Chapter 6

U.S. Tropical Forests: Caribbean and Western Pacific

Contents

List of Tables

List of Figures

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HIGHLIGHTS

- Past poor land-use practices have degraded forest resources in the U.S. Caribbean and Pacific tropical territories and have resulted in significant amounts of abandoned land and relatively unproductive secondary forest. Related resources (e. g., water supplies and coastal marine resources) are, in many places, threatened by forest loss.
- Although not a problem at present, overexploitation of island forests is likely to occur as populations grow and expectations rise. Much of this could be avoided if forest resource development were integrated with economic development.
- Only Puerto Rico has significant potential for commercial forestry, but both the Pacific and Caribbean territories could provide a greater share of their domestic forest product needs.
- The territorial governments all have designated natural resource agencies and have expressed their recognition of the need to integrate forestry into development, but most of the agencies are small and lack adequate funding and personnel.

INTRODUCTION

Less than 1 percent of the world's tropical forests fall under U.S. jurisdiction. These are located primarily in Puerto Rico, the U.S. Virgin Islands, the U.S. Pacific territories of American Samoa and Micronesia (Guam, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands), and Hawaii. Both the Caribbean and Pacific territories have a long history of land-use practices that have created relatively large areas of degraded or abandoned forest land. For over a century, Hawaii has restricted use of its forest areas, primarily to protect their watershed values.

Puerto Rico includes the adjacent small islands. It includes the easternmost islands of the Greater Antilles in the West Indies. It is a mountainous land with a variety of ecosystems. Today, at least one-third of Puerto Rico's 2.2 million acres* is under forest cover, mostly second growth trees, fruit tree plantations, and shade covers in the remaining coffee regions. Despite this, Puerto Rico produces less than 1 percent of its domestic wood requirements (43).

The U.S. Virgin Islands are an unincorporated territory east of Puerto Rico containing about 86,500 acres, including about 50 islands and islets. They have been administered since 1951 by the U.S. Department of the Interior. The three largest islands—st. Croix, St. John, and St. Thomas—are used extensively for tourism and have effectively no forest products industry. However, three-fourths of the island of St. John is the Virgin Island National Park.

*All land areas in this chapter will appear in acres, as this is the common measurement for U.S. lands. One hectare = 2.47 acres.

Water retention and control, protection of critical marine habitats, and esthetic values are the primary purposes of the forests on these islands.

The U.S. tropical forests in the western Pacific are located in Micronesia and American Samoa. Micronesia includes some 2,000 islands within 3 million square miles in the western Pacific north of the Equator, southwest of Hawaii, and extending west to within 500 miles of the Philippines. They range in size from small, unoccupied coral atolls to large, populated volcanic islands. American Samoa consists of seven islands located south of the Equator. Some wood products are harvested on these islands for local use, although on American Samoa nearly all wood products except fuelwood are imported from nearby independent Western Samoa, and from the United States and New Zealand (5).

Reliable information on the original extent of the forests on the U.S. western Pacific islands does not exist, but forests probably covered most of the island. On many islands—such as Guam, Tinian, and Saipan—man and nature have so changed the islands that it is nearly impossible to identify the original forest types.

The State of Hawaii lies in the middle of the northern Pacific Ocean between Mexico and Micronesia. Hawaii has 8 major islands and 124 smaller islands that cover about 4 million acres. About half this acreage is forest- and shrub-covered.

Since the late 1800's, Hawaii has pursued a policy of protecting its forests for watershed values (16). A well-developed land-use plan was enacted in 1961. All lands were zoned according to allowed use: urban, rural, agricultural, and conservation. Most forested lands are under conservation zoning. Forests on agricultural land can be manipulated, but forests on conservation land cannot without special permission by the Hawaii Board of Land and Natural Resources (9). In 1962, the Hawaii Department of Land and Natural Resources produced the first of three lo-year multiple-use programs for managing water, timber, livestock forage, recreation, and wildlife habitat in the islands' forests.

Industrial forestry recently has become a focus of economic development in Hawaii. There are 47,000 acres of forest plantations in Hawaii, most of which are on public lands (7). However, about 1 million acres have been designated as commercial forest land (areas suitable for growing timber and with some forest cover but not necessarily stocked with timber trees). Of this, the State owns nearly 45 percent. An additional 290,000 acres of extensively grazed lands also are suited for timber crops, but now have no forest cover (16).

Hawaii also hosts a number of organizations dedicated to sustaining tropical forest resources in the islands and the tropical world. For example, an AID-funded project on nitrogen fixation by tropical agricultural legumes (NiFTAL), which produces inoculants on a pilot scale for researchers and legume growers, is based in Hawaii. The East-West Center, created by Congress in 1960 to promote interchange among the United States, Pacific, and Asian countries, is a regional center for discussion and study of natural resource issues. The Pacific Tropical Botanical Garden, the only privately supported tropical botanical garden chartered by the U.S. Congress, is in Hawaii. Forestry research and education are pursued by the University of Hawaii and the Bishop Museum. Hawaii also houses the U.S. Forest Service Institute of Pacific Island Forestry (IPIF], which supports research on forest resources in Hawaii and the U.S. western Pacific, and a cooperative State and Private Forestry division.

In 1979, the U.S. Forest Service and C. Brewer & Co. created the BioEnergy Development Corp., funded by the Department of Energy, to implement and demonstrate IPIF research activities. This joint venture has become one of the largest forestry research and development projects directed at biomass fuel production in the United States. It is cultivating more than 200 acres of fast-growing eucalyptus species on Hawaii Island that will be chipped for use as boilerfuel at two nearby sugar plan-

tation powerplants. Plantings are planned for 400 acres of abandoned sugar cane land and 500 acres of wasteland and undeveloped forest areas (8).

The problems that Hawaii has experienced related to forest resource management (e.g., increased runoff, severe erosion, inadequate water supply) are similar to other tropical forested areas. However, the State is atypical of tropical areas in that its institutional capacity for dealing with these problems is well-developed. Because of this, the expertise and experience embodied in Hawaiian people and organizations working with tropical forest resources can contribute to sustaining tropical forest resources in the U.S. territories and in the developing world.

COMMON CHARACTERISTICS OF ISLAND TROPICAL FORESTS

Island forests share many common features with continental tropical forests, yet display numerous unique ecological and historical attributes. Some characteristics shared by many U.S. Pacific and Caribbean island forests are:

- history of species-richness;
- abundance of endemic (unique, area-specific) species;
- great vulnerability to invasion by exotic plants and animals;
- dependence of water and coastal resources on forests; and
- severe pressure on land resources from human populations.

Species=Rich Forests

Island tropical forests found near continents are rich in tree species (26,48). The 547 native tree species found in Puerto Rico (19,20) approximate the number of tree species found in all the continental United States (18). Some 500 native tree species and several hundred introduced or exotic species grow in the U.S. Virgin Islands (30).

Smaller islands and islands farther from continents have fewer native species, but many exotic species have been introduced to these areas, For example, about 800 tree species were planted in the State of Hawaii between 1908 and 1960 (16). The western Pacific islands have varying numbers of species depending on their distance from Asia and their history of disturbance and replanting.

Abundance of Endemic Species

Many rare species and unique ecosystems have evolved on these islands because of their small size and geographic isolation. Hawaii and the western Pacific islands are especially rich in rare, endemic species; for some tree species only one or two individuals are known (31). In many cases, the insular bird, mammal, and fish life also are endemic. Among the many endangered, endemic species are the Puerto Rican parrot, the Micronesia megapode, and the Yapese fruit bat. In Hawaii, 90 percent of

Photo credit: J, Bauer

Endangered Puerto Rican parrots nesting at artificial nest site; these parrots remain only in the Caribbean National Forest

the species in many plant and animal families are endemic and as many as 2,000 plants and animals may be endangered (36).

Local endemism is highly developed in cloud forests. These are, in a sense, islands within islands (28). Cloud forests (also called dwarf or moss forests] occur on steep slopes and hill crests extending into the cloud zone. Thin, leached soil and steep, windswept terrain limit tree growth so trees have a low, bushy appearance, some with bare trunks and branches and broomlike tufted tops. Much is known about cloud forests in Puerto Rico (28), but information on these forests in Micronesia (on Ponape and Kosrae) is meager. This type of forest is very sensitive to disturbances (15).

Island ecosystems provide values to science disproportionate to their small size. Because of the high rates of endemicity, islands provide many species for botanical and zoological investigation. Their clearly defined boundaries facilitate study of species migration, competition, adaptation, and extinction. General principles of evolution can be distilled from island studies and applied to, for example, the design of parks and reserves.

Vulnerability to Invasion by Exotic Plant and Animal Species

The survival of native plants and animals in the U.S. tropical islands is threatened by the conversion of forests to agriculture and urban uses. Introduced plants and animals also pose a great threat because they prey upon or outcompete native species. The result has been a continuing decline in the quality of the forests and a selective elimination of native species.

Photo credit: J. Bauer

Cloud or dwarf forests are important for water retention and as habitat for many endemic species in both Puerto Rico and the U.S. western Pacific islands

Introduction of pigs, goats, cattle, rats, and some birds and insects, affects both the Pacific and Caribbean islands. In the western Pacific islands, for example, introduction of the Rhinoceros beetle contributed greatly to the decline of coconut plantations, and the Giant African snail inhibits nursery production for horticulture and forestry (15,22). In the Caribbean, animals have affected dry ecosystems to a greater degree than moist ecosystems.

Mammals are being introduced to Hawaii by man at 90,000 times the natural rate: one species or population has been successfully introduced every 11 years for the last 200 years. For land birds, the rate is one successful species or population every 4 years. Most of these species are successful at the expense of endemic or indigenous forms (39). Research performed during the 1970's documented the heavy impacts by feral animals on both wet and dry native Hawaiian forests. Results from this research have led to a decision to reduce or eliminate these animals in some areas (17).

Dependence of Water Resources on Forests

On all of the islands, the primary value of forests is their regulation of water regimes. Tropical oceanic islands, except coral atolls, are usually small with steep slopes. The natural freshwater habitat is streams rather than lakes (38). Streams and forests are concentrated in the interior highlands and stream ecology is closely linked with forest ecology. Diversion of water for domestic purposes, plantation agriculture, and industrial needs can leave insufficient waterflow for riverine fauna and flora.

Island ecosystems often host animal populations that depend on local freshwater and forest habitats. Many species spend part of their early lives in the ocean but migrate through streams to complete their lifecycle. In the natural state, much of the stream where they live and migrate lies within the forest. But when forests are altered or removed, stream habitats change. Any uninhabitable stretch can destroy a population that must migrate through it to reach its normal adult habitat upstream (38).

Photo credit: J Bauer

La Mina Falls: Regulation of water regimes is the most important function of forests on tropical high islands. Most upper watersheds have steep slopes and should remain forest-covered to reduce erosion and siltation of reservoirs and coastal ecosystems

On many islands, deforestation has resulted in turbid, erratic, and seasonally disappearing streams (11). For example, the U.S. Virgin Islands have no remaining permanent streams (30). Aquifer water levels are declining as populations pump out more than is recharged. Because of inadequate freshwater resources, water in the U.S. Virgin Islands is expensive, ranging from $10 per 1,000 gallons from a desalination plant to as much as $12 per 1,000 gallons for water barged in from Puerto Rico (32).

Dependance of Coastal Ecosystems on Forests

Disruption of water regimes in tropical islands has considerable influence on coastal marine environments. when forested watersheds are cleared, waterflow and erosion accelerate, depositing a blanket of sediment on coral reefs. This deprives corals of light and oxygen and causes the bottom to become soft and unstable, thereby preventing recolonization. The addition of large amounts of freshwater runoff also is damaging because corals can only live within a limited salinity range (29).

Normally, mangrove forests along the coastline act to filter and chemically buffer the sediments. Seagrass meadows also can filter sediment that escapes the mangroves. Unfortunately, little is known about how these filtering and silt-adjusted biotic communities operate, how they are affected by and affect the nutritional levels of lagoon and reef waters, or how they affect fish nurseries and the coral reef community.

The approximately 31,000 acres of mangroves in the U.S. Micronesia territories provide food and building materials for local people and are important to traditional Micronesia life. Mangroves also are found along the coastlines of American Samoa, Hawaii, and the U.S. Caribbean islands. Here, too, they are the spawning grounds and nurseries for many forms of marine and reef life. Coral reefs, protected by mangroves, are basic in the food chain of shallow waters, affecting fish and other marine resources of both subsistence and commercial importance to island people of the U.S. tropical territories (23). Reefs have economic importance not only from their food production and tourist value but also as a basis for industry built around scientific research (6).

Photo credit: *E. Petteys*

Coastal mangrove forests capture, filter, and chemically buffer sediments from runoff. Little is known about the operation and carrying capacity of these communities and their relation to fish nurseries and the coral reef community

Vulnerability to Land Degradation

Because of small land areas, rapidly growing populations, and transportation barriers, appropriate land-use is especially important for island development. Lacking enough land for shifting cultivation, indigenous peoples on small tropical islands developed land-intensive systems of agriculture. Small-plot land-use systems were common in both the U.S. western Pacific and Puerto Rico. Today, these agricultural systems can no longer support the growing populations. Because of limited land, farmers displaced by residential or commercial construction move to the more easily eroded island hillsides, and roads may be routed through susceptible mangrove forests (6).

U.S. CARIBBEAN TERRITORIES: PUERTO RICO AND THE U.S. VIRGIN ISLANDS

Forest Resources: Status and Trends

Puerto Rico

Puerto Rico's total land area, including that of adjacent small islands, is 2,198,000 acres. Originally, most of Puerto Rico was forested, but agricultural colonization reduced forest cover to only 9 percent by 1950—4 percent government forests and 5 percent privately owned forests. Today, at least one-third of Puerto Rico is again under forest cover, mostly second growth trees, fruit tree plantations, and shade cover in the remaining coffee regions. Original forest cover is found only in a few inaccessible regions, Some 98,000 acres are public forest, divided between Federal and Commonwealth administration. Abandonment of coffee plantations and farmlands, particularly on steep slopes, released 1.1 million acres now potentially available for forestry activities,

Some of this land is probably too steep to use, although some recreation and gathering activities might be allowed. Some acreage will be required for future development; nevertheless, a considerable amount of land could be used for productive forestry, Some 200,000 acres are estimated suitable for commercial forestry (42, 44) and some could be used for forestry-agriculture combinations.

Pronounced differences in natural vegetation occur because of sharp variations in altitude, climate, and soil characteristics. Using the Holdridge Life Zone system, six zones are found in Puerto Rico (12). At least 98 percent of the land area is covered by three of the life zones (table 17). The other three are found only at or near mountaintops and are very wet. Generally, they are unproductive for agricultural or forest crops and still exist in their natural state. Most of these lands are in public forests and are important for watershed protection.

Table 17.—Life Zones and Area in Puerto Rico

Life zone	Total acres	Percent of total
Subtropical moist forest	1,314,582	59.2
Subtropical wet forest	524,830	23.6
Subtropical dry forest	346,936	15.6
Subtropical lower montane forest	26,950	1,2
Subtropical rain forest	3,260	0.1
Subtropical lower montane rain forest	3,040	0.1

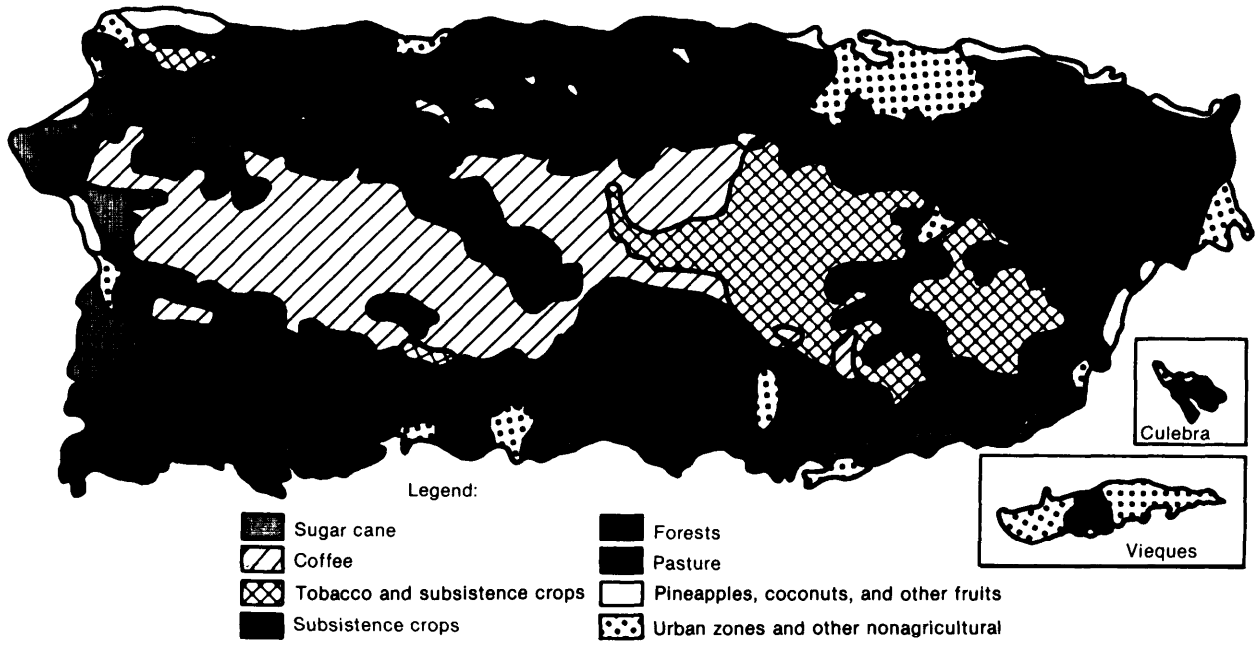
SOURCE: Adapted from: J. J. Ewel and J L. Whitmore, *The Ecological Life Zones of Puerto Rico and the U.S. Virgin Islands,* USDA Forest Service Research Paper ITF-18, 1973, *In:* Schmidt, 1982, and S. I. Somberg, *Virgin Islands forestry Research: A Problem Analysis* (St Croix: College of the Virgin Islands, Virgin Islands Agricultural Experiment Station, 1976).

Subtropical dry forests support a forest cover rich in tree species, but they do not have good potential for commercial forest production. In Puerto Rico and throughout the Tropics, dry forests often are converted to grazing land (fig, 18), The southern coastal plain of Puerto Rico and associated small islands contain most of the dry forests, limiting the potential for commercial forestry and increasing their need for effective conservation programs.

The subtropical moist life zone, with 1,000 to 2,000 mm of rainfall per year, covers most of Puerto Rico. Agriculture, urban, and industrial uses are common in this zone, Subtropical wet forests are found higher in the mountains of Puerto Rico where rainfall is above 2,000 mm. Pasture is common in this zone, which is cooler, and coffee, bananas, plantains, and other fruits grow well. *

*Ewel and Whitmore (12) provide more detailed descriptions of all life zones in Puerto Rico and the U.S. Virgin Islands.

Figure 18.—Land Use in Puerto Rico



SOURCE: Rafael Pico, *The Geography of Puerto Rico* (Chicago: Aldine Publishing Co., 1974), p. 360.

This wet forest life zone presents a substantial management challenge. Forests composed of abandoned coffee shade trees, in particular, contain some commercially valuable trees, but most of their volume is in three legumes ***(Inga vera, I. laurina,*** and ***Erythrina poeppingiana)*** and other marginally valuable species (e.g., ***Guarea guidonia) (2).*** These forests supply little useful timber, but they offer excellent watershed and soil protection, wildlife habitat, and recreational and esthetic opportunities.

U.S. Virgin Islands

The U.S. Virgin Islands are part of the Lesser Antilles Archipelago. Its three largest islands are St. Thomas (17,000 acres), St. John Island (15,000 acres), and St. Croix (55,000 acres). Only two Holdridge ecological life zones are found in the U.S. Virgin Islands: subtropical dry forests and subtropical moist forests (table 18). The subtropical dry forest zone occupies almost three-fourths of the islands' land. There are no permanent rivers or streams in the U.S. Virgin Islands outside the Virgin Islands National Park. All water retained in aquifers comes from rainfall (30); these are depleted and many wells are dry. Despite the high costs of desalinating water or importing it from Puerto Rico by barge, little attempt has been made to institute a revegetation program to increase water retention and to prevent the flooding and marine siltation (32).

Tabie 18.—Life Zones of the U.S. Virgin isiands

Island	Square miles	Acres	Subtropical dry forests (acres)	Subtropical moist forests (acres)	Percent of total area
St. Croix	84	54,563	45,469	9,094	63.9
St. Thomas.	28	17,984	7,001	10,983	21.1
St. John	20	12,835	8,214	4,621	15.0
Total	132	85,382	60,684	24,698	—
Percent of total . .			71.1	28.9	100.0

SOURCE: S. I. Somberg, *Virgin Islands Forestry Research: A Problem Analysis* (St. Croix: College of the Virgin Islands, Virgin Islands Agricultural Experiment Station, 1976).

These islands were once largely forest covered (fig. 19). Less data are available on forest use and potential in the U.S. Virgin Islands than for Puerto Rico. However, an estimated 35,300 acres of forest and brushland exist, including 5,000 acres of commercial forests and 15,800 acres of noncommercial forests. The remaining 14,500 acres are unclassified and are mountainous. Most of the forested area outside the Virgin Islands National Park is in private ownership (30).

The majority of land considered suitable for agriculture (including forestry) is on St. Croix. Two high-value timber species, mahogany and teak, are grown at the U.S. Forest Service Estate Thomas Experimental Forest on that island. Teak can be established on marginal land common in central St. Croix and has proved compatible with grazing.

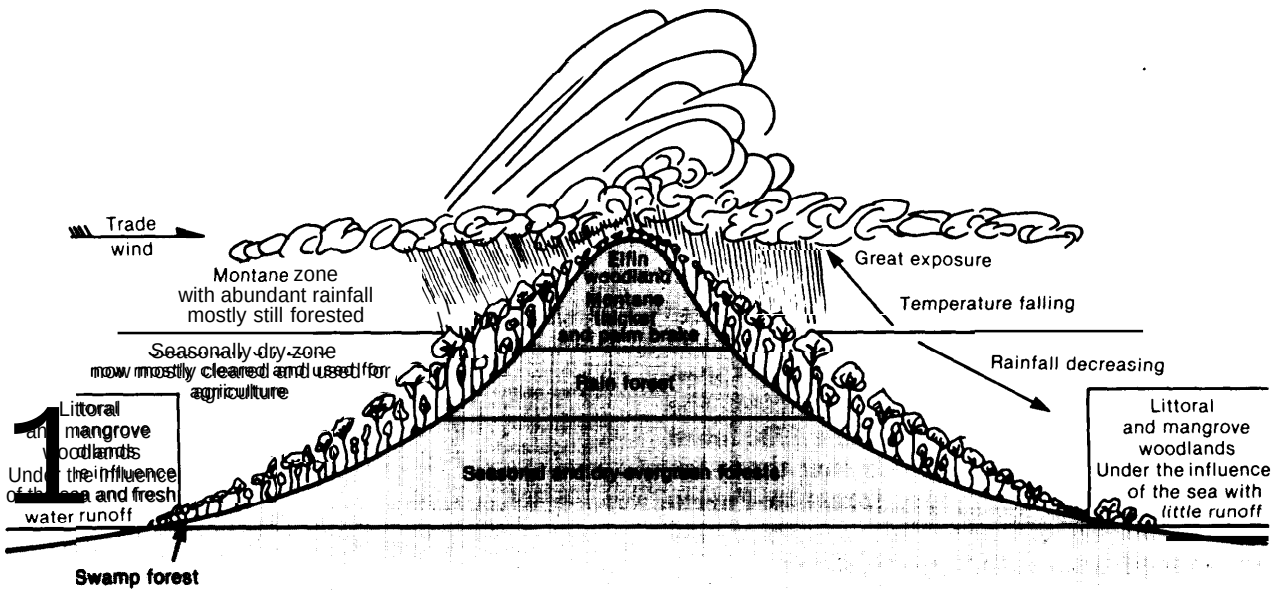
A combination of high land prices, competing land uses, and certain adverse soil and topography factors probably preclude most commercial forestry on the U.S. Virgin Islands (30). However, potentials exist for agricultural tree crops (e.g., coconut, mango, limes), management of watershed forests, and roadside and urban forestry.

History Of Forest Use

Puerto Rico and the U.S. Virgin Islands share a similar forest-use history. Essentially all of Puerto Rico was forested on the arrival of Columbus in 1493 (fig. 20). Then agricultural and urban expansion into the forests gradually took place. Until the early 20th century, most wood harvested was used for fuel or construction, but construction wood was being imported as early as the 1700's. The only exports were rare and valuable native species such as lignumvitae and satinwood (Guaiacmn ***officinale*** and Zanthoxylum flavwn). The economic depression in the 1930's, combined with increased population, had heavy adverse impacts on Puerto Rico. Agriculture was pushed farther up the hills across the island. By 1935, only about 2 percent of the land area—the most inaccessible and infertile areas—had not been deforested at some time.

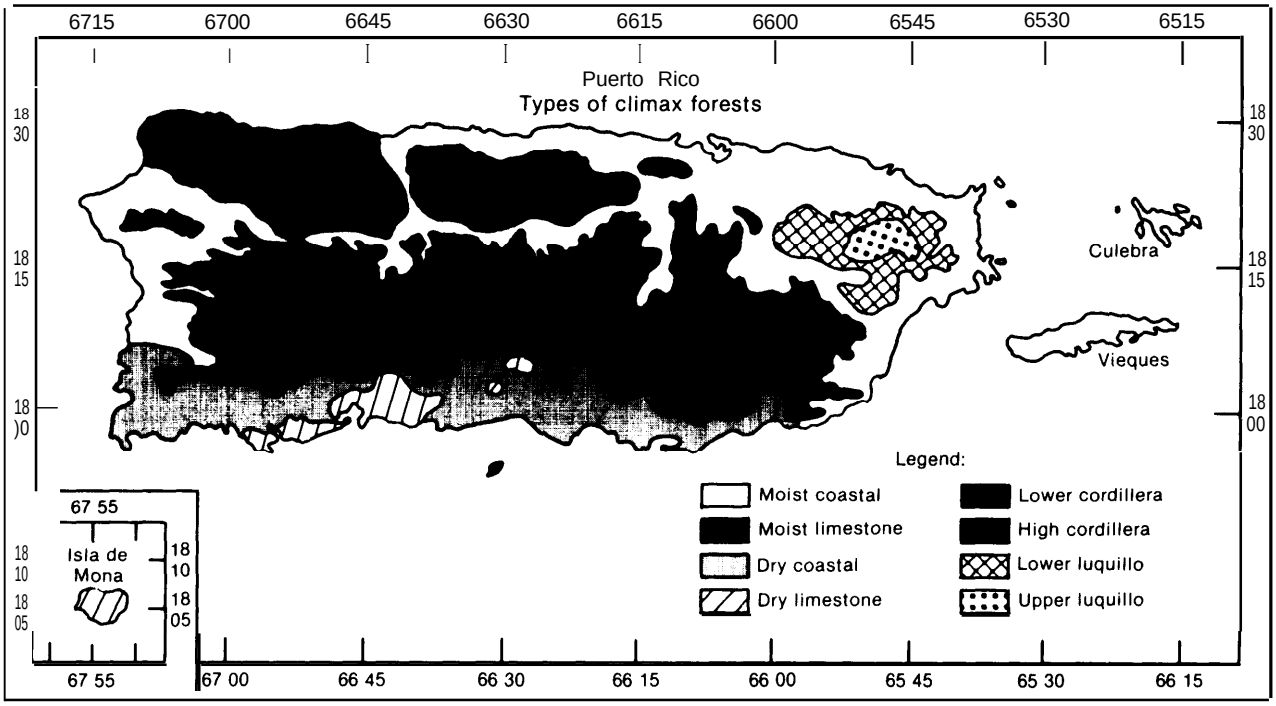
In the 1920's and 1930's, the Federal Government acquired about 50,000 acres of mountain land in Puerto Rico for forest and watershed

Figure 19.—An Idealized Transect Through a Caribbean Island in the Lesser Antilles



SOURCE: Adapted from J. S. Beard, The *Natural Vegetation* of the *Windward and Leeward Islands* (Oxford, England: Clarendon Press, 1949). In: Schmidt, 1982

Figure 20.—Original Vegetation of Puerto Rico



SOURCE: Rafael Pico, *The Geography of Puerto Rico* (Chicago: Aldine Publishing Co., 1974), p. 180,

protection. In the late 1930's and early 1940's, the Civilian Conservation Corps planted some 25,000 acres of timber trees that survive today, mostly in public forests. Today 100,000 acres are in public forest lands, divided between Federal and Commonwealth administration. Caribbean pine ***(Pinus caribaea*** var. ***hondurensis)*** was first established on the island in 1962. Through the 1960's and 1970's, from 100 to 500 acres per year of timber trees, mostly pine, were established on private lands. About 200 acres per year of various species were planted on public forest lands.

Planting records of the Institute of Tropical Forestry indicate that 95,000 acres of trees have been planted in Puerto Rico (2), but no forest plantation inventory has been conducted. The 1973 land-use inventory (10) and the 1980 forest resources survey (2) indicated that there are 800,000 acres of secondary forest in Puerto Rico. About half of Puerto Rico consists of land abandoned from farming or grazing.

The Natural Resource Inventory performed by the U.S. Department of Agriculture in 1977 estimated average annual soil loss for different land uses in the Caribbean (Puerto Rico and the U.S. Virgin Islands), all of which are considerably higher than the average annual soil loss for the United States (table 19). These erosion rates reflect the extensive historical deforestation of the islands and the continuing cultivation and inadequately managed grazing of lands unsuitable for permanent agriculture.

Table 19.—Average Annual Sheet and Rill Erosion in the U.S Caribbean (tons/acre)

Land use	U.S. Caribbean average	U.S. average
Cropland.	49	5.1
Rangeland	50	2.8
Forest land:		
Grazed	6	3.9
Not grazed	10	0.6

SOURCE: Adapted from USOA, 1977 Natural Resources Inventory, Washington, D.C,

Geoclimatic Regions in Puerto Rico

Five basic rock types are present in Puerto Rico. Composition within each rock type varies and there are hundreds of soil types (3,21). However, changes in forest growth and composition are noticeable only across the major rock types. These five rock types can be overlayed with Holdridge Life Zones to form 17 geoclimatic regions (14). The regions with potential for commercial forestry use include:

- ***Moist-alluvial region.***—This is the zone of mechanized agriculture, urban development, and protected coastal mangroves and wetlands. These uses are considered higher priority than forestry and probably will preclude it in this zone in the future.
- ***Moist-volcanic regioin.***—This extensive zone is very important for forest development. It is a prime zone for growing Caribbean pine, mahogany, teak, blue mahoe, and eucalyptus. Where soils are poor, degraded, or on moderately steep slopes, agricultural practices have ceased. Native pastures, especially where ferns invade, can be of very low productivity. Regenerated native forests can be developed for conservation or timber production. However, most abandoned land in this region is deforested and is not regenerating into secondary forests of native species (27).
- ***Moist-limestone region.***—This is an area of extensive agricultural abandonment in northwestern Puerto Rico. Mahogany, teak, and ***Eucalyptus deglupta*** grow well on the lower slopes of the rounded hills of this region; blue mahoe ***(Hibiscus elatus)*** grows well in moist valley bottoms. Well-managed plantations of these species are grown in three Commonwealth forests in this zone.
- ***Moist-granodioritic region.***—Large areas of abandoned farms are common throughout this region. Caribbean pine is one tree species that thrives on these deep, infertile sands.
- ***Moist and wet serpentine region.***—This region in southwestern Puerto Rico has shallow soils that are low in nitrogen and phosphors and very permeable. Agriculture fails on these lands and tree growth is slow (45). Two Commonwealth forests covering 17,300 acres located in the region contain important watersheds. Some areas can support plantations of Caribbean pine, maria ***(Calophyllum calaba),*** and, with heavy fertilizers, avocados.
- ***Wet-volcanic region.***—Most of the wet life zone in Puerto Rico is found over volcanic soil and the main crop is coffee. In the late 1960's and early 1970's, many coffee plantations were left untended due to a shortage of laborers, and shrubs and trees invaded. From the late 1970's to the present, the coffee crop area has again expanded, apparently because of a shadeless coffee production system that uses nets for harvest (41) and a $2 million incentive program offering up to $1,000 Per acre for coffee planting. Since the new production is more intensive, cosiderable areas of abandoned coffee shade still exist.

In 1981, Puerto Rico produced about 100,000 board feet of hardwood timber with a retail value of about $200,000, while the island's imports of forest products totaled $410 million. softwoods were imported largely from Canada and the United States, and hardwoods derived primarily from the United States and Brazil (table 20). The growth in forest product imports, now increasing by $25 million per year, has been rapid over the past 40 years: 1940–$5 million to $8 million, 1950–$20 million, 1970—$144 million (27).

Forest cover in Puerto Rico has increased from 9 percent in 1950 to 40 percent of the total area today because of a complex set of social, economic, and cultural factors. Agricultural exploitation of tropical lands is often cyclical. Lands of marginal agricultural productivity are exhausted by cropping, then abandoned to *nat-*

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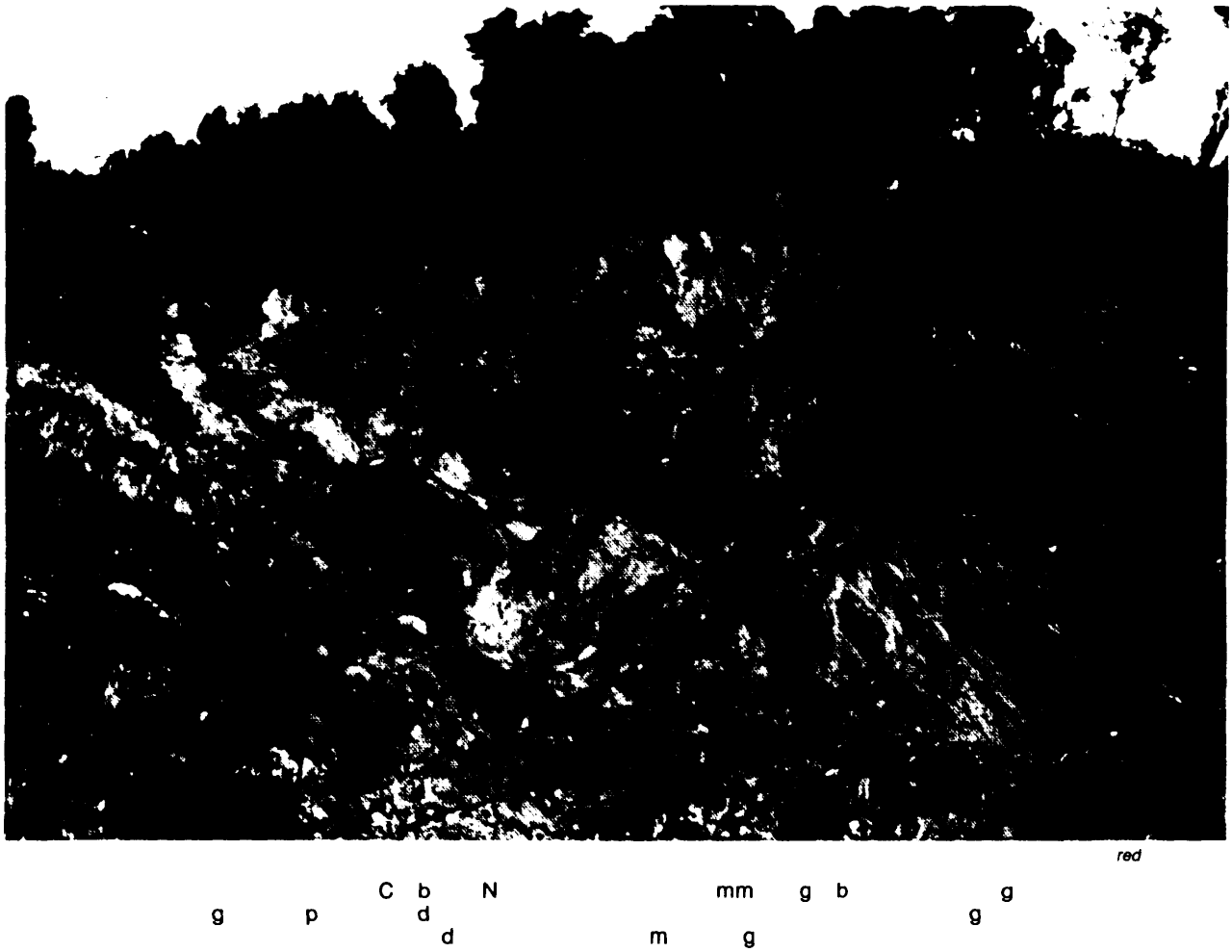


ural succession. If and when some measure of fertility is restored, the lands maybe cleared and cropped again. A peak of agricultural activity in Puerto Rico in the 1930's and 1940's severely degraded the productivity of large areas of land and led to their abandonment.

In both Puerto Rico and the U.S. Virgin Islands, the abandonment of the sugar cane industry decreased the amount of land under cultivation and some of this has reverted to brush. Brush and nonwoody species associated with forest and brush lands are important for soil and water management and have esthetic importance to the tourism industry in the drier areas of the Caribbean.

Beginning in the 1950's, industrial development led to more attractive employment opportunities in industry than in agriculture, lower priority for agricultural programs, and increased abandonment of land from farming. The growth of tourism also attracted capital and labor away from agriculture, Complementing the increased availability of alternative employment were easy air transportation to the mainland United States and social support programs (e.g., food stamps) offered by the Federal Government. Thus, the need to scratch out a meager living on steep infertile slopes was greatly reduced, These activities continue to reduce dependence on marginal agricultural activities.

Table 20.—1981 Lumber Imports Into Puerto Rico by Species and Country of Origin

Species	Country	Totals	
		Quantity (MBF)	Wholesale dollar value
softwoods:			
Cedar (other)	Canada	**599**	$ 144,000
	United States	**468**	149,000
Douglas fir	Canada	**6,733**	1,330,000
	United States	**764**	357,000
Hemlock ... ,	Canada	**30,544**	5,973,000
	United States	**31**	15,000
Pine	Canada	**1,928**	391,000
	Honduras	**1,240**	336,000
	United States (Southern Ponderosa White)	31,986	10,770,000
Redwood	United States	220	314,000
Spruce	Canada	7,548	1,212,000
Western red cedar	Canada	535	179,000
Other softwoods	United States	765	666,000
	Brazil	39	12,000
	Colombia	51	3,000
Subtotal		83,451	$21,851,000
Hardwoods:			
Mahogany	Brazil	3,261	2,096,000
Maple	United States	1,417	815,000
Spanish cedar	Brazil	260	87,000
	Colombia	291	55,000
	Honduras	98	95,000
	Surinam	10	5,000
Walnut	United States	42	35,000
White oak	United States	2,075	478,000
Other hardwoods	Brazil	1,255	731,000
	Colombia	459	117,000
	French Guiana	64	10,000
	Malaysia	23	15,000
	United States	1,829	1,349,000
Subtotal		11,084	$5,888,000
Total		94,535	$27,739,000

SOURCE R C Schmidt, "Forestry: Puerto Rico and the Virgin Islands," OTA commissioned paper, 1982

In addition, the price of rural land has long since come to reflect scarcity rather than productivity. Forest land in Puerto Rico may cost $1,000 to $2,000 per acre, and land values in the U.S. Virgin Islands have exceeded $10,000 per acre. Consequently, land speculation is common and much land lies idle awaiting development. Puerto Rico maintains a law against private individuals or corporations owning more than 500 acres and, in general, the land is in small holdings. Nearly 90 percent of the land ownerships are less than 48 acres (33).

The potential for plantation forestry in Puerto Rico has been greatly increased as lands previously used for agriculture have become available. Also, natural secondary forest may supply useful forest products in the future. However, the total volume of wood in the secondary forest in Puerto Rico is not great—22 cubic meters per acre (m^3/acre) in abandoned coffee plantations and 18 ins/acre in secondary forests (2). Undisturbed moist tropical forests often support more than 80 m^3 of wood per acre.

Trends in the growth of forest area or volume are not yet known. In 1980, field work was done for the first comprehensive inventory of Puerto Rico's forests, and future inventories in 1985 and 1990 will begin to show trends. Observations indicate that forest area is increasing slightly or is stabilized (27). The only cutting occurring in these secondary forests is for fence posts, which probably does not decrease overall volume growth significantly.

Organizations Dealing With Tropical Forests

Although several Commonwealth and Federal agencies are involved in tree planting in Puerto Rico and the U.S. Virgin Islands, the U.S. Forest Service, the Virgin Islands Department of Agriculture (VIDA), and the Puerto Rico Department of Natural Resources (DNR) are the agencies with primary responsibility for forestry (table 21). U.S. Forest Service activities include research at the Institute of Tropical Forestry (ITF), administration of the Caribbean National Forest, and cooperative programs with the DNR and VIDA.

ITF uses the Luquillo Experimental Forest, several Commonwealth forests, and the 120-acre Estate Thomas Experimental Forest in the Virgin Islands as sites for research. Even though timber management has been ITF's main research objective, cooperative programs have been under way with AID, the Peace Corps, U.S. Fish and Wildlife Service, and several universities and Caribbean nation governments.

Neither the land grant University of Puerto Rico nor the College of the Virgin Islands has a forestry curriculum or an integrated natural resource management curriculum. The Virgin Islands Department of Agriculture's Forestry Program, with five staff members, operates a nursery, an urban forestry program, and a rural reforestation program. Nearly 400 acres have been reforested since the program's inception in 1967.

Changing public attitudes toward Puerto Rico's forests is the primary focus of DNR's Forest Service. It has begun a media campaign, trained field agents in each of the five regions of Puerto Rico, and recently embarked on a program to bring private landowners into commercial forestry. State and private forestry programs administered by the U.S. Forest Service provide technical assistance to guide the DNR Forest Service's forest management, utilization, and extension programs.

Table 21.-Organizations Dealing With Tropical Forests in Puerto Rico and the U.S. Virgin Islands

Agency/Responsibilities

Federal Government:

- *Forest Service:* **Administers the Caribbean National Forest, participates in the Cooperative Forest Management Act, and conducts research** in forest management, recreation, wildlife, and tropical tree culture.
- *Soil Conservation Service:* **Advises landowners about land-use alternatives, including forestry practices.**
- **Agricultural Stabilization and Conservation** *Service:* **Approves incentive applications for forestry practices included under the Rural Environmental Assistance Program Act.**
- *Agricultural Extension Service:* **Handles island-wide education campaign promoting tree-planting for ornamental, recreational, environmental, and commercial purposes.**
- *Mayaguez Institute of Tropical Agriculture:* **USDA agricultural research station specializing** in developing and testing crops suited for tropical areas including fruit trees and cacao.
- *National Park Service:* Administers San Juan National Historic Site, Puerto Rico; Virgin Islands National Park, St. John; Buck Island Reef National Monument, St. Croix; Christianstead National Historic Site, St. Croix.
- *Federal Highway Authority:* Develops specifications regulating tree-planting along roads built with Federal funds.

Commonwealth and Territory *Governments:*

- *Forest Service, Department of Natural Resources, Puerto Rico:* Manages the 13 Commonwealth forests for watershed, recreation, research, wildlife, and timber. Under the Cooperative Forest Management Act, conducts field work related to private reforestation programs. Produces and distributes seedlings from three nurseries.
- *Agricultural Services Administration, Puerto Rico:* Grows forest, ornamental, fruit, and shade tree seedlings at the Monterrey Nursery in Dorado, Puerto Rico.
- Forestry *Program,* Department of *Agriculture, U.S. Virgin Islands:* Operates a nursery, manages urban forestry on public lands, and runs a rural reforestation program for private landowners.
- *Department of Conservation and Cultural Affairs, U.S. Virgin Islands:* Administers territorial parks, Earth Change Permit System restrictions on earth-moving, and Sediment Reduction Program managing watersheds related to marine sedimentation.

Universities *and colleges:*

- University *of Puerto Rico:* Offers undergraduate and graduate programs in biology, ecology, agronomy, and administers system of agricultural experiment stations.
- College *of the Virgin Islands:* Offers undergraduate programs in biology and chemistry and administers the Virgin Islands Experiment Station which maintains Forest Service experimental plots.

SOURCE: Adapted from L. H. Liegel, "Woodland Conservation in Puerto Rico: Its Past, Present, and Future," New York College of Environmental Science and Forestry, Syracuse, NY., thesis, 1973.

U.S. PACIFIC TERRITORIES: AMERICAN SAMOA, TRUST TERRITORY OF THE PACIFIC ISLANDS, COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS, AND GUAM

American Samoa is the only U.S. territory that lies south of the Equator. The Trust Territory of the Pacific Islands, Commonwealth of the Northern Mariana Islands, and Territory of Guam constitute most of Micronesia, * which lies north of the Equator between Hawaii and the Philippines (fig. 21). Micronesia covers an area of the western Pacific roughly equivalent to that of the conterminous United States (3 million square miles) embracing some 2,000 islands lying in three major archipelagoes: the Marianas, the Carolines, and the Marshalls (fig. 22).

American Samoa and Guam are unincorporated territories (to which the U.S. Constitution has not been expressly extended) under the administration of elected Governors. American Samoa has been administered by the United States since 1900 and by a Governor appointed by the Secretary of the Department of the Interior specifically since 1951. Although relations between the government of Guam and the Federal Government also are conducted under the jurisdiction of the Department of the Interior, residents of Guam elect their own officials.

The Trust Territory of the Pacific Islands (TTPI), which originally included the Northern Mariana Islands, was established under U.N. sanction after World War II. Administration of the Trust Territory has been the responsibility of the Department of the Interior through an organization composed of the High Commissioner and District Adminstrators. TTPI is treated as domestic except that the Peace Corps has special congressional authorization to operate there.

Under an executive order signed by President Ford, each district was given the opportunity to determine its own form of government and degree of independence from the United States. The Commonwealth of the Northern Mariana Islands was established and separated from the Trust Territory in 1978, although some relations between the Marianas and the U.S. Government continue under the jurisdiction of the Department of the Interior. The remaining polical entities—the Republic of Palau, the Federated States of Micronesia (Yap, Truk, Ponape, and Kosrae), and the Republic of the Marshall Islands—now must decide whether or not to become nations in free association with the United Staes. Free association would allow them free control of internal affairs while assuring them fiscal aid and national defense provisions from the United States.

By January 1981, each emerging nation had installed a constitutional government with democratically elected officials (table 22). All of these provisional entities are weak economically and have existed almost entirely on Federal funding since world War 11. U.S. appropriations for the Trust Territory, excluding Federal categorical programs, exceeded $100 million in fiscal year 1980 (40). The government employs 56 percent of the work force, and provides 76 percent of the wages (37).

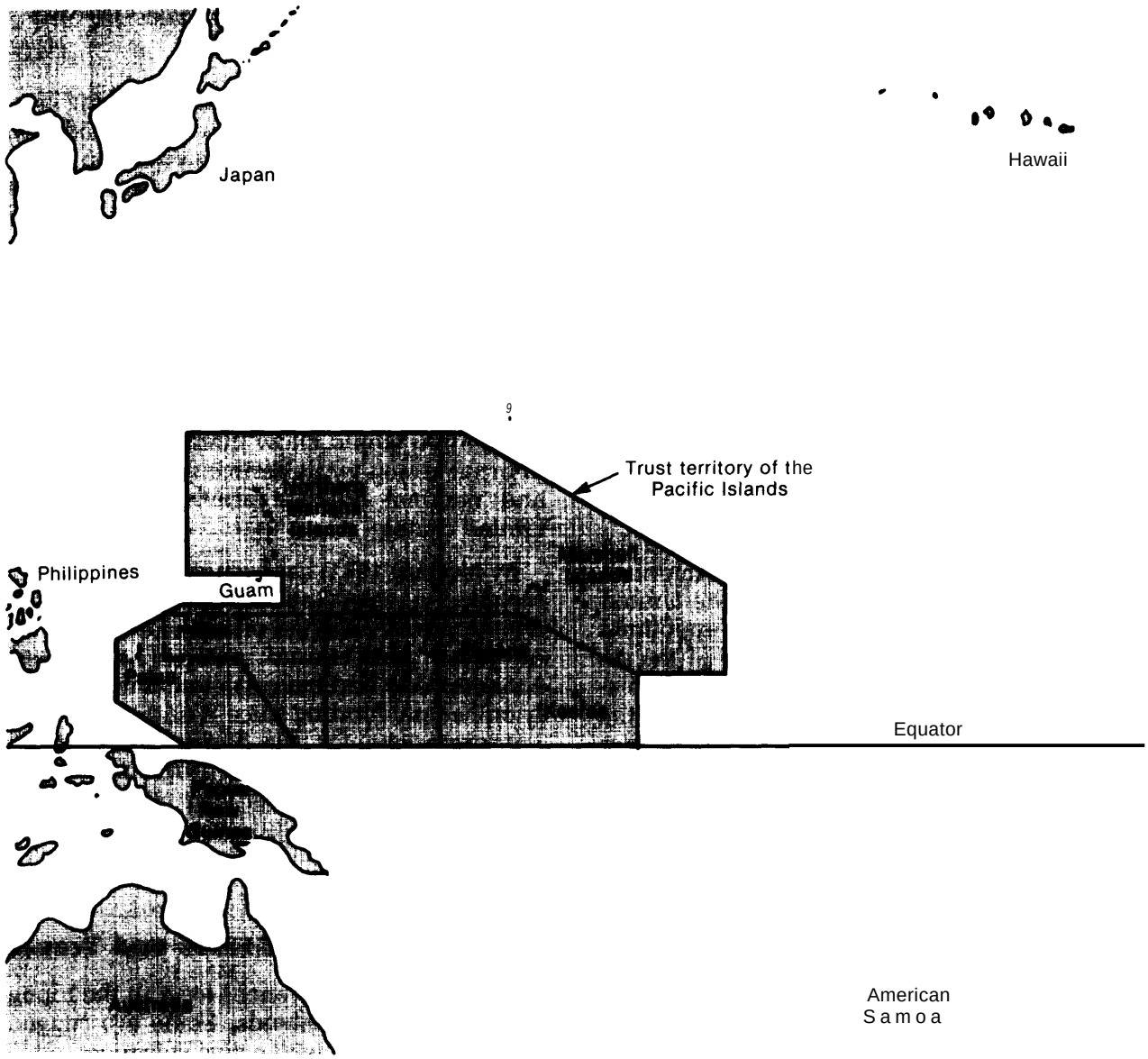
Forest Resources: Status and Trends

Considerable differences exist in the topography among the islands. Some are rugged, high islands, some with active volcanoes, while others are low islands and coral atolls.

The original vegetation of the high volcanic islands included rain forests on the windward slopes, and drier forests on the leeward slopes. On some of these islands, grass or fern savanna naturally occurred. The natural cover of elevated coral limestone areas is dense forest with species composition different from the high volcanic type. High coral islands are floristically much richer than the forests of low

*Other islands in Micronesia are Wake, Marcus, Volcano, Benin, Nauru, and Kiribati,

Figure 21.—Location of the U.S. Western Pacific Territories

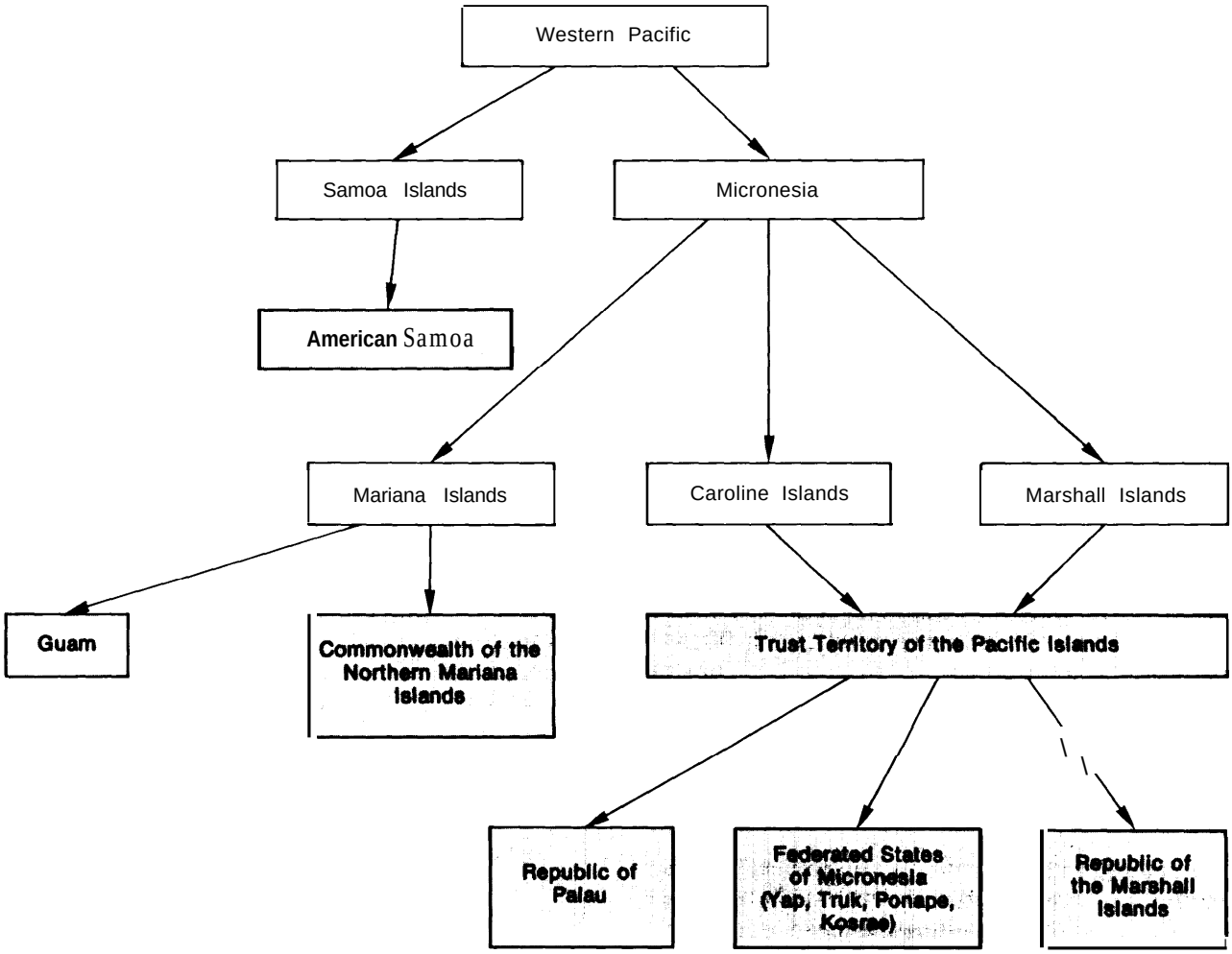


SOURCE: Office of Technology Assessment.

coral islands. Even an elevation change of a few feet results in a much richer flora. The natural vegetation of low coral islands is a "beach" type, adapted to highly saline water and soils. Some of the drier islands have little more than coconuts, scrub, and bunch-grass savanna, or salt flats.

The current extent and condition of forests in the U.S. Pacific vary greatly from one island to the next. A long history of disturbance by man and natural forces left little undisturbed forest. A decline in agricultural production for export, plus urban migration and dependence on U.S. Federal income supports and imported

Figure 22.—Geopolitical Breakdown of the U.S. Western Pacific Territories



SOURCE: Office of Technology Assessment.

products are probably the reasons why agriculture has lost prominence. Most abandoned agricultural land naturally revegetates to savanna or to secondary forest. Little of the secondary forest is suitable for commercial timber exploitation due to poor quality and low volume of commercial tree species.

Timber exploitation has declined since World War II. Much of the choice timber had been cut by 1950. Most of the islands could sustain forest production to help meet local needs, although there is little potential for export. Rapidly increasing populations will consume any available forest products produced within short land or sea hauls.

Amarican Samoa

American Samoa is comprised of the seven eastern islands of the Samoan group, with a total land area of about 50,000 acres. Two

Table 22.—Pacific Territories of the United States

Territory or island	Approximate number of islands[a]	Dryland (acres)	1980 population	Current (C) or projected (P) relationship with the United States
American Samoa	7	49,200	32,400	Unincorporated territory (C)
Guam	1	135,000	105,000	Unincorporated territory (C)
Commonwealth of the Northern Mariana Islands	21	76,000	16,900	Commonwealth of the United States (C) (established 1978)
Trust Territory of the Pacific Islands (except Northern Mariana Islands).	2,182	**291,340**	116,345	
Federated States of Micronesia.	607	**165,095**	73,500	Free association, U.S. funded (P)
Kosrae	5	**26,270**	5,500	—
Ponape	165	**90,000**	22,300	
Truk	290	20,950	37,500	
Yap	149	27,875	8,200	
Republic of the Marshall Islands.	1,225	17,945	31 ,045b	Free association, U.S. funded (P)
Republic of Palau	350	108,300	11,800	Free association, U.S. funded (P)
Total	2,211	551,540	275,645	—

[a]Sources: American Samoa Government, *American Samoa's Annual Report, Fiscal Year 1980* (Pago Pago: Office of Samoan Information, 1981); Government of Guam, *Annual Report FY 1980, Territory of Guam,* Office of the Governor of Guam, 1981; U.S. Department of State, *Trust Territory of the Pacific Islands*, 1980, Report to the United Nations on the Administration of the Trust Territory of the Pacific Islands, Washington, D.C., 1981.
[b]1980 population figure from Department of State.

SOURCE: C. D. Whitesell, C. W. Philpot, and M. C. V. Falanruw, "Congressional Action to Improve the Sustainability of U.S. Tropical Forest Resources in the Pacific," OTA commissioned paper, 1982.

islands are coral atolls, whereas the others rise steeply from the sea. Tutuila Island, with a land area of 34,000 acres, has approximately 90 percent of the population. It has one flat coastal plain of about 3,200 acres where urban growth is concentrated. outside of Tutuila, the economy is classified as subsistence. At least 95 percent of American Samoa is communally owned (25) and land disputes are common,

Through massive infusion of Federal money from the United States, American Samoa has in recent years developed a cash economy. This has resulted in less land used for cultivation and subsistence. Most land in American Samoa is classified as undeveloped (table 23).

The original forest cover for most of American Samoa was dense tropical rain forest. However, nearly two-thirds of the rain forest has been destroyed or damaged by man's activities, leaving undisturbed forests only on steep slopes. Plantations (primarily taro and coconut) are the most extensive land use, covering 34 percent of the land. Secondary forest covers 20 percent and includes all of those successional vegetation stages present after agricultural land has been abandoned. The only types of vegetation left relatively undisturbed are cloud forest, montane scrub, and littoral (coastal) vegetation. Unlike elsewhere in the Pacific, disturbed vegetation and secondary forest in American Samoa are not dominated by exotic plants (4).

Table 23.—Land Use in American Samoa, 1977

Land use"	Acres
Developed land	7,830
Residential	2,475
Subsistence agriculture	1,620
American Samoa Government	1,087
Other	2,648
Undeveloped land	40,930
Total land area	48,760

SOURCE American Samoa Government, Economic Development Plan for Amen-*can Samoa, FY* 1979-1984 (Pago Pago' Development Planning Office, 1979)

Trust Territory Of the Pacific Islands

The Trust Territory of the Pacific Islands (TTPI) includes roughly two-thirds of Micronesia: the Caroline and Marshall archipelagoes. TTPI includes high volcanic islands of varying ages, elevated platforms of coral limestone, and low flat coral islets and atolls (table 24). Coral atolls are characterized by the coconut palm and its related plant associates—breadfruit, pandanus, and shore plants. The high volcanic islands usually have mangrove swamps on the tidal flats, coconut vegetation inland and on the slopes, and mixed forest growth on the uplands (fig. 23).

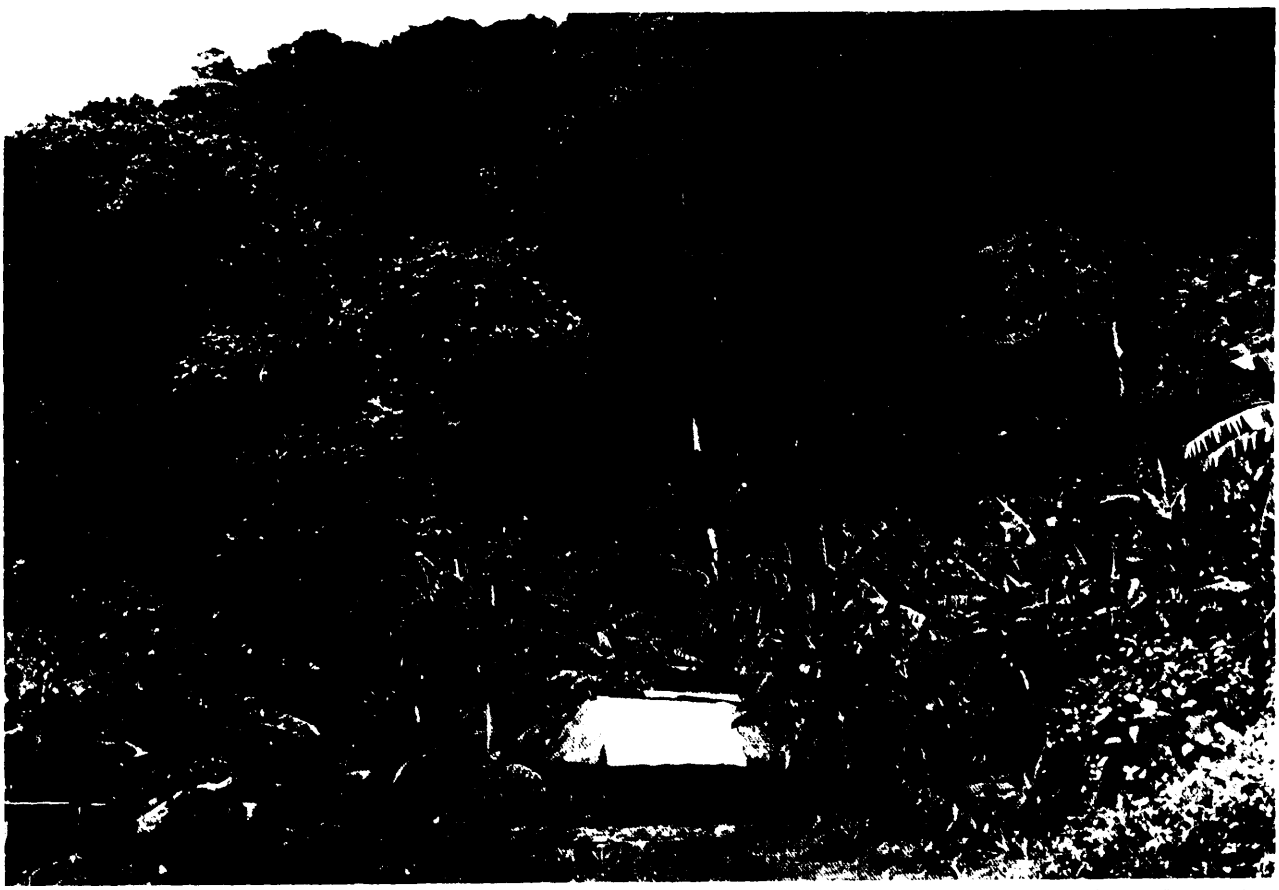


Photo credit: C. Hodges

Subsistence agriculture, a major land use in the western Pacific, is one cause of American Samoa's forest loss

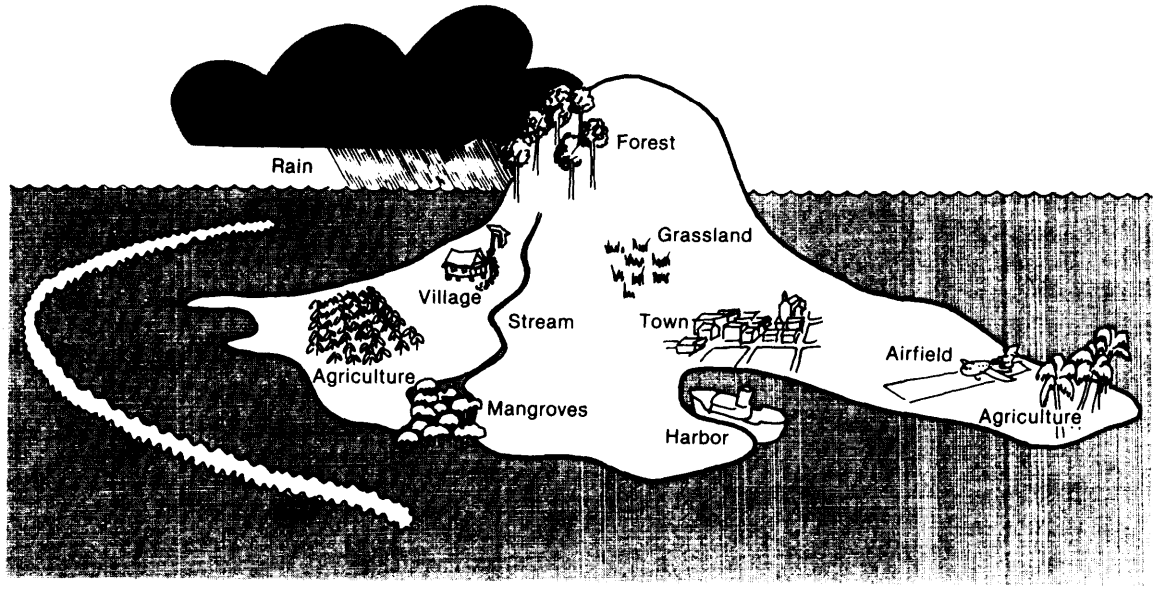
Table 24.—island Types and Forest Areas of Micronesia (acres)

District	Dominant type of island	Mangrove forest	Savanna	Other forest
Federated States of Micronesia:				
Ponape[a]	High volcanic	13,690	3,567	67,614
Kosrae[a]	High volcanic	4,030	38	22,723
Truk	Volcanic peak	3,315	89	133
Yap[a]	Low volcanic	906	4,989	8,040
Republic of the Marshall Islands	Low coral atolls	10	n.a.	640
Republic of Palau:				
Northern islands	Low volcanic	9,344	19,560	18,816
Southern islands	Limestone			

[a]Forest area figures from C. D. Whitesell, personal communication, 1983.

SOURCE: Compiled from Burton R. Emmons, "Forestry in Micronesia" (unpublished paper, located at Library of the Office of Territorial Affairs, Department of the Interior), 1971; and U.S. Department of State, *Trust Territory of the Pacific Islands, 1980.* Report to the United Nations on the Administration of the Trust Territory of the Pacific Islands, Washington, D.C., 1981.

Figure 23.—Diagram of a "Typical" Micronesia Island Indicating Some Relationships Between Land Development and Island Resources



SOURCE: N. H. Cheatham, "Land Development: Its Environmental Impact on Micronesia," *Micronesian Reporter,* Third Quarter 1975, pp. 8-10

Soil fertility is sufficient for the subsistence farming that is practiced—coconut culture and manmade taro pits on coral islands, and taro swamps, agroforestry, and garden culture on the volcanic and limestone islands. Where production is intensified, fertilizers must be used to sustain continuous production.

Leaching of plant nutrients is considered a more severe land-use problem than erosion. The combined loss of soil fertility from leaching and crop harvest has so depleted the available plant nutrients that certain areas in the high islands no longer can support sufficient vegetation either to protect against erosion or to provide enough nitrogen and organic material for crop growth (35).

Commonwealth of the Northern Mariana Islands

The Commonwealth of the Northern Mariana Islands comprises 14 islands of the Marianas archipelago, excluding Guam. The archipelago can be divided into a group of young, mostly active volcanoes and a group of older islands of elevated limestone and old, weathered volcanic rocks. The Northern Marianas have a land area of 76,000 acres. The largest islands of Saipan, Rota, and Tinian (covering 30,000 acres; 25,000 acres; and 21,000 acres respectively) are high limestone/volcanic combinations.

The steep ash slopes of the volcanoes are generally covered by a dense, coarse grass ***Miscanthus).*** Mixed forest and coconut plantations cover the flatter areas near the sea. Volcanic areas can be quickly colonized by exotic nitrogen-fixing ***Casuarina*** and other trees, but the common practice of burning maintains these areas in grasslands (4). The limestone regions of the older islands are predominantly covered with dense secondary forest. Some sugar cane is grown where the soil is deep enough.

Man has influenced the vegetation of the Marianas for at least 3,500 years. On old volcanic soils, accelerated clearing and burning in recent centuries have created a secondary forest in some areas and much secondary savanna. Erosion and soil deterioration have accompanied the process, making natural regeneration of the savanna a slow process. On fertile limestone soils, the forest has been

replaced by coconut plantations, pastures, open fields and gardens, or secondary forest.

Guam

Guam is the largest and southernmost island of the Marianas chain, covering 135,000 acres. The northern half of the island is mostly flat or gently sloping limestone with a thin lateritic soil. In contrast, the southern half is composed of ancient, deeply weathered volcanic material. Except for a coastal plain on the western side, this southern area has a generally rugged terrain with a thick, acidic clay soil that contains little humus. More fertile soils occur on the coastal plains and valley mouths.

Once forest covered the entire island, but human disturbances and frequent typhoons, together with military activities during and after World War II, has left little undisturbed forest on Guam. Only scattered patches remain in inaccessible areas. Southern savannas are believed to be mostly the result of repeated burning. In this region, forests are scattered in ravines, valley bottoms, and steep slopes.

In Guam, towns, villages, and military reservations occupy under 10 percent of the land, although the U.S. military controls roughly one-third of the island (25). About two-thirds of Guam is in public ownership, both Federal and territorial (table 25). Private landholdings are largely in the southeastern and central parts

Table 25.—Landownership in Guam

Landownership	Acres
Private ownership	55,000
Public ownership	80,000
U.S. military and other holdings	52,000
Territorial Government of Guam	28,000
Total land area	135,000

SOURCE: C. D. Whitesell, C. W. Philpot, and M. C. V. Falanruw, "Congressional Action to Improve the Sustainability of U.S. Tropical Forest Resources in the Pacific," OTA commissioned paper, 1982.

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of the island. They are mostly in small parcels and titles are often uncertain.

Little land on Guam is used intensively. No more than 2 percent of the land is actively cultivated (46). About 70,000 unmanaged acres (52 percent) have a cover of brush or trees including some 10,000 acres of abandoned coconut groves. About 50,000 acres (37 percent) of open or grass-covered land exist, little of which is grazed. In the southern part of the island, some of the open land is barren and actively eroding. Significant portions of both wooded and grass-covered lands are under military control, which restricts or prevents other uses.

In general, Guam's forests typify those of Micronesia; they remain unmanaged and their productivity is relatively low. Local populations seem little concerned with productive land use as imports provide more desirable substitutes (46). Growing populations are gradually generating pressures that will lead to conversion of the native forest to agriculture and urban areas. Eventually, however, agricultural lands will be largely depleted of nutrients and will be abandoned. These lands, and those already converted to nonproductive wasteland or scrub forest, may be designated "forest land," but foresters can only make such lands productive with great ingenuity, patience, and substantial investments.

History of Forest Use

Pre-U.S. Administration

The original inhabitants of Micronesia made few modifications of their environment. Traditional agriculture activities caused only minimal soil erosion. Low areas just inland of the coastal mangrove forests have been used for taro patches, changing the mangrove's species composition but retaining their capacity to filter and retain sediment.

Traditional agroforestry practices still found on the islands of Truk, Yap, and Ponape produce food while maintaining a cover of trees to protect and stabilize the soil. Coconut and breadfruit are interplanted on Truk's steep lower slopes. On Ponape, yams are planted below trees which they climb. The tree drops some or all of its leaves as the yam grows, providing green manure. Many species of food trees grow on Yap, and their harvest is alternated with produce from taro patches and yam gardens. Burning is used to open up small garden areas and to produce ash fertilizer under trees and bamboo patches (13).

Forests began a gradual decline following the arrival of the Spanish on Guam some 300 years ago. As the Spanish, and later the Germans, gained control, many islands—especially atolls—were eventually cleared, primarily for coconut plantations. The Germans also introduced teak, kapok, and a few other forest tree species during their administration from 1887 to 1914.

In 1914, the Japanese occupied nearly all of Micronesia except Guam and a few small islands. Within a few years, the Japanese had cleared all lands considered suitable for agriculture, and new crops such as pineapple and sugar cane were introduced. Copra production was increased, forests were cut for lumber and charcoal, and thousands of laborers, tradesmen, and their families came from Japan and Okinawa. Refineries, packing plants, large towns, and fortifications were built. Agriculture and forest experiment stations were established and research was conducted, including studies on nitrogen-fixing legumes and forest tree species introductions.

Most of these developments were destroyed during World War II. Commercial agriculture ceased and most fields were abandoned. Now they are covered with brush, grass, or trees, and are degraded from erosion and fires. By the middle of this century, most of the forests of Micronesia had been at some time either destroyed, cut, or converted to agriculture. Many forests are recovering and trees are approaching merchantable size. However, these frequently are species of limited use and commercial value. Remaining native forests and some secondary forests in Palau, Ponape, and Kosrae contain useful native species.

Centuries of colonial rule and great distances between Micronesia islands have resulted in many different forms of landownership. Much landownership is communal, and in some places items such as buildings or individual trees may be owned separately from the land. Land transfer and management authority may be vested in a family member, a village officer, or a village group. Individual ownership is relatively new. This leads to landownership disputes that have major impacts on the status of forest lands, especially the mangroves.

U.S. Administration

Administration of forest resources in Micronesia has been conducted by the U.S. Navy, Department of the Interior, Territory Governments, and now the emerging semi-independent governments. During the 37 years of American control, the forest resource "managers" at various times have been American foresters, agriculturists, biologists, conservationists, military planners, and local island foresters. Some have initiated, while others have ignored, forest management practices and forestry-related research. Political changes and frequent personnel turnover have eventually negated much of the constructive work started over the years in Micronesia. Other factors also have played important roles in determining the present condition of the forest lands, including World War II destruction, fires, typhoons, vandalism, timber theft, neglect, noxious weeds, impoverished soils, and inadequate funding of conservation programs.

One of the more successful U.S.-supported efforts in Micronesia has been the work of agriculturists. Specialists have come and gone over the years, but a dedicated core accomplished some important work with limited budgets, staff, and facilities. Technologies such as those available through the U.S. Agency for International Development programs to lesser developed countries were seldom funded to any significant extent in Micronesia. Consequently, little is known about such things as soil nutrient deficiencies and crop nutrient requirements under the islands' conditions (46).

Fire is the biggest technical problem to overcome in rehabilitating grass lands. Each year, fires are started and allowed to burn uncontrolled. They sweep through the grasses to the edge of the forest, destroying forest along the margin. This deforestation is disrupting island hydrology. For example, older inhabitants of Northern Babeldaob (Palau) remember when the streams ran all year long. Now, due to repeated burnings, the forest cover has been destroyed and the streams run only when it rains, and then they are often fast and muddy (11).

In the 1960's, the TTPI agriculturists brought thousands of improved varieties of coconuts from Yap to the Marshalls and other islands. However, this rehabilitation project was not completed. Local economies now suffer and two new processing plants, one in the Marshalls and one in Palau, have had low production and low profits because of a copra shortage. In fact, it has been necessary to import copra from Papua New Guinea to keep the Palau plant operating.

The condition of coconut plantations on many islands is of serious concern. Many were planted by the Germans around the turn of the century and they are now senescent. For many inhabitants of the U.S. Pacific, coconut growing is the only nongovernment source of cash income. Despite its importance, the copra industry in Micronesia and American Samoa is in trouble on three fronts: 1) the world price is low (in competition with other copra producing areas and other vegetable oils); 2) yields are low and most of the plantings are old, well beyond the productive life of the palm; and 3) while copra is not the only product derived from the coconut, the other major potential product–coir fiber–is wasted (34).

Organizations Dealing With Tropical Forests

Forestry programs in the U.S. Pacific consist primarily of localized extension efforts and limited nursery activities. Industrial forest use is limited to harvesting small commercial

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mangrove forests on Ponape and Kosrae. Individual trees are used by the crafts industry on most islands. The forests also provide some home construction materials on many islands. Forest use is being included in the economic development plans by the new governments.

The only forest research activities in the U.S. Pacific since the 1930's have been those conducted during the past 15 years by the American Pacific Islands Forestry Research Work Unit of the U.S. Forest Service. This Unit is one of three research teams that make up the Institute of Pacific Islands Forestry (IPIF) located in Hawaii. The Institute, in turn, is part of the Pacific Southwest Forest and Range Experiment Station. The Pacific Islands Forestry Research Work Unit is responsible for conducting cooperative research and information exchange with the U.S. Pacific Islands. Support is provided by the Forest Service Northwest Forest Experiment Station and the Hawaii Division of Forestry and wildlife. The State and Private Forestry branch of the Forest Service provides technical assistance and cooperative funds to the forestry programs in the western Pacific.

The Forestry and Soil Resources Division of the Department of Agriculture in Guam has three professional foresters and two technicians. The land grant University of Guam has designated an experimental forest area, but no school in the U.S. Pacific has a forestry or integrated natural resource management curriculum. Ponape State passed a Forest Manage-

ment Act in 1978 that provided for the protection and management of its forest and watershed areas. No forestry program exists in American Samoa. In 1983, the Commonwealth of the Northern Mariana Islands initiated a forestry program (47). Each emerging island government, with the exception of Palau, has a research memorandum of understanding with the IPIF and includes forestry in proposed development plans.

The forestry agencies responsible for forest protection and management in the U.S. western Pacific are either small or nominal. The extant and emerging governments have expressed an intent to include forestry in development and have designated forest agencies, but they lack funding and adequate professional personnel. Also, IPIF is attempting to address the forest research problems on 2,000 islands with only three professional staff and annual funding for only 2 scientist-years (table 26).

Table 26.—Organizations Dealing With Tropical Forest Resources in the American Western Pacific

Agency/Responsibilities
Federal Government: • *Forest Service;* Conducts research and cooperative resource inventories; provides State, Territorial, and private landownership support, and manages Pacific Islands Forestry Information Center. • Soil *Conservation Service;* Advises landowners about land-use alternatives including forestry practices; conducts cooperative soil surveys. • *Fish and Wildlife Service:* Administers Rose Atoll Wildlife Refuge, American Samoa: conducts cooperative terrestrial inventories. • *National Park Service:* Administers the National Historic Park in Guam. • *Department of Defense:* Maintains a chief conservation officer on Guam overseeing DOD activities in the Pacific; maintains Patti Point Natural Area. • *Peace Corps:* Sponsors volunteers to aid village development, forestry, etc. • *Pacific Basin Development Council:* Partnership among U.S. Federal Government, American Samoa, Guam, Northern Mariana Islands, and State of Hawaii to determine the future development needs and priorities of the American Pacific Islands.
Island ***Governments:*** These territorial agencies conduct programs in agriculture, forestry, fire prevention, fish and wildlife management, and outdoor reaction. Two forestry stations test nursery techniques and methods of rehabilitating and reforesting degraded grasslands and woodlands. • *Territory of American Samoa:* Department of Agriculture • *Territory of Guam:* Department of Agriculture, Bureau of Planning • *Commonwealth of Northern Mariana Islands:* Department of Natural Resources • *Republic of the Marshall Islands:* Department of Resources and Development • *Republic of Pa/au:* Deparment of Natural Resources, Nekken Forestry Experiment Station • *Federated States of Micronesia:* Kosrae State, Department of Resources and Development; Ponape State, Department of Conservation, Metalinin Forestry Experiment Station; Truk State, Department of Resources and Development; Yap State, Department of Resources and Development
Universities and colleges: . *American Samoa Community College."* Designated a land grant college in 1983. • College *of Micronesia.* Designated a land grant college i n 1983. . *University of Guam.* Land grant COIlege.
Other: . *South Pacific Commission."* Provides technical assistance, training, and some monetary assistance for agroforestfy and ecology. . *Yap Institute of Natural science.* Identifies flora and fauna of western Pacific islands and traditional uses of medicinal plants on Yap.

SOURCE Adapted from C D. Whitesell, C W Philpot, and M. C. V. Falanruw, "Congressional Action to Improve the Sustainability of U S Tropical Forest Resources in the Pacific, " OTA commissioned paper, 1982.

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PART II
Technology **Assessment**