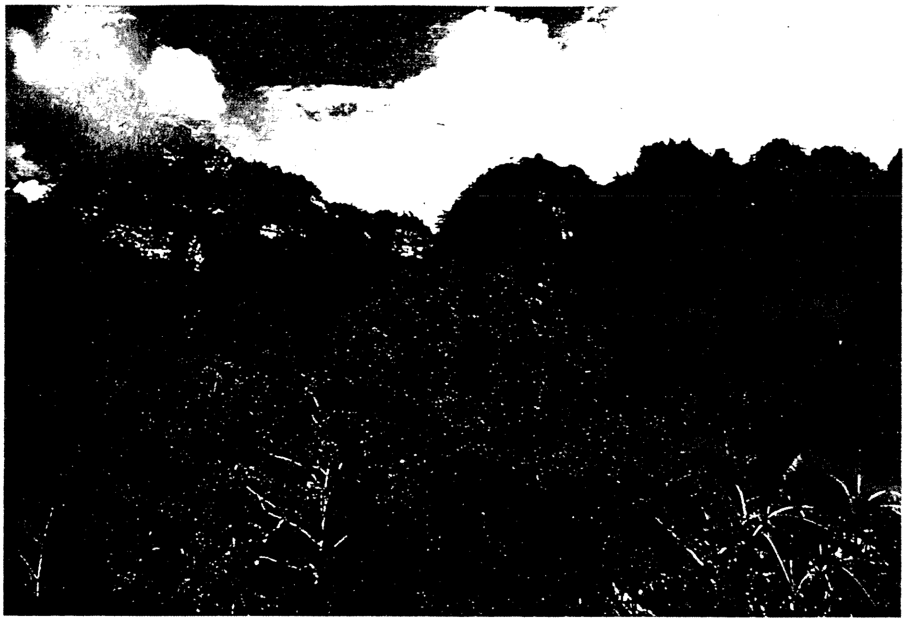
Figure 7.—*Basal area of the most common tree species, Puerto Rico timberland, 1980.*

most common species are extensively planted for coffee shade, accounting for 30 percent of the basal area on timberland. Significantly, 6 of the 7 most common species are potential timber species and account for 38 percent of the basal area.

Many of the common species tallied are pioneers of abandoned cropland or pasture. These species regenerate freely and many have rapid early growth rates. Large trees of species used for timber in the past are only found in isolated patches of mature forest. Most large trees found today are old ornamentals or fruit trees.

Some species occur with great frequency in the smaller diameter classes. These include 3 excellent timber species which can grow into larger size classes, *Guarea guidonia, Andira inermis,* and *Tabebuia heterophylla,* and some species which are found only in the understory, such as *Coffea arabica, Casearia guianensis,* and *Guettarda scabra*. Common coffee shade trees (*Inga* spp.) and fast-growing secondary species, especially *Cecropia peltata,* are relatively scarce in the smaller diameter classes but common in intermediate classes. Large trees (diameter class 55 centimeters or more) average only about 2 per hectare, the most common being *Guarea guidonia, Spathodea campanulata, Mangifera indica, Erythrina poeppigiana,* and *Spondias mombin*. Although some of these species can be used for wood products, the large, open grown trees common in Puerto Rico generally have poor form.

Coffee Shade Forests Less Complex Than Secondary Forests—Abandoned coffee shade forests contain fewer than half the species found in other reforested areas. A smaller number of species accounts for a higher percentage of the basal area; the 10 most common species in secondary forests account for 37 percent of the total basal area, while accounting for 69 percent and 80 percent in abandoned



Several forest types and rugged topography characterize the wet limestone region of the Rio Abajo Forest Reserve.

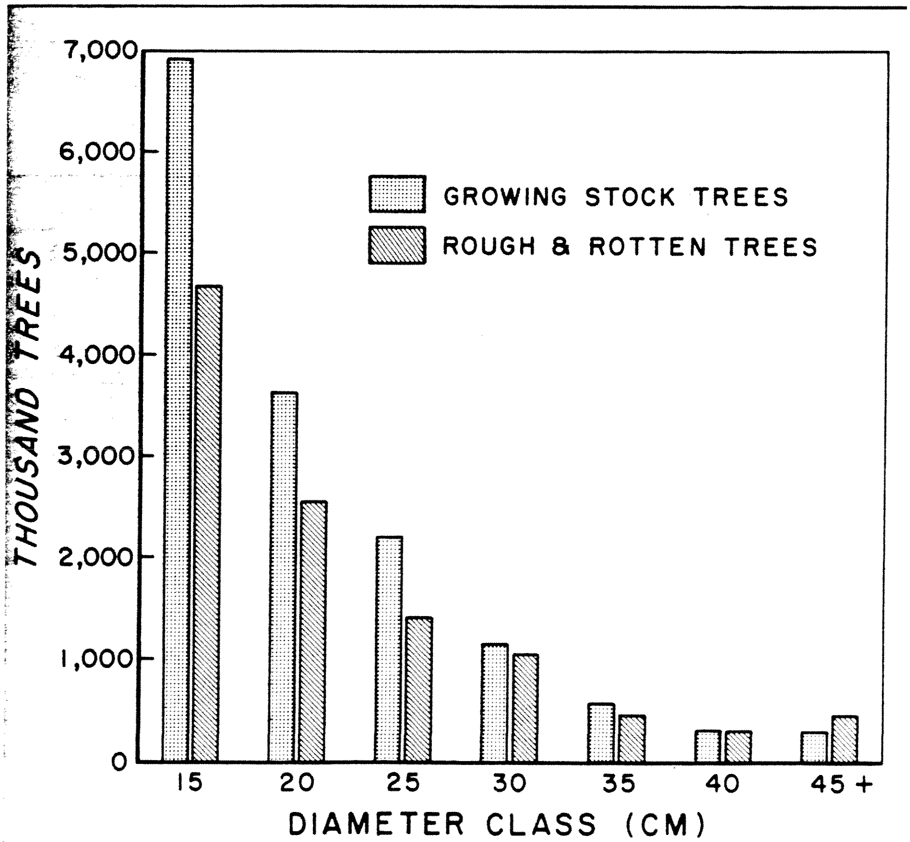


Figure 8.—*Number of trees by tree class and diameter class, Puerto Rico timberland, 1980.*

A variety of species and a few older "wolf" trees are evident on this secondary forest land.

and active coffee shade, respectively. Average basal area per hectare in active coffee shade is about 10 square meters.

Coffee shade forests are less complex because species used as shade trees now dominate the stand. Coffee has generally been grown on deep clay soils in the Subtropical Wet Forest Life Zone, a relatively uniform region compared to the site diversity of other reforested areas.

Smaller diameter trees are less common in coffee shade forests. Cultivated shade trees occupy most of the growing space and account for the greater number of stems found in the middle and upper diameter classes.

There are important species differences as well. More frequently encountered in secondary forests are the palms and two timber species, *Tabebuia heterophylla* and *Calophyllum calaba*. Coffee shade forests include more coffee, fruit, ornamentals, and other planted trees. *Inga vera* and *Cecropia peltata* are common in all forest classes, and both *Guarea guidonia* and *Andira inermis* are common species which produce cabinet quality timber.

The most promising timber species are found in the small diameter classes in young secondary forests. These stands have the potential to develop into desirable sawtimber stands since the rough trees which dominate the coffee shade forests are absent. Less management effort would be required to concentrate the growth potential of the site in young, vigorous, desirable timber species.

Poor Tree Quality—Good timber stands are now found only in isolated, protected areas. The forests of 1980 more typically include a high percentage of rough and open-grown trees above a fairly dense, complex understory.

The basal area of rough and rotten poletimber- and sawtimber-size trees is about 46 percent of the total. The larger diameter classes tend to have a higher percentage of rough and rotten trees than the smaller diameter classes (fig. 8). Coffee shade forests have the highest proportion, about half, of rough and rotten trees, although secondary forests are not far behind. Rough trees predominate on shallow volcanic and granitic soils.

Some pioneer species with good form, such as *Cecropia peltata, Tabebuia heterophylla,* and *Didymopanax morototoni,* are good timber species. Coffee shade species and fruit trees, all essentially open-grown, tend to include a high percentage of rough trees. Rotten trees amount to only about 3 percent of the basal area.

Timber Volume

Puerto Rico's timberland has been influenced by a series of land uses common in the tropics: removal of valuable timber species, clearing for agriculture, erosion and degradation, and finally abandonment. The forests now beginning to reclaim the land are extremely valuable as vegetative cover, yet they carry low timber volumes and a rather unfavorable mix of species and quality. The merchantable sawtimber volumes per hectare are generally low.

Most Volume in Abandoned Coffee Country— The timber volume per hectare (stocked timberland) averaged 53.1 cubic meters in abandoned coffee plantations, 44.4 cubic meters in secondary forests, and 36.3 cubic meters in active coffee growing areas. Timber volume is highest on deep volcanic soils, averaging 73.3 cubic meters per hectare in the Subtropical Moist Forest Life Zone and 56.1 cubic meters per hectare in the Subtropical Wet Forest Life Zone. The lowest volumes are found on granitic soils, which were recently abandoned, and limestone soils, which include much scrub vegetation.

More than 60 percent of the timber volume is found on slopes greater than 45 percent. Site quality is poor, and timber volumes average less than 50 cubic meters per hectare.

The species accounting for most of

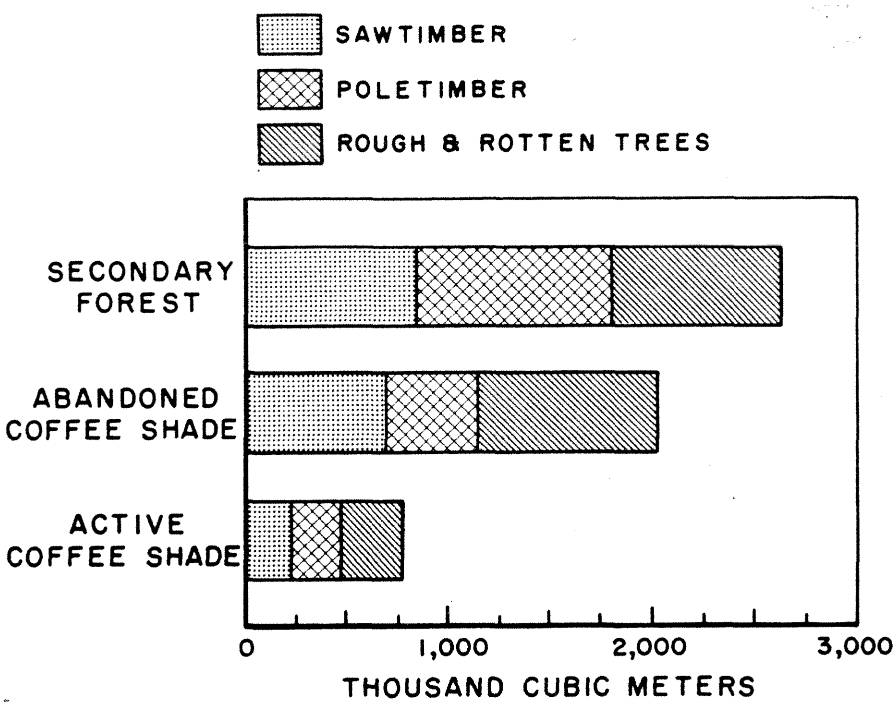


Figure 9.—*Timber volume by class of timber and forest class, Puerto Rico timberland, 1980.*

the wood volume reflect past land use. Ten species comprise about 60 percent of the timber volume, eight of which were commonly used for coffee shade, fruit, or ornament. Some species such as *Coffea arabica, Thouinia striata, Casearia guianensis, Cyathea arborea,* and *Myrcia splendens* rarely attain large size, and this decreases their contribution to timber volume despite their abundance. Some species grow to larger sizes and have a high ratio of volume to basal area. Examples are the palms (*Prestoea montana* and *Roystonea borinquena*), *Hymenaea courbaril* and *Dacryodes excelsa.*

Low Sawtimber Volume—The volume of sawtimber (International ¼ inch rule) is less than one-tenth the timber volume. Only about one quarter of all sound wood (timber volume) is found in the sawlog portion of sawtimber-size trees, compared to about half for the Southern U.S. Poletimber trees and rough trees each account for about as much volume as sawtimber trees (fig. 9). Most existing stands are not ready for a sawtimber harvest, but timber growth might be stimulated by removal of rough trees and unwanted species.

Stocked timberland averages about 4 cubic meters of sawtimber per hectare. Ten species represent 65 percent of the sawtimber volume. These are the most common species, however a few such as *Cordia alliodora* and *Dacryodes excelsa,* are less common but grow to large size and have good form. *Erythrina poeppigiana* has the most sawtimber volume in the larger diameter classes, but it is not a good timber species.

These low sawtimber volumes indicate that extensive harvests for sawtimber are unlikely in the near future. Immediate returns from the forest could come from mixed hardwood pulp, fuelwood, or a combination of wood products.

Commercial Prospects For Timberland

Commercial prospects for harvesting timber are generally limited by economic factors, such as volume per hectare of merchantable species, size of forest tracts, operability, and distance to existing all-weather roads. Other factors such as ownership patterns and attitudes, and distance to highways, lakes, and rivers are also important (FAO 1978, Deal 1980, Lee 1980).

Information about these items can be used to identify timberland which is currently suitable for commercial removals. Two critical assumptions must also be made, however, concerning factors outside the scope of this survey. First, that a market exists for all wood products of acceptable quality, and second, that private owners of timberland are willing to manage their land for timber production. These two relatively unknown factors have a great deal of influence on commercial prospects.

The area of timberland with the greatest potential for timber production can be determined by sequentially eliminating areas which cannot satisfy a set of constraints, using a screening technique described by Knight (1980). The constraints would vary with the value and nature of merchantable wood products and with the size and nature of the harvesting operation. For example, a small operator removing selected trees for specialty wood products would not be concerned with small tract sizes or low timber volumes per hectare. The constraints used here (table VIII) screen out all but the best timber stands, leaving those which would interest a small or medium size commercial enterprise. Characteristics of these stands can then help determine commercial prospects.

Elimination of areas unsuitable for harvest under these constraints removes ¾ of the timberland. Low sawtimber volume is clearly the

most important factor, followed by poor operating conditions. The best timberland contains about 250,000 cubic meters of sawtimber, or an average of 8 cubic meters per hectare. This volume is relatively high for Puerto Rico. Much of the wood is in valuable hardwoods. About ½ of this forested area is abandoned coffee shade.

Physical conditions on harvestable timberland are much the same as for timberland in general. Most stands are close to an all-weather road. The terrain is rugged, generally uphill or up and down to the road. Many stands are littered with obstacles which would adversely affect felling and skidding. About half of the area is on slopes greater than 45 percent, difficult or impossible for most skidding equipment to negotiate, especially on wet clay soils. Skidding would also be heavily damaging to the site, an unacceptable practice for the wet, steep terrain. Practical alternatives to skidding include cable harvesting or low technology operations such as a winch and tractor, gravity, or animals (Pestal 1976, FAO 1977, 1979).

Although the current situation is generally unfavorable for extensive harvesting, some good stands are developing. Most of the forests are very young and timber volumes should increase significantly in the more vigorous stands. Better management could also bring about improvements in stocking and species composition. Commercial prospects in the future will depend on the development of effective management strategies.

Management Opportunities

Natural tropical forests, because of their complexity and diversity, are not as readily managed as forests in the temperate regions. There are only a few instances where a management system, based on sound silvicultural practices, has been successfully applied to mixed tropical forests. A more common practice has been to replace the natural vegetation with fast-growing native or exotic plantation species. In the absence of proven natural forest management techniques, plantations are more likely to succeed and produce a profitable crop. Puerto Rico's secondary forests fall somewhere in between; that is, they are not plantations, yet have been heavily influenced by man.

In mountainous tropical regions conversion to plantation forests must be done carefully. Some vegetative cover must be maintained to minimize erosion and protect the water supply. Accelerated erosion can also reduce site productivity drastically, thus directly affecting wood yields. This constraint is particularly significant for a large area of forest land in the noncommercial survey region which protects critical watersheds for the island. Management on these and other forest lands in the noncommercial category should continue to be custodial to preserve important resource values such as watershed, recreation, and wildlife habitat protection.

Natural forest management schemes have had limited success in the tropics. Puerto Rico's secondary forests exhibit many characteristics which hinder forest management:

—Difficult working conditions
—Numerous species
—Diverse ecosystems and site characteristics
—High percentage of poor quality trees
—Low stocking levels
—Variable stand structure

Management attempts have also been limited by funding, technician availability, and transportation facilities. Despite these difficulties, the presence of numerous young growing stock trees of good timber species makes management worthy of investigation. Recent advances in understanding the tropical forest ecosystem may provide a reasonably sound scientific basis for developing successful management practices in Puerto Rico and elsewhere.

Some practices commonly applied in both temperate and tropical forests can be suggested as alternative management opportunities for various categories of timberland (table IX). These opportunities illustrate a range of possible courses of action. Only some of the techniques have been studied extensively in Puerto Rico. The de-

Table VIII.—*Timberland with currently unfavorable commercial characteristics, Puerto Rico, 1980*

Limiting factor	Maximum area	Area sequentially removed
	hectares	
Current sawtimber volume less than 2.5 cubic meters per hectare	77,000	77,000
Poor operating conditions (obstacles, precipices)	25,800	12,000
Tract size less than 5 hectares	12,900	3,100
Distance to all weather road more than 1 kilometer	12,800	6,400
Tract within 50 meters of highway, lake, or river	4,700	900
Total area eliminated		99,400
Prospective harvest area		31,100
All timberland		130,500

Table IX.—*Management opportunities for various timberland categories. Puerto Rico, 1980*

Timberland category	Area (ha.)	Characteristics	Management opportunities
Prospective harvest area (less active coffee and sapling/seedling)	27,600	Highest volume stands (see table VIII)	Harvest and regenerate Commercial thinning Timberland Stand Improvement[1]
Nonstocked timberland	11,700	Brush and inhibiting vegetation present	Artificial regeneration after site preparation Leave for natural regeneration
All sapling/seedling stands (except active coffee shade)	29,100	Timber species present, but not majority, some rough trees	Artificial regeneration after site preparation Pre-commercial thinning
Active coffee shade	21,400	Low basal area, many rough trees, few small trees, species less complex	Intensify agro-forestry efforts by maximizing timber production and coffee production
Abandoned coffee shade: Sawtimber stands (less exploitable timb.)	7,900	Medium basal area, many rough trees, few small trees, species less complex	Stand conversion[2] Enrichment planting and cleaning
Abandoned coffee shade: Poletimber stands (less exploitable timb.)	11,300	Medium basal area, some timber species present, many rough trees	Stand conversion Enrichment planting and cleaning Timber Stand Improvement (best stands only)
Secondary forests: Sawtimber (less exploitable timberland)	7,400	Low basal area, some rough trees, complex species, number of growing stock trees acceptable	Enrichment planting and cleaning Timber Stand Improvement
Secondary forests: Poletimber (less exploitable timberland)	14,100	High basal area, many growing stock trees, complex species include timber species	Timber Stand Improvement No treatment

[1]Cleaning, release, or other intermediate cutting.
[2]Remove or kill all trees and regenerate.

velopment of management practices appropriate for Puerto Rico's young forests is the critical element which would allow the island's timber production potential to be realized.

Timber stand improvement via the removal or killing of undesirable trees or inhibiting vegetation offers promising results on a significant area of poletimber and sawtimber. As long as the current stand contains adequate stocking of acceptable trees, this is one of the easiest and most reliable ways of improving commercial prospects. Harvestable timber already present could also be removed to help defray the treatment costs.

Site preparation and artificial regeneration would be appropriate on all of the nonstocked timberland, and on a large proportion of the poorly stocked sapling-seedling stands. About 30,000 hectares could be treated this way.

Many of the low volume sawtimber stands not included in harvestable timber are stocked with poor quality large trees which should be killed or removed. Enrichment planting or a full conversion to plantation would then be necessary. These treatments are expensive, however, and they offer little immediate return other than fuelwood or wood fiber.

More than 20,000 hectares of coffee shade forests could supply timber as well as coffee and fruits, if timber production were incorporated into land management objectives. Some prior research would be needed, however, to determine which tree species could provide optimum shade.

A sawtimber harvest followed by regeneration would be possible on about 30,000 hectares, and a larger area could be harvested for fuelwood or fiber. Much of the area would supply only a small return or no return on investment at all. A more appropriate treatment might be a commercial thinning or a stand improvement cut.

Tables VIII and IX constitute classifications which attempt to provide direction in a complex situation. A management program would have to consider also the different soils, Life Zones, and regions. This analysis is intended to establish very broad guildelines for the kind of research on management of secondary forests, and agroforestry, which is urgently needed in Puerto Rico, and elsewhere in the tropics.

Implications Of This Study

Several features of the Life Zone system make it useful for inventory work in the complex forests of the tropics: it is based on simple climatic data (rainfall and temperature) which are likely to be available for many regions; it encompasses variation within the respective forests without creating an unwieldy number of vegetation units; it is reproducible by independent investigators working in distinct regions; it is hierarchial, allowing subdivisions into associations or meaningful local sub-units; and its units bear close relationship to natural landscapes (Ewel and Whitmore 1973).

Climax forests within a Life Zone demonstrate a remarkable similarity in physiognomy. The system has proved useful for the introduction of rapid-growing exotic plantation species from one region to another with a high rate of success, and it is probable that the physiognomy, floristics, and rates of change of biomass accumulation of seral stages in widely separate regions within comparable Life Zones will also prove similar.

The 6 Life Zones found in Puerto Rico are also found in other countries of the Caribbean and Latin America. The most common are the Subtropical Moist Forest and Subtropical Wet Forest Life Zones which constitute 44 and 6 percent of Hispaniola (Haiti and the Dominican Republic), 15 and 15 percent of Central America (including Panama), and 3 and 6 percent of Venezuela, Colombia, Ecuador, and Peru, respectively.[5] Other countries within the region also contain one or more of these Life Zones (i.e. Jamaica, the Lesser Antilles), but have not been surveyed using the Holdridge system. Preliminary estimates of the areas occupied by each Life Zone could be derived from climatic data.

The stratification of the data by Life Zone and soil group, as well as the exclusion of areas based on climate, slopes, soils and other uses which preclude forestry, may prove useful in the assessment of commercial forest resources in other countries within the region, and at the same time recognize the non-timber values of forest cover. This design is efficient, since fieldwork is most intense in accessible and actively used forest areas, and virtually eliminated from primarily agricultural regions or extremely rugged, mountainous terrain. The Life Zone and soil association stratification is easily applied and provides a way to treat similar forest formations as a unit, thereby reducing data variability and aiding in the interpretation of survey results. Adding dimensions such as forest land use, topography, or stand age can account for the more significant characteristics of the forest.

The classification of vegetation is general enough not to conflict with systems used elsewhere. The data can be compared to any other region with similar characteristics.

The results of this survey will facilitate a forest management program for Puerto Rico's secondary forests by providing data on the nature of these forests. The development of small-scale forest industries to meet local timber needs is a logical extension of improved management. Broader considerations include monitoring and evaluating forest resources which have a multitude of values and functions. Puerto Rico's forests are an integral part of the island ecosystem and must be managed wisely.

[5]These estimates are based on available publications of the Life Zones in the neotropics. Changes in the classification system (Holdridge 1967) have made some of these estimates high.

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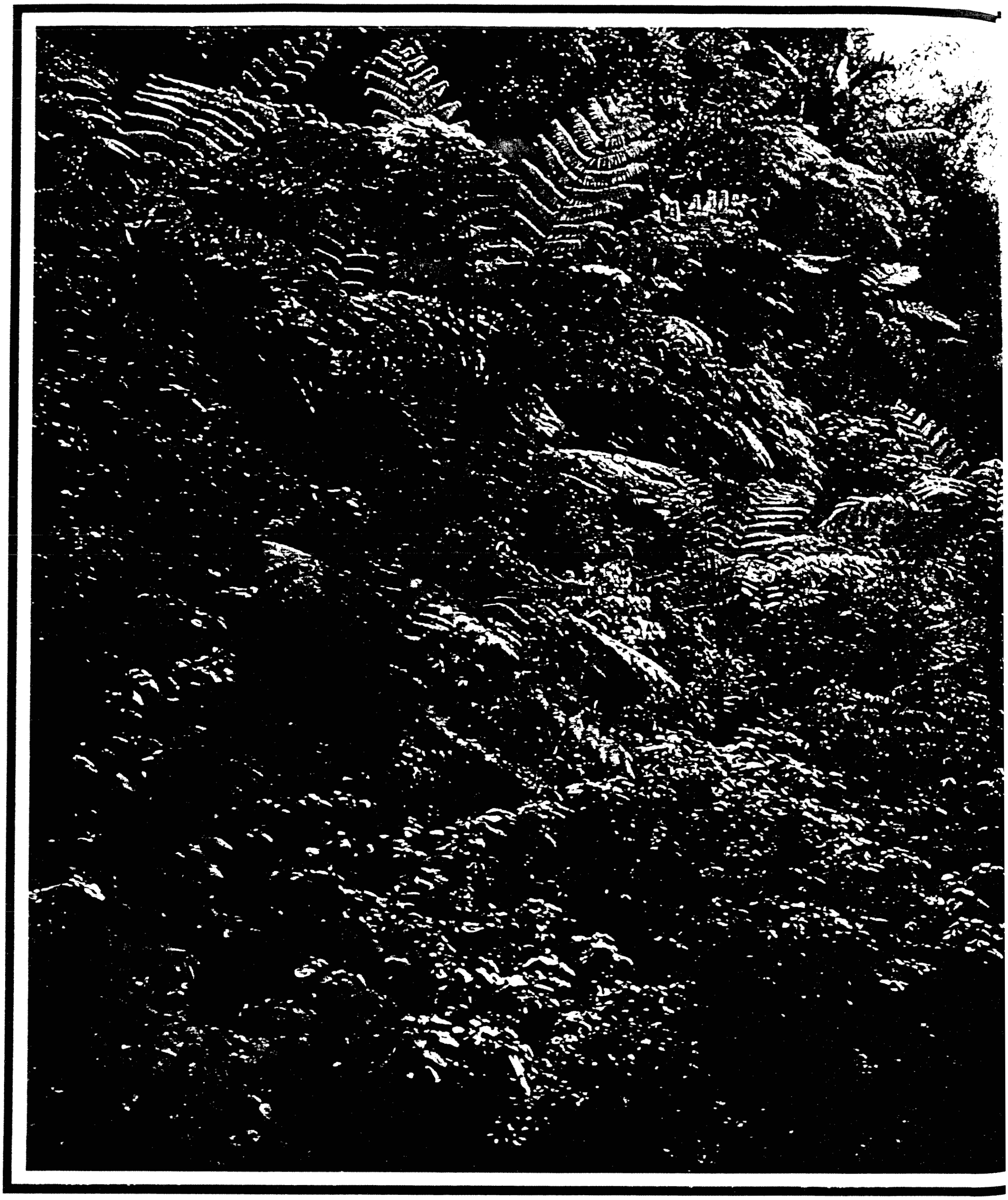
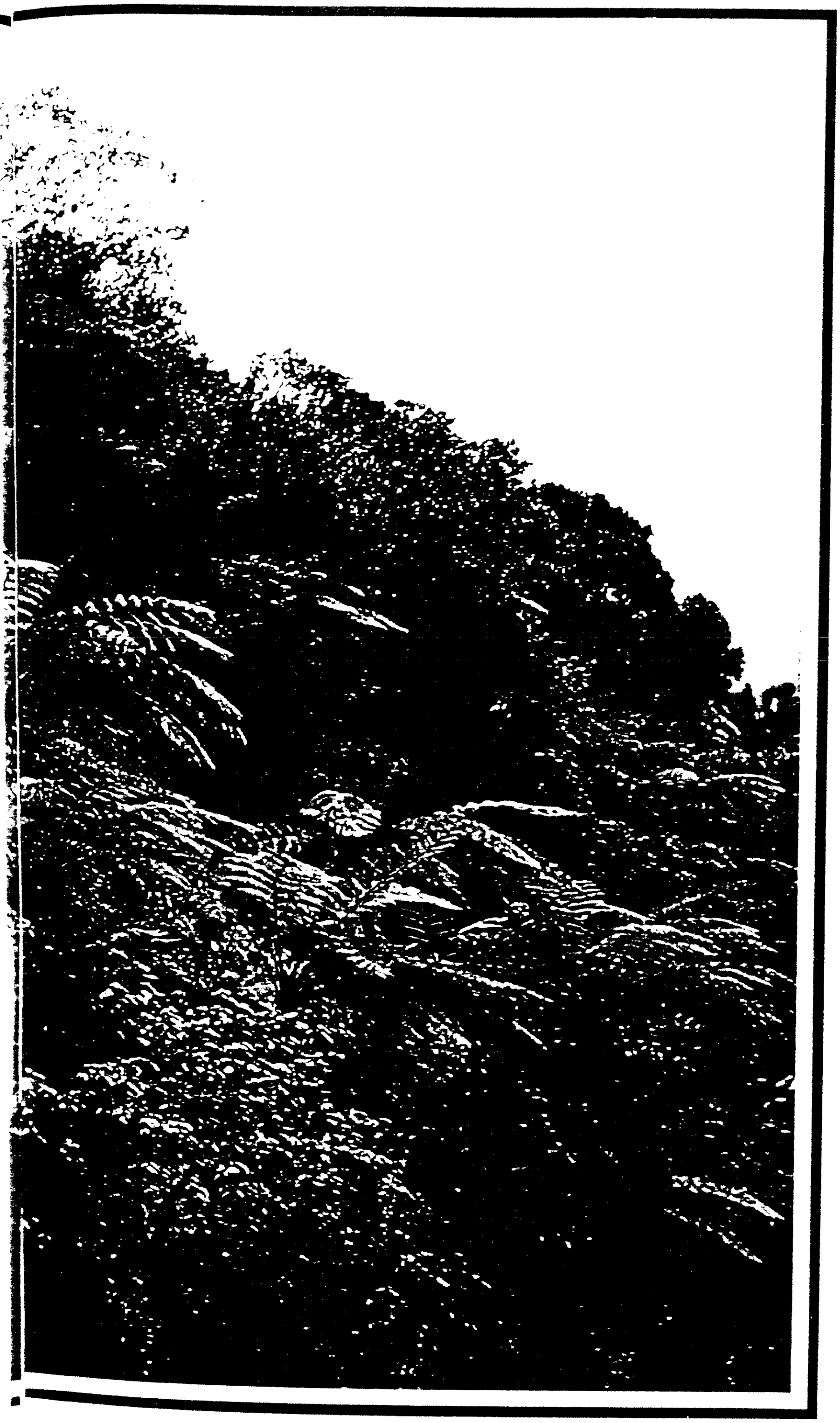


Tree ferns in the Caribbean National Forest.



Appendix

SURVEY METHODS

The 1980 survey was primarily descriptive and exploratory. The main purpose was to assess the secondary forests of Puerto Rico. The data are used to describe both the timber resource in Puerto Rico and the ecological characteristics of secondary tropical forests. The survey also establishes the basis for a continuous assessment of Puerto Rico's forest resources. Subsequent surveys will build upon the existing data base.

In order to focus the survey on areas with commercial potential, land uses which exclude intensive timber production were identified and delineated on a 1:120,000 scale base map and excluded from the ground sample. The potential commercial region was stratified by ecological Life Zone and soil type.

The data on forest acreage, timber volume, and species composition were obtained by a sampling method involving a forest-nonforest classification on aerial photographs and on-the-ground measurements of trees at sample locations. The sample locations were at the intersections of a grid of lines spaced 3 kilometers apart. Within the area of commercial potential, 10,925 photographic classifications were made and 437 ground locations were visited. The estimates of forest area obtained from the aerial photographs were adjusted on the basis of the ground check.

The estimates of forest acreage and timber volume for areas excluded from the ground sample were developed using several data sources. Partial aerial photographic coverage enabled an additional 3,875 forest-nonforest classifications to be made. Adjustments to these estimates of forest area were made by extrapolating ground truth information from similar regions visited in the ground sample. Regions without adequate photographic coverage were assessed using reference material.

A cluster of 3 variable-radius plots was established at each ground sample location. Each sample tree on the variable-radius plot represented 2.5 square meters of basal area per hectare, or 0.83 square meters of basal area per hectare when the plots were clustered. Trees less than 12.5 centimeters in diameter at breast height were tallied on fixed-radius plots of approximately 40 square meters around the plot centers.

Each sample location was classified by numerous site characteristics. Each sample tree 12.5 centimeters and larger was measured and assessed to determine wood volume and quality. Species was accurately determined for more than 99 percent of all sample trees.

Ground sample locations were selected on U.S. Geological Survey topographic maps and transferred to aerial photographs. The center of each forest location was established on the ground by running a computed azimuth and distance from a selected starting point. Each plot at a sample location was marked so that future surveys can reestablish the plot and estimate growth, mortality, removals, and changes in land use.

Specific measurements and estimates made at each sample location generally follow the procedures used to assess timber in the Southern U. S. (USDA Forest Service, 1977). Modifications were made, however, to account for basic differences in the nature of secondary tropical forests as compared to southern forests. All procedures followed in Puerto Rico were assembled into a handbook of field instructions. Important modifications included the use of the metric system for measurements, separate assessments of sound and unsound cull volume, and a tally of all sound wood in bole and branches to a minimum 10 centimeter diameter.

RELIABILITY OF THE DATA

Reliability of the estimates may be affected by two types of errors. The first stems from the use of a sample to estimate the whole and from variability of the items being sampled. This is termed sampling error; it is susceptible to a mathematical evaluation of the probability of error. The second type —often referred to as reporting or estimating error —derives from mistakes in measurement, judgment, or recording, and from limitations of method or equipment. The Forest Service attempts to hold it to a minimum by proper training, supervision, and precision.

The Puerto Rico survey required a special team approach to satisfy fieldwork requirements for accuracy. In addition to the regular problems associated with measuring and estimating tree characteristics, the heterogeneous species composition required special knowledge of Puerto Rican dendrology. The approach teamed experienced timber cruisers from the Southern area with dendrologists and botanists from Puerto Rico.

A one-week training session was held in Puerto Rico to familiarize the timber cruisers with the characteristics of tropical trees, to standardize measurements and estimates, and to develop working teams. A noted taxonomist was hired as a consultant to identify unrecognized tree species.

Statistical analysis of the data indicates a sampling error of plus or minus 1.5 percent for the estimate of total timberland, and 7.6 percent for timber volume. As these totals are broken down by various strata, species, tree size, and other subdivisions, the possibility of error increases and is greatest for the smallest subdivisions. The order of this increase is suggested in the following tabulation, which shows the sampling error to which the timber volume and area estimates are liable, two chances out of three:

Sampling errors for timberland and timber volumes, Puerto Rico, 1980

Timberland	Sampling error[1]	Timber volume	Sampling error[1]
hectares	*percent*	*thousand cubic meters*	*percent*
130,500	1.5	5433.8	7.6
51,200	3.5	2519.7	14.0
20,800	4.4	348.6	19.6
8,900	9.9	...	...

[1]By random-sampling formula

The sampling error for estimates based on extrapolated or secondary information cannot be determined. These estimates should be considered less reliable than the estimates for timberland and timber volume.

DEFINITIONS OF TERMS

Forest Land Class

Forest Land—Land at least 10 percent stocked[6] by forest trees of any size, or formerly having had such tree cover and not currently developed for nonforest use. The minimum area for classification of forest land is ½ hectare, and the minimum width for forest strips is 35 meters. Unimproved roads and trails, streams, and clearings in forest areas are classed as forest if less than 35 meters in width.

Timberland—Forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization. Forest lands with higher priority uses, yet not specifically withdrawn from timber utilization, are excluded from this class of forest land. These excluded lands were delineated on a base map. Coffee shade is included in this category.

Noncommercial forest land—Forest land incapable of yielding crops of industrial wood because of adverse site conditions, forest land withdrawn from timber utilization through statute or administrative regulation, or forest land with higher priority use (except coffee shade).

[6]Ten percent of "normal" stocking as defined for the Midsouth forest survey.

Nonstocked land—Commercial forest land less than 10 percent stocked[6] with growing-stock trees. This includes areas covered by inhibiting vegetation (brush, vines, ferns, etc.) classed as forest land.

Secondary forest land—Forest land resulting from the abandonment of cropland or pasture, and forest resulting from the regeneration of previously cutover or disturbed forest land. Abandoned coffee shade is excluded from this class.

Coffee shade—A multi-story, multi-crop system used principally for the production of coffee. An upper story of shade trees is characteristic.

Abandoned coffee shade—Secondary forest land resulting from the abandonment of coffee production under shade trees.

Timberland Strata

Subtropical Moist Forest—Forest occurring in an ecological Life Zone delineated by a mean annual rainfall of 1000 or 1100 millimeters to about 2000 or 2200 millimeters, and a mean biotemperature between about 18 and 24 degrees centigrade (Holdridge 1967).

Subtropical Wet Forest—Forest occurring in an ecological Life Zone delineated by a mean annual rainfall of about 2000 to 4000 millimeters, and a mean annual biotemperature between about 18 and 24 degrees centigrade (Holdridge 1967).

Deep volcanic soils—Deep soils of the wet volcanic uplands, with clayey texture, typically red and acid (Zambrana 1978). The soil depth is generally more than 50 centimeters.

Shallow volcanic soils—Shallow soils of the wet volcanic uplands, with clayey texture (Zambrana 1978). The soil depth is generally less than 50 centimeters.

Granitic soils—Shallow soils of the wet uplands with granitic origin, and with a typically sand clay loam texture (Zambrana 1978).

Limestone soils—Shallow soils over limestone, found in the moist coastal hills (Zambrana 1978).

Noncommercial Forest Strata

Subtropical Dry Forest—An ecological Life Zone delineated by a mean annual rainfall of between 600 millimeters and 1000 or 1100 millimeters, and a mean annual biotemperature between about 18 and 24 degrees centigrade (Holdridge 1967).

Critical watersheds—Upland areas with an average slope greater than 60 percent or rainfall greater than 2500 millimeters per year. These areas require a continuous protective forest cover. Some timber removal would be feasible; however, much of the area is not highly productive.

Unproductive soils—Soils incapable of yielding crops of industrial wood.

Alluvial regions—River floodplains with agricultural land use.

Metropolitan regions—Regions with primarily urban or residential use.

Mangrove and swamp—Coastal wetlands with unique characteristics and values requiring special management considerations.

Noncontiguous regions—Islands and other land bodies separated from mainland Puerto Rico.

Class of Timber

Growing stock trees—Sawtimber trees, poletimber trees, saplings, and seedlings; that is, all live trees except rough and rotten trees.

Desirable trees—Growing-stock trees that have no serious defects to limit present or prospective use, are of relatively high vigor, and contain no pathogens that may result in death or serious deterioration before rotation age. These trees would be favored in silvicultural operations.

Acceptable trees—Trees meeting the specifications for growing stock but not qualifying as desirable trees.

Rough and rotten trees—Live trees that are unmerchantable for sawlogs now or prospectively because of defect or rot.

Sawtimber trees—Growing stock trees, 22.5 centimeters and larger in dbh for softwoods and 27.5 centimeters and larger for hardwoods, and containing at least one 3.5 meter sawlog.

Poletimber trees—Growing stock trees 12.5 to 22.5 centimeters in dbh for softwoods and 12.5 to 27.5 centimeters for hardwoods, and of good form and vigor.

Saplings—Growing stock trees 2.5 to 12.5 centimeters in dbh, and of good form and vigor.

Salvable dead trees—Standing or down dead trees that are currently or potentially merchantable.

Stand-Size Class

Sawtimber stands—Stands with at least 5 square meters per hectare of basal area in sawtimber or poletimber-size trees, and with sawtimber basal area at least equal to poletimber basal area.

Poletimber stands—Stands with at least 5 square meters per hectare of basal area in sawtimber or poletimber-size trees, and with poletimber basal area exceeding that of sawtimber basal area.

Sapling-seedling stands—Stands with at least 5 square meters per hectare of basal area, with more than half of this basal area in saplings or seedlings, or stands with less than 5 square meters per hectare of basal area.

Volume

Volume of sawtimber—Net volume of the sawlog portion of sawtimber trees in cubic meters, calculated according to the International rule, 0.635 centimeter (1/4 inch) kerf.

Volume of growing stock—Volume of sound wood (less cull volume) in the bole and branches of sawtimber and poletimber trees from stump to a minimum 10 centimeter diameter outside bark or to the point past which a one-meter section meeting minimum qualifications can no longer be measured because of limbs or other cull.

Volume of timber—Volume of all sound wood (including sound cull) in the bole and branches of growing stock, rough, rotten, and salvable dead trees 12.5 centimeters and larger in dbh, from stump to a minimum 10 centimeter diameter outside bark. The minimum length of any section included is one meter.

Miscellaneous Definitions

Basal area—The area in square meters of the cross section at breast height of a single tree or of all the trees in a stand, expressed as square meters per hectare.

Dbh (diameter at breast height)—Tree diameter in centimeters, outside bark, measured at 1.3 meters above ground.

Log grades—A classification of logs based on external characteristics as indicators of quality or value. Logs are graded according to standards used for hardwoods in the southern U.S. Grade 1 logs have very little sweep, crook, cull, or other defects, are the largest, and are suitable for standard lumber. Grade 4 logs need only be 20 centimeters at the small end, and are used only for ties and timbers. Grades 2 and 3 are between the two extremes.

STANDARD TABLES

Forest Area

Species Composition

Timber Volume

Table 1.—*Area by land classes, Puerto Rico, 1980*

Land class	Area
	hectares
Forest	
Commercial survey region (timberland)	
Public	8,200
Private	122,300
Total	130,500
Noncommercial survey region	
Subtropical Dry Forest Zone	30,000
Critical watersheds	74,400
Other[1]	43,800
Total	148,200
Total Forest	278,700
Nonforest	
Commercial survey region	
Cropland	41,500
Pasture	187,700
Other[2]	76,900
Total	306,100
Noncommercial survey region	305,500
Total Nonforest	611,600
All land	890,300

[1]Unproductive soils, alluvial and metropolitan regions, mangroves and swamps, non-contiguous land areas.
[2]Idle farmland, water, roads and rights of way, urban and industrial areas.

Table 2.—*Forest area by Life Zone and forest land class, Puerto Rico, 1980*

Subtropical Life Zone[1]	All forest land	Timberland	Noncommercial forest land
	hectares		
Dry Forest	40,500	.....	40,500
Moist Forest	122,400	60,400	62,000
Wet Forest	103,700	70,100	33,600
Rain Forest	1,300	.....	1,300
Lower Montane Wet Forest	9,600	.....	9,600
Lower Montane Rain Forest	1,200	.....	1,200
Total	278,700	130,500	148,200

[1]According to Holdridge system (Holdridge 1967).

Table 3.—*Area of timberland by Life Zone, soil group, and forest class, Puerto Rico, 1980*

Life Zone and soil group	Forest class: All classes	Secondary forest	Abandoned coffee shade	Active coffee shade	Nonstocked areas
	hectares				
Subtropical Moist Forest					
Deep volcanic soils	8,700	4,800	1,900	1,000	1,000
Shallow volcanic soils	21,300	12,500	4,400	.....	4,400
Granitic soils	9,600	8,100	1,500	.....	.....
Limestone soils	20,800	12,400	2,800	1,400	4,200
Total	60,400	37,800	10,600	2,400	9,600
Subtropical Wet Forest					
Deep volcanic soils	51,200	14,400	19,700	16,100	1,000
Shallow volcanic soils	9,200	1,200	5,700	2,300	.....
Granitic soils	8,900	5,000	2,200	600	1,100
Limestone soils	800	800	.....	.....	.....
Total	70,100	21,400	27,600	19,000	2,100
	130,500	59,200	38,200	21,400	11,700

Table 4.—Area of timberland by stand-volume class and forest class, Puerto Rico, 1980

Timber volume (cubic meters per hectare)	Forest class				
	All classes	Secondary forest	Abandoned coffee shade	Active coffee shade	Nonstocked areas
	---------- hectares ----------				
Less than 25	52,700	27,200	5,200	8,600	11,700
25 to 50	39,200	14,700	15,800	8,700	.....
50 to 75	16,400	3,700	9,500	3,200	.....
75 to 100	12,000	5,500	5,600	900	.....
More than 100	10,200	8,100	2,100	.....	.....
All classes	130,500	59,200	38,200	21,400	11,700

Table 5.—*Area of timberland by stand-volume class and soil group, Puerto Rico, 1980*

Timber volume (cubic meters per hectare)	Soil group				
	All groups	Deep volcanic	Shallow volcanic	Granitic	Limestone
	---------- hectares ----------				
Less than 25	52,700	14,600	15,900	7,800	14,400
25 to 50	39,200	19,900	7,400	7,600	4,300
50 to 75	16,400	8,100	3,400	2,000	2,880
75 to 100	12,000	9,000	1,900	1,100	.....
More than 100	10,200	8,300	1,900	.....	.....
All classes	130,500	59,900	30,500	18,500	21,600

Table 6.—*Area of timberland by stand-size class and forest class, Puerto Rico, 1980*

Stand-size class	Forest class				
	All classes	Secondary forest	Abandoned coffee shade	Active coffee shade	Nonstocked areas
	---------- hectares ----------				
Sawtimber	40,900	15,300	17,800	7,800	.....
Poletimber	44,700	18,700	16,500	9,500	.....
Sapling and seedling	33,200	25,200	3,900	4,100	.....
Nonstocked areas	11,700	.....	.....	.....	11,700
All classes	130,500	59,200	38,200	21,400	11,700

Table 7.—*Area of timberland by stand-size class and soil group, Puerto Rico, 1980*

Stand-size class	Soil group				
	All groups	Deep volcanic	Shallow volcanic	Granitic	Limestone
	hectares				
Sawtimber	40,900	21,800	9,700	5,000	4,400
Poletimber	44,700	27,900	5,600	8,300	2,900
Sapling and seedling	33,200	8,200	10,800	4,100	10,100
Nonstocked areas	11,700	2,000	4,400	1,100	4,200
All classes	130,500	59,900	30,500	18,500	21,600

Table 8.—*Area of timberland by stand age class and forest class, Puerto Rico, 1980*

Stand age (years)	Forest class				
	All classes	Secondary forest	Abandoned coffee shade	Active coffee shade	Nonstocked areas
	hectares				
Less than 30	86,300	42,200	16,900	15,500	11,700
More than 30	38,000	14,900	18,100	5,000	.....
Mixed ages	6,200	2,100	3,200	900	.....
All ages	130,500	59,200	38,200	21,400	11,700

Table 9.—*Area of timberland by stand age class and soil group, Puerto Rico, 1980*

Stand age (years)	Soil group				
	All groups	Deep volcanic	Shallow volcanic	Granitic	Limestone
	hectares				
Less than 30	86,300	38,300	22,600	15,300	10,100
More than 30	38,000	18,900	7,900	2,600	8,600
Mixed ages	6,200	2,700	.....	600	2,900
All ages	130,500	59,900	30,500	18,500	21,600

Table 10.—*Area of timberland by basal area class and forest class, Puerto Rico, 1980*

Basal area (square meters per hectare)	Forest class				
	All classes	Secondary forest	Abandoned coffee shade	Active coffee shade	Nonstocked areas
	hectares				
Less than 5	21,100	8,000	1,400	.....	11,700
5 to 10	34,900	13,200	9,300	12,400	.....
10 to 15	32,600	15,800	10,500	6,300	.....
15 to 20	24,700	8,100	13,900	2,700	.....
20 to 25	8,700	6,500	2,200	.....	.....
25 to 30	8,500	7,600	900	.....	.....
All classes	130,500	59,200	38,200	21,400	11,700

Table 11.—*Area of timberland by basal area class and stand-size class, Puerto Rico, 1980*

Basal area (square meters per hectare)	Stand-size class				
	All classes	Sawtimber	Poletimber	Sapling & seedling	Nonstocked areas
	hectares				
Less than 5	21,100	.....	.....	9,400	11,700
5 to 10	34,900	15,500	5,400	14,000	.....
10 to 15	32,600	7,000	18,600	7,000	.....
15 to 20	24,700	12,700	10,600	1,400	.....
20 to 25	8,700	2,900	4,400	1,400	.....
25 to 30	8,500	2,800	5,700	.....	.....
All classes	130,500	40,900	44,700	33,200	11,700

Table 12.—*Area of stocked timberland by Life Zone, soil group, and slope class, Puerto Rico, 1980*

Life Zone and soil group	Percent slope class				
	All classes	0 to 10	11 to 25	26 to 45	More than 45
	hectares				
Subtropical Moist Forest					
Deep volcanic soils	7,700	1,900	.....	1,900	3,900
Shallow volcanic soils	16,900	2,900	2,200	5,200	6,600
Granitic soils	9,600	.....	3,700	1,500	4,400
Limestone soils[1]	17,400	5,800	.....	.....	11,600
Total	51,600	10,600	5,900	8,600	26,500
Subtropical Wet Forest					
Deep volcanic soils	50,200	1,800	5,400	12,500	30,500
Shallow volcanic soils	9,200	.....	.....	2,300	6,900
Granitic soils	7,800	.....	.....	1,100	6,700
Total	67,200	1,800	5,400	15,900	44,100
All areas	118,800	11,400	11,300	24,500	70,600

[1]Includes small area from Subtropical Wet Forest.

Table 13.—*Number of live trees by species and diameter class, ranked by basal area plurality, Puerto Rico, 1980*[1]

Species code[2]	Scientific name	Total basal area (square meters)	All classes	5	10	15	20	25	30	35	40	45	50	55 and greater
			Diameter class (centimeters)											
			thousand trees											
64	*Inga vera* Willd.[3]	175,245	7,835	2,498	1,660	1,274	916	657	451	180	119	48	26	7
109	*Guarea guidonia* (L.) Sleumer	151,068	12,938	8,462	2,031	1,068	392	259	335	157	72	65	43	53
20	*Cecropia peltata* L.	82,048	3,731	2,001	179	269	363	524	205	110	44	10	13	11
81	*Andira inermis* (W. Wright) DC.	79,913	8,506	4,332	2,482	857	414	289	88	16	28	0	0	1
62	*Inga fagifolia* (L.) Willd.	63,097	3,645	1,041	1,422	440	230	253	170	46	19	15	5	3
188	*Eugenia jambos* L.	50,767	9,605	8,012	581	424	393	96	66	8	11	10	0	3
236	*Tabebuia heterophylla* (DC.) Britton	44,394	9,746	7,168	1,713	642	120	50	34	14	0	5	0	0
234	*Spathodea campanulata* Beauv.	41,165	6,693	5,698	436	162	205	61	66	20	10	6	11	17
131	*Mangifera indica* L.	40,001	1,057	805	73	0	0	33	9	24	15	11	17	69
100	*Citrus sinensis* Osbeck	37,263	4,479	2,193	1,190	700	367	29	0	0	0	0	0	0
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	34,043	607	193	45	0	109	116	23	46	30	4	13	27
200	*Dendropanax arboreus* (L.) Decne. & Planch.	31,992	3,039	2,279	191	274	92	63	64	31	22	10	2	10
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	26,127	2,407	1,100	650	426	131	46	24	7	10	5	4	4
240	*Coffea arabica* L.	25,662	25,425	25,257	168	0	0	0	0	0	0	0	0	0
48	*Ocotea leucoxylon* (Sw.) Mez.	24,506	3,963	2,839	586	283	143	68	31	12	0	0	0	0
7	*Prestoea montana* (R. Grah.) Nichols.	24,125	946	0	0	479	340	120	0	0	6	0	0	0
161	*Calophyllum calaba* L.	21,923	3,411	2,833	276	93	58	60	33	25	19	5	8	0
9	*Roystonea borinquena* O.F. Cook	21,499	241	0	0	0	26	11	69	73	46	11	4	0
118	*Alchornea latifolia* Sw.	20,204	1,571	653	315	353	178	19	49	0	0	0	4	0
143	*Thouinia striata* Radlk.	16,051	3,903	2,405	1,372	126	0	0	0	0	0	0	0	0
171	*Casearia guianensis* (Aubl.) Urban	15,303	12,224	11,899	325	0	0	0	0	0	0	0	0	0
1	*Cyathea arborea* (L.) J.E. Smith	15,068	1,695	147	1,296	253	0	0	0	0	0	0	0	0
193	*Myrcia splendens* (Sw.) DC.	14,490	5,231	4,483	622	82	26	18	0	0	0	0	0	0
22	*Ficus citrifolia* Mill.	14,298	566	354	0	62	44	19	36	20	9	9	4	9

224	*Cordia sulcata* DC.	13,831	2,213	1,737	134	222	39	43	18	15	0	5	0	0
163	*Clusia rosea* Jacq.	13,043	797	418	0	189	90	66	15	8	6	5	0	0
227	*Citharexylum fruticosum* L.	12,930	1,958	1,249	482	117	65	41	0	0	0	4	0	0
249	*Terebraria resinosa* (Vahl) Sprague	12,548	2,908	2,196	590	92	21	0	9	0	0	0	0	0
592	*Miconia* sp.	11,828	2,144	1,790	119	127	48	18	19	22	0	0	0	0
172	*Casearia sylvestris* Sw.	11,789	8,815	8,635	180	0	0	0	0	0	0	0	0	0
195	*Psidium guajava* L.	11,781	7,656	7,385	243	0	28	0	0	0	0	0	0	0
999	Unidentified species	11,707	2,281	2,014	139	69	0	0	29	7	9	13	0	0
199	*Tetrazygia elaeagnoides* (Sw.) DC.	11,577	3,851	3,028	732	90	0	0	0	0	0	0	0	0
221	*Cordia alliodora* (Ruiz & Pav.) Oken	11,349	1,542	1,174	168	96	37	13	40	14	0	0	0	0
86	*Lonchocarpus pentaphyllus* (Poir.) DC.	11,096	1,227	712	296	64	103	33	11	8	0	0	0	0
228	*Petitia domingensis* Jacq.	11,086	1,111	596	354	60	51	23	27	0	0	0	0	1
334	*Nectandra sintenisii* Mez.	10,710	2,030	1,457	416	96	34	18	0	0	0	2	0	5
208	*Dipholis salicifolia* (L.) A.D.C.	10,685	1,044	236	472	251	86	0	0	0	0	0	0	0
108	*Cedrela odorata* L.	10,617	445	294	0	40	57	0	0	22	18	5	3	5
244	*Guettarda scabra* (L.) Vent.	10,082	8,637	8,519	118	0	0	0	0	0	0	0	0	0
134	*Spondias mombin* L.	9,982	449	120	296	0	0	0	8	0	11	0	0	14
211	*Micropholis chrysophylloides* Pierre	9,899	847	368	221	132	53	33	31	9	0	0	0	0
102	*Zanthoxylum martinicense* (Lam.) DC.	9,232	987	712	60	124	43	31	0	0	6	11	0	0
115	*Byrsonima coriacea* (Sw.) DC.	9,144	355	120	60	67	20	38	28	7	10	4	0	0
17	*Artocarpus altilis (Parkinson) Fosberg*	8,888	167	60	0	27	0	29	8	13	23	0	0	7
198	*Miconia prasina* (Sw.) DC.	8,774	4,686	4,353	326	0	0	0	0	7	0	0	0	0
213	*Pouteria multiflora* (A.DC.) Eyma	8,226	227	118	0	0	46	19	11	24	6	0	0	4
151	*Montezuma speciossima* Sesse & Moc.	7,974	340	236	0	0	22	31	15	20	14	0	0	3
	Other species (142)	244,106	68,566	60,044	5,388	1,477	767	386	205	131	89	40	15	24
	All species	1,573,138	258,747	204,223	28,409	11,606	6,157	3,612	2,230	1,097	654	305	172	278

[1]Totals may not add due to rounding.
[2]Species code numbers are consistent with Little and Wadsworth (1964) and Little *et al.* (1974).

Table 14.—*Number of growing stock trees by species and diameter class, ranked by basal area plurality, Puerto Rico, 1980*[1]

Species code	Scientific name	Total basal area (square meters)	Diameter class (centimeters) All classes	15	20	25	30	35	40	45	50	55 and greater
			thousand trees									
20	*Cecropia peltata* L.	68,055	1,292	225	279	407	205	101	41	10	13	11
64	*Inga vera* Willd.	67,592	1,894	871	448	282	167	63	40	15	8	0
109	*Guarea guidonia* (L.) Sleumer	53,137	1,168	493	277	163	78	83	24	21	4	25
81	*Andira inermis* (W. Wright) DC.	37,006	1,251	672	304	211	34	16	12	0	0	1
62	*Inga fagifolia* (L.) Willd.	30,872	685	219	129	137	131	41	13	15	0	0
7	*Prestoea montana* (R. Grah.) Nichols.	24,125	946	479	340	120	0	0	7	0	0	0
234	*Spathodea campanulata* Beauv.	19,514	354	106	100	43	59	14	10	2	11	8
9	*Roystonea borinquena* O.F. Cook	18,855	214	0	26	11	53	66	46	11	0	0
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	18,762	169	0	45	50	15	18	10	0	8	22
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch	17,580	607	394	131	46	11	7	4	5	4	4
161	*Calophyllum calaba* L.	13,127	261	93	37	60	23	25	14	5	4	0
236	*Tabebuia heterophylla* (DC.) Britton	12,702	629	481	100	38	10	0	0	0	0	0
118	*Alchornea latifolia* Sw.	10,471	395	240	119	0	36	0	0	0	0	0
188	*Eugenia jambos* L.	8,764	279	114	118	31	9	0	6	0	0	0
224	*Cordia sulcata* DC.	7,971	229	145	20	30	18	10	0	5	0	0
592	*Miconia* sp.	7,903	235	127	48	18	19	22	0	0	0	0
200	*Dendropanax arboreus* (L.) Decne. & Planch.	7,013	234	202	0	0	30	0	0	0	0	1
208	*Dipholis salicifolia* (L.) A.D.C.	6,615	337	251	86	0	0	0	0	0	0	0
221	*Cordia alliodora* (Ruiz & Pav.) Oken	6,542	164	96	14	0	40	14	0	0	0	0
76	*Hymenaea courbaril* L.	6,123	181	72	62	26	8	7	5	0	0	0
213	*Pouteria multiflora* (A.DC.) Eyma	5,749	85	0	46	19	11	0	6	0	0	4
108	*Cedrela odorata* L.	5,525	92	39	27	0	0	7	13	0	3	3
100	*Citrus sinensis* Osbeck	5,393	263	156	106	0	0	0	0	0	0	0
106	*Dacryodes excelsea* Vahl	5,238	94	0	53	0	20	15	6	0	0	0

211	*Micropholis chrysophylloides* Pierre	5,238	163	84	25	33	21	0	0	0	0	0
712	*Anthocephalus chinensis* (Lam.) A. Rich. ex Wal	5,238	230	173	27	29	0	0	0	0	0	0
48	*Ocotea leucoxylon* (Sw.) Mez.	5,086	234	171	42	21	0	0	0	0	0	0
134	*Spondias mombin* L.	4,965	24	0	0	0	8	0	6	0	0	11
184	*Terminalia catappa* L.	4,925	68	0	17	0	33	10	8	0	0	0
115	*Byrsonima coriacea* (Sw.) DC.	4,828	94	35	20	12	10	7	10	0	0	0
334	*Nectandra sintenisii* Mez.	4,714	141	96	22	18	0	0	0	3	0	3
102	*Zanthoxylum martinicense* (Lam.) DC.	4,407	87	34	27	8	0	0	6	11	0	0
17	*Artocarpus altilis* (Parkinson) Fosberg	4,292	68	27	0	13	8	13	4	0	0	2
131	*Mangifera indica* L.	3,815	27	0	0	11	0	0	6	6	0	4
180	*Buchenavia capitata* (Vahl) Eichl.	3,667	55	0	18	14	0	9	8	5	0	0
332	*Nectandra membranacea* (Sw.) Griseb.	3,600	35	0	0	0	19	11	0	0	0	5
340	*Phoebe elongata* (Vahl) Nees	3,475	35	0	0	11	0	14	0	3	6	0
1	*Cyathea arborea* (L.) J.E. Smith	3,038	195	195	0	0	0	0	0	0	0	0
163	*Clusia rosea* Jacq.	2,863	97	35	41	21	0	0	0	0	0	0
86	*Lonchocarpus pentaphyllus* (Poir.) DC.	2,857	58	0	22	18	11	8	0	0	0	0
181	*Bucida buceras* L.	2,400	95	0	96	0	0	0	0	0	0	0
215	*Symplocos martinicensis* Jacq.	2,400	106	88	0	0	18	0	0	0	0	0
87	*Ormosia krugii* Urban	2,302	99	84	0	15	0	0	0	0	0	0
144	*Meliosma herbertii* Rolfe	2,245	55	36	0	0	12	8	0	0	0	0
208	*Dipholis salicifolia* (L.) A.D.C.	1,853	51	0	31	20	0	0	0	0	0	0
228	*Petitia domingensis* Jacq.	1,827	66	36	20	10	0	0	0	0	0	0
45	*Nectandra coriacea* (Sw.) Griseb.	1,812	62	0	49	13	0	0	0	0	0	0
212	*Micropholis garciniaefolia* Pierre	1,693	32	0	0	26	6	0	0	0	0	0
	Other species (35)	37,149	927	345	235	214	64	36	21	3	0	9
	All species	585,323	15,167	6,919	3,611	2,202	1,189	625	326	121	65	113

[1]Totals may not add due to rounding.

Table 15.—*Number of live trees on stocked timberland by diameter class and forest class, Puerto Rico, 1980*

Diameter class (centimeters)	Forest class			
	All classes	Secondary forest	Abandoned coffee shade	Active coffee shade
	trees per hectare			
5	1,719	2,220	1,307	1,068
10	239	310	191	130
15	98	107	96	76
20	52	55	49	48
25	30	26	35	36
30	19	16	24	17
35	9	8	11	11
40	6	5	7	3
45	3	2	4	(1)
50	1	1	2	(1)
55 +	2	(1)	4	2
All classes	2,178	2,752	1,728	1,393

[1]Less than one tree per hectare.

Table 16a.—*Basal area and number of live trees per hectare of stocked timberland for selected species, secondary forests, Puerto Rico, 1980*[1]

Species code	Scientific name	Basal area		Number of trees per hectare
		Square meters per hectare	Percent	
20[2]	*Cecropia peltata* L.	0.69	5.0	29
236[2]	*Tabebuia heterophylla* (DC.) Britton	0.67	4.8	160
109[2]	*Guarea guidonia* (L.) Sleumer	0.60	4.3	56
188	*Eugenia jambos* L.	0.59	4.3	94
64[2]	*Inga vera* Willd.	0.50	3.6	25
81[2]	*Andira inermis* (W. Wright) DC.	0.50	3.6	81
234	*Spathodea campanulata* Beauv.	0.44	3.2	92
7	*Prestoea montana* (R. Grah.) Nichols.	0.41	3.0	16
161[2]	*Calophyllum calaba* L.	0.35	2.5	57
131[2]	*Mangifera indica* L.	0.35	2.5	17
9	*Roystonea borinquena* O.F. Cook	0.32	2.3	4
143	*Thouinia striata* Radlk.	0.27	2.0	66
48[2]	*Ocotea leucoxylon* (Sw.) Mez.	0.27	2.0	33
118[2]	*Alchornea latifolia* Sw.	0.26	1.9	20
201[2]	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	0.25	1.8	17
193	*Myrcia splendens* (Sw.) DC.	0.23	1.7	80
163	*Clusia rosea* Jacq.	0.22	1.6	13
249	*Terebraria resinosa* (Vahl) Sprague	0.21	1.5	49
171	*Casearia guianensis* (Aubl.) Urban	0.21	1.5	168
62[2]	*Inga fagifolia* (L.) Willd.	0.21	1.5	16
199	*Tetrazygia elaeagnoides* (Sw.) DC.	0.20	1.4	65
208	*Dipholis salicifolia* (L.) A.D.C.	0.18	1.3	18
999	Unidentified species	0.17	1.2	37
244	*Guettarda scabra* (L.) Vent.	0.17	1.2	146
195	*Psidium guajava* L.	0.17	1.2	119
	Other species (147)	5.40	39.0	1,273
	All species	13.84	100.0	2,752

[1]Totals may not add due to rounding.
[2]Potential timber species.

Table 16b.—*Basal area and number of live trees per hec*[illegible]*cked timberland for selected species, abandoned coffee shade, Puerto Rico, 1980*[1]

Species code	Scientific name	Basal area: Square meters per hectare	Basal area: Percent	Number of trees per hectare
109[2]	*Guarea guidonia* (L.) Sleumer	2.41	17.2	227
64[2]	*Inga vera* Willd.	2.07	14.8	96
62[2]	*Inga fagifolia* (L.) Willd.	.95	6.8	57
20[2]	*Cecropia peltata* L.	.89	6.3	27
81[2]	*Andira inermis* (W. Wright) DC.	.80	5.7	66
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	.68	4.9	14
200[2]	*Dendropanax arboreus* (L.) Decne. & Planch.	.58	4.1	51
100	*Citrus sinensis* Osbeck	.49	3.5	56
131[2]	*Mangifera indica* L.	.46	3.3	1
234	*Spathodea campanulata* Beauv.	.39	2.8	28
188	*Eugenia jambos* L.	.37	2.6	92
201[2]	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	.30	2.1	35
240	*Coffea arabica* L.	.23	1.6	206
48[2]	*Ocotea leucoxylon* (Sw.) Mez.	.22	1.6	47
334[2]	*Nectandra sintenisii* Mez.	.20	1.4	35
224	*Cordia sulcata* DC.	.15	1.1	47
227	*Citharexylum fruticosum* L.	.14	1.0	19
102	*Zanthoxylum martinicense* (Lam.) DC.	.14	1.0	6
198	*Miconia prasina* (Sw.) DC.	.14	1.0	82
221[2]	*Cordia alliodora* (Ruiz & Pav.) Oken	.13	0.9	22
	Other species (61)	2.26	16.1	514
	All species	14.02	100.0	1,728

[1]Totals may not add due to rounding.
[2]Potential timber species.

Table 16c.—*Basal area and number of live trees per hectare of stocked timberland for selected species, active coffee shade, Puerto Rico, 1980*[1]

Species code	Scientific name	Basal area: Square meters per hectare	Basal area: Percent	Number of trees per hectare
64[2]	*Inga vera* Willd.	3.10	30.4	126
109[2]	*Guarea guidonia* (L.) Sleumer	1.09	10.7	45
81[2]	*Andira inermis* (W. Wright) DC.	.91	8.9	55
240	*Coffea arabica* L.	.71	7.0	748
62[2]	*Inga fagifolia* (L.) Willd.	.67	6.6	24
100	*Citrus sinensis* Osbeck	.60	5.9	80
20[2]	*Cecropia peltata* L.	.33	3.2	45
200[2]	*Dendropanax arboreus* (L.) Decne. & Planch.	.27	2.6	3
712[2]	*Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.	.24	2.4	11
1	*Cyathea arborea* (L.) J.E. Smith	.22	2.2	30
332	*Nectandra membranacea* (Sw.) Griseb.	.17	1.7	2
221[2]	*Cordia alliodora* (Ruiz & Pav.) Oken	.16	1.6	9
22	*Ficus citrifolia* Mill.	.14	1.4	3
236	*Tabebuia heterophylla* (DC.) Britton	.13	1.3	10
721	*Coffea dewevrei* Wildem. & T. Dur.	.12	1.2	60
592	*Clidemia umbrosa* (Sw.) Cogn.	.11	1.1	19
496[2]	*Hibiscus elatus* Sw.	.11	1.1	5
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	.10	1.0	1
131[2]	*Mangifera indica* L.	.09	.9	(3)
224	*Cordia sulcata* DC.	.09	.9	2
	Other species (24)	.84	8.2	144
	All species	10.20	100.0	1,393

[1]Totals may not add due to rounding.
[2]Potential timber species.
[3]Less than 1.

Table 17.—*Basal area of poletimber and sawtimber trees by tree class and forest class, Puerto Rico, 1980*

Tree class	Forest class: All classes	Secondary forest	Abandoned coffee shade	Active coffee shade
	square meters of basal area			
Poletimber-size trees:				
Growing stock	333,900	183,700	98,400	51,800
Rough & rotten	227,000	96,300	87,000	43,700
Total	560,900	280,000	185,400	95,500
Sawtimber-size trees:				
Growing stock	251,400	111,300	107,000	33,200
Rough & rotten	265,400	103,100	120,300	41,900
Total	516,800	214,400	227,300	75,100
All growing stock	585,300	295,000	205,400	85,000
All rough & rotten	492,400	199,400	207,300	85,600
All poletimber & sawtimber	1,077,700	494,400	412,700	170,600

Table 18.—*Basal area of poletimber and sawtimber trees by tree class, Life Zone, and soil group, Puerto Rico, 1980*

Tree class and Life Zone	Soil group: All groups	Deep volcanic soils	Shallow volcanic soils	Granitic soils	Limestone soils
	square meters of basal area				
Subtropical Moist Forest					
Poletimber-size trees					
Growing stock	104,200	18,500	30,600	20,300	34,800
Rough & rotten	77,800	13,700	30,000	19,700	14,400
Total	182,000	32,200	60,600	40,000	49,200
Sawtimber-size trees					
Growing stock	79,800	30,600	19,600	9,200	20,400
Rough & rotten	104,000	26,600	41,000	16,000	20,400
Total	183,800	57,200	60,600	25,200	40,800
All growing stock	184,000	49,100	50,200	29,500	55,200
All rough & rotten	181,800	40,300	71,000	35,700	34,800
Total	365,800	89,400	121,200	65,200	90,000
Subtropical Wet Forest					
Poletimber-size trees					
Growing stock	229,700	191,600	18,200	19,900	.....
Rough & rotten	149,200	107,000	26,000	16,200	.....
Total	378,900	298,600	44,200	36,100	.....
Sawtimber-size trees					
Growing stock	171,600	133,200	25,900	12,500	.....
Rough & rotten	161,400	113,000	32,600	15,800	.....
Total	333,000	246,200	58,500	28,300	.....
All growing stock	401,300	324,800	44,100	32,400	.....
All rough & rotten	310,600	220,000	58,600	32,000	.....
Total	711,900	544,800	102,700	64,400	.....
All Life Zones	1,077,700	634,200	223,900	129,600	90,000

Table 19.—*Volume of timber on timberland by class of timber and forest class, Puerto Rico, 1980*

Class of timber	Forest class: All classes	Secondary forest	Abandoned coffee shade	Active coffee shade
	thousand cubic meters			
Growing stock trees				
Sawtimber trees				
Sawlog portion	1,273.3	644.2	473.0	156.1
Upper stem	309.4	115.8	140.0	53.6
Branches and forks	53.2	21.9	20.7	10.6
Sound cull	137.6	57.4	63.4	16.8
Timber volume	1,773.5	839.3	697.1	237.1
Poletimber trees				
Bole volume	1,532.0	897.6	422.6	211.8
Branches and forks	32.1	23.0	7.3	1.8
Sound cull	73.1	43.2	18.7	11.2
Timber volume	1,637.2	963.8	448.6	224.8
All growing stock trees	3,410.7	1,803.1	1,145.7	461.9
Rough and rotten trees				
Rough trees				
Bole volume	1,370.1	437.7	589.0	203.4
Branches and forks	157.2	68.5	70.3	18.4
Sound cull	442.5	177.9	188.2	76.4
Timber volume	1,899.8	754.1	847.5	298.2
Rotten trees				
Bole volume	83.8	47.5	27.5	8.7
Branches and forks	11.5	9.0	1.5	1.0
Sound cull	28.0	15.1	6.6	6.4
Timber volume	123.3	71.6	35.6	16.1
All rough and rotten trees	2,023.1	825.7	883.1	314.3
All timber	5,433.8	2,628.8	2,028.8	776.2

Table 20.—*Volume of timber on timberland by Life Zone, soil group, and tree class, Puerto Rico, 1980*

Life Zone and tree class	Soil group: All soil groups	Deep volcanic soils	Shallow volcanic soils	Granitic soils	Limestone soils
	thousand cubic meters				
Subtropical Moist Zone					
Sawtimber trees	615.4	269.0	135.2	54.6	156.6
Poletimber trees	498.0	107.2	156.6	89.3	144.9
All growing stock trees	1,113.4	376.2	291.8	143.9	301.5
Rough trees	683.1	180.7	261.8	110.8	129.8
Rotten trees	52.3	7.8	18.0	20.5	6.0
All rough and rotten trees	735.4	188.5	279.8	131.3	135.8
All timber	1,848.8	564.7	571.6	275.2	437.3
Subtropical Wet Zone					
Sawtimber trees	1,158.1	924.6	146.3	87.2	.....
Poletimber trees	1,139.2	983.8	73.7	81.7	.....
All growing stock trees	2,297.3	1,908.4	220.0	168.9	.....
Rough trees	1,216.7	849.1	252.5	115.1	.....
Rotten trees	71.0	57.3	6.4	7.3	.....
All rough and rotten trees	1,287.7	906.4	258.9	122.4	.....
All timber	3,585.0	2,814.8	478.9	291.3	.....
All Life Zones	5,433.8	3,379.5	1,050.5	566.5	437.3

Table 21.—*Volume of timber on timberland by species and diameter class, Puerto Rico, 1980*[1]

Species code	Scientific name	All classes	Diameter class (centimeters) 15	20	25	30	35	40	45	50	55 and greater
		thousand cubic meters									
64	*Inga vera* Willd.	734.7	74.8	113.3	137.4	157.5	91.2	78.1	44.0	34.0	4.4
109	*Guarea guidonia* (L.) Sleumer	596.7	64.1	50.3	55.7	116.0	75.1	52.0	57.0	48.3	78.2
20	*Cecropia peltata* L.	439.5	25.1	46.5	143.6	79.7	62.9	34.3	11.7	18.2	17.3
81	*Andira inermis* (W. Wright) DC.	253.9	57.2	60.5	67.6	33.1	10.3	20.0	0.0	0.0	5.2
62	*Inga fagifolia* (L.) Willd.	265.3	31.2	32.2	54.3	73.2	32.5	18.5	13.4	3.6	6.4
188	*Eugenia jambos* L.	121.7	29.3	42.0	17.8	14.2	3.0	5.9	5.8	0.0	3.7
236	*Tabebuia heterophylla* (DC.) Britton	85.7	36.7	17.6	8.5	12.4	5.1	0.0	5.4	0.0	0.0
234	*Spathodea campanulata* Beauv.	159.1	9.1	23.4	9.7	23.5	12.2	10.4	6.4	14.1	50.3
131	*Mangifera indica* L.	173.2	0.0	0.0	7.9	2.4	5.3	7.6	10.0	14.3	125.8
100	*Citrus sinensis* Osbeck	60.2	29.5	26.3	4.4	0.0	0.0	0.0	0.0	0.0	0.0
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	184.7	0.0	8.8	19.8	7.2	21.5	18.5	3.9	15.6	89.3
200	*Dendropanax arboreus* (L.) Decne. & Planch.	114.6	15.1	9.3	10.0	24.5	12.6	15.1	7.5	0.5	20.0
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	103.6	23.2	27.7	13.9	6.3	5.6	5.0	5.3	5.4	11.2
48	*Ocotea leucoxylon* (Sw.) Mez.	60.9	18.9	14.3	14.2	6.1	7.4	0.0	0.0	0.0	0.0
7	*Prestoea montana* (R. Grah.) Nichols.	140.6	34.1	63.7	37.8	0.0	0.0	5.1	0.0	0.0	0.0
161	*Calophyllum calaba* L.	117.7	4.2	12.5	22.9	13.4	17.6	23.8	8.2	15.2	0.0
9	*Roystonea borinquena* O.F. Cook	218.5	0.0	11.0	3.1	58.7	56.3	66.3	19.4	3.5	0.0
118	*Alchornea latifolia* Sw.	79.8	25.3	32.4	2.2	14.4	0.0	0.0	0.0	5.6	0.0
22	*Ficus citrifolia* Mill.	45.4	1.5	1.8	1.0	9.0	7.0	3.3	8.5	6.8	0.0
224	*Cordia sulcata* DC.	56.5	19.4	5.7	11.2	9.5	6.4	0.0	4.3	0.0	6.5
163	*Clusia rosea* Jacq.	61.4	9.5	8.0	10.4	12.5	7.3	7.0	6.7	0.0	0.0
227	*Citharexylum fruticosum* L.	21.4	5.1	4.5	9.0	0.0	0.0	0.0	2.9	0.0	0.0

592	*Miconia* sp.	55.3	6.9	9.2	8.3	11.3	19.6	0.0	0.0	0.0	0.0
999	Unidentified species	43.9	5.4	0.0	0.0	13.4	4.3	9.4	11.3	0.0	0.0
221	*Cordia alliodora* (Ruiz & Pav.) Oken	53.2	10.7	4.5	3.5	23.7	10.8	0.0	0.0	0.0	0.0
86	*Lonchocarpus pentaphyllus* (Poir.) DC.	35.3	5.0	14.2	6.5	5.8	3.8	0.0	0.0	0.0	0.0
228	*Petitia domingensis* Jacq.	26.6	3.3	10.5	6.1	6.0	0.0	0.0	0.0	0.0	0.7
334	*Nectandra sintenisii* Mez.	36.0	7.8	9.4	3.1	0.0	0.0	0.0	5.6	0.0	9.9
208	*Dipholis salicifolia* (L.) A.DC.	29.1	18.3	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	*Cedrela odorata* L.	47.8	2.6	3.9	0.0	0.0	11.0	12.0	2.2	3.9	12.3
134	*Spondias mombin* L.	37.8	0.0	0.0	0.0	3.9	0.0	6.2	0.0	0.0	27.7
211	*Micropholis chrysophylloides* Pierre	37.0	7.0	5.2	8.4	13.5	2.8	0.0	0.0	0.0	0.0
102	*Zanthoxylum martinicense* (Lam.) DC.	39.5	8.3	5.4	7.1	0.0	0.0	5.9	12.8	0.0	0.0
115	*Byrsonima coriacea* (Sw.) DC.	54.9	6.5	3.3	12.4	12.3	5.4	9.8	5.2	0.0	0.0
17	*Artocarpus altilis* (Parkinson) Fosberg	45.4	1.9	0.0	5.9	2.9	5.7	17.3	0.0	0.0	11.8
213	*Pouteria multiflora* (A.DC.) Eyma	48.6	0.0	7.9	3.3	4.5	11.3	4.8	0.0	0.0	16.7
151	*Montezuma speciossima* Sesse & Moc.	30.0	0.0	2.3	3.8	3.5	5.0	10.7	0.0	0.0	4.7
76	*Hymenaea courbaril* L.	55.7	5.2	15.9	9.0	6.8	6.7	5.7	6.2	0.0	0.0
106	*Dacryodes excelsa* Vahl.	41.0	0.0	9.7	0.0	12.6	13.5	5.1	0.0	0.0	0.0
180	*Buchenavia capitata* (Vahl) Eichl.	38.8	0.0	2.1	8.0	0.0	5.4	5.8	8.9	0.0	8.6
181	*Bucida buceras* L.	21.0	0.0	11.9	0.0	3.3	0.0	0.0	0.0	0.0	5.7
184	*Terminalia catappa* L.	35.6	0.0	7.9	0.0	11.0	9.8	6.9	0.0	0.0	0.0
230	*Vitex divaricata* (Sw.)	29.1	0.0	4.1	0.0	0.0	10.6	9.4	0.0	0.0	5.0
332	*Nectandra membranacea* (Sw.) Griseb.	31.2	0.0	0.0	0.0	7.2	12.3	0.0	0.0	0.0	11.7
340	*Phoebe elongata* (Vahl) Nees	32.6	2.2	0.0	3.6	0.0	10.0	0.0	2.2	14.5	0.0
712	*Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.	22.0	9.8	3.9	8.3	0.0	0.0	0.0	0.0	0.0	0.0
	Other species	411.1	113.8	60.7	82.2	44.1	29.6	28.0	18.0	9.0	26.4
	Totals	5,433.8	728.1	814.6	841.8	859.6	616.8	507.9	292.9	212.6	559.5

[1]Totals may not add due to rounding.

Table 22.—*Volume of growing stock on timberland by species and diameter class, Puerto Rico, 1980*[1]

Species code	Scientific name	All classes	15	20	25	30	35	40	45	50	55 and greater
						Diameter class (centimeters)					
						thousand cubic meters					
64	*Inga vera* Willd.	344.0	54.7	61.8	62.2	66.3	39.4	33.4	17.8	8.4	0.0
109	*Guarea guidonia* (L.) Sleumer	249.6	36.4	33.7	33.8	25.8	43.7	18.3	18.0	5.8	34.2
20	*Cecropia peltata* L.	384.9	19.3	39.3	113.6	77.4	58.7	31.4	11.3	17.2	16.7
81	*Andira inermis* (W. Wright) DC.	175.0	46.2	42.9	48.7	13.7	9.6	11.0	0.0	0.0	3.0
82	*Inga fagifolia* (L.) Willd.	175.8	18.2	17.6	32.4	56.0	27.1	11.9	12.7	0.0	0.0
3	*Eugenia jambos* L.	37.8	11.4	17.5	6.2	2.4	0.0	0.2	0.0	0.0	0.0
36	*Tabebuia heterophylla* (DC.) Britton	57.0	30.4	16.0	6.2	4.4	0.0	0.0	0.0	0.0	0.0
234	*Spathodea campanulata* Beauv.	107.2	7.1	12.4	6.4	18.4	10.5	10.0	2.5	12.2	27.7
131	*Mangifera indica* L.	23.5	0.0	0.0	3.2	0.0	0.0	3.7	5.2	0.0	11.4
100	*Citrus sinensis* Osbeck	12.1	5.8	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	103.4	0.0	4.6	10.0	4.4	8.6	6.4	0.0	10.4	58.9
200	*Dendropanax arboreus* (L.) Decne. & Planch.	27.9	12.3	0.0	0.0	8.7	0.0	0.0	0.0	0.0	6.9
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	94.2	21.0	26.9	13.2	4.1	5.6	2.7	5.3	4.9	10.5
48	*Ocotea leucoxylon* (Sw.) Mez.	24.7	12.2	5.7	6.8	0.0	0.0	0.0	0.0	0.0	0.0
7	*Prestoea montana* (R. Grah.) Nichols.	139.5	34.1	63.7	37.1	0.0	0.0	4.6	0.0	0.0	0.0
161	*Calophyllum calaba* L.	85.8	4.2	8.6	21.7	8.2	12.8	16.5	6.3	7.4	0.0
9	*Roystonea borinquena* O.F. Cook	202.1	0.0	11.0	3.1	48.8	53.4	66.3	19.4	0.0	0.0
118	*Alchornea latifolia* Sw.	56.8	20.8	26.4	0.0	9.5	0.0	0.0	0.0	0.0	0.0
1	*Cyathea arborea* (L.) J.E. Smith	16.2	16.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
224	*Cordia sulcata* DC.	41.1	14.3	3.3	7.3	8.3	4.6	0.0	3.2	0.0	0.0
592	*Miconia* sp.	54.2	6.9	9.2	8.3	10.6	19.2	0.0	0.0	0.0	0.0
221	*Cordia alliodora* (Ruiz & Pav.) Oken	44.3	10.1	1.8	0.0	23.3	9.1	0.0	0.0	0.0	0.0
86	*Lonchocarpus pentaphyllus* (Poir.) DC.	16.4	0.0	2.1	4.7	5.8	3.7	0.0	0.0	0.0	0.0
334	*Nectandra sintenisii* Mez.	29.1	7.5	7.8	3.0	0.0	0.0	0.0	4.9	0.0	5.9
208	*Dipholis salicifolia* (L.) A.D.C.	28.2	18.0	10.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	*Cedrela odorata* L.	24.6	2.6	2.1	0.0	0.0	3.3	8.4	0.0	3.5	4.6
134	*Spondias mombin* L.	28.5	0.0	0.0	0.0	3.5	0.0	4.7	0.0	0.0	20.3
211	*Micropholis chrysophylloides* Pierre	25.0	5.1	1.9	8.0	10.0	0.0	0.0	0.0	0.0	0.0
102	*Zanthoxylum martinicense* (Lam.) DC.	22.1	1.4	3.6	3.5	0.0	0.0	4.6	9.0	0.0	0.0
115	*Byrsonima coriacea* (Sw.) DC.	31.0	4.4	3.0	4.8	4.2	5.1	9.4	0.0	0.0	0.0
17	*Artocarpus altilis* (Parkinson) Fosberg	21.0	1.9	0.0	2.9	2.9	5.0	3.4	0.0	0.0	4.9
45	*Nectandra coriacea* (Sw.) Griseb.	12.9	0.0	5.8	7.2	0.0	0.0	0.0	0.0	0.0	0.0
76	*Hymenaea courbaril* L.	48.2	5.2	15.9	8.1	6.8	6.6	5.5	0.0	0.0	0.0
87	*Ormosia krugii* Urban	11.1	7.8	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
106	*Dacryodes excelsa* Vahl.	41.0	0.0	9.7	0.0	12.6	13.5	5.1	0.0	0.0	0.0
144	*Meliosma herbertii* Rolfe	13.7	2.8	0.0	0.0	6.6	4.3	0.0	0.0	0.0	0.0
180	*Buchenavia capitata* (Vahl) Eich.	20.9	0.0	2.0	5.6	0.0	5.1	1.7	6.6	0.0	0.0
181	*Bucida buceras* L.	11.5	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
184	*Terminalia catappa* L.	24.5	0.0	2.6	0.0	10.5	5.3	6.1	0.0	0.0	0.0
340	*Phoebe elongata* (Vahl) Nees	28.1	0.0	0.0	3.4	0.0	9.8	0.0	1.5	13.4	0.0
712	*Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.	22.0	9.8	3.9	8.3	0.0	0.0	0.0	0.0	0.0	0.0
213	*Pouteria multiflora* (A.DC.) Eyma	31.4	0.0	5.2	1.9	4.5	0.0	4.8	0.0	0.0	0.0
	Other species	251.9	30.6	46.6	56.8	33.6	34.6	19.8	3.8	0.0	15.1
	Totals	3,200.1	479.6	542.8	541.7	491.2	398.6	289.8	127.6	83.2	245.4

[1]Totals may not add due to rounding.

Table 23.—*Volume of sawtimber on timberland by species and diameter class, Puerto Rico, 1980*[1]

Species code	Scientific name	Diameter (centimeters)						
		All classes	30	35	40	45	50	55 and greater
		thousand cubic meters						
64	*Inga vera* Willd.	54.2	22.1	12.3	12.3	6.1	1.5	0.0
109	*Guarea guidonia* (L.) Sleumer	43.9	8.8	14.2	6.8	5.9	2.1	6.1
20	*Cecropia peltata* L.	79.5	26.9	22.1	11.9	4.8	7.1	6.7
81	*Andira inermis* (W. Wright) DC.	12.6	2.6	5.0	4.8	0.0	0.0	0.2
62	*Inga fagifolia* (L.) Willd.	35.5	19.3	6.2	5.4	4.6	0.0	0.0
188	*Eugenia jambos* L.	1.5	0.5	0.0	1.0	0.0	0.0	0.0
234	*Spathodea campanulata* Beauv.	24.5	7.1	4.2	3.3	0.0	1.4	8.5
131	*Mangifera indica* L.	6.9	0.0	0.0	1.3	2.1	0.0	3.5
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	25.8	1.4	3.2	2.3	0.0	1.9	17.0
200	*Dendropanax arboreus* (L.) Decne. & Planch.	5.7	3.2	0.0	0.0	0.0	0.0	2.5
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	13.3	1.9	2.5	1.0	2.1	1.9	3.9
161	*Calophyllum calaba* L.	10.1	1.5	1.1	6.1	0.0	1.4	0.0
118	*Alchornea latifolia* Sw.	2.9	2.9	0.0	0.0	0.0	0.0	0.0
224	*Cordia sulcata* DC.	2.2	0.3	1.7	0.0	0.1	0.0	0.0
592	*Clidemia umbrosa* (Sw.) Cogn.	14.4	3.9	10.5	0.0	0.0	0.0	0.0
999	Unidentified species	2.7	0.0	0.0	2.7	0.0	0.0	0.0
221	*Cordia alliodora* (Ruiz & Pav.) Oken	14.1	9.4	4.6	0.0	0.0	0.0	0.0
86	*Lonchocarpus pentaphyllus* (Poir.) DC.	4.1	2.4	1.7	0.0	0.0	0.0	0.0
334	*Nectandra sintenisii* Mez.	2.3	0.0	0.0	0.0	2.2	0.0	0.1
108	*Cedrela odorata* L.	6.1	0.0	1.7	2.5	0.0	0.0	1.8
134	*Spondias mombin* L.	10.0	1.2	0.0	2.2	0.0	0.0	6.6
211	*Micropholis chrysophylloides* Pierre	4.2	4.2	0.0	0.0	0.0	0.0	0.0
102	*Zanthoxylum martinicense* (Lam.) DC.	5.1	0.0	0.0	1.7	3.5	0.0	0.0
115	*Byrsonima coriacea* (Sw.) DC.	7.9	2.7	1.8	3.3	0.0	0.0	0.0
17	*Artocarpus altilis* (Parkinson) Fosberg	5.5	0.7	1.6	1.4	0.0	0.0	1.8
198	*Miconia prasina* (Sw.) D.C.	1.8	0.0	1.8	0.0	0.0	0.0	0.0
213	*Pouteria multiflora* (A.DC) Eyma)	9.9	1.1	0.0	1.5	0.0	0.0	7.2
151	*Montezuma speciossima* Sesse & Moc.	1.7	0.0	0.0	1.7	0.0	0.0	0.0
34	*Magnolia portoricensis* Bello	3.3	0.0	1.8	1.5	0.0	0.0	0.0
76	*Hymenaea courbaril* L.	6.6	3.7	1.1	1.8	0.0	0.0	0.0
106	*Dacryodes excelsea* Vahl	14.6	5.5	7.2	1.9	0.0	0.0	0.0
133	*Spondias dulcis* Parkinson	1.7	0.0	0.0	0.0	1.7	0.0	0.0
144	*Meliosma herbertii* Rolfe	4.8	2.6	2.2	0.0	0.0	0.0	0.0
149	*Sloanea berteriana* Choisy	2.5	0.0	0.0	2.5	0.0	0.0	0.0
164	*Mammea americana* L.	1.7	0.0	0.0	0.0	0.0	0.0	1.7
180	*Buchenavia capitata* (Vahl) Eichl.	7.3	0.0	2.7	2.0	2.6	0.0	0.0
184	*Terminalia catappa* L.	3.7	3.5	0.0	0.2	0.0	0.0	0.0
215	*Symplocos martinicensis* Jacq.	1.6	1.6	0.0	0.0	0.0	0.0	0.0
230	*Vitex divaricata* Sw.	2.3	0.0	0.0	0.0	0.0	0.0	2.3
324	*Rollinia mucosa* (Jacq.) Baill.	1.5	1.5	0.0	0.0	0.0	0.0	0.0
332	*Nectandra membranacea* (Sw.) Griseb.	11.5	1.3	5.3	0.0	0.0	0.0	4.9
340	*Phoebe elongata* (Vahl) Nees	8.6	0.0	3.7	0.0	0.8	4.1	0.0
428	*Polygala penaea* L.	1.1	1.1	0.0	0.0	0.0	0.0	0.0
	Other species	3.8	2.9	0.0	0.0	0.0	0.0	1.0
	Totals	484.7	147.9	120.2	83.0	36.4	21.5	75.8

[1]Totals may not add due to rounding.

Table 24.—*Volume of sawtimber on timberland by species and butt log grade. Puerto Rico, 1980*

Species code	Scientific name	All classes	Butt log grade[1] 1	2	3	4	Volume in ungraded portion
		thousand cubic meters					
64	*Inga vera* Willd.	54.2	1.9	6.6	36.9	0.7	8.1
109	*Guarea guidonia* (L.) Sleumer	43.9	1.8	11.6	23.9	1.1	5.4
20	*Cecropia peltata* L.	79.5	9.0	6.7	44.1	0.0	19.7
81	*Andira inermis* (W. Wright) DC.	12.6	1.6	3.4	4.1	0.0	3.5
62	*Inga fagifolia* (L.) Willd.	35.5	0.0	3.6	23.8	0.7	7.4
234	*Spathodea campanulata* Beauv.	24.5	0.8	0.8	14.2	0.9	7.9
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	25.8	7.9	3.3	6.4	0.0	8.1
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	13.3	2.4	3.5	2.6	0.0	4.8
161	*Calophyllum calaba* L.	10.1	0.0	0.7	3.6	1.5	4.3
592	*Miconia* sp.	14.4	4.2	4.7	0.0	0.0	5.6
221	*Cordia alliodora* (Ruiz & Pav.) Oken	14.1	0.0	1.8	7.5	0.0	4.8
134	*Spondias mombin* L.	10.0	1.3	5.8	0.8	0.0	2.1
106	*Dacryodes excelsea* Vahl	14.6	4.9	3.4	0.0	0.0	6.3
332	*Nectandra membranacea* (Sw.) Griseb.	11.5	1.3	2.8	2.8	0.0	4.6
	Other species	120.7	1.4	35.0	49.5	3.7	31.1
	All Species	484.7	38.5	93.7	220.2	8.6	123.7

[1]Graded by hardwood log grade standards used in the southern U.S.

Table 25.—*Volume of timber, growing stock, and sawtimber on timberland by stand-size class, Puerto Rico, 1980*

Stand-size class	Volume of timber	Volume of growing stock	Volume of sawtimber
	thousand cubic meters		
Sawtimber	2,565.5	1,435.1	286.1
Poletimber	2,519.7	1,584.7	179.1
Sapling-seedling	348.6	180.3	18.7
All classes	5,433.8	3,200.1	484.7

Table 26.—*Volume of timber on timberland by Life Zone, soil group, and slope class, Puerto Rico, 1980*

Life Zone and soil group	Percent slope class: All classes	0 to 10	11 to 25	26 to 45	More than 45
	thousand cubic meters				
Subtropical Moist Forest					
Deep volcanic soils	564.7	63.8	0.0	70.6	430.3
Shallow volcanic soils	571.6	104.7	75.5	199.8	191.6
Granitic soils	275.2	0.0	123.3	42.4	109.5
Limestone soils	437.3	256.1	0.0	0.0	181.2
Total	1,848.8	424.6	198.8	312.8	912.6
Subtropical Wet Forest					
Deep volcanic soils	2,814.8	118.4	291.4	624.3	1,780.7
Shallow volcanic soils	478.9	0.0	0.0	97.2	381.7
Granitic soils	291.3	0.0	0.0	40.4	250.9
Total	3,585.0	118.4	291.4	761.9	2,413.2
All Life Zones	5,433.8	543.0	490.2	1,074.7	3,325.9

UNIT CONVERSION FACTORS

Metric to English and English to Metric Conversions

1 cm. = 0.3937 in.	1 in. = 2.54 cm.
1 m. = 3.281 ft.	1 ft. = .3048 in.
1 km. = .6214 mi.	1 mi. = 1.6093 km.
1 sq. m. = 10.7639 sq. ft.	1 sq. ft. = 0.0929 sq. m.
1 sq. km. = 0.3861 sq. mi.	1 sq. mi. = 2.59 sq. km.
1 ha. = 2.471 ac.	1 ac. = 0.4047 ha.
1 cu. m. = 35.3145 cu. ft.	1 cu. ft. = 0.0283 cu. m.
1 sq. m. per ha. = 4.356 sq. ft./ac.	1 sq. ft./ac. = 0.2296 sq. m./ha.
1 cu. m. per ha. = 14.29 cu. ft./ac.	1 cu. ft./ac. = 0.07 cu. m./ha.

METRIC INVENTORY STANDARDS USED IN THE 1980 SURVEY

Item	Metric standard
Prism size	BAF 2.5
Grid spacing	3 km.
Cluster point spacing	25 m.
Fixed plot size	40 m.^{2}(r = 3.6 m.)
	15 m.^{2}(r = 2.2 m.)
Breast height	1.3 m.
Stump height	30 cm.
Diameter classes	5cm. = 2.5 to 7.5 cm. dbh
	10cm. = 7.5 to 12.5cm. dbh
	15cm. = 12.5 to 17.5cm. dbh
	20cm. = 17.5 to 22.5cm. dbh etc.
Tree size classes	
Sapling	2.5 to 12.5 cm. dbh
Poletimber (hardwood)	12.5 to 27.5 cm. dbh
Sawtimber (hardwood)	27.5 cm. + dbh
Sawtimber (softwood)	22.5 cm. + dbh
Minimum top D.O.B.	
Cubic volume	10 cm.
Hardwood sawlog	22.5 cm.
Softwood sawlog	17.5 cm.
Sapling	2.5 cm.
Minimum D.I.B. sawlog	
Hardwood	20 cm.
Softwood	15 cm.
Minimum length	
Cubic section	1 m.
Sawlog	2.5 m.
Sawtimber tree	3.5 m. sawlog

LIST OF TREE SPECIES INCLUDED IN STANDARD TABLES

Code number	Scientific name	Common name
1	*Cyathea arborea* (L.) J.E. Smith	Helecho gigante, tree-fern
7	*Prestoea montana* (R. Grah.) Nichols.	Palma de sierra, sierra palm
9	*Roystonea borinquena* O.F. Cook	Palma real, royal palm, Puerto Rico royalpalm
17	*Artocarpus altilis* (Parkinson) Fosberg	Panapen, pana de pepitas, breadfruit
20	*Cecropia peltata* L.	Yagrumo hembra, trumpet-tree
22	*Ficus Citrifolia* Mill.	Jaguey blanco, shortleaf fig
34	*Magnolia portoricensis* Bello	Jaguilla
45	*Nectandra coriacea* (Sw.) Griseb.	Laurel avispillo, Jamaica nectandra
48	*Ocotea leucoxylon* (Sw.) Mez	Laurel geo
62	*Inga fagifolia* (L.) Willd.	Guama, "sweetpea"
64	*Inga vera* Willd.	Guaba
76	*Hymenaea courbaril* L.	Algarrobo, West-Indian-locust
81	*Andira inermis* (W. Wright) DC.	Moca, cabbage angelin
84	*Erythrina poeppigiana* (Walp.) O.F. Cook	Bucayo gigante, mountain immortelle
86	*Lonchocarpus pentaphyllus* (Poir.) DC.	Retama
87	*Ormosia krugii* Urban	Palo de matos
100	*Citrus sinensis* Osbeck	China, sweet orange
102	*Zanthoxylum martinicense* (Lam.) DC.	Espino rubial, white-prickle
106	*Dacryodes excelsea* Vahl	Tabonuco
108	*Cedrela odorata* L.	Cedro hembra, Spanish-cedar
109	*Guarea guidonia* (L.) Sleumer	Guaraguao, American muskwood
115	*Byrsonima coriacea* (Sw.) DC.	Maricao
118	*Alchornea latifolia* Sw.	Achiotillo
131	*Mangifera indica* L.	Mango
133	*Spondias dulcis* Parkinson	Jobo de la India, ambarella
134	*Spondias mombin* L.	Jobo, hogplum, yellow mombin
143	*Thouinia striata* Radlk	Ceboruquillo
144	*Meliosma herbertii* Rolfe	Aguacatillo
149	*Sloanea berteriana* Choisy	Motillo
151	*Montezuma speciossima* Sesse & Moc.	Maga
161	*Calophyllum calaba* L.	Maria, santa-maria
163	*Clusia rosea* Jacq.	Cupey, wild-mammee, copey clusia
164	*Mammea americana* L.	Mamey, mammee-apple
171	*Casearia guianensis* (Aubl.) Urban	Palo blanco, wild-coffee
172	*Casearia sylvestris* Sw.	Cafeillo
180	*Buchenavia capitata* (Vahl) Eichl.	Granadillo
181	*Bucida buceras* L.	Ucar, gregre, oxhorn bucida
184	*Terminalia catappa* L.	Almendra, Indian-almond
188	*Eugenia jambos* L.	Pomarrosa, Rose-apple
193	*Myrcia splendens* (Sw.) DC	Hoja menuda
195	*Psidium guajava* L.	Guayaba, common guava
198	*Miconia prasina* (Sw.) DC	Camasey
199	*Tetrazygia elaeagnoides* (Sw.) DC	Verdiseco
200	*Dendropanax arboreus* (L.) Decne. & Planch.	Pollo
201	*Didymopanax morototoni* (Aubl.) Decne. & Planch.	Yagrumo macho, matchwood
208	*Dipholis salicifolia* (L.) A.D.C.	Sanguinaria, wild mespel, willow bustic
211	*Micropholis chrysophylloides* Pierre	Caimitillo
212	*Micropholis garciniaefolia* Pierre	Caimitillo verde
213	*Pouteria multiflora* (A.DC.) Eyma	Jacana

LIST OF TREE SPECIES INCLUDED IN STANDARD TABLES—Continued

Code number	Scientific name	Common name
215	*Symplocos martinicensis* Jacq.	Aceituna blanca, candlewood
221	*Cordia alliodora* (Ruiz & Pav.) Oken	Capa prieto, capa
224	*Cordia sulcata* DC.	Moral, white manjack
227	*Citharexylum fruticosum* L.	Pendula, pasture fiddlewood, Florida fiddlewood
228	*Petitia domingensis* Jacq.	Capa blanco
230	*Vitex divaricata* Sw.	Higuerillo, white fiddlewood
234	*Spathodea campanulata* Beauv.	Tulipan africano, African tuliptree
236	*Tabebuia heterophylla* (DC.) Britton	Roble blanco, "white-cedar"
240	*Coffea arabica* L.	Cafe, coffee
244	*Guettarda scabra* (L.) Vent	Palo de cucubano, "greenheart," roughleaf velvetseed
249	*Terebraria resinosa* (Vahl) Sprague	Aquilon
324	*Rollinia mucosa* (Jacq.) Baill.	Anon cimarron
332	*Nectandra membranacea* (Sw.) Griseb.	Laurel prieto
334	*Nectandra sintenisii* Mez.	Laurel amarillo
340	*Phoebe elongata* (Vahl) Nees	Laurel avispillo
428	*Polygala penaea* L.	. . . .
496	*Hibiscus elatus* Sw.	Majo, mahoe
592	*Clidemia umbrosa* (Sw.) Cogn.	Camasey
712	*Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.	Kadam
721	*Coffea dewevrei* Wildem. & T. Dur.	Cafe excelsa, dewevre coffee