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CR 12-67

September 1967

FORESTS OF SOUTHEAST ASIA, PUERTO RICO, AND TEXAS

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Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE
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ADVANCED RESEARCH PROJECTS AGENCY

DEPARTMENT of DEFENSE

-

FORESTS OF SOUTHEAST ASIA,

PUERTO RICO, AND TEXAS

BY

LLEWELYN WILLIAMS
Crops Research Division

CR 12-67

Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE
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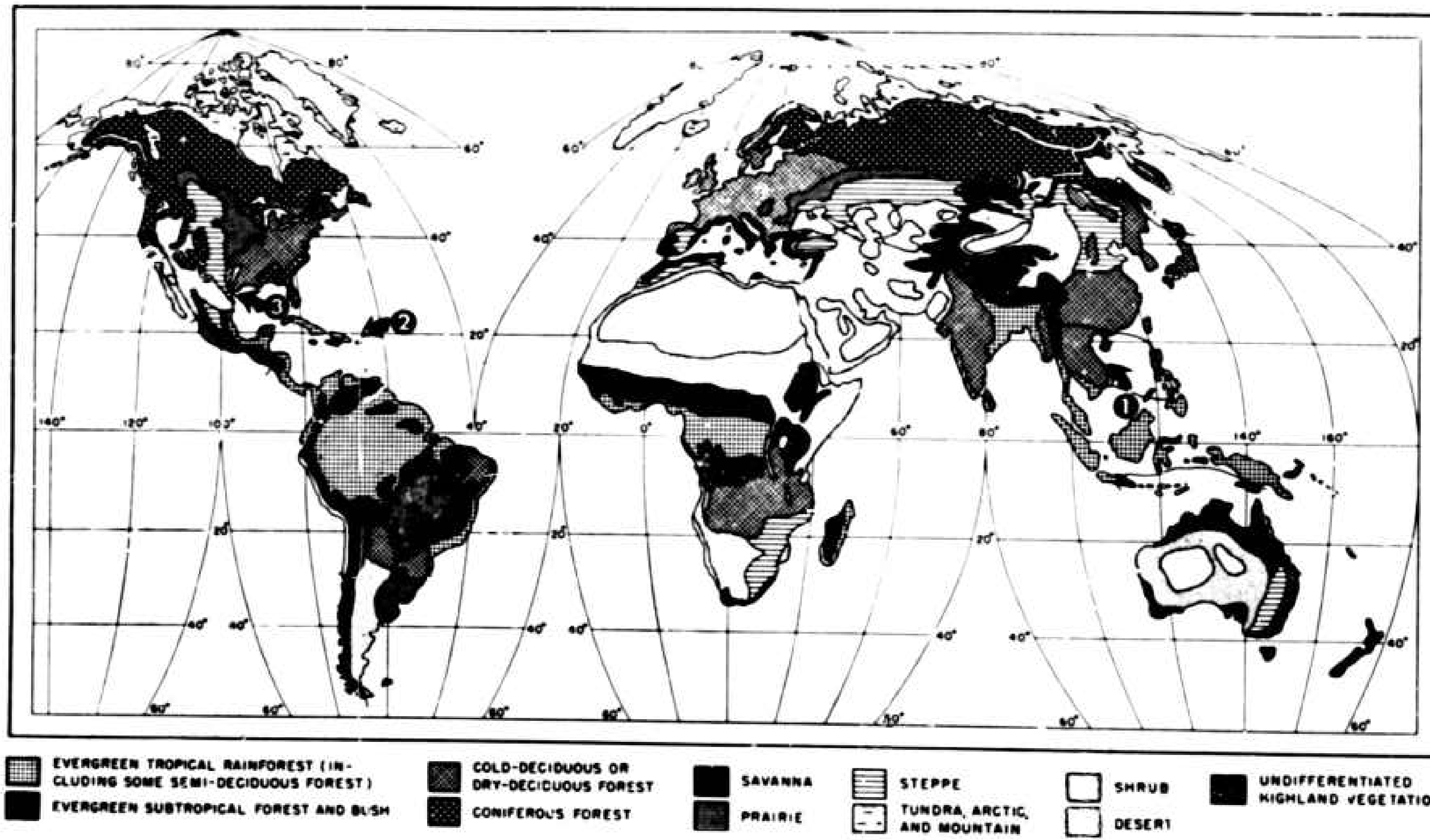
FOREST TYPES OF THE WORLD



Areas investigated: (1) Southeast Asia; (2) Puerto Rico; (3) Texas.

FOREWORD

This Report has been prepared in accordance with the Contract signed, on January 30, 1963, by the Agricultural Research Service, U. S. Department of Agriculture, and the Advanced Research Projects Agency, Department of Defense (ARPA Order No. 424, Program Code No. 3860).

One phase of the Contract involved Botanical Research, aimed at classifying and correlating the principal forest types or formations of Southeast Asia, Puerto Rico and Continental United States, as represented by the vegetation of eastern Texas. Information on the floristic composition and structure of a particular forest type, occurring under tropical, subtropical or temperate conditions, is essential for comparative purpose, and is of value to the ecologist, forester, geographer and others. In brief, vegetation is the summation of climate, soil types, and general conditions in a particular environment.

Throughout the Report emphasis is placed on analogous and anomalous features of the forests of Southeast Asia, Puerto Rico and Texas. This comparison is based principally on investigations conducted by the author throughout Thailand at intervals during 1963 to 1965; in Puerto Rico in April 1963 and June 1966; and in eastern Texas in September 1966. Other studies, especially on seedlings appearing in successional growth, were conducted in Puerto Rico by J. A. Duke during 1963 to 1965. The illustrations and maps included in this Report were taken or prepared by the author, unless otherwise indicated.

The requirements specified in ARPA Order No. 424, involving Botanical Research, have been fulfilled with the publication of "Vegetation of Southeast Asia: Studies of Forest Types" (CR 49-65), issued by the Department of Agriculture in December 1965, and compiled by this author, supplemented by this comparative study of the forests of Southeast Asia, Puerto Rico and Texas.

Crops Research Division
Agriculture Research Service
U. S. Department of Agriculture

Llewelyn Williams

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Summary

The objective of this Report is to evaluate and to correlate the forests and associated factors of the three geographically distinct regions. In order to establish their affinities and anomalies, the specific composition and structure of the principal forest types are discussed. A comparison is made between the forests of Thailand and those of the other Mekong basin countries. These, in turn, are correlated with the forests of Puerto Rico and Texas. The field covered is so vast and diverse, and the literature somewhat fragmentary, that this Report is necessarily of the nature of a general reconnaissance.

The five countries of Southeast Asia - Cambodia, Laos, Thailand, North and South Vietnam - have a combined area of about 505,000 square miles, almost twice the size of the State of Texas (262,120 sq. mi.), and approximately 14? times the area of Puerto Rico (3,420 sq. mi.). The three widely separated regions are rich in plant life. Because of latitudinal and altitudinal variations in climate, from equatorial to temperate, with high annual rainfall, in excess of 100 in. (2,500 mm.), at one extreme, to less than 40 in. (1,016 mm.) at the other, variable topography from coastal plains, plateaus to mountain ranges with high peaks, and different soil types, it is natural that the forests of the three widely separated areas should exhibit considerable variations, each with distinctive and characteristic flora.

The forests of Southeast Asia, Puerto Rico and to a large extent of Texas have suffered severely over the centuries from human disturbance, especially around populated areas. Considerable felling has been in progress to supply useful timbers, for fuelwood and charcoal, and to clear land for agricultural use. Grazing by domestic animals and wildlife, and damage by fires deliberately set or spontaneous have also affected the forests. So that the primary vegetation in many parts has been completely replaced by secondary plant communities, such as extensive bamboo brakes frequent throughout Southeast Asia, and it is now difficult to reconstruct the original plant cover.

Many plants of American origin, and considered of economic value, such as tobacco, corn, cassava or manioc, fiber plants, edible fruits and seeds, and others esteemed as ornamentals, have been introduced into Southeast Asia. Likewise, a number of useful plants native to Asia, such as bamboos, tung-oil tree, and soybean, have become well established in the New World. In all areas these are generally found around abodes, rarely in the forests.

Although the three regions contain manifold Forest Types, with sharp contrasts in floristic composition, certain well-defined affinities are readily recognizable. For example, a large series of identical genera, and even many species, occur within the limits of the three regions. Also, there is a distinct similarity in the structure or physiognomy of certain types of forests, such as the Evergreen Humid forest, Mangrove woodland, Pine forest, Savanna, and Thorn scrub that are present, especially in Southeast Asia and tropical America.

Conifers figure prominently in the vegetation of Texas, including species of juniper, Douglas-fir, and especially pines. On the other hand, in Puerto Rico there is only one native Conifer, Podocarpus of the Yew family, although several exotic species have been introduced. Several genera of Conifers, including pines, are native to Southeast Asia. Despite their widespread distribution, Conifers form only a small proportion of the entire forested area of the Mekong basin region. So that, whereas the forests of North America may be grouped into Conifers or Softwoods and Broad-leaved or Hardwood, this classification is not applicable to the forests of Southeast Asia. There, the forests are more aptly segregated into: Evergreen, including Conifers; and Deciduous or Seasonal.

The vegetation of the Indochina Peninsula is rather homogeneous throughout and is representative of the entire region from the Bay of Bengal to the Gulf of Tonkin.

The most characteristic forest type of Southeast Asia, including Indo-Malaysia, but entirely lacking in this Hemisphere, is the Dipterocarp. This is composed of several genera of small to large trees of the wood-oil or Philippine mahogany family (Dipterocarpaceae). In Thailand, Dipterocarp forests constitute about 45 percent of the country's total forested area. In Laos, Cambodia and Vietnam, also, Dipterocarp forest represents the most widespread type of forest growth.

Teak (Tectona grandis), long the principal commercial timber of sections of Southeast Asia, is not found in this

Hemisphere, except under propagated conditions. In northern Thailand and northwestern Laos teak grows naturally in abundance, and forms the dominant tree in Mixed deciduous forest. It has been propagated successfully in sections of South Vietnam and Cambodia, as well as in Puerto Rico and elsewhere in tropical America.

The most complex primary type, and the richest from the standpoint of number of species, volume and density, is the Tropical Rain forest. Extensive areas of this are found in sections of Southeast Asia, where the annual rainfall exceeds 100 in. (2,540 mm.). An analogous type, of somewhat lower stature and more limited in area, occurs in Puerto Rico in the Luquillo National Forest and in the central mountain region of Toro Negro. The Temperate Rain forest in Continental United States is similar in physiognomy to the Tropical Rain forest. Although it does not occur in Texas, the tall, wet forest of the Pacific Northwest is representative of this. Some of the trees in that forest are larger in dimension and stature, but it contains fewer species than in the Tropical Humid forest.

Vegetation in swamps or marshlands is a characteristic feature of the landscape in Southeast Asia, Puerto Rico and Texas, as in other tropical and temperate regions. Mangrove woodland in coastal belts, and flourishing in saline waters, forms the most homologous type of forest, from the standpoint of structure, occurring in Southeast Asia and Puerto Rico. Stands of Mangrove occur along the north and south coasts of Puerto Rico. More extensive and somewhat taller stands are scattered along the southern Peninsula and southeast coast of Thailand; sections of Cambodia; cover considerable areas of South Vietnam, especially in the region of the Camau Peninsula and in the lower Mekong delta; and smaller areas in North Vietnam, east of Haiphong. Mangrove does not occur in Texas, but the Cypress-Tupelo swamp in the lower Mississippi delta, and the Mangrove swamps of southern Florida are analogous in physiognomy to those of Puerto Rico and Southeast Asia.

A characteristic feature of the plant cover in Puerto Rico and Southeast Asia, as in all tropical and temperate regions, is the contrast in specific composition and structure between lowland and mountain forests. The canopy in the multi-storied Lowland or Hill Evergreen Rain forest, at elevations up to about 3,000 ft. (1,000 m.), is composed of large trees, averaging 90 to 110 ft. (30 - 36 m.) in height, with long, column-like trunks, often with buttresses, and with up to 50 or more woody species growing within an area of one acre, in addition to lianes, palms, grasses and herbaceous plants.

At higher elevation, from 3,000 to about 4,500 ft. (1,000 - 1,500 m.), in the Mid-mountain forest of Khao Yai in central Thailand, for example, oaks (Quercus), chestnut (Castanopsis), and Conifers (species of Podocarpus and Dacrydium) are frequent. This forest is somewhat lower in stature than the Rain forest, has two strata, the trees in general are rather slender, and palms and other plants, typical of the Humid forest, are scarce or absent. At still higher altitudes, the oak-chestnut association is gradually supplanted by stands of pines, and on the crest of mountain ranges by small, gnarled trees.

In Puerto Rico, likewise, there is a gradual gradation from the Rain forest into the Mid-mountain forest. At still higher elevations, along the upper slopes, the dwarf Elfin woodland occurs in sites exposed to constant wind and high humidity, while on sheltered, leeward slopes the Mossy forest flourishes.

Seasonal or deciduous forest at lower elevations in tropical regions, such as stands of teak mixed with other hardwoods in northern Thailand, and especially when the tree crowns are bare of leaves at the height of the dry season in late January or February, resembles the mixed deciduous hardwood forest of temperate zones.

Several species of oaks (Quercus), usually mixed with other hardwoods, and at higher elevations with conifers, are frequent in the Mountain forests of central and northern Thailand, as well as in Laos, Vietnam and Cambodia. These are particularly abundant in the northern section of North Vietnam, or what was formerly known as Tonkin. Native oaks form an insignificant fraction of the vegetation of Puerto Rico, although several species have been introduced from the United States and Asia. Oaks constitute a major element in the forests of Texas, being represented by about 35 species, and a number of varieties.

Riverain or gallery forests, fringing streams and rivers, are of common occurrence in both tropical and temperate regions.

Thorn thickets are widespread in the Caribbean and mainland tropical America and are frequent also in Southeast Asia. Several species of trees and shrubs, cacti, grasses and herbs that flourish in these thickets have a pantropical distribution, and are of frequent occurrence in Southeast Asia, Puerto Rico and sections of Texas.

Savannas, such as the llanos of Venezuela or the pampas of Argentina, cover much larger areas in tropical America than in Southeast Asia. The post-oak savanna of eastern Texas is reminiscent of limited stretches of savanna in eastern and northeastern Thailand, in which Dipterocarp trees of small stature are abundant.

Grasses are exceedingly well represented in Texas. In fact, grasses are more abundant in that State, in terms of species, than in Southeast Asia or Puerto Rico.

Bamboos are abundant throughout Southeast Asia in all types of forests, especially where clearings have been made or when tilled land is abandoned. They play an important role in the local economy, as sources of shelter and food, and constitute an article of export. Several Asiatic species, including Bambusa vulgaris and B. tulda, have been introduced into Puerto Rico, and now grow spontaneously. There is only one species of bamboo, the giant cane (Arundinaria gigantea), in Texas.

Palms are not as well represented in Puerto Rico as in Southeast Asia, although a number of species have been introduced. However, the sierra palm (Prestoea montana) is widely distributed in the island and forms large brakes in humid sites, in the middle and upper elevations. Nowhere in Southeast Asia are there palm brakes comparable in extent to those of the Puerto Rican sierra palm.

The composition and structure of secondary or successional growth that invariably develops, following felling, clearing or burning of the original or primary forest is described. The sequence of development of successional growth is similar in all tropical regions.

Aerial survey, supplemented by photographs, is an important method of expediting the task of assessing the density, area, and the delineation of different types of forests. Certain tree species occurring in tropical forests can be identified from the air by their height, form of trunk and crown, color of bark, density and hue of foliage, and at certain times of the year by the color of their flowers. Furthermore, aerial survey is an invaluable tool to supplement ground studies.

There are many plants in Southeast Asia, as in tropical America, that furnish edible fruits, seeds, and tubers which serve as sources of food during emergency. Only a small percentage of tropical plants may be considered toxic or hazardous. A concise description and methods of preparing survival plants, and a list of edible seeds and others useful as potherbs are given.

The forests of Southeast Asia, Puerto Rico and Texas contain a large number of useful timbers which have long been used, both domestically and for export, for general construction, as sources of fuelwood and charcoal, and multiple other purposes. A concise description is given of the general properties and uses of the principal commercial timbers of Southeast Asia and Puerto Rico.

A series of 13 maps are included. To illustrate the various types of primary and secondary forests described, 106 illustrations, taken by the author during field investigations, are included. Line drawings of edible and hazardous plants supplement the descriptions and listings of survival plants.

The Report terminates with bibliographies, citing references to the forests and forest products of Cambodia, Laos, Thailand and Vietnam; Puerto Rico and Texas; also aquatic and survival plants.

FORESTS OF SOUTHEAST ASIA, PUERTO RICO, AND TEXAS

INTRODUCTION

Tropical forests occur roughly within the thermal belts approximating the Tropics of Cancer and Capricorn. In a general manner, they are distributed in three major belts: (a) from south-central Mexico and the West Indies to southeastern Brazil and northern Argentine, with the largest continuous mass concentrated in the equatorial basin of the Amazon; (b) in central and southern regions of Africa, south of the Sahara and north of South Africa, centered around the Congo basin, extending eastward toward the Great Lakes, and westward to the Cameroons, Nigeria, Ghana, Liberia and Gambia; and (c) in the eastern tropics from West Pakistan, western India and Ceylon to Burma, the Indochina Peninsula, Malaysian Archipelago to New Guinea and northern Australia.

For many decades the floristics of temperate regions have been a fertile field for intensive studies by taxonomists, ecologists, plant geographers, foresters and other specialists. Considerable information has been gathered during the past 50 to 100 years on tropical vegetation. Although the forests of some tropical countries or regions have been thoroughly studied, and voluminous data published on their flora, there are vast areas, such as the headwaters of the numerous tributaries of the Amazon, still to be investigated botanically. Consequently, no precise information is yet available on the specific composition of the forests or the natural products of many remote, in parts almost inaccessible, tropical regions.

Of the areas discussed in this Report, the forests and their plant components of Puerto Rico, as well as of Texas, have been the object of intensive field investigations and have been well described during the course of this century. In some areas of Southeast Asia, also, considerable plant collections for study have been made during the last five or six decades. But until recently other less accessible sections were imperfectly known from the standpoint of plant cover. The construction of trunk highways and lateral roads, and the establishment of air routes in Thailand, during the last 10 to 20 years, for example, have contributed greatly to the problems of penetrating isolated areas and to a better knowledge of the forest types prevailing in hitherto little explored sections.

In northern Thailand the Dry and Moist Deciduous forests, where teak abounds, have been studied ecologically and taxonomically during the past 50 years or so by British botanists, Craib and Kerr, and in recent years by botanists and foresters of the Royal Forest Department, Kasetsart University, and other scientific institutions, including, American, Danish and Japanese investigators. But extensive areas still remain to be surveyed, particularly the Evergreen Rain forest in the southern Peninsula, covering the eastern mountain ranges along the Cambodian border, in the Kheo Yai National Forest in the central section bordering the Korat plateau, or the various types of forests in the extreme northeastern and northwestern sections of Thailand.

When Vietnam, Cambodia and Laos, formerly known collectively as Indochina, were under French administration spanning a period of about 90 years, botanists, ecologists and foresters, mostly French and some nationals, attached to the local Forest Department, made large plant collections, and extensive ecological and silvicultural studies. As a result, a series of publications are available on the floristics and forest types of those countries, including the voluminous and comprehensive "Flore Générale de l'Indo-Chine," edited by Lecomte. These studies were concentrated mainly in Tonkin, now forming the northern part of North Vietnam; Annam or central Vietnam; Cochinchina, now the southernmost part of South Vietnam; and Cambodia. Investigations in Laos were concentrated mainly in the central and southern regions especially in the Mekong basin. Much information still remains to be assembled on the specific composition and extent of even the principal forest types in the northern half of that little kingdom, as well as of the most northern and western sections of North Vietnam along the border with China.

Map 1. The five countries of S. E. Asia have a combined area of 505,000 sq. miles; and a population of about 60 millions.

GENERAL FEATURES

OF

SOUTHEAST ASIA, PUERTO RICO AND TEXAS

Southeast Asia: Some geographers consider Southeast Asia to include the countries of the Indochina Peninsula and the adjacent Indo-Malaysian Archipelago: Thailand, North and South Vietnam, Laos, Cambodia, Burma, Malaysia, and Indonesia as far as New Guinea. The region covered in this Report, however, is limited to the countries surrounding the Mekong basin, namely North and South Vietnam, Cambodia, Laos and Thailand. These have a total area of approximately 505,000 square miles, almost twice the size of Texas and more than double the area of France. The population is estimated at approximately 60 millions, with an average density of 118 inhabitants per square mile.

The Indochina Peninsula projects far down into the tropical oceanic zone, so that the climate of the Mekong basin countries is influenced to a large degree by their position as part of the great continental land mass of Asia, by the prevailing winds, accompanied by a wide latitude in humidity and aridity. The monsoon is the dominating factor. Monsoons are seasonal winds blowing from one direction during part of the year, and from another direction during the remaining months. The presence of mountain ranges, which intercept moisture-laden winds, results in a rainfall pattern, with alternating periods of rainy southwest monsoon, and dry northern or northeastern monsoon. The varying distribution of rainfall during the year has a decided influence on the type and distribution of forest formations in this great area. Except in mountainous areas, the temperatures are fairly high throughout, with no frost at lower elevations.

It is estimated that there are approximately 10.000 species of plants in the five countries of the Mekong basin. These include herbaceous plants, epiphytes, bamboos, rattans, slender vines and stout lianes, palms, and shrubs to giant trees typical of the luxuriant Rain forest; in addition to oaks, chestnuts, magnolias, conifers and other plants usually associated with temperate forests. A high percentage of the genera found in the countries east of the Mekong river occur also to the west of that river, in Thailand. So that there is considerable uniformity in the types of forests occurring in the entire Indochina Peninsula. The Thai forests contain many useful timbers, including teak (Tectona grandis), rosewood (Dalbergia cochinchinensis), other hardwoods such as Afzelia and Xylia, and various species of Dipterocarps (Dipterocarpus, Shorea and Hopea) of the wood-oil family, which have long figured in domestic and international trade of those countries.

The forests of the Indochina Peninsula, represented by lowland and upland Wet or Moist Evergreen forests, Moist and Dry Mixed Deciduous, Dipterocarp, Scrub and Thorn forests, Bamboo brakes and Savannas, in the aggregate cover from 40 to 50 percent of the total land area of North and South Vietnam; about 25 percent of Cambodia; and 60 to 65 percent of Thailand and Laos. In comparison, only about 20 percent of the area of Puerto Rico is covered by vegetation of one type or another, of which less than 5 percent is of original or primary growth, and the remaining 15 percent or so by successional or secondary growth, which has developed following felling, clearing and burning for agricultural purpose. In Texas, of its total area of 167 million acres (250,000 square miles), it is estimated that there are approximately 26.5 million acres (41,400 square miles), or 16 percent, of forests.

The forests of the Mekong basin countries are reviewed in "Vegetation of Southeast Asia - Studies of Forest Types 1963 - 1965" (CR 49-65), by this author and issued in December 1965.

Puerto Rico: This is the smallest, easternmost and most southern of the islands forming the Greater Antilles, which also include Hispaniola (The Dominican Republic and Haiti), Jamaica and Cuba. According to geologists, Puerto Rico and the other islands of the Antilles and Central America and northern South America were formerly a united and distinct continental land mass - the Antillean continent.

Almost rectangular in outline, this island is approximately 113 miles long and 41 miles wide, with its axis from east to west. It has a land area of 3,423 square miles, equal to about five-sixths that of Hawaii, or slightly less than one-sixtieth the area of Thailand. Situated between 17° 54' and 18° 31' north latitude and 65° 13' and 67° 15' west longitude, it is well within the American tropics. The coast line is nearly straight, and usually low, especially on the southern side.

Few countries of comparable size are so well watered as Puerto Rico. It is reported that the island has about 1,300 streams, of which the Rio de la Plata, about 45 miles long, is considered the longest. Streams flowing northward from the main divide are much more numerous and longer than those from the south side, and they likewise carry a greater and more constant volume of water. None of the rivers are navigable, except for small boats, and then only in their tidal reaches. Nevertheless, they are of great importance as a source of water supply for drinking and irrigation, and their potential hydroelecteric possibilities are considerable.

There is little doubt that Puerto Rico was at one time forested from the shores of the Atlantic to the Caribbean. Severe cutting, clearing, and culling of the more desirable timber trees were recorded by early travelers. For decades the people of Puerto Rico have consumed several times as much wood as the forests of the island are able to produce. Great quantities of timber have been cut or burned to make small clearings for agricultural use. After two or three crops the clearings were abandoned and later became a mere thicket. This extensive felling over a period of decades and clearing of forests for commercial timbers and agricultural use have resulted in the destruction of many species.

About 1,500 species of plants are found in the island, of which about one-third are woody. These include: shrubs and small trees, many of them thorny, in dry areas such as around Guánica, in the southwest; palm and bamboo brakes; dwarf trees in the elfin woodland, on upper slopes below the summit of the peak El Yunque in the northeast; and moderately tall to large trees in the luxuriant Moist Evergreen forest at middle elevations in the Luquillo National Park. Apparently, this fine forest was cut over in former years for construction timbers, so that today there are only a limited number of large trees, mainly species of Dacryodes, Manilkara, Sloanea and Cyrilla, comparable to dominants in the Rain forest of southern peninsular and southeastern Thailand, and other areas in the Mekong basin countries. Many plant families and genera, found in Southeast Asia, occur also in Puerto Rico and Texas.

Many native species have been transplanted from their natural haunts to other tropical regions. Also, many tree species of economic or ornamental value have been introduced from other countries and propagated throughout the island. Of the 1,577 species of plants, native and introduced, reported in Puerto Rico, 529 (about 33 percent) are found in North and/or South Vietnam, and 293 (approximately 18 percent) in Thailand.

Texas: This large State extends for about 800 miles (1,280 kms.), from the estuary of the Rio Grande to the northwestern corner of the Panhandle, and 770 miles (1,232 kms.) at its greatest width from east to west. It has an area of about 262,120 sq. miles, equivalent to nearly one-eleventh of the total land cover of continental United States, or slightly less than half the size of the five Mekong basin countries.

The general surface of the State is a dissected plain, tilted toward the southwest. It rises from sea level to more than 4,000 ft. (1,230 m.) in the extreme northwest. In the most western part a number of mountains rise from 5,000 to 9,000 ft. (1,540 - 2,770 m.) above sea-level, with some peaks more than 5,000 ft. (1,540 m.) above the general level of the surrounding country. Many rivers flow in a southeasterly direction through broad valleys. Some large areas are nearly flat; others are undulating to rolling; and still others are hilly or rugged with deep valleys.

The vegetation of Texas attracted botanists even before the colony declared its independence from Mexico. Prior to its annexation to the Union, Texas had become an interesting field of observations and research for botanists and naturalists.

William Bray, one of Texas' outstanding botanists, after a statewide survey in 190[illegible], concluded that Texas is "the battleground for supremacy of the plant races." Parts of three of the six main forest types of the United States are represented within the boundaries of this vast State. Because of their ability to resist heat, drought, winds and adaptability to different types of soils, many trees which are common to other sections of the country have developed, through the ages, into well established Texas varieties. Because of this adaptability there are about 800 species or varieties of woody plants within the State, growing on an estimated 26.5 million acres of forests. These do not include extensive areas of mesquite and other small woody growth considered as pests, because of their rapid development and expansion on rangeland.

P h y s i o g r a p h y

The five Southeast Asian countries may be considered as a unit, based on the similarity of their respective physiography, climate, soil types, as well as their vegetation. Briefly stated, their general physiography is that of great plains and plateaus, rising to mountain ranges with peaks upwards of 6,500 feet (2,000 m.) in altitude. The entire region is drained by a network of large and small rivers, and their tributaries, most of which flow in a southerly or southwesterly direction. The estuaries of the larger rivers form extensive deltas, with a distinctive vegetation, predominantly mangrove woodland, which is also present in Puerto Rico. These rivers are navigable for considerable distances into the interior.

Puerto Rico has three major physiographic regions: (a) a central mountain core of volcanic origin; (b) an elevated area of coral limestone, formerly marginal marine deposits, surrounding the mountain ranges; and (c) the north and south coastal plains. The upland area is the source of many swift-running streams, flowing through gorges and steep-sloped valleys. Except for small boats, these streams are navigable only in their tidal reaches.

There are four broad physiographical regions in Texas: the coastal or east Texas plain; the north-central plains; the great plain; and mountains and basins of the Trans-Pecos. Some large areas are nearly flat, others are undulating, and still others are hilly to mountainous, ranging from sea level to about 9,000 feet (2,770 m.), and with peaks rising to more than 5,000 feet (1,540 m.) above the general level of the surrounding country. Many streams dissect the State, flowing irregularly from the northwest to the Gulf of Mexico.

C l i m a t e

The climatic conditions of the three regions discussed in this report range, on the one hand, from tropical, in parts with annual rainfall in excess of 150 in. (3,750 mm.) distributed throughout the year, to a temperate climate, at the other extreme as in Texas, where annual precipitation fluctuates between 30 and 50 in. (750 - 1,250 mm.), in the eastern section and as low as 8 in. (200 mm.), or even less in the western part.

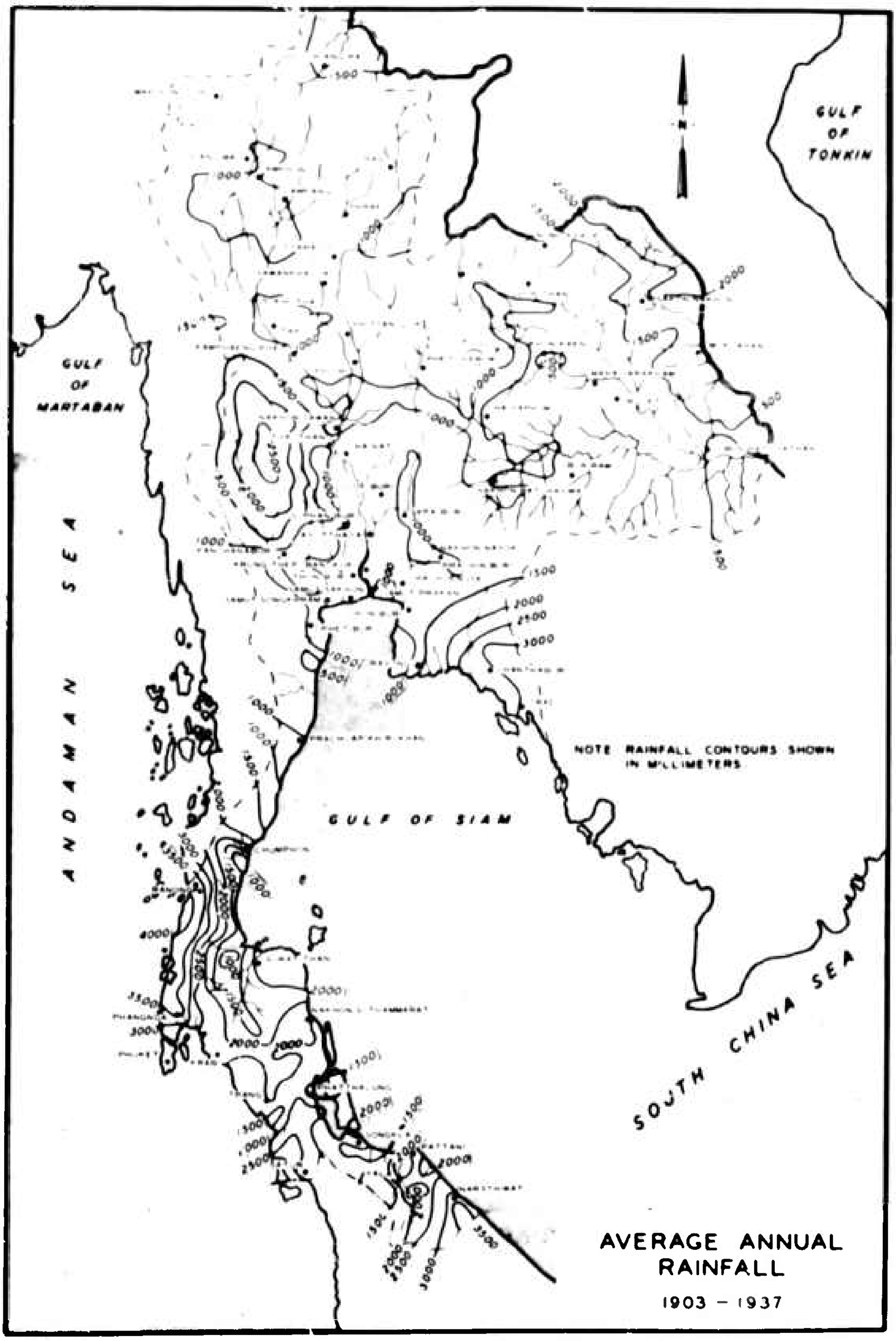
Throughout most of Southeast Asia the climate is dominated by the monsoon, and modified by regional topography. This is characterized by seasonal winds, blowing from one direction during certain months, and from the opposite direction during the remainder of the year. Two broad types of climatic conditions prevail: that of the Rain forest, characterized by uniformly high precipitation and high temperature; and the other, the Seasonal or Monsoon, or what some ecologists or plant geographers prefer to call Savanna type. This is characterized by a rainy season and a dry period more or less of equal duration.

Thailand: Under monsoon conditions, four fairly well-defined seasons may be recognized in Thailand, and likewise in the adjacent Mekong basin countries: (a) Northeast monsoon from December to February, with little rain, which corresponds to the cool or dry season; (b) the warm season, also almost rainless, with highly variable winds and transitional hot weather, during March to May; (c) the rainy season, from May to October, when the rains cool the atmosphere and the temperature is generally lower; and (d) the retreating monsoon period of October and November.

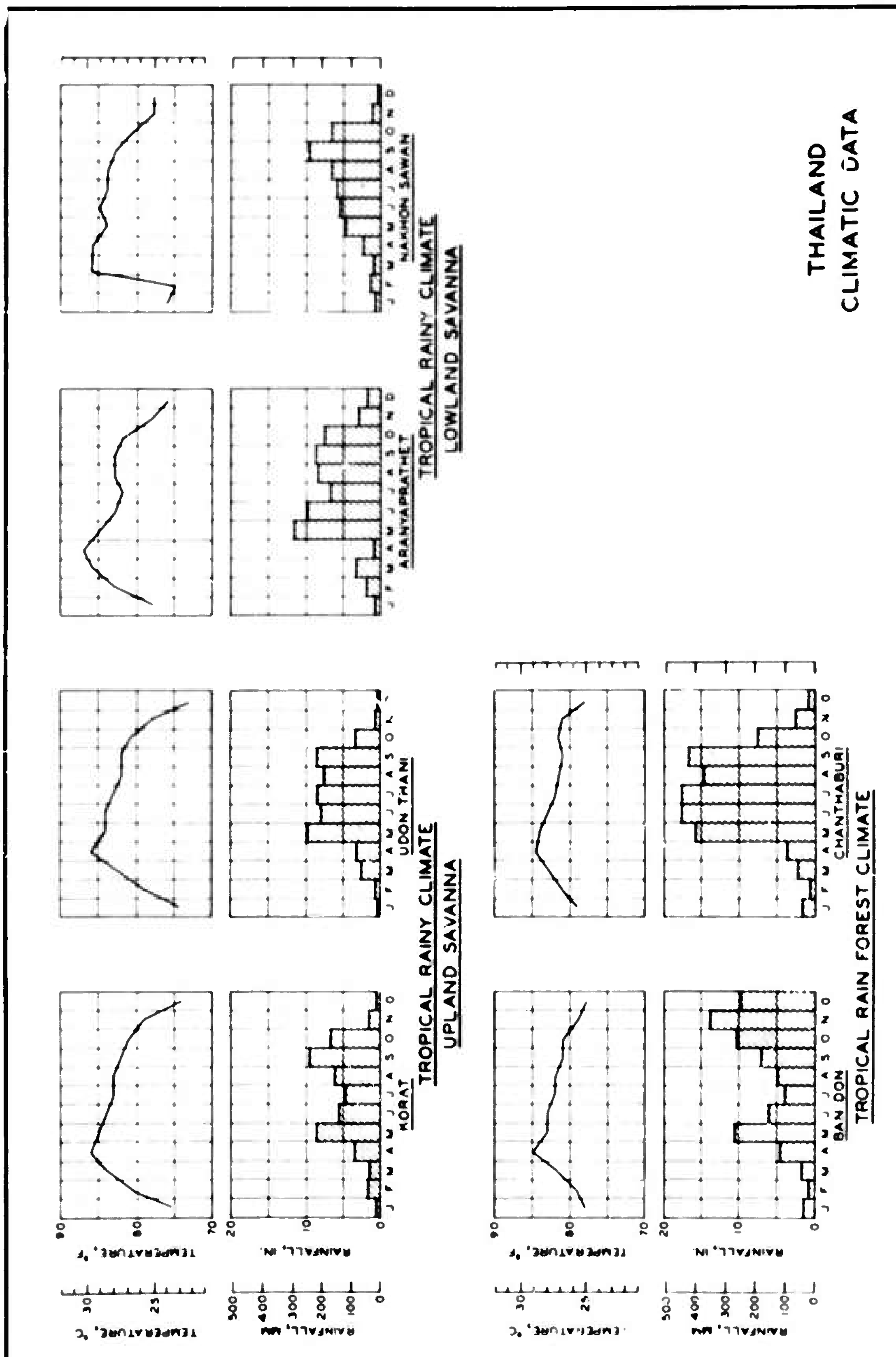
As in Texas, temperatures in Southeast Asia exhibit extreme range, from the torrid zones in the plains to cool temperate climate in the highlands with freezing temperatures on the peaks. In most areas of Thailand the mean monthly temperature ranges from mid 70°'s (F.) during the coolest months (December and January), to mid-80°'s for the warmest Spring months (April or May). With the advent of the Northeast monsoon in November, when the dry season normally begins, Thailand enjoys cool nights, and temperatures as low as 40° F. may prevail in some of the northern upland areas. During the hot months of February and March, daytime temperatures in Bangkok are almost always in the 90°'s, and often reach 100° F. in the interior.

In the Peninsula temperature conditions are fairly constant, owing to its proximity to the sea. The transition from wet to dry season is less pronounced than in the central and northern regions. The annual variation in temperature is more restricted, with a daily range of about 16° F., with the annual minimum temperatures of 68° F. and a maximum of 95° F.

The intensity, distribution and timing of rainfall appear to exert more influence on vegetation than temperature in Southeast Asia. The volume of rainfall generally decreases in Thailand, as in other parts of Southeast Asia, with increasing distances from the sea. This may be modified locally by the variation in topography. This phenomenon is reflected in the vegetation cover of Thailand. Evergreen Rain forest dominates



Map 2. Thailand - Annual Rainfall. 1" - 25.4 mm.


THAILAND
CLIMATIC DATA
TROPICAL RAINY CLIMATE
UPLAND SAVANNA
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NAKHON SAWAN
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TEMPERATURE, °F
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Figure 1

in the southernmost part of the Peninsula and along the southeast coast, where annual precipitation ranges up to 150 inches in parts, whereas drier Deciduous forests predominate in the drier continental section of the country.

With the exception of the Peninsula, in most parts of Thailand almost 90 percent of the annual precipitation of 40 to 80 in. (1,000 - 2,000 mm.) falls during the southwest monsoon, from May to October. At that time the relative humidity seldom falls below 70 percent. In the central plain of Thailand the average annual rainfall decreases progressively from south to north. For example, Bangkok has an average of 59 in. (1,475 mm.); Lophuri, 54 in. (1,250 mm.); and Nakhon Savan, in the upper part of the central plain, has 43 in. (1,075 mm.). The driest regions are in the rain shadow of escarpments between the central plain and the Korat or northeastern plateau; and along the eastern base of the Tenasserim range, on the west, from the upper Peninsula northward to Kanchanaburi and Tak. The influence of the rain shadow on the vegetation in that area is shown by the frequency of dry bamboo brakes, intermixed with thorn brush.

In the Peninsula, southward from Chumphon to the Malaysian border, rains fall at some time during all seasons. The mountain ranges intercept the moisture-laden air masses borne by the southwest monsoon and benfit also from the northeast monsoon. No station in the southern Peninsula has less than 60 in. (1,500 mm.) of annual rainfall, and in most sites it exceeds 80 in. (2,000 mm.).

The high ranges along the southwest coast of the Peninsula, especially between Ranong and Takuapa, receive the full effect of the monsoon sweeping in from the Andaman Sea. These air masses saturated with vapor cause extremely heavy rains. At Takuapa, for instance, annual precipitation reaches 166 in. (4,150 mm.), among the highest recorded in Southeast Asia, and in some years up to 260 in. (6,500 mm.). This abundant and relatively well distributed rainfall, accompanied by constant soil moisture and continuously moist tropical heat, produce a luxuriant vegetation, culminating in the climax or optimum Rain forest. Similar prolific Rain forest cover appears in some sites on the Cardamom mountain range in the southeast, between Thailand and Cambodia, where the annual rainfall is the highest in Southeast Asia.

Vietnam: The climate of Vietnam is also a tropical monsoon or seasonal type, generally with high temperatures and ample rainfall in the wet period. The considerable latitudinal and altitudinal range of the country is reflected in the noticeable

INDOCHINA PENINSULA

Average Annual Temperature and Rainfall
(Figures in parentheses are years of record)

Locality	Air Temperature (°F.) Mean	Mean Maximum	Mean Minimum	Precipitation (Inches) Mean	Absolute Maximum	Absolute Minimum	Mean No. of Days with Precipitation
Hanoi, North Vietnam	75 (33)	82 (33)	69.3 (27)	66.2 (31)	92.7 (31)	44.1 (31)	136 (34)
Hue, Central Vietnam	78 (24)	84.7 (38)	71.4 (24)	114.3 (18)	168.1 (18)	74.0 (18)	142 (18)
Saigon, South Vietnam	80 (31)	90 (31)	73.9 (24)	78.1 (33)	107.0 (33)	57.3 (33)	153 (34)
Luang Prabang, Laos	78 (28)	89 (28)	67.5 (24)	51.5 (31)	74.0 (31)	20.1 (31)	100 (32)
Thakhek, West-central Laos	78 (11)	87 (11)	69 (11)	92.6 (13)	115.4 (11)	71.7 (11)	123 (14)
Phnom Penh, Cambodia	81 (39)	90 (39)	74.8 (25)	55.4 (33)	90.9 (33)	36.8 (33)	121 (34)
Chiengrai, Northern Thailand	76.5 (11)	87.5 (11)	65.7 (15)	63.3 (25)	72.6 (11)	44.1 (11)	
Bangkok, Thailand	81.9 (27)	89.4 (27)	74.5 (34)	54.2 (49)	77.4 (21)	33.8 (21)	131 (13)
Chantaburi, South-east Thailand	81.2 (14)	89.8 (13)	72.7 (17)	109.9 (30)	139.9 (26)	76.0 (26)	
Songkla, South Peninsula	82.3 (13)	88.7 (13)	75.6 (17)	84.3 (31)	124.2 (15)	53.1 (15)	

variations in climate from one region to another. The rainfall accordingly is subject to considerable annual fluctuations. As in Thailand, in South Vietnam the rainy season ends in October, followed by a relatively dry, cool season from November to March. Along the narrow coastal plains of Annam, or central Vietnam, the rainy season, influenced by prevailing typhoons, may extend into January.

In South Vietnam overall annual rainfall averages about 80 in. (2,000 mm.), compared with 70 in. (1,750 mm.) in North Vietnam. But unlike South Vietnam, in the North the rainfall is more evenly distributed throughout the year. In addition to the rainy season, a moderate amount of precipitation during the dry, cool months is sufficient to produce a second rice crop. In South Vietnam, however, it is impossible to obtain a second crop, without irrigation, during the dry season because of insufficient precipitation.

In North Vietnam the range of temperature during the entire year is greater than in the South. Nevertheless, even in the North, the mean monthly temperature seldom drops below 63° F.

<u>Cambodia</u>: The climate of Cambodia is similar to that of mainland Thailand, with a dry season during the northeast monsoon, from December to May, and a wet period, during the southwest monsoon, from June through November.

The mean annual precipitation at Phnom Penh, the capital, over a 22-year period is 56 in. (1,400 mm.), with an absolute maximum of 91 in. (2,275 mm.), and an absolute minimum of 38 in. (950 mm.). On the summit of mountain ranges precipitation, however, is much higher. The Cardamom and Elephant mountain ranges in the western part along the Thai border lie in the path of the southwest monsoon, and have the highest annual rainfall in the entire Indochina Peninsula. At Val d'Emeraude, for example, the mean annual precipitation is 210 in. (5,250 mm.), with an absolute maximum of 246 in. (6, 150 mm.), and an absolute minimum of 160 in. (4,000 mm.). Nine-tenths of the precipitation falls during the rainy season, and is characterized by torrential showers of short duration.

The temperature ranges between 68° and 97° F., with the coolest period occurring in December and January, and the hottest during April and May. Humidity is constantly high.

<u>Laos</u>: This country, also, has two distinct seasons: a rainy period from May or June to October, during the southwest

PUERTO RICO and EAST TEXAS

Mean Temperature and Rainfall
(Number of years recorded in parentheses)

Locality	Temperature (°F.)				Rainfall (Inches)		
	Jan. (Ave.)	July (Ave.)	Max.	Min.	Jan. (Ave.)	July (Ave.)	Mean Annual
Puerto Rico:							
San Juan (North coast)	74.8 (39)	80.0 (39)	94.0 (39)	62.0 (39)	2.83 (39)	4.90 (39)	55.40 (39)
Ponce (South coastal plains and hills)	75.4 (32)	81.1 (32)	96.0 (32)	55.0 (32)	3.56 (23)	6.17 (23)	65.98 (23)
Cayey (Interior)	69.2 (36)	75.6 (36)	94.0 (36)	44.0 (36)	4.75 (25)	7.53 (25)	89.04 (25)
East Texas:							
College Station	51.2 (36)	84.0 (36)	110.0 (36)	0 (36)	3.03 (38)	2.82 (38)	38.66 (38)
Cuero	53.9 (39)	84.9 (39)	109.0 (39)	4.0 (39)	2.29 (40)	3.32 (40)	35.74 (40)
Llano	48.7 (38)	85.1 (38)	115.0 (38)	-7 (38)	1.28 (40)	2.01 (40)	25.10 (40)
Huntsville	50.4 (38)	83.1 (38)	107.0 (38)	-2 (38)	3.24 (40)	3.60 (40)	44.09 (40)

Source:
U.S. Dept. of Agriculture. 1941. Yearbook of Agriculture--Climate and Man.

monsoon, with an average of 11 - 12 in. (275 - 300 mm.) of rainfall per month; and a rainless, cool season from November to February, with a warmer period from March to May. Humidity is high throughout the year, and the heat is oppressive and enervating especially in the lowlands.

At Vientiane, the administrative capital, temperatures ranges between 70° and 90° F., although temperatures under 50° F. and above 100° F. have been recorded.

Throughout Laos, the temperature and rainfall vary appreciably from one zone to another. For example, on the plateaus of Bolovens and Tran-Ninh, temperature during the cool months may be severe enough to damage local crops. In the province of Xieng Khouang, in the north, temperatures frequently fall below freezing at elevations of 4,000 ft. (1,300 m.).

Puerto Rico: Although well within the tropics, Puerto Rico has an equable climate, influenced by its position in the direct path of the prevailing North Atlantic trade winds, blowing from the northeast. As a result, the temperature is uniform throughout the year. Records maintained by the United States Weather Bureau show an average annual temperature of 76° F. The daily range in temperature is more pronounced than the seasonal. The annual rainfall throughout the country is much more variable than the temperature. The average for a 12-year period showed 77.30 in. (1,965 mm.). The heaviest precipitation is recorded on the Luquillo mountains, in the northeast, where the average annual rainfall reaches 135 in. (3,375 mm.), and at times up to 170 in. (4,318 mm.). There the dominant vegetation type is Evergreen Rain forest. The minimum average annual rainfall of 37 in. (925 mm.) is recorded at Guánica, on the southwest coast, although an absolute minimum of 21 in. (525 mm.) has been recorded there in recent years.

Texas: Located within the latitude of the temperate zone, Texas has three climatic types. The coastal type prevails over a comparatively narrow strip of the Coastal Plain. The continental type, characterized by rapid changes of temperature, is prevalent over the greater part of the State. The mountain type is confined to a comparatively small area of western Texas, the Trans-Pecos.

Climatic areas in Texas have been characterized as arid or semi-arid to wet or sub-humid. Over the entire State temperatures show a wide range between summer and winter. In the extreme south in the Lower Rio Grande Valley, subtropical conditions prevail, and freezing temperatures are infrequent. But in the northern section cold fronts, sweeping down from the north, drop the winter temperatures occasionally to zero or slightly below.

The rainfall pattern of the State is highly erratic. Precipitation decreases progressively from east to west. The highest rainfall is in the eastern section, with an annual average of 55 in. (1,400 mm.), at times up to 80 in. (2,032 mm.). In the El Paso area, it is less than 8 in. (203 mm.), and in some years it may drop to 2 in. (50 mm.). Drought is frequent and reflects its impact on the vegetation.

Biotic Factors

The forests of Southeast Asia, Puerto Rico and to a large extent in Texas have suffered severely over the centuries from human interference, through felling of trees for timbers, fires either deliberately set or spontaneous, grazing by domesticated livestock and wildlife, and damage by insect pests. Direct or indirect disturbances have had a profound effect throughout history on the distribution and composition of vegetation, and on agricultural practices in Southeast Asia, Puerto Rico, as elsewhere. In some of the more densely populated areas of both hemispheres, the natural vegetation has been so completely replaced by anthropogenetic plant communities that it is now difficult to reconstruct with certainty the original optimum plant cover.

Throughout Vietnam, particularly in the northernmost and southernmost parts of delta areas, the forests have been devastated for many decades, whereas in mountainous, less penetrable sections of the central region extensive stands of primary forests still remain more or less intact. The land was first occupied by Nomadic people who destroyed the forests without discrimination. After them came the Annamites. In spite of a more advanced civilization, they regarded the forests as capable of natural regeneration indefinitely. Despite ample rainfall and other favorable conditions for growth the forests were unable to become re-established. Consequently much of the climax forest that formerly covered considerable areas of South Vietnam has either been replaced by brush of secondary growth or cleared for rice culture. This is also true of areas of North Vietnam, especially in the Red river delta region.

Shifting agriculture, the simple, primitive "ray" system, accompanied by periodical burning has been practiced for centuries in Southeast Asia as in other tropical regions. A small plot is selected in the forest to grow food crops. After two or three seasons the soil becomes impoverished. The site is then abandoned and soon becomes covered with Imperata and other grasses, shrubs, and fast-growing, soft-wooded trees of small stature, of entirely different species from the original growth.

Apart from deliberate burning done by the natives, to clear small patches for tilling, violent spontaneous fires also break out every year in the forests, during the dry season, destroying thousands of acres of useful timber trees. These are especially numerous and widespread when the dry period is prolonged. Natural regeneration which has been in progress for many decades is rendered ineffective within a few hours. In the coastal province of Baria in South Vietnam, for example, fires are often exceptionally severe because of high winds blowing in from the sea, so that it is now impossible to find a stand which has not been damaged by fire at some time or other. Even in the forests in western South Vietnam, which are flooded over during a great part of the year, fires break out. Such devastation is continued under the pretext of clearing for agricultural purpose.

The effects of uncontrolled exploitation of forests are also well demonstrated in northeast Thailand, where open Dipterocarp forests predominate. There, the soils are poor, the rainfall is low, and prolonged periods of drought often prevail. Consequently, northeastern Thailand has long been considered the least developed section of the country. In northern Thailand, also, large tracts of forests furnishing timbers of commercial value have been destroyed. In former years, while in private ownership, valuable forests in which Teak abounds were exploited indiscriminately, because of inadequate supervision. Many of these dense forests are concentrated in the uplands, around the headwaters of streams that feed the great rivers flowing through the central plains, so that their protection is imperative to provide sufficient water to irrigate the rice areas. Efforts have been made in recent years by the Forest Department of Thailand, and of the other Mekong basin countries, to protect the forests more adequately from overcutting, fraudulent cutting and fires.

There is little doubt that Puerto Rico at one time was forested from the shores of the Atlantic to the Caribbean. Severe cutting, clearing and culling of the more useful timber trees were recorded by the earliest travelers. Extensive areas of timberland were felled and burned to make clearings for agricultural use. After two or three crops, the land was abandoned and soon reverted to secondary growth. In more recent years considerable areas have been cleared for more permanent crops such as coffee and sugarcane. Today primary forests are fragmentary, limited in extent, and have been so materially modified by human interference during several centuries that now they afford only a limited basis for classification and comparison with the climax vegetation formations of other regions.

Of the extensive tropical forests that once flourished in Puerto Rico. there remain only isolated remnants scattered over the island, limited mostly to mountain areas. The best known and largest of these is the Rain forest, covering a considerable portion of the Luquillo mountains, and which has not been encroached upon as much as in other areas. Factors that impede intrusion into this forest are abruptness of the slopes, high precipitation and exposure to constantly strong winds. Other forest tracts, more limited in extent and in part virgin or partly culled are: Maricao, in the western part, part of which (10,023 acres) constitutes a Commonwealth forest; Toro Negro, (6,612 acres), also in the west; Carite (6,669 acres), in the south central part; and Rio Abajo (5,220 acres), in the northwest. Today the area of high forest is less than 2 percent of the total area of the island.

In addition, there are small timber tracts and brush-land, the bulk of which are found in the southern, southeastern and southwestern parts of the island, on limestone hills and other land of little agricultural value. Such forests are also found along the north coast on thin-soiled, conical limestone hills, called "haystacks" or "mogotes."

The total wooded area of Puerto Rico, including Moist Evergreen forest, Mangrove woodland along the north and south coasts, and secondary growth, which has developed following the clearing of the original vegetation, is estimated to cover approximately 450,000 acres, or equivalent to perhaps 20 percent of the total land area of Puerto Rico.

In Texas, also, the major factors which influence the type and distribution of vegetation are biotic, influenced by the direct effects of disturbance by man, such as lumbering, burning or clearing for agricultural use; grazing by domesticated animals and wildlife; and damage by insects and diseases. Of these, grazing perhaps has had the greatest influence on the growth, specific composition and distribution of forest formations in the State. Texas leads in beef and sheep production, and is the center of the Angora goat industry. These have had a considerable biotic influence on the vegetation complex.

MAJOR FOREST TYPES

Their

Affinities and Contrasts

While the vegetation of the regions under review shows an extreme range from that of temperate, on the one hand, to typically tropical, on the other, certain plant communities or formations show well-defined affinities. For example, the Mixed Mesophytic forest of North America approaches the Tropical Rain forest of Southeast Asia in its structure and floristic richness. A large part of this Formation consists of mixed associations in which a considerable number of species may share dominance. The grass-covered plains of Texas and other sections of the Southwest are reminiscent in a general way of the wooded or open savannas, with a dominant ground cover of grasses, which are interspersed with other plant formations and rice fields in Southeast Asia.

If we exclude the southern Peninsula of Thailand, up to about 10° N. latitude, the vegetation of Southeast Asia is fairly homogeneous and is characteristic of the entire region from the Bay of Bengal to the Gulf of Tonkin. Covered mostly by tropical vegetation, the Mekong basin countries are separated from Burma and India, in the northwest, by mountains ranges; and from China and the Himalayas, on the north, with their essentially distinctive temperate flora. On the other hand, the vegetation of southern peninsular Thailand, with almost year-round rainfall, closely resembles the vegetation of Malaysia.

The forests of Thailand may be classed into about twelve Types or Formations. All of these, with the exception of Mangrove woodland which is not found in Laos, occur in the other Mekong basin countries. These primary Types may be divided into Sub-types or Associations, influenced by variations induced by such factors as microclimate, and local edaphic or biotic conditions.

Forest Types, characteristic of the Indochina Peninsula, include: Humid (Wet and Moist) forests; Dry Evergreen; Montane; Conifers; Swamps, which include saline (Mangrove) and fresh-water; Deciduous or Seasonal, represented by Moist and Dry Mixed; Dipterocarp forests; Thorn forest; Coastal woodland; Savannas;

and Bamboo brakes. Several of these Types or Formations are also represented in Puerto Rico. Although they are different floristically, there is a considerable degree of affinity in the structure or physiognomy of various Formations which occur in the two geographically distinct and widely separated regions.

Detailed information on the forests and forest resources of Thailand, Vietnam, Cambodia and Laos is contained in "Vegetation of Southeast Asia" (CR 49-65) by this author. This was published in December 1965 by the United States Department of Agriculture, in cooperation with Advanced Research Projects Agency of the Department of Defense (ARPA Contract No. 424).

The forest type that is most characteristic of all the countries of the Indochina Peninsula, as well as of Indo-Malaysia, but is entirely lacking in Puerto Rico and Texas, is the Dipterocarp, represented by several genera - Dipterocarpus, Shorea, Pareshorea, Hopea - of the wood-oil family (Dipterocarpaceae). In Thailand Dipterocarp forests cover about 45 percent of the country's total forested area and have long been an important source of useful timbers both for domestic use and for export. They are especially well represented throughout the continental part of Thailand, particularly in the east and northeast, forming almost pure stands or mixed with other Hardwoods, and some genera constitute a characteristic element of wooded savannas. Several species of Dipterocarps are also represented in the Rain or Moist Evergreen forest. They are of extremely variable dimensions, from dwarf trees, such as Shorea obtusa in savannas, to the tall, corpulent, ubiquitous "yang" (Dipterocarpus alatus). In Laos, Cambodia and Vietnam, also, Dipterocarp forest constitutes the most widespread type of forest growth.

Conifers are prominent in the vegetation of Texas, represented by 5 genera: Cypress (Cupressus), Juniper (Juniperus), Douglas-fir (Pseudotsuga), Bald cypress and Montezuma cypress (Taxodium), and particularly Pines (Pinus). In Puerto Rico the only native Conifer is Podocarpus coriaceus, of the Yew family (Taxaceae). This genus is represented in Southeast Asia by 4 species. Pines (Pinus) are not native to Puerto Rico, but several species have been introduced. Other exotic Conifers have been planted as ornamentals, including species of Araucaria, Cupressus, Chamaecyparis, Cryptomeria, Juniperus and Taxus.

In Southeast Asia Conifers are well represented, especially by pines. The most widespread are the 2-needled Pinus merkusii and the 3-needled P. khasya. They occur at medium and upper elevations on mountain slopes, ridges and plateaus, infrequently at low altitudes, as in the case of P. merkusii, and occur in pure stands or mixed with hardwoods. In addition, species of Dacrydium and Podocarpus occur in the Montane forest of Thailand.

Conifers are of frequent occurrence in central Vietnam. Stands of the 2-needled and 3-needled pines cover thousands of acres in sparsely populated, almost inaccessible areas. The province of Lang Bian is said to contain the most extensive stands of pine. In addition, other Coniferous species grow in central Vietnam, some of which extend to the northern part of North Vietnam. These include species of Chamaecyparis, Cunninghamia, Taxus, Thujopsis and Keteleeria. In the plateau du Sud, in South Vietnam, with an altitude of 3,280 to 6,560 ft. (1,000 - 2,000 m.), the 2-needled and 3-needled pines constitute the dominant species. In the lower valleys and ravines they are mixed with hardwoods and bamboos.

Although Conifers, especially the two pines, form either pure or mixed stands of appreciable extent, they constitute only a small fraction of the total forested area of Southeast Asia. In Puerto Rico, likewise, Conifers form only a small fraction of the vegetation. But in the Piney woods section of eastern Texas, three species of native pines (loblolly, shortleaf and longleaf) constitute a high proportion of the Pine-Hardwood forests. They cover about 12.5 million acres of a total estimated 26.5 million acres of forests in the entire State.

Of the total area of Thailand, approximately 120,000 square miles are covered by some type of forest. Of these, 36,000 square miles are evergreen forests, including Mangrove woodland and stands of pines. Humid forests form the bulk of these, while pine forests represent less than 5 percent of the total forested area. Of the remaining 84,000 square miles, about 30,000 square miles are covered by Mixed Deciduous forest, concentrated mostly in the north and northwest, and Dipterocarp forests (about 45,000 square miles) form extensive open stands, especially in the east and northeast.

So that, whereas the trees of Texas may be grouped into Conifers or Softwoods and Broad-leaved or Hardwood, this broad classification is not applicable either to the forests of Southeast Asia or Puerto Rico. There the forests are more properly segregated into: Evergreen, including Conifers and Mangrove woodland; and Deciduous forests.

Several species of oak (Quercus), usually mixed with other Hardwoods, and at higher elevations with Conifers, are frequent at medium altitudes in the Montane forest of central and northern Thailand, as well as in Vietnam, Laos and Cambodia. They are particularly abundant in North Vietnam along the Chinese border. Species of oak are also found occasionally in the Moist Evergreen forest, such as in southern peninsular Thailand.

Oaks are insignificant in the vegetation of Puerto Rico. Several Asiatic species were introduced 45 to 50 years ago and planted successfully. Other species introduced into the island is swamp or pin oak (Quercus palustris Muenchh.) of Eastern United States.

Oaks represent a major element in the vegetation of Texas, being represented by about 35 species, in addition to a number of varieties. Mixed with pines and Hardwoods they rank among the principal timbers in the eastern Piney Woods; constitute the dominants in the Post-Oak region; post oak and blackjack oak occur throughout the most of the East and West Cross Timbers; live and post oak are among the principal timbers in the Coastal forests; live oak is one of the principal trees in the flood plains between Lavaca and Nueces river drainages, and several species grow in the Mountain forest region of West Texas.

A survey of the vegetation of Puerto Rico indicates the presence of a large series of different plant associations. Some of these occupy fairly large areas and were probably continuous before they were partly destroyed by man. Others cover only small, scattered areas and are generally isolated. Some associations have had a precarious existence because of modification in their environment; some show no evidence of any radical change by human agency; while still others are the direct result of cutting, clearing and burning for agricultural purpose.

As in Southeast Asia the factors of greatest diversity in Puerto Rico are: (1) varying altitudes and correspondingly different barometric phenomena; (2) variable amount of precipitation; and (3) the range of soil types. As elsewhere, these factors influence the distribution of plants in Puerto Rico. The lower elevation may be designated as the belt below 1,500 ft. (500 m.) altitude; the middle altitudes from about 1,500 to 3,000 ft. (500 - 1,000 m.); and the high elevations as the area above 3,000 ft. (1,000 m.) to the crest or summit of ridges.

The moist northeasterly trade-winds, almost continuous during cyclonic disturbances, impinge upon the land masses and precipitate their moisture in the form of showers of varying intensity, from mere sprinkles to excessive cloudbursts. The high mountains cause the greater part of the atmospheric moisture to be precipitated over the northern and central areas, so that by the time the winds reach the southern coast they are dry, with the result that truly desert conditions prevail in the southwestern coastal zone.

The variation in the distribution of precipitation is an important factor in the natural distribution of native plants. In passing from north to south, over the central axis of Puerto Rico, the change from one type of vegetation to another is conspicuous and abrupt in places. Trees, shrubs and other plants of the northern slopes give place to different species on the southern slopes, while the vegetation of the moist northern districts, around San Juan and Arecibo, for example, is almost entirely different from that of the drier area in the south, around Guánica and Ponce.

The wettest areas are in the Luquillo Mountains and in the higher western and central Cordillera Central, where the rainfall may exceed 117 inches (300 cm.). The driest areas are in the extreme southwest coastal parts of Puerto Rico, where the average annual rainfall is usually less than 24 inches.

The best known forest type in Puerto Rico is the Rain forest, covering a considerable portion of the Luquillo Range, and which has not been encroached upon as much as other areas. The abruptness of the slopes and the size of the trees have made timber exploitation by native methods difficult. Exposure to excessive and constant strong winds, heavy precipitation, and prolonged cloudiness are factors which have prevented invasion by coffee planters and for the clearing of small patches for shifting agriculture, so long as other lands were available. This tract has an aggregated area of between 35,000 and 40,000 acres, in addition to several thousand acres of Elfin woodland and Mossy forest, low, gnarled vegetation on the upper wind-swept slopes and crest.

Other tracts of more limited extent, in part of primary growth and some more or less culled high forest, are in the region of Maricao, in the west; Toro Negro, also in the west; Carite, in the south-central part of the island; Rio Abajo, in the northwest; and others. The aggregate of these areas, not including the Federal Forest of Luquillo, is well within 50,000 acres. On this basis the total area of primary forest is probably less than 2 percent of the total land area.

There are other timber and brush lands, the bulk of which are found in the southern, southeastern and southwestern parts of the island, on limestone hills and other land of little agricultural value. Such forests are also found on the north coast on thin-soiled, conical limestone hills, "haystacks" or "mogotes." In addition, there are Mangrove woodland along the north and south coasts. The total wooded area, including Rain or Moist Evergreen, Mangrove forest and secondary forests amount to about 450,000 acres, equivalent to about 20 percent of the total land area.

Mangrove woodland, controlled by edaphic or soil factors, forms the most homologous type of forest, from the standpoint of its structure, occurring in Puerto Rico and Southeast Asia. Although some differences exist in the species composition, several genera are represented both in Puerto Rico and Southeast Asia. Wherever it occurs the physiognomy of this forest is similar, with contiguous crowns, dense foliage of various shades of green, and the flat canopy is generally of uniform height. Stands of Mangrove occur along the north and south coasts of Puerto Rico. These are generally lower in stature than the more extensive Mangrove forests in southern peninsular and southeastern Thailand, sections of Cambodia, the large stands in the Camau Peninsula and other coastal parts of South Vietnam, and smaller stands northeast of Haiphong, North Vietnam.

Mangrove does not occur in Texas, but the Cypress-Tupelo swamp. found in sections of the lower Mississippi delta, is comparable to Mangrove woodland of tropical areas. This swamp lies under water of fluctuating level except during periods of prolonged drought. In this environment cypress and tupelo appear to be the only trees able to tolerate constant flooding.

A characteristic feature of the vegetation in Puerto Rico and Southeast Asia, as in all tropical and temperate regions, is the contrast between lowland and mountain forests. As we ascend mountain slopes the composition and structure of the vegetation undergoes a gradual change. In the Lowland and Hill humid forests of Thailand, the trees are tall, with columnar trunks, multistoried, with upwards of 50 species within the area of one acre, in addition to shrubs, lianes, palms, and ground layer of herbaceous plants. At higher elevation, in Mid-mountain forest of Khao Yai, central Thailand, the most frequent forest trees are species of oaks (Quercus), chestnut (Castanopsis), and a conifer, Podocarpus. These do not appear in the surrounding Hill Evergreen forest at lower elevation. On the flat summit other trees become dominant, such as species of Schima and a conifer, Dacrydium. Unlike the Rain forest, Montane forest has two, not well marked stories, and most of the trees are slender, with fairly small crowns, and form rather close stands. On the mountains of northern Thailand the oak-chestnut association is gradually supplanted by stands of the 3-needled pine (Pinus khasya).

In Puerto Rico Montane forest is represented by the "colorado" type, in which Cyrilla racemiflora is dominant on the slopes of Luquillo mountain range. The canopy is fairly uniform and does not exceed 45 to 50 feet in height. All the trees are evergreen, and the leaves are typically thick and leathery. The ground is generally covered by leaves, and in some sites by a thick organic surface layer. Sphagnum moss abounds in moist sites.

Other forest types of similar structure, occurring in Puerto Rico and Southeast Asia, are the Elfin woodland and Mossy forest. In Puerto Rico Elfin woodland grows on the upper slopes of Luquillo mountain at altitude above the Montane belt. Because of constant clouds passing over the range, humidity is high. Strong gusts of wind blow constantly, so that the crowns of the low trees appear as if they had been sheared. In association with this formation, but on the leeward side, Mossy forest appears. Similar formations occur on the summit of Inthanon mountain in northern Thailand, and in limited bogland in Khao Yai National Forest in the central region.

Many species of bamboos occur throughout Southeast Asia in all types of soils and under a variety of climatic conditions. They are used for a great variety of purposes, such as for shade, windbreak, water conduits to irrigate rice fields, and the tender shoots of most species are edible. Wherever a clearing is made in a forest or when tilled land is abandoned, certain species of bamboos are among the first plants to develop in successional growth. Puerto Rico has only a limited number of native bamboos, but several species have been introduced from Asia and other tropical areas. Some of these, particularly Bambusa vulgaris and B. tulda, have become firmly established, and are widely distributed throughout the island, along highways, banks of streams, and spread into pastures and sugar-cane fields. In Texas only one species of bamboo, the giant cane (Arundinaria gigantea), is represented, usually growing in moist sites.

In terms of species, palms are not as well represented in Puerto Rico as in Southeast Asia. Nevertheless, the sierra or mountain cabbage palm (Prestoea montana) is widely distributed in the island, especially in humid areas at middle and upper elevations. It is a frequent component of the understory in the Rain forest of Luquillo, especially where there are openings caused by falling trees. It becomes more abundant, at times forming large breaks, at higher elevations extending up to the Elfin woodland on the summit. In the Commonwealth forest of Toro Negro, in the central part of the island, pure breaks of this palm cover the upper slopes and constitute the dominant element in that humid area. Nowhere in Thailand are there palm breaks comparable in extent to those of the sierra palm in Puerto Rico. Two of the most frequent species in Southeast Asia are Borassus flabellifer, usually growing individually or in open stands in rice fields, where this palm is protected, and the Areca or betel-nut palm (Areca catechu), frequently propagated around hamlets, mostly in humid areas. Other frequent palms in Thailand are Livistona speciosa and a species of Corypha.

Savannas are much more widespread in tropical America, than in Southeast Asia. Savannas may be broadly classed into grass and wooded. Small or medium-sized trees are seldom absent in any savanna. In both types the dominant factor is the grass cover. Typical examples of savannas in tropical America are the great llanos of Venezuela; the campo firme and caatinga of Brazil; the pampas of Argentina; and the oakridge and pine ridge of British Honduras. In Puerto Rico small savannas occur on the upper slopes of the Luquillo range. The so-called Acacia - Prosopis savanna of southwestern Puerto Rico belongs more properly to Thorn woodland, because the herbaceous ground layer is not considered dominant. In Thailand stretches of wooded savanna are found in the eastern, northeastern and northern sections of the country, while rolling or flat open savanna occurs in the Kra Isthmus in the Peninsula. Because of the open nature of savanna in all tropical areas visibility, both horizontal and vertical, is not a problem.

Thorn thickets are also more frequent in the Caribbean and mainland tropical America than in Southeast Asia. This formation is particularly abundant in Venezuela along the northeast coast and on the offcoast islands, on the northern edge of the llanos, and in the Guajira peninsula to the west. The caatingas of northeastern Brazil also contain some thorn woodland and cactus scrub.

In Puerto Rico thorn thicket occurs on non-saline flats and coves between Ponce and Guánica, along the southwest coast, with cactus scrub on the slopes. Among characteristic trees in these thickets several are of pantropical distribution and are found in Puerto Rico, Texas and Southeast Asia. These include: Acacia farnesiana, Parkinsonia aculecta, Leucaena leucocephala and Prosopis juliflora, also the pantropical Lantana camara, and other woody plants limited to tropical America.

Thorn thicket is well developed in the drier sections of Thailand, particularly in the upper Peninsula and on the Korat plateau, in the northeast. As in Puerto Rico and elsewhere in tropical America, annual rainfall in these areas is usually less than 40 inches. As in Puerto Rico and Texas, many of the shrubs or small trees in this formation are armed with sharp spines. These include Acacia farnesiana and species of Bombax, Randia, Feroniella, Croton, Spondias, Zizyphus and Vitex; also the armed bamboo (Bambusa arundianacea) and a pricklypear (Opuntia).

Brush on rangeland in Texas is similar to thorn thicket of tropical regions. There are several genera, and even species, in this brush which occur also in Puerto Rico and Southeast Asia. These include: mesquite (Prosopis glandulosa), huisache (Acacia farnesiana) and other Acacias, retama (Parkinsonia aculeata), and Macartney rose (Rosa bracteata).

In tropical America and Southeast Asia the developmental pattern of secondary growth is essentially the same. The first growth that develops following disturbance of dense, humid tropical forest is usually dominated by grasses and weeds, generally short-lived. As a rule, plants that develop in the initial stage of secondary growth are entirely different from those that grow in the primary forest, and likewise, seldom do any species in the secondary growth appear in the primeval forest. The next phase may be dominated by shrubs, followed by trees of quick growth. Or the succession may lead directly from the herbaceous stage to tree dominance. The secondary forest is usually composed of fast-growing trees, with soft wood and their seeds are wind- or animal-dispersed.

Within the Rain forest belt the differences in length and severity of the seasonal dry period are expressed in variations in the composition and structure of the vegetation. An example of this is the Evergreen Seasonal forest, with 4 to 6 rainless months. Many of the trees are deciduous. Such type of forest covers large areas in Southeast Asia, and resembles the Rain forest floristically and in its three-storied structure. A similar forest type is widely distributed in the Caribbean area and in mainland tropical America.

Timber species represented in three of the six principal forest regions of the United States are found within the boundaries of Texas. The Southern Pine belt extends into the extreme eastern part of this vast State. Species of the Central Hardwood forest are also found in the Post Oak, the East and West Cross Timbers, and in miscellaneous forests of Texas. Three species typical of the Rocky Mountain forests are also found on the summit of the higher mountains of West Texas. Although they do not constitute a major forest type in Texas, tree species that thrive in tropical climate are also found in the southern area of the State. Ability to resist drought, heat and wind, and to adapt themselves to the environment has resulted in about 800 species of woody plants growing in Texas, on an estimated 26.5 million acres of forest, or 10 percent of the State's total land area. This figure does not include extensive areas of mesquite and other small woody growth covering large areas and frequent on rangeland.

The Texas Forest Service recognizes 7 forest Formations or Types: Coastal forests; Pine-Hardwood; Post Oak; East and West Cross Timbers; Cedar Breaks; Mountain forests; and Miscellaneous forests.

Coastal forests cover approximately 500,000 acres in a region extending westward from Galveston to the drainage of the Lavaca river in Jackson and Calhoun counties. The topography is comparatively flat and drainage is poor. The principal tree species found in this area are water willow (Salix caroliniana), live oak (Quercus virginiana) and post oak (Q. stellata), pecan (Carya aquatica), ash (Fraxinus caroliniana), hackberry (Celtis), cottonwood (Populus), sycamore (Platanus occidentalis), and some loblolly pine (Pinus taeda). The region has modified maritime climate, characterized by a comparatively uniform mean annual temperature of 69° F. The mean annual precipitation is 45 in. (1,140 mm.). Clay soils are extensive throughout the region; dark gray to reddish-brown calcareous silt loams, clay loams and clays are found in the bottomlands where most of the wooded areas occur.

The Pine-Hardwood region covers about 12.5 million acres in the extreme eastern section of the State. In this area, sometimes called Piney Woods, commercial products have been harvested for more than a century. The native pines in this formation are loblolly (Pinus taeda), shortleaf (P. echinata) and longleaf (P. palustris). In addition, during the past 40 years, slash pine (P. caribaea) has played an important part in the reforestation of cutover pine areas. In much of the Piney Woods area hardwoods mixed with pines, especially on upland areas. Hardwoods dominate the timberland ajacent to some of the major streams of eastern Texas. Principal species are: red, black and tupelo gum, white and black oaks, magnolia, elm, hickory, walnut, maple, beech, white ash and cypress.

The average annual rainfall in the Pine-Hardwood area is 45 - 50 in. (1,140 - 1,270 mm.). The average temperature is 65° F. Characteristic soils are light-colored sandy loams. Sub-soils range from loamy to plastic clay in texture and from red to yellow in color.

The Post Oak region covers approximately 5.5 million acres. Tree species often in this formation include: post oak, hackberry, elm, pecan, live oak, ash and hickory. Better quality of timber trees are found in the bottomlands. Loblolly pine occurs on the western fringe of the Post Oak region. Average annual precipitation in this area is 35 - 45 in. (890 - 1,140 mm.). Low water-holding capacity of the soil increases the hazard of drought when annual precipitation falls below the average. With the exception of somewhat lower rainfall, the climate of the Post Oak region is similar to that of the Pine-Hardwood area. The soils are mostly of the prairie type but less acid. Uplands comprise about 85 percent of the range and bottomlands 15 percent.

East and West Cross Timbers cover a total area of approximately 2.25 million acres. The topography is more rolling than that of the Post Oak region. The East Cross Timber is a long strip of woodland separating the Blackland from the Grand Prairie. Only a few miles in width, it has an area of close to 200,000 acres extending from the Red river into Hill County. West Cross Timber is the wooded section of the Grand Prairie in northcentral Texas, extending from the Red river southward into Coleman and Brown counties.

Post Oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) occur over most of the region, while pecan, cottonwood, elm, and other hardwoods are found along streams. Annual precipitation is somewhat lower than in the Post Oak region, ranging between 25 - 35 in. (635 - 990 mm.). The soils are low in fertility.

Mountain cedar (*Juniperus virginiana*) is the dominant tree in the Cedar break. This formation occurs in hilly regions of east-central Texas, and covers about 4.5 million acres. The region extends southwestwardly from the western and southern edge of the Grand Prairie to the Burnet-Llano basin and to the Edwards Plateau. Much of the cedar grows mixed with oak, elm, sumach and other species. Average annual precipitation in the Cedar Break zone is 20 - 35 in. (508 - 890 mm.). A thin, stony, calcareous soil, developed from limestone and marl, covers much of the area, with alluvial soils in the flood plains along streams.

Mountain forest, covering approximately 350,000 acres, is confined to the Trans-Pecos of West Texas, mostly in Jeff Davis county. The mountainous terrain is covered with juniper, pinyon (*Pinus edulis*), several species of oak, scattered species of western yellow pine and Douglas fir. Annual rainfall averages 10 - 15 in. (254 - 380 mm.). Soils are generally shallow, stony, non-arable, although some sites are fertile. Shrubs and short grasses are the characteristic vegetation in the basins and valleys.

Miscellaneous forests are characteristic of the warm, dry Rio Grande Plain. They occur in flood plains along major stream courses, except in areas where live oak predominates. These areas are located south of the Edwards Plateau in Medina and Bexar counties, and in Brooks, Kenedy, DeWitt and Goliad counties. The climate is subtropical, with a mean annual temperature of 72° F. The soils in the bottomlands are black to brown calcareous clay loams and clays with slow drainage.

Brush is a serious problem on Texas grasslands. A survey made by range conservationists of the Soil Conservation Service showed that 88.5 million acres, or 82 percent, of Texas' once luxuriant grasslands are now infested with one or more low-value or worthless woody plants. About 50 percent of this acreage is so densely covered and grass is so suppressed that little improvement can be expected without reduction of the brush competition. Furthermore, brush is increasing despite extensive control efforts.

Selected Genera Representative of Thailand 1/

In Relation to Number of Species, Native and Introduced, in Indochina, 2/ Puerto Rico and Texas

AqG = aquatic grass
AqH = aquatic herb
B = bamboo
C = climber
Ca = cactus
CB = climbing bamboo
CH = climbing herb
CrH = creeping herb
CO = creeping orchid
CP = climbing palm
CUS = climbing undershrub
EF = epiphytic fern
EH = epiphytic herb
EO = epiphytic orchid
ES = epiphytic shrub
F = fern
G = grass
H = herb
O = orchid
P = palm
ParC = parasitic climber
ParH = parasitic herb
ParS = parasitic shrub
S = shrub
ST = small tree
T = tree
US = undershrub

		Species in			
	Habit	Thailand	Indochina	Puerto Rico	Texas
Aoroma	S, ST	1	1		
Abrus	C, S	3	4	2	
Abutilon	US	3	4	6	10
Acacia	C, S, T	17	10	7	13
Acalypha	S, T	5	14	7	9
Acampe	EO	1	1		
Acanthus	S	2	4		
Acer	T	1	2		5
Achras	T	1	1	1	
Achyranthes	AqH, H, US	3	6	7	
Acnemia	T	1	1		
Acorus	H	2	2		1

1/ This list is based, for comparative purpose, on plants occurring in Thailand.

2/ Embraces Cambodia, Laos and North and South Vietnam.

	Habit	Thailand	Indochina	Puerto Rico	Texas
Acronychia	S, ST	1	2	1	
Acrostichum	F	2	2	6	2
Actiphila	S	1	10		
Adenanthera	T	2	3	1	
Adenia	CUS	5	8		
Adenochlaena	S	1	1		
Adenosma	H	1	9		
Adenostemma	H	1	1	1	
Adhadota	S	1		4	
Adiantum	F	8	12	15	2
Adina	T	3	4		
Adinandra	ST	1	1		
Aegiceras	S	1	1		
Aerides	EO	2	5		
Aerua	CUS	1	1		
Aeschynanthus	CUS	4+	12		
Aeschynomene	H, US	2+	2	3	2
Aesculus	T	1	1		2
Afzelia	T	1	4		
Aganosma	C	3	3		
Agathis	T	1		1	
Agati	ST	1	1		
Agave	US	3+		3	11
Ageratum	H	1	1	1	1
Aglaia	T	10	25	28	1
Aglamorpha	EF	3	1		
Aglaonema	C, H	4	14		
Ailanthus	T	1	3	1	1
Alangium	ST, T	3	4		
Albizzia	T	7	13	3	1
Alchornea	S	1	5	1	
Aleurites	T	3	4	5	
Allaeanthus	C	1	1		
Allamanda	S	2	1	2	
Allium	H	8	9	6	13
Allomorphia	S	2	7		
Allophylus	S	3	12	3	
Alocasia	H	9	11	2	
Aloe	H	1			7
Alphonsea	S, ST	3	5		
Alpinia	H	6	18	4	
Alstonia	T	3	3	1	
Alternanthera	H	3	3		3
Althaea	H	1		1	
Altingia	T	1	1		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Alysicarpus	CH	1	3	1	
Alyxia	C	4	11		
Amalocalyx	C	1	1		
Amaranthus	H	4	7	9	23
Ammannia	H	2	3	2	3
Amomum	H	5	10	3	
Amorphophallus	H	9	27		
Ampelocissus	C	2	6	1	
Amphilophis	C	1	2	2	
Anacardium	ST	1	1	1	
Anacolosa	ST	1	3		
Anamirta	C	1	1		
Ananas	H	1	1	8	
Anaxagorea	ST	2	1	1	
Ancistrocladus	C	3	4		
Andropogon	G	1	3	4	24
Aneilema	H	2	21		1
Anethum	H	1		1	1
Angiopteris	F	1	10		
Anisomeles	H	1	1		
Anisopappus	H	1	1		
Anisoptera	T	4	5		
Anneslia	ST	1	1	4	
Annona	ST	3	3	8	
Anodendron	C	1	1		
Anogeissus	T	1	3		
Anomianthus	C	1	1		
Anplectrum	S	2	1		
Antheroporum	ST	1	2		
Anthocephalus	T	1	1	1	
Anthurium	H	5	22	5	
Antiaris	T	1	1	1	
Antidesma	S, ST	4	31		
Antigonon	C	1	1	2	1
Antirrhinum	H	1	2	1	
Antrophyum	EF	1	6	3	
Aphania	S, ST	1	6		
Apium	H	1	1	1	2
Apluda	G	1	1		
Aponogeton	AqH	2	6		
Aporosa	S, ST	3	11		
Aquilaria	T	3	1		
Arachis	H	1	1	11	1
Aralia	S, ST	2	2	1	2
Araucaria	T	3		3	
Archytaea	S, ST	1	9		
Ardisia	S, ST	23	79	1	
Areca	P	2	3	5	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Arenga	P	2	1	1	
Arfeuillea	T	1	1		
Argemone	H	1	7	1	8
Argostemma	CH	3	7		1
Argyreia	C	2	18	1	
Arisaema	H	3	13		2
Aristolochia	C	5	8	7	7
Artabotrys	C	7	5	2	
Artanema	H	1	1		
Artocarpus	T	9+	13	4	
Arundina	O	1	4		
Arundinaria	B	3	5	5	1
Arundinella	G	1	6	1	
Arundo	G	1	2	1	1
Arytera	T	2	1		
Asclepias	H	1	1	2	33
Asparagus	CUS	5	4	3	1
Aspidistra	H	1	1	1	
Aspidopterys	C	2	6		
Asplenium	G	3	42	22	4
Aster	H	3	1	2	18
Asystasia	CH	1	4		
Atalantia	ST	3	11	2	
Atherolepis	C	1	1	1	
Athyrium	F	2	12		1
Atylosia	CH	1	3		
Averrhoa	T	2	2	2	
Avicennia	T	2	5	1	1
Azima	C	1	1		
Azolla	AqF	1	1	1	1
Baccaurea	ST	8	7		
Bacopa	H	1	2	1	3
Baeckia	S, ST	1	1		
Balanophora	H	1	5		
Baliospermum	S	1	4		
Bambusa	B	10	21	5	
Barclaya	AqH	1	2		
Barleria	US	6	4	3	
Barringtonia	ST	11	11	1	
Basella	CH	1	1	2	
Bauhinia	S	32	41	8	1
Beaumontia	C	3	3	1	
Begonia	H	10	29	12	
Beilschmiedia	T	1	3	1	
Belamcanda	H	1	2	1	1

	Habit	Thailand	Indochina	Puerto Rico	Texas
Beleperone	US	1		3	
Benincasa	CH	1	1		
Berrya	T	2	2	2	
Beta	H	1	1	1	
Bidens	H	5	2	5	7
Bilbergia	H	1		1	
Biophytum	H	2	4		
Bischofia	T	1	1	1	
Bixa	S, ST	1	1	1	
Blachia	S	1	7		
Blechnum	F	1	2	3	
Blinkworthia	S	1	1		
Blumea	H	8	30		
Blyxa	AqH	1	2		
Boea	H	1	14		
Boehmeria	S, ST	3	6	5	1
Boerhaavia	H	2		2	12
Bolbitis	F	1	7		
Bombax (Salmalia)	ST	2+	6	1	
Bonnaya	H	2	7		
Bootia	AqH	1	2		
Borassus	P	2	1	1	
Borreria	H	1		6	1
Bouea	T	2	2		
Bougainvillea	C	1	1	2	
Brachiaria	G	1	6		
Brachystelma	C	1	2		
Brassica	H	7	1	8	7
Breynia	S	4	13	1	
Bridelia	ST, C	4	10	2	
Bromheadia	O	1	1		
Broussonetia	T	1	3	2	1
Brownea	ST	2		1	
Brucea	S	2	3		
Brugmansia	ParH	1	2		
Bruguiera	T	4	3		
Brunfelsia	S	2		5	
Buddleia	S	3	3	4	5
Buettneria	C	4	6		
Bulbophyllum	EO	1	30		
Burmannia	H	2	7	2	2
Bursera	T	1	1	3	
Butea	C	2	2	1	
Buxus	S	1	4	3	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Cabomba	AqH	1		2	1
Caesalpinia	ST, T, C	12	10	5+	3
Cajanus	S	2	1	4	
Caladium	H	3	1	3	
Calamus	CP	10	21		
Calanthe	O	3	15		
Calathea	H	3		4	
Calendula	H	1		1	
Calliandra	S	1		5	4
Callicarpa	T, S	6+	17	3	1
Callistephus	H	1		1	
Calonyction	CH	1		2	
Calophyllum	T	8	12	4	
Calotropis	S, T	1	2	2	
Calycopteris	S, C	1	1		
Camellia	S, ST	3	1	1+	
Campsis	C	2	2	1	1
Cananga	T	2	2	3	
Canarium	T	2	11	4	
Canavalia	CH	5	3	3	1
Canna	H	2	2	7	
Cannabis	H	1	1		
Canscora	H	1	5		
Cansjera	S, C	1	1		
Canthium	S	9	12		
Capparis	S	18	23	11	
Capsicum	US	1	5	2	1
Carallia	T	2	3		
Carapa	T	3	4	1	
Cardamine	H	1	1	1	
Cardiochlamys	C		1		4
Cardiopteris	CH	1	1		
Cardiospermum	CH	1	1	4	2
Carex	G	2	24	2	75
Careya	T	2	2		
Carica	T	1	1	2	
Carissa	S	2	2	2	
Carpinus	T	1	4		1
Carthamus	H	1	1		1
Carum	H	1	1	1	
Caryota	P	2	7	2	
Casearia	S	3	13	6	
Cassia	S, T	5	18	7+	7
Castanopsis	T	4	44		
Ceratophyllum	AqH	1	1	2	
Ceratopteris	AqF	1	1	2	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Cerbera	ST	22	2	2	
Cereus	Ca	1		4	3
Ceriops	ST	2	2		
Ceropegia	CH	1	5	1	
Cestrum	S	1	2	6	
Chaelocarpus	ST	1	1		
Chasalia	S	4	2		
Cheilanthes	F	3	6	3	15
Cheiropleuria	F	1	1		
Chirita	H	1	17		
Chisocheton	T	2	7		
Chloranthus	US	2	4		
Chloris	G	1	4	3	14
Chlorophytum	H	2	2	1	
Christisonia	ParH	1	1		
Chrysalidocarpus	P	2		1	
Chrysanthemum	H	3	3	3	
Chrysophyllum	T	1	1	5	
Chrysopogon	G	1	3		
Chukrasia	T	2	1		
Cibotium	F	1	1		
Cicca	ST	1		2	
Cicer	H	1		1	
Cinchona	S,T	2		2	
Cinnamomum	T	7	12	2	
Cipadessa	S	1	1		
Cissampelos	C	1	1	4	
Cissus	C	10	12	7	1
Citrullus	CrH	1	1	3	1
Citrus	ST	14	8	12	1
Commelina	H	3	8	2	7
Commersonia	ST	1	1		
Congea	C	2	4	1	
Connarus	S, ST	5	7		
Convolvulus	CH	3	1	2+	3
Corchorus	H	3	3	8	1
Cordia	T	7	8	5+	2
Crataeva	T	5	2	2	
Crescentia	ST	2	1	2	
Crinum	H	5	4	11	2
Crossandra	S	1	1	1	
Crossostephium	S	1	1		
Crotalaria	US	12	28	14	6
Croton	S, ST	2	38	17	19
Dacrydium	T	1	1		
Dactyloctenium	G	1	1	1	1

	Habit	Thailand	Indochina	Puerto Rico	Texas
Daemonorops	CP	7	3	2	
Dahlia	H	1	1	2	
Dalbergia	C, T	21	35	3	
Dasymaschalon	S	2	2		
Datura	H	1	2	4	3
Daucus	H	1	1	1	2
Davallia	EF	3	5	7	
Debregasia	S	2	5		
Decaschistia	S	1	5		
Deeringia	C	1	2		
Deloportea	T	1	1		
Delonix	T	1	1	1	
Delpya	T	1	1		
Dendrobium	EO	64	95	3	
Dendrocalamus	B	7	11	1	
Dendrophthoe	ParS	1	1		
Derris	C, ST, T	11	14	1	
Descasperum	ST	2	2		
Desmodium	S, US, CH	28	50	20	23
Dialium	T	3	1	1	
Dianella	H	1	1	1	
Dianthus	H	2	1	2	
Dichroa	S	1	2		
Didymocarpus	H	1	10		
Didymochlaena	F	1	1		
Didymosperma	F	1	1		
Dieffenbachia	US	1	1	1	
Digitaria	G	1+	9	5	7
Dillenia	ST	9	11	2	
Dioscorea	CH	23	51	9	1
Diospyros	T	45	63	6	2
Diplazium	F	2	1	9	
Diploclisia	C	1	1		
Diplospora	T	3	5		
Dipteris	F	1	2		
Dipterocarpus	T	15	12		
Dischidia	H	6	9		
Disporum	H	1	3		
Dodonaea	S	1	1	2	
Dolichandrone	T	3	1		
Dolichos	CH	2	1	2+	
Dombeya	S, ST	1	1	2	
Donax	US	2	1		
Dopatrium	H	1	2		
Doritis	O	1	1		
Dracaena	S	10	5	5	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Dracontomelum	T	2	2		
Drosera	H	3	3	1	
Drymoglossum	EF	1	1		
Drymaria	H	4	6	3	4
Dryopteris	F	10	5	32	8
Duabanga	T	1	1	1	
Duchesnea	H	1	2		1
Dunbaria	C, US	1	9		
Duperrea	S	1	1		
Duranta	C	2	2	3	
Durio	T	3	1	1	
Dysolobium	C	1	2		
Dysophylla	H	2	12		
Ecdysanthera	C	1	1		
Echinocactus	H	1		1	8
Echinochloa	C	3	3	3	5
Eclipta	H	2	1	5	1
Egenolfia	F	1	5		
Ehretia	ST	6	8	1	1
Elaeis	P	1	1	2	
Elaeocarpus	ST	10	22	2	
Elaeodendron	S, ST	1	1	2	
Elatostema	H	1	10		
Eleocharis	G	3	2		30
Elephantopus	H	1	2	1	3
Elettaria	H	1	1	1	
Eleusine	G	2	2	1	1
Eleutherine	H	1	2	2	
Ellipanthus	ST	1	2		
Ellipeia	S, C	1	1		
Elsholtzia	H	1	5		
Elytranthe	ParS	1	2		
Emilia	H	1	4	3	
Engelhardtia	T	3	5		
Enhydra	H	1	1	1	
Entada	C	4	7	1	
Enterolobium	T	1	2	3	
Epigeneium	EO	4	3		
Epiphyllum	S, C	2	1	2	
Epipremnum	C	2	2		
Epithema	H	1	1		
Equisetum	F	1	2		5
Eragrostis	G	6	25	9	32
Eranthemum	S	1	3	1	
Erechtites	H	1	12		1
Eremochloa	G	1	3	1	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Eria	EO	3	39		
Eriachne	G	1	2		
Eriobotrya	T	2	2	1	
Eriocaulon	H	1	27		5
Eriochloa	G	1	1	4	4
Erioglossum	ST	1	1		
Eriolaena	T	2	2		
Eriosema	S	1	1		
Erismanthus	S	1	3		
Erycibe	S	6	6		
Eryngium	H	1	1	2	8
Erythrina	T	5	7	11	1
Erythropalum	C	1	1		
Erythrophloeum	T	3	3		
Erythroxylum	S	3	3	5	
Eucalyptus	T	1	1+	7	
Eucharis	H	1		2	
Eugenia	S, ST	21	57	36	
Eulalia	G	1	8	1	
Eulophia	O	1	13	1	
Euonymus	ST	2	11	1	2
Eupatorium	H	3	6	10	25
Euphorbia	ST	18	29	7	62
Euphoria	T	2	3	2	
Eurya	S, ST	1	2		
Eurycles	H	1	1	1	
Eurycoma	S, ST	1	2		
Evodia	S	4	7		
Exacum	H	2	8		
Excoecaria	S, ST	5	6	4	
Fagraea	ST	7	5		
Feronia	ST	1	2	1	
Feroniella	ST	2		2	
Fibraurea	C	1	2		
Ficus	T	35	92	27	1
Fimbristylis	G	8	55	9	5
Finetia	T	1	1		
Finlaysonia	C	1	1		
Firmiana	T	2	1		
Flacourtia	S, T	6	6	3	
Flagellaria	CH	1	1		
Fleurya	H	1	2	2	
Floscopa	CH	1	3		
Flueggea	S, ST	4	2		
Foeniculum	H	2		2	1
Fortunella	S, T	2		3	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Fragaria	H	1	2	1	2
Fraxinus	T		2	2	8
Freycinetia	C	1	1		
Fuirena	G	2	4	2	2
Gaillardia	H	2	1		8
Galactia	CH	1	3	4	9
Galeola	CO	1	7		
Garcinia	T	15	22	13	
Gardenia	T	15	19	3	
Garuga	T	1	2		
Geissaspis	H	1	1		
Gelonium	S, ST	1	4		
Gelsemium	C	1	1	2	1
Gendarussa	S	1	3		
Genianthus	C	1	1		
Geodorum	O	1	7		
Geophila	H	1	1	1	
Gerbera	H	2	1		
Gigantochloa	B	3	4		
Girardinia	H	1	1		
Gironniera	T	1	3		
Gladiolus	H	1+	1	1	1+
Gleichenia	F	2	8	7	
Globba	H	5	27	1	
Glochidion	ST	2	24		
Gloriosa	CH	1	1	1	
Glossocarya	C	2	2		
Glossogyne	H	1	2		
Gluta	ST	4	1		
Glycine	H	1	3	6	
Glycosmis	S	4	7		
Glyptopetalum	S, ST	1	7		
Gmelina	T	6	8	1	
Gnetum	C	3	8		
Gomphostemma	H	1	9		
Gomphrena	H	1	1	2	7
Gonatanthus	H	2	1		
Goniothalamus	T	6	4		
Gonocaryum	S	2	3		
Gossypium	S	4	4	11	1+
Gouania	C	3	2	3	
Grammatophyllum	EO	1	2		
Grangea	H	1	1		
Graptophyllum	S	1	1		
Greenea	S	1	1		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Grevillea	T	1	1	1	
Grewia	ST	15	17		
Guettarda	ST	1	1	9	
Guioa	ST	1	3		
Gymnema	C	3	10		
Gymnogrammitis	EF	1	1		
Gymnopetalum	CH	3	3		
Gymnosporia	S	2	8		
Gynandropsis	H	2	2	2	
Gynura	CH	4	7		
Gyrocarpus	T	1	1		
Habenaria	O	5	47	5	11
Haemanthus	H	1		1	
Haemaria	C	1	5		
Halopegia	H	1	2		
Hamelia	S	1	1	2	
Hapaline	H	2	2		
Harpullia	T	2	3		
Harrisonia	S, C	1	2		
Hedychium	H	5	6	1	
Hedyotis	H	17	39		21
Helianthus	H	2		3	18
Helichrysum	H	1	1	1	
Helicia	ST	4	1	1	
Heliconia	H	1		2	
Heliotropium	H		4	11	14
Helixanthera	ParS	1	1		
Helminthostachys	S, ST	1	1		
Hemicyclea	T	1	9		
Hemigraphis	S, H	3	11	1	
Henslowia	ParC	1	4		
Heptapleurum	T	1	2		
Heracleum	H	2	2		
Heritiera	T	2	3		
Hernandia	T	2	5	2	
Herpestis	H	1	3	2	
Hesperethusa	ST	1	1	1	
Heteropanax	ST	1	1		
Heterophragma	T	2	1		
Heteropogon	G	1	2	1	1
Hevea	T	1	1	1	
Hibiscus	H, S, T, C	13	22	13	11
Hippeastrum	H	2		3	
Hippocratea	C	1	4	5	
Hiptage	S, C	3	9		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Hodgsonia	C	1	1		
Holarrhena	ST	3	4	1	
Holigarna	T	1	1		
Holoptelea	T	1	1		
Homalium	T	5	10	3	
Homalomena	H	5	7		
Homonoia	S, ST	1	2		
Hopea	T	8	9	1	
Horsfieldia	T	2	4		
Hoya	EC	12	22	1	
Humata	EF	2	4		
Hunteria	T	1	1		
Hura	T	1	1	1	
Hydnocarpus	T	6	2	1	
Hydnophytum	ES	1	1		
Hydrangea	S	1	2	1	
Hydrilla	AqH	1	1		
Hydrocera	H	1	1		
Hydrocotyle	H	2	5	5	4
Hydrolea	H	1	1	1	3
Hygrophila	H	1	7	2	
Hygroryza	AqG	1	1		
Hylocereus	C	2	1	5	
Hymenachne	G	1		1	
Hymenocallis	H	2	2	4	4
Hymenocardia	S, ST	1	2		
Hymenodictyon	T	1	1		
Hymenopogon	ES	1	1		
Hyophorbe	P	1		2	
Hypericum	S	1	3	2	17
Hyptis	H	1	2	9	1
Ichnocarpus	C	1	4		
Ilex	T	2	13	13	8
Illicium	T	1	2		
Illigera	C	2	9		
Impatiens	H	6	25	2	
Imperata	G	1	2	1	1
Indigofera	H, US, S	10	23	5	3
Intsia	T	3	2	1	
Inula	S	4	5		
Iodes	C	1	2		
Ipomoea	CrH, AqH, C	13	52	32	29
Iresine	H	1		5	4
Iris	H	1	1	1	3
Irvingia	T	1	2		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Ischaemum	G	3	11		
Isoloma	H	1	1	2	
Itea	S	1	3		1
Ixora	S	19	34	6	
Jacaranda	T	1		1	
Jacquemontia	CH	2	2	6	1
Jasminum	C	24	31	8	
Jatropha	S, ST	5	5	3	3
Juncellus	G	1	3	1	
Juncus	G	1+	8	1	26
Juniperus	S, ST	3	1	4	8
Jussiaea	H, AqH, US	3	5	5	7
Justicia	S	4	42	4	2
Kadsura	C	1	2		
Kaempferia	H	5	13	2	
Kalanchoe	H	6	7	5	
Kandelia	ST	1	1		
Kayea	T	1	4		
Kleinhovia	ST	1	1	1	
Knema	ST	4	5		
Knoxia	H	2	5		
Kochia	H	1			2
Kopsia	S	2	5		
Kurrimia	T	1	1		
Kydia	ST	1	2		
Kyllinga	G	1	6	5	
Labisia	H	1	1		
Lactuca	H	3	9	3	4
Lagenaria	CH	1		2	
Lagerstroemia	T	17	28	3	1
Laggera	H	2	3	2	
Lannea	T	1	1		
Lansium	T	1+	26	1	
Lantana	S, C	4	1+	7	4
Laportea	S, ST	3	7		
Lasia	H	1	1		
Lasianthus	S	7	37	2	
Latania	P	1		2	
Lathyrus	CH	1	1	1	5
Lawsonia	CH	1	1	1	
Leea	H, S	11	2		
Leersia	G	1	1	2	
Lemna	AqH	3	3	1	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Lens	H	1		1	
Leonotis	H	1	1	2	1
Leonurus	H	1	1	2	
Lepionurus	S	1	3		
Lepironia	G	1	1		
Lepisanthes	ST	2	1		
Leptaspis	G	1	1		
Leptochilus	F	2	1+	5	
Leptochloa	G	1	2	3	9
Leucaena	S, ST	1	1	1	4
Leucas	H	2	2	1	
Leucomeris	S, ST	1	1		
Leucopogon	S	1	1		
Leucostegia	EF	2	3		
Licuala	P	5	10	1	
Ligustrum	ST	2	3	7	
Lilium	H	1	2	3	1
Limatodes	O	1	1		
Limnophila	H	3	14		
Limnophyton	H	1	1		
Limonia	H	1	1		2
Lindenbergia	H	1	3		
Linociera	T	6	9	5	
Linostoma	C	4	3		
Lipocarpha	H	1	4		
Litchi	T	1	1	1	
Lithocarpus	T	27	3+		
Litsea	T	5	17		
Livistona	P	4	3	3	
Lobelia	H	2	3	3	8
Lonicera	C	3	7	3	3
Lophatherum	G	1	1		
Loranthus	ParS	1	21	7	
Lourea	H	4	6	1	
Ludwigia	H	1	1		7
Luffa	CH	2	2	2	1
Lumnitzera	ST	2	2		
Luvunga	C	1	2		
Lycium	C	1	1	2	5
Lycopersicon	CH	1	1	3	
Lycopodium	F	2	2	15	3
Lygodium	CF	5	12		1
Lyonia	S, ST	1		3	2
Lysimachia	H	1	11	1	2

	Habit	Thailand	Indochina	Puerto Rico	Texas
Macaranga	ST	5	13	1	
Madhuca	T	5	4		
Maesa	ST	4	1		
Magnolia	S, T	2	1	2	4
Mahonia	T	1	1		4
Malaisia	C	1	1		
Mallotus	S	4	3		
Malpighia	S	2		9	1
Malvaviscus	S	1	1	1	
Mangifera	T	7	11	1	
Manglietia	T	2	2		
Manihot	S, ST	2	3	2	1
Manilkara	T	2	1	3	
Maoutia	S	1	1		
Mappia	ST	1	1	1	
Maranta	H	1	1		
Mariscus	G	1	3		1
Markhamia	T	1	3	1	
Marsdenia	C	4	9		1
Marsilea	F	1	2		4
Martinezia	P	1		1	
Martynia	H	1	1	1+	3
Mastixia	T	1	2		
Mayodendron	T	1	1		3
Medinilla	S	1	4	1	
Melastoma	S	6	14		
Melia	ST	2	2	2	1
Melientha	S, ST	1	1		
Meliosma	T	2	3	2	
Melocalamus	CB	1	1		
Melochia	H, US	2	2	1	
Melodinus	C	2	2		
Melodorum	S	3	11		
Melaleuca	S, ST	1	1	1	
Melampodium	H	1		1	4
Melanorrhoea	T	4	4		
Meliosma	ST	3	3	3	
Melothria	CH	5	6	1	
Memecylon	S, ST	14	15		
Mentha	H	3	2	2	4
Merremia	CH	1	5		1
Merrillia	ST	1		6	
Mesua	T	1	1	1	
Metroxylon	P	1		1	
Mezoneurum	C	6	4		
Michelia	S, T	6	4	1	
Microglossa	C	1	1		
Microlepia	F	2	8	3	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Microdesmis	S	1	1		
Micromelum	S, ST	2	5		
Microsaccus	O	1	1		
Microsorium	EF	3	4		
Microstylis	O	1	11		
Microtoena	H	1	1		
Microtropis	S	2	2		
Miliusa	S, ST	3	8		
Millettia	T	16	41	1	
Millingtonia	T	1	1	1	
Mimosa	US	1	1	4	10
Mimulus	CrH	1	3		3
Mimusops	T	1	1	1	
Mirabilis	H	1	1	1	24
Mischocarpus	T	1	4		
Mitragyna	T	6	1		
Mitrasacme	H	1	4		
Mitrephora	T	6	3		
Moghania	C	7	1		
Mollugo	H	2	4	3	2
Momordica	CH	3	6		1
Monochoria	H	2	5		
Monogramma	F	1	1		
Morinda	S, ST	8	7	1	
Morinda	S, ST	8	7	1	
Morindopsis	ST	1	2		
Moringa	ST	1	2	1	
Morus	ST	3	4	3	4
Mucuna	CUS	6	9	2	
Muntingia	ST	1	1	1	
Murraya	S, ST	3	4	1	
Musa	H	9	7	3	
Mussaenda	S, C	10	23	2	
Myrica	ST	1	2	1	1
Myriophyllum	ST	1	3		3
Myriopteron	C	1	1		
Myristica	T	4	3	1	
Myrtus	S	1		2+	
Myxopyrum	C	1	1		
Naravelia	C	4	2		
Narcissus	H	1		1	3
Nasturtium	H	2	4	9	
Nauclea	T	3	2	1	
Nelsonia	H	1	1	2	1
Nelumbo	AqH	1	1	1	1

	Habit	Thailand	Indochina	Puerto Rico	Texas
Neolitsea	T	1	3		
Nepenthes	CUS	3	8		
Nephelium	T	8	10		4
Nephrolepis	F	7	6	6	1
Neptunia	AqH	2	3	3	4
Nerium	S	1	2	1	1
Nervilia	O	1	2		
Neuropeltis	C	1	1		
Nicotiana	H	1	1	1	4
Niebuhria	S, T	1	2		
Nipa	P	1	1		
Nopalea	S, ST	1	1	1	
Nothopanax	S	1	2		
Nyctanthes	C, S, ST	2	1	1	
Nymphaea	AqH	4	3	7	3
Nymphoides	AqH	4	1+	2	1
Nyssa	T	1	1		2
Oberonia	EO	1	20		
Ochna	S, ST	1	3	1	
Ochrocarpus	T	2	2		
Ochroma	T	1		2	
Ocimum	H, US	4	3	3	
Odontadenia	C	1		2	
Oenanthe	H	1	4	1	
Olax	C	1	3		
Oldenlandia	H	8	71	4	5
Olea	S	3	6	1	
Oleandra	CF	3	4	2	
Oncosperma	P	2	1		
Ophioglossum	EF	1	5		5
Ophiopogon	H	1	10	1	
Ophiorrhiza	H	2	13	2	
Opilia	S	1	2		
Oplismenus	G	1	2	3	2
Opuntia	S	2	1	12	23
Ormocarpum	S, ST	1	1		
Ormosia	T	1	7	2	
Ornithobaea	H	1	3		
Orophea	S, ST	2	9		
Oroxylum	ST	1	1		
Orthosiphon	H	2	9		
Oryza	G	2	4	2	1
Osbeckia	S	4	16		
Osmanthus	S	1	2		
Osmunda	F	2	4	2	2

	Habit	Thailand	Indochina	Puerto Rico	Texas
Otophora	ST	4	4		
Ottelia	AqH	1	3		
Ouratea	S	2	2	2	
Oxalis	H	2	2	10	10
Oxymitra	C	2	2		
Oxyspora	S	2	1		
Oxystelma	CH	1	1		
Oxytenanthera	B	4	11		
Pachygone	C	1	2	1	
Pachyrhizus	CH	1	1	4	
Pachystoma	O	1	1		
Paederia	S	6	7	1	
Palaquium	T	3	3		
Panax	S	2	1	2	
Pandanus	S,T	9	12	5	
Panicum	G	15	36	94	
Papaver	H	1	1		2
Paphiopedilum	EO	4	9		
Parabaena	C	1	1		
Parabarium	C	2	10		
Paramignya	C	2	2		
Paranephelium	T	2	2		
Parashorea	T	1	1		
Paravallaris	T	2	2		
Parinarium	T	2	1		
Parkia	T	3	2	3	
Parkinsonia	ST	1	1	1	1
Parsonsia	C	1	1	4	
Parthenocissus	C	1	2		3
Paspalum	G	7	6	30	33
Passiflora	C	4	10	15	7
Pavetta	S	5	1	2	
Payena	T	4	6		
Pedilanthus	S	1	1	6	
Pelargonium	US	1		2	
Peliosanthes	H	1	5		
Peltophorum	T	2	4	3	
Pemphis	S	1	1		
Pennisetum	G	1	1	8	3
Pentace	T	1	2		
Pentacme	T	1	2		
Pentapetes	H	1	1	1	
Pentaphragma	H	1	3		
Peperomia	H	3	4	27	
Pereskia	S,C	1	2	3	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Pericampylus	C	1	1		
Perilla	H	1	2		1
Peristrophe	H	1	2		
Petraea	C, ST	1	1	2	
Petunga	S	1	1		
Petunia	H	1	1	1	1
Peucedanum	H	2	1	1	
Phaius	O	1	1		
Phalaenopsis	EO	3	4		
Phaseolus	CH	5	13	11	7
Phegopteris	F	17	15		
Phlogacanthus	S	2	12		
Phlox	H	1		2	15
Phoebe	T	2	6	2	
Phoenix	P	6	3	9	
Pholidota	EO	1	9		
Photinia	ST	1	4		
Phragmites	G	1	2	2	1
Phrynium	H	4	9		
Phyla	CrH	1	1		5
Phyllanthus	H, S, ST	10	33	5	7
Phyllocarpus	T	1		1	
Phyllochlamys	S	2	2		
Phymatodes	F	4	13	3	
Physalis	H	2	2	6	12
Phytocrene	C	1	1		
Picrasma	T	1	1	2	
Pilea	H	1	12	16	1
Pilostigma	ST	1	1		
Pinanga	P	3	7	1	
Pinus	T	2	5	18	7
Piper	H, C, S	12	36	16	
Pisonia	C	2	2	4	1
Pistia	AqH	1	1	1	
Pisum	CH	1	2	1	
Pithecolobium	S, T	7	12	5	2
Pittosporopsis	S, T	1	1		
Pittosporum	T	2	6	5	
Pityrogramma	F	1		4	
Planchonella	ST	5	2		
Plantago	H	1	1	2	10
Platanthera	O	1	9		
Platycerium	EF	2	2		
Plectocomia	CP	1	5		
Plectranthus	H	1	7	2	
Pleopeltis	EF	1	18		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Pluchea	S	2	4	2	4
Plumbago	S	3	2	6	1
Plumeria	ST	2	2	7	
Podocarpus	T	7	4	3	
Podochilus	O	1	2		
Pogonia	O	1	3	3	1
Pogostemon	H	2	8		
Polianthes	H	1	2	1	
Pollia	H	2	6		
Polyalthia	ST	8	14	1	
Polycarpaea	H	1	4		
Polychroa	CrH	1		1	
Polygala	ST	4	13	4	20
Polygonum	H,S	12	25	10	26
Polyosma	T	1	2		
Polypodium	EF	2	6	32	3
Pometia	T	1	1	1	
Pongamia	T	1	1		
Popowia	ST	1	4		
Porana	C	2	3	1	
Portulaca	H	4	7	8	6
Pothos	C	4	11	4	
Pouzolzia	H	1	3	2	
Premna	C	7	16		
Prismatomeris	S	2	3		
Protium	T	1	1	1	
Prunus	T	2	8	4	14
Pseuderanthemum	S	5	9	3	
Pseudodracontium	H	3	6		
Psidium	ST	1	1	6	
Psilotrichum	H	1	1	6	
Psilotum	EF	1	1	1	1
Psophocarpus	CH	1	1	1	
Psychotria	S	3	26	19	
Pteridium	F	1	2	2	1
Pteridrys	F	1	5		
Pteris	F	9	29	10	1
Pternandra	T	2	2		
Pterocarpus	T	5	4	5	
Pterolobium	C	4	5		
Pterospermum	T	7	8		
Ptychosperma	P	1		2	
Pueraria	C	5	8		1
Punica	S,T	1	1	1	
Putranjiva	T	1	1		
Pygeum	T	1	2		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Pyrostegia	C	1	1	1	
Pyrrhosia	EF	4	15		
Pyrus	ST	2		1	2
Quamoclit	CH	3	1	2	3
Quassia	S	1	1	1	
Quercus	T	13	39	7	35
Quisqualis	C	2	3	1	
Radermachera	T	1	10		
Randia	C, S, T	19	27	4	1
Ranunculus	H	1	3		13
Rapanea	H	1	2	2	
Raphanus	H	1	1	2	1
Raphiolepis	S	1	1	1	
Raphistemma	C	2	2		
Rauwolfia	S	4	5	3	
Ravenala	ST	1	1	1	
Ravenia	S	1		2	
Reinwardtia	US	1	1		
Remusatia	EH	1	3		
Renanthera	EO	2	5		
Rhapis	P	2	7	1	
Rhinacanthus	S	1	3		
Rhizophora	T	2	2	1	
Rhodamnia	S	3	1		
Rhododendron	S, ST	5	23		4
Rhodomyrtus	S	1	1	1	
Rhus	ST	3	2	2	8
Rhynchosia	US	2	4	4	7
Rhynchospora	G		6		25
Rhynchostylis	EO	3	3		
Ricinus	H, S, ST	1	1	1	1
Rinorea	S	2	1		
Rivina	H	1	1	1	1
Rosa	C, S	5	8	6	10
Rotala	S	1	5	2	1
Roureopsis	C	1	1		
Roydsia	C, S	1	10		
Roystonea	P	1	1	2	
Rubus	C, US	8	24	11	11
Rumex	H	2	6	3	13
Ruta	US	1	1	2	2
Saccharum	G	5	4	5	
Saccolobium	EO	1	3		
Sageraea	T	1	1		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Sagittaria	AqH	1	1	3	9
Salacia	C	6	10		
Salix	T	3	6	3	11
Salomonia	H	1	3		
Salvia	H	2	3	9	21
Salvinia	AqH	2	2	1	
Samanea	T	1	1	1	
Sambucus	S	2	4	2	3
Sanchezia	S	1	1	1	
Sandoricum	T	1	2		
Sansevieria	H	4	1	4	
Sapindus	ST	2	3	1	1
Sapium	T	3	6	1	
Saprosma	S	3	8		
Saraca	T	8	5	1	
Sarcanthus	EO	2	20		
Sarcolobus	C	1	2		
Sarcosperma	T	1	1		
Sarcostemma	C	2	1	2	3
Saurauja	S, ST	2	4		
Sauropus	S	3	22		
Scaevola	S	1	1	1	
Schefflera	E, ST	6	6		
Schima	T	1	3		
Schismatoglottis	H	2	3		
Schizaea	F	1	2	4	
Schizocasia	H	1	1		
Schizocapsa	H	1	2		
Schizostachyum	B	2	5		
Schleichera	T	1	1		
Schoepfia	ST	2	3		
Schoutenia	T	2	2		
Schrebera	ST	1	1		
Scindapsus	C	3	6	1	
Scirpus	G	5	11	4+	14
Scleria	G	5	22	16	10
Scleropyrum	T	1	1		
Scoparia	H	1	1	1	1
Scurrula	ParS	1	1		
Scyphellandra	S	1	1		
Scyphiphora	S	2	1		
Secamone	C	1	6		
Securidaca	C	1	1	1	
Selaginella	F	3	4	10	13
Semecarpus	T	2	6		
Senecio	S	1	9	1	14

	Habit	Thailand	Indochina	Puerto Rico	Texas
Serissa	S	1	1		
Sesbania	H, US, S	3	5	4	4
Sesuvium	CrH	1	1	2	3
Setaria	G	2	7	14	12
Shorea	T	15	10		
Sida	US	4	7	25	16
Siegesbeckia	H	1	1		
Sindora	T	4	3		
Sinningia	H	1		1	
Siphonodon	T	1	1		
Sloanea	T	1	2	2	
Smilax	C	4	29	5	11
Smithia	H	1	4		
Solanum	H, C, S, ST	17	20	30	21
Solidago	H	1	1	3	23
Sonchus	H	2	2	2	3
Sonerila	H	1	10		
Sonneratia	T	3	2		
Sophora	S	1	4	2	5
Sopubia	H	1	3		
Sorghum	G	2	4	3	3
Spathiphyllum	H	2	1		
Spathodea	T	1	1	2	
Spathoglottis	O	3	4		
Spatholobus	C	3	4		
Sphaeranthus	H	2	2		
Sphenoclea	H	1	1	1	1
Sphenodesma	C	4	8		
Sphenomeris	F	1	1	1	
Spilanthes	H	1	1	6	
Spirolobium	S	1	1		
Spondias	T	2	5	3	
Stachyphrynium	H	2	4		
Stachys	H	1	2	2	5
Stellaria	AqH	1	1	2	4
Stemona	CH	4	10		
Stenochlaena	CF	1	1	4	
Stenolobium	ST	1	1	2	
Stephania	C	5	3		
Sterculia	T	19	30	3	
Stereospermum	T	5	6		
Streblus	T	1	1		
Streptocaulon	C	3	5		
Streptolirion	CH	1	3		
Strobilanthes	S	4	36	2	
Strophanthus	C	3	5	1	
Strychnos	C, T	12	13	1	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Styrax	T	6	6	2	4
Suaeda	H, US	1	1		5
Swertia	H	2	3		1
Swietenia	T	2	1	3	
Swintonia	T	1	1		
Symphorema	C	1	1		
Symplocos	S, ST	8	43	8	1
Syzygium	T	24	12	2	
Synedrella	H	1	1	1	
Tabebuia	T	1		8	
Tacca	H	6	7		
Taenitis	F	1	1	6	
Tagetes	H	3	1	2	1
Talauma	T	3	3	1	
Talinum	S	1		2	7
Tamarindus	T	1	1	1	
Tamarix	ST	1	3	3	5
Tarenna	S	5	20		
Tarrietia	T	2	1		
Taxotrophis	S, ST	1	6		
Tecoma	C	1	1		1
Tectaria	F	4	24	6	1
Tectona	T	1	1	1	
Teinestachyum	CB	1	1		
Telanthera	H	1		4	
Telosma	C	3	1		
Tephrosia	US	3	9	7	5
Terminalia	T	21	18	4	
Ternstroemia	ST	1	2	2+	
Tetracera	C	4	6		
Tetrameles	T	1	1		
Tetrastigma	C	3	18		
Teysmannia	P	1	1		
Thea	S, ST	1	8	1	
Thelypteris	F	2	19		
Themeda	G	3	7		
Theobroma	ST	1	1	3	
Thespesia	S, ST	1	2	1	
Thevetia	S, ST	1	2	2	
Thrinax	P	1		3+	
Thryallis	S	1			1
Thuja	ST	1	1	2	
Thunbergia	C	5	9	4	
Thyrsostachys	B	2	1		
Thysanolaena	G	1	1		
Tiliacora	C	1	1		

	Habit	Thailand	Indochina	Puerto Rico	Texas
Timonius	T	1	1		
Tinospora	C	5	5		
Tithonia	H	1	1	3+	
Toddalia	C	1	1		
Toona	T	1	2	1	
Torenia	H	2	28		
Tournefortia	C	2	5	9	1
Toxocarpus	C	3	8		
Trachelospermum	C	2	3		1
Tradescantia	H	1	12	3	12
Tragia	C	1	1	3	7
Trapa	AqH	3	2		
Trema	ST	2	4	2	
Trevesia	ST	2	1		
Trewia	T	1	1		
Trianthema	H	3	1	1	
Tribulus	H	2	1	1	1
Trichoglottis	EO	1	1		
Trichomanes	EF	2	22	22	
Trichosanthes	CH	5	15	2	
Trigonostemon	S, ST	2	18		
Triphasia	S	1	2	1	1
Tristania	ST	3	2		
Tristellateia	C	1	1		
Triticum	G	1	1	1	1
Triumfetta	H, US	3	4	6	
Tupistra	H	2	1		
Turnera	US	1	1	3	1
Turpinia	ST	3		3	
Tylophora	CUS	4	14		
Typha	H	1	3	2	2
Ulmus	T	1	1		5
Uncaria	C	8	9		
Uraria	US	8	14		
Urena	US	3	4	3	
Urostachys	EF	5		14	
Utricularia	AqH	3	26	2+	6
Uvaria	C	4	13	1+	
Vaccinium	S	7	1	1	6
Vallaris	C	2	1		
Vallisneria	AqH	1	1		1
Vanda	EO	10	17		
Vandopsis	EO	1	2		
Vanilla	CO	2	3	5	

	Habit	Thailand	Indochina	Puerto Rico	Texas
Vatica	T	5	6		
Ventilago	C	4	8		
Verbena	H	3	2	3+	34
Vernonia	H	14	29	6+	7
Vetiveria	G	1	2	1	
Viburnum	S	3	8		5
Vicia	CH	1	1	1	9
Victoria	AqH	1	1	1	
Vigna	C	4	1	6	2
Villarsia	AqH	2	1		
Vinca	US	1	1	2	
Viola	H	3	12	1	15
Viscum	ParS	1	4	10	
Vitex	T	11	20	5	2
Vitis	C	1	4	2	16
Vittaria	F	2	2	3	
Wallichia	P	2	1		
Walsura	T	6	6		
Waltheria	H	1	1	2	1
Wedelia	CH	3	5	7	
Wendlandia	ST	2	12		
Willughbeia	C	4	1	5	1
Winchia	C	1	1		
Wissadula	US	1	1	3	3
Wolffia	AqH	1	1		4
Wrightia	C, S, ST	5	10		
Xanthium	S	1	1	2	6
Xanthophyllum	S, ST	5	6		
Xanthosoma	H	1		7	
Xantonnea	S	2	2		
Xerospermum	T	1	4		
Xylia	T	2	2		
Xylinabaria	C	1	1		
Xyris	H	1	6	3	9
Yucca	S	1		2	23
Zanthoxylum	S	4	9	6	4
Zea	G	1	1	1	1
Zephyranthes	H	4	1	4	9
Zingiber	H	7	15	4	
Zinnia	H	1	1	2	4
Zizyphus	H	7	7	4	1
Zollingeria	T	1	1		
Zoysia	G	1	1		

CRITERIA FOR CLASSIFICATION

Various systems of classifying the vegetation of temperate and tropical regions have been described or proposed. Some have been formulated by ecologists or plant geographers, familiar solely with temperate regions, others by individuals with experience limited to the study of tropical vegetation, while some methods of classification may be considered purely theoretical. Some systems are based on a single criterion, such as floristics, others may take a series of factors into consideration. A system may be applicable to a single or specialized purpose, or may be adapted to a particular region or country. Others, such as Richards' classical publication on "Tropical Rain Forest," discuss various forest types on a world-wide basis.

Indicative of the formidable task involved in classifying vegetation, approximately 100 forest types are recognized east of the Mississippi, and about 60 types west of that river. In the Temperate Rain forest of North America, as in Europe, there may be only one or a few dominant species in a particular stand, or in extreme instances from 20 to 25 species may be present. In contrast, the pattern of vegetation in a Tropical forest is generally more complex. A stand of Evergreen Rain forest, for example, seldom contains less than 15 tree species upwards of 4 inches (10 cm.) dbh. per acre. In some instances there may be between 60 and 80 woody species within an equivalent area. Normally they vary in dimensions, form of trunk, size and shape of crown, type and size of foliage, and color, thickness and texture of bark. Seldom does a single species form a compact, pure stand.

The forest types of torrid zones, such as those occurring in Southeast Asia for example, range from the true Rain forest, with high temperature, abundant precipitation in excess of 100 inches annually, distributed almost throughout the year, and abundant soil moisture; the less humid Evergreen Moist forest, also with a dense, luxuriant, multistoried growth; the Moist or Dry Deciduous forests; the pine, oak and chestnut forests at upper elevations; Dry Dipterocarp forest often merging into savannas where grasses dominate; to the hot, dry, thorn forest and bamboo brakes in semi-arid or arid areas. Furthermore, the vegetation may vary from undisturbed forests in remote, uninhabited areas, to degraded forests in populated sites.

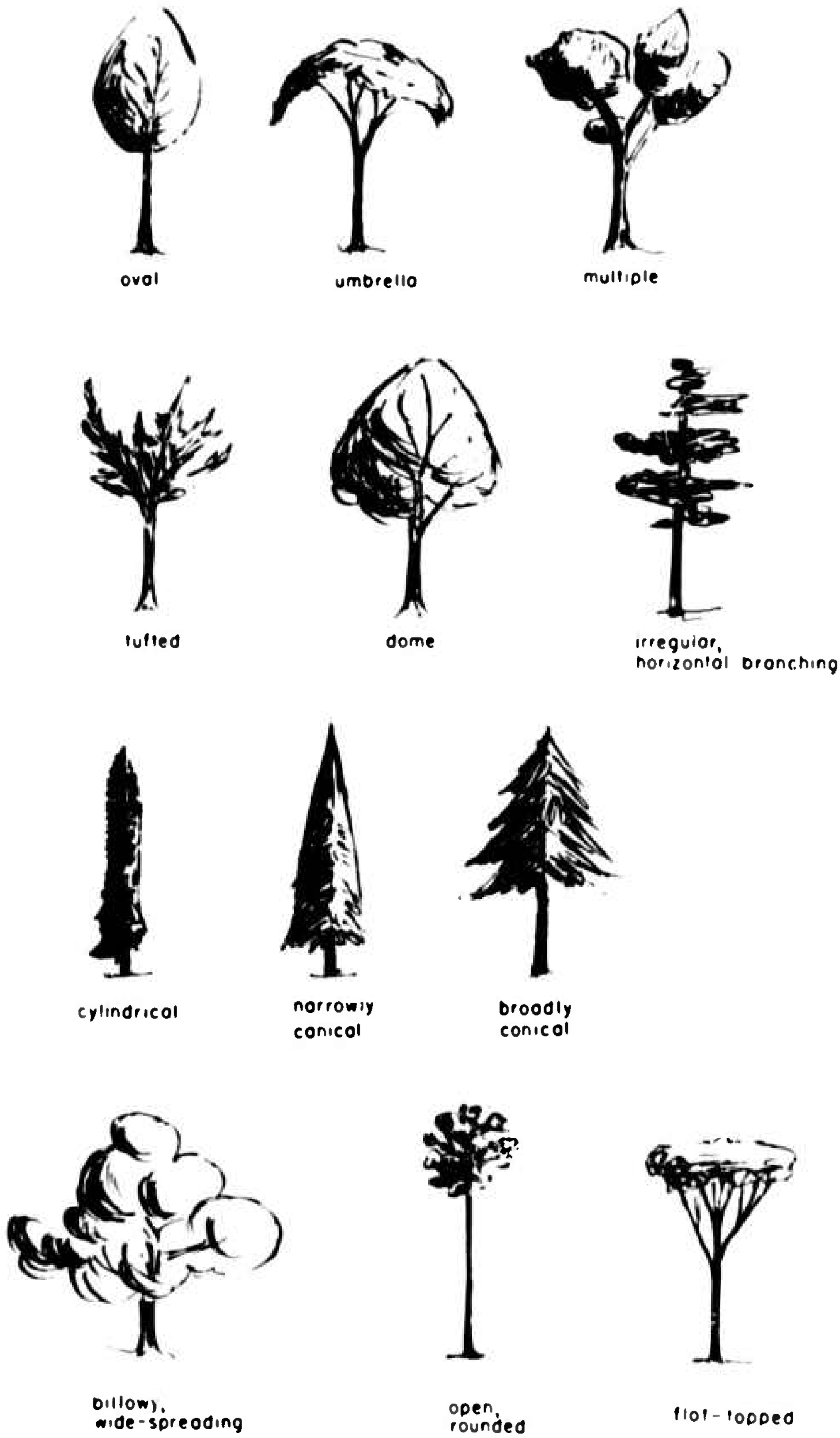

Fig. 2. Types of crowns occurring among trees in tropical and temperate forests

There are four methods which may be used as guidelines in establishing a classification of forests, either tropical or temperate, and which are applicable in the present project. These are: (1) Floristic; (2) Physiognomic; (3) Bioclimatic; and (4) Holistic, from the Greek meaning "whole" or "entire."

(1) Floristic: This approach involves assembling and identifying plant materials so as to prepare as complete a list as possible of species present in a plant community. This entails the collection of plants growing together which, in the aggregate, have a certain individuality. The total flora of a forest may be regarded as the building material of a particular plant community.

The floristic method involves some quantitative estimate of the relative occurrence of individual species in a community. Some ecologists consider it unnecessary to list the species in a particular plant community or a series of communities. But data on floristic composition contribute to the evaluation of the structure and composition of a particular community, whereas the contrary usually is not possible. Data on floristics also furnish information on the specific composition of primary and successional growth, as well as having a practical value in such specialized projects as the study of the effects of chemical defoliants, evaluation of ground mobility, surveillance and horizontal or vertical visibility, especially in a dense, closed forest.

(2) Physiognomy: The physiognomic method is concerned with the various factors that contribute to the appearance, composition and structure of a plant community. The study of vegetation along these lines has been used with appreciable success in recent years in tropical regions. It enables a comparison to be made of unfamiliar vegetation, and at the same time brings out certain characteristics that may not be otherwise apparent.

The general appearance or physiognomy of a forest is determined by the stature and spread of the species composing it, especially the predominant and dominant trees forming the canopy. In assessing these physiognomic characters, consideration should be given to structure in the horizontal sense, or spacing, and in the vertical dimension, corresponding to stratification or layering. The constitutent trees of the forest may stand at certain average distances apart, some in close proximity, and others may be widely spaced. The canopy may be open, permitting good visibility both upward and downward, or it may be continuous, dense and close as in the Rain forest, in which case visibility would be low to nil.

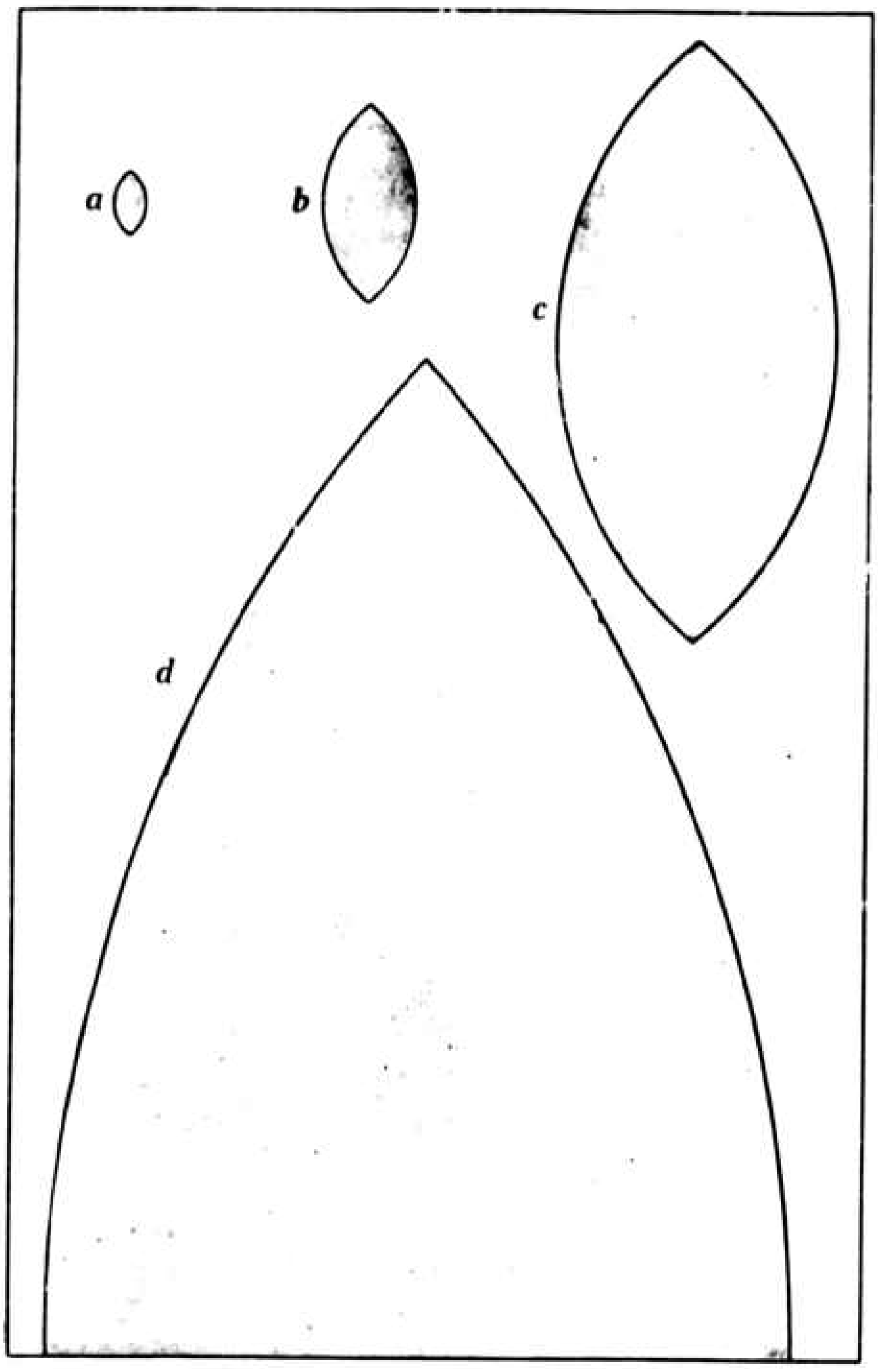

Fig. 3. Raunkiaer recognized 6 leaf sizes: Leptophyll (a) = 25 sq. mm.; Nanophyll (bet. a & b) - 9 x 25 = 225 sq. mm.; Microphyll (bet. b & c) - 9^2 x 25 = 2,025 sq. mm.; Mesophyll (bet. c & 2 x d) - 9^3 x 25 = 18,225 mm.; Macrophyll (bet. 2 x d & 8 x size of diagram) - 9^4 x 25 = 164,025 sq. mm.; and Megaphyll - 8 x size of diagram. (After Raunkiaer's "The Life Forms of Plants and Statistical Plant Geography.")

Stratification or layering is one of the primary characteristics of all but the simplest plant communities. This may be sharply defined, as in a Rain or Moist Evergreen forest, may be poorly demarcated, as in a Dipterocarp forest, or it may be absent. Where the forest consists of a single or few tree species of uniform height and are widely scattered, there is usually no stratification. The Dry Dipterocarp forest of Southeast Asia or a wooded savanna are typical communities in which there is no apparent stratification.

Additional recognizable characters of trees in certain tropical forest types include: the size of the crown and type of branching; whether a tree is evergreen or deciduous; the presence of buttresses, stilt roots and pneumatophores or "breathing roots"; the presence of thorns on the trunk and/or pecularities of the bark, such as texture and color; exudations such as oleoresin or latex; and succulent leaves or stems. The texture of the leaf blade is also important features and its size may be determined according to Raunkiaer's classification of leaf-size. The presence of woody vines or lianes, palms, cycads, rattans, pandans and epiphytes are important growth- or life-forms to be recorded.

The physiognomic approach, supplemented by data on microclimate and soils, appears to be a practical method in evaluating a type of forest, aimed at establishing the homologues and dissimilarities between the overall vegetation of Southeast Asia, and that of Puerto Rico and Texas. As already stressed, it is practical and particularly useful in classifying a stand of forest when its specific components have not been determined or are unknown. Information on a forest established along the lines of its structure, general appearance and life-forms is of more practical value for certain phases of military science, for example, than the accumulation of data on its floristic composition. When important structural characters, combined with climatic and soil conditions are similar, the problems of mobility, visibility and surveillance would probably be the same in the dense Rain forest of southern peninsular Thailand as in the Upland Rain forest in the Luquillo mountains of northeastern Puerto Rico. Furthermore, the effectiveness of chemical defoliants probably would be largely dependent upon the reaction of individual species, determined partly by leaf size and texture, rather than on their effect on the total species within a formation.

(3) Bioclimatic method: This system stresses the influence of climate on the development and nature of vegetation. Factors to be considered under bioclimate include: local

Comparison of Leaf Classes and Physiognomies in three Forest Types in Puerto Rico.

SPECIES	BLADE AREA	RAUNKIAER'S CLASSIFICATION	TEXTURE	LEAF TYPE	GENUS IN S.E.ASIA (X)1/
Bucida buceras	1400 sq. mm.	Microphyll	Membranaceous	Simple	
Cordia angustifolia	480 sq. mm.	Microphyll	Membranaceous	Simple	X
Haematoxylon campechianum	180 sq. mm.	Nannophyll	Membranaceous	Compound	
Lantana camara	300 sq. mm.	Microphyll	Membranaceous	Simple	X
Leucaena leucocephala	15 sq. mm.	Leptophyll	Membranaceous	Bicompound	X
Pithecollobium unguis-cati	180 sq. mm.	Nannophyll	Coriaceous	Compound	X
Randia mitis	40 sq. mm.	Nannophyll	Membranaceous	Simple	X
Swietenia mahagoni	500 sq. mm.	Microphyll	Membranaceous	Compound	X
Zanthoxylon monophyllum	1825 sq. mm.	Microphyll	Membranaceous	Simple	
THORN FOREST MODE (Ave.)	507 sq. mm.	Microphyll	Membranaceous	Simple	
Calophyllum calaba	2650 sq. mm.	Mesophyll	Coriaceous	Simple	X
Cordia lima	800 sq. mm.	Microphyll	Coriaceous	Simple	X
Guarea ramiflora	2600 sq. mm.	Mesophyll	Membranaceous	Compound	
Guettarda ovalifolia	2500 sq. mm.	Mesophyll	Coriaceous	Simple	
Inga laurina	3000 sq. mm.	Mesophyll	Coriaceous	Compound	X
Podocarpus coriaceus	600 sq. mm.	Microphyll	Coriaceous	Simple	X
Psychotria maricaensis	600 sq. mm.	Microphyll	Subcoriaceous	Simple	X
Rapanea ferruginea	1500 sq. mm.	Microphyll	Membranaceous	Simple	
Terebraria resinosa	1675 sq. mm.	Microphyll	Membranaceous	Simple	
Turpinia paniculata	1300 sq. mm.	Microphyll	Subcoriaceous	Compound	X
MARIA FOREST MODE (Ave.)	1717 sq. mm.	Microphyll	Coriaceous	Simple	
Ardisia guadalupensis	12500 sq. mm.	Mesophyll	Subcoriaceous	Simple	X
Dacyrodes hexandra	8250 sq. mm.	Mesophyll	Membranaceous	Compound	
Mammea americana	13500 sq. mm.	Mesophyll	Coriaceous	Simple	
Ormosia krugiana	28000 sq. mm.	Macrophyll	Subcoriaceous	Compound	
Miconia serrulata	20000 sq. mm.	Macrophyll	Membranaceous	Simple	
Miconia sintenisii	5000 sq. mm.	Mesophyll	Membranaceous	Simple	
Psychotria berteriana	6400 sq. mm.	Mesophyll	Membranaceous	Simple	X
Sapium laurocerasus	8400 sq. mm.	Mesophyll	Subcoriaceous	Simple	X
Sloanea berteriana	12000 sq. mm.	Mesophyll	Subcoriaceous	Simple	
Tabebuia heterophylla	2150 sq. mm.	Mesophyll	Coriaceous	Compound	
RAIN FOREST MODE (Ave.)	11621 sq. mm.	Mesophyll	Subcoriaceous	Simple	

1/ Prepared by J. A. Duke.

variations in seasonal or annual rainfall, the range of daily or seasonal temperatures, velocity of wind, and intensity of light. Data are essential on the mean temperature of the hottest and coldest month; absolute maxima and minima temperatures; mean rainfall of separate months; length of dry period or periods; mean number of consecutive days with negligible rain or without rain; prevailing winds and periodic or seasonal winds of special significance.

If we follow the climatic-vegetative method, the Evergreen and Deciduous forests of Southeast Asia may be broadly classified into at least 9 major Formations or Associations, varying according to the average annual rainfall in that area and influenced also by the type of soils in a particular locality or region. Most of these are represented, on the basis of their structure, rather than floristics, in Puerto Rico and some in Texas. These are:

a) Evergreen Rain or Moist forests: tall, dense, multistoried, in which the dominants are entirely or mainly evergreen; mean annual rainfall exceeds 80 in. (2,030 mm.) and there is little or no deficiency of atmospheric or soil moisture at any period of the year; in lowlands and on hill slopes at lower elevations.

b) Oak - Chestnut (Quercus - Lithocarpus - Castanopsis) forest: at middle to upper elevations, in ravines and on mountain slopes, often with abundant moisture throughout the year.

c) Coniferous forests: also evergreen, represented in Southeast Asia by species of Pinus, Podocarpus, Keteleeria, Dacrydium and Cunninghamia; occur on ridges approaching altitudinal limits with subtropical climate, although one species of pine (P. merkusii) in Southeast Asia descends to tropical lowlands at 400 or 500 ft. (120 - 150 m.).

d) Moist deciduous, or so-called Seasonal or Monsoon, forests: many of the dominant trees have a leafless aspect usually during the dry season; annual rainfall ranges from 50 to 80 in. (1,270 - 2,030 mm.), sometimes more, and with 4 to 6 dry months. Teak (Tectona grandis) is characteristic of this formation in northern Thailand and northwestern upper Laos.

e) Dry deciduous forests: in areas where the climate is too dry, the soil too porous to hold sufficient moisture, and therefore often too infertile to support a more luxuriant vegetation; annual rainfall is 50 in. (1,270 mm.) or less, with upwards of 6 months of dry period, at times of prolonged drought; dominant trees are entirely deciduous or almost so, and are leafless generally during the dry season. Included in this type are Dry Dipterocarp and Thorn forest, a xerophytic growth composed of shrubs and small trees mostly thorny. The latter are comparable to those around Guánica in southwestern Puerto Rico, and stands of "huisache" (Acacia farnesiana) in Texas.

f) Swamp formations: (1) Saline swamps, typified by Mangrove forests, an edaphic, evergreen formation, not dependent on rainfall, which is widespread along the coasts of Southeast Asia, especially Thailand and Vietnam, and Puerto Rico, flourishing in muddy soil around estuaries and in deltas subject to submersion by tidal waters; and (2) Freshwater swamps, wherein plant species are entirely different from those in the coastal saline swamps.

g) Littoral formation: along sandy shores and on slightly higher coastal sites, separated from the mangrove and post-mangrove forests and beyond reach of tidal influence.

h) Bamboo brakes: considered essentially as a generic or seral community, frequent in Moist Deciduous forests, and appear also as secondary growth in other formations, especially after felling or when clearings are made in the forests.

(4) Holistics: This approach, in the broad sense, takes into consideration all the factors that constitute, exert an influence upon, or are associated with a particular plant community. A thorough study of any Association or Formation on such a broad scale involves the coordination of several disciplines. It involves the gathering of data on floristics, the bioclimate and physiognomy, supplemented by information on the soils, topography, edaphic and biotic features, and other characteristics of the habitat.

The Holistic method is the most comprehensive and thorough system of classifying the vegetation. It presents a closer insight into the vegetation and the factors that influence the development and distribution of distinct plant communities.

E V E R G R E E N   F O R E S T S

The term "Rain forest" is generally applied to the luxuriant, humid evergreen forest, which attains its optimum development under certain favorable tropical conditions. Synonymous terms for this forest type are: Wet, Moist, or Humid Evergreen, Broadleaved Evergreen, and the "Foret dense humide" of French ecologists and foresters.

Distinctive features of this climax forest are the luxuriance of the vegetation, and the preponderance of woody plants. This forest community in tropical zones may contain a large number of co-dominants or there may be only one or a few dominants, as in certain temperate regions. Although the species in a tropical Rain forest may be numerous, they are remarkably uniform in general appearance and physiognomy.

In a restricted sense, the true Rain forest generally occurs only in areas with high temperature and high annual rainfall, ranging from about 80 to 175 in. (2,030 - 4,450 mm.), and sometimes more, distributed throughout the year and with no definite or prolonged dry period. The prevailing climate is usually marked by constantly high temperatures, at times up to more than 100^{o} F. Soil temperatures are equally constant.

In addition to high temperature and abundant rainfall, the Rain forest is characterized by uniformly high humidity. This remains high throughout most of the day, even during the dry season, and reaches almost the saturation point at night, especially at higher elevations. Humidity tends to increase with altitude. This factor may compensate for lower rainfall at certain periods in most parts of Southeast Asia. In the Rain forest, also, soil moisture is usually sufficiently abundant to sustain a constantly evergreen, luxuriant growth.

In a broader concept, some ecologists consider the Rain forest to include the Evergreen Moist forest, in which the annual rainfall is somewhat lower than in the true Rain forest, ranging from 80 to 100 in. (2,030 - 2,540 mm.), and with well-defined wet and dry seasons of about equal duration.

The trees composing the tropical Rain forest are extremely varied in dimensions. Because of variations in height, the forest is stratified or multi-layered in structure, usually composed of three tree strata, in addition to an undergrowth of shrubs, palms, rattans (Calamus spp.) and bamboos,

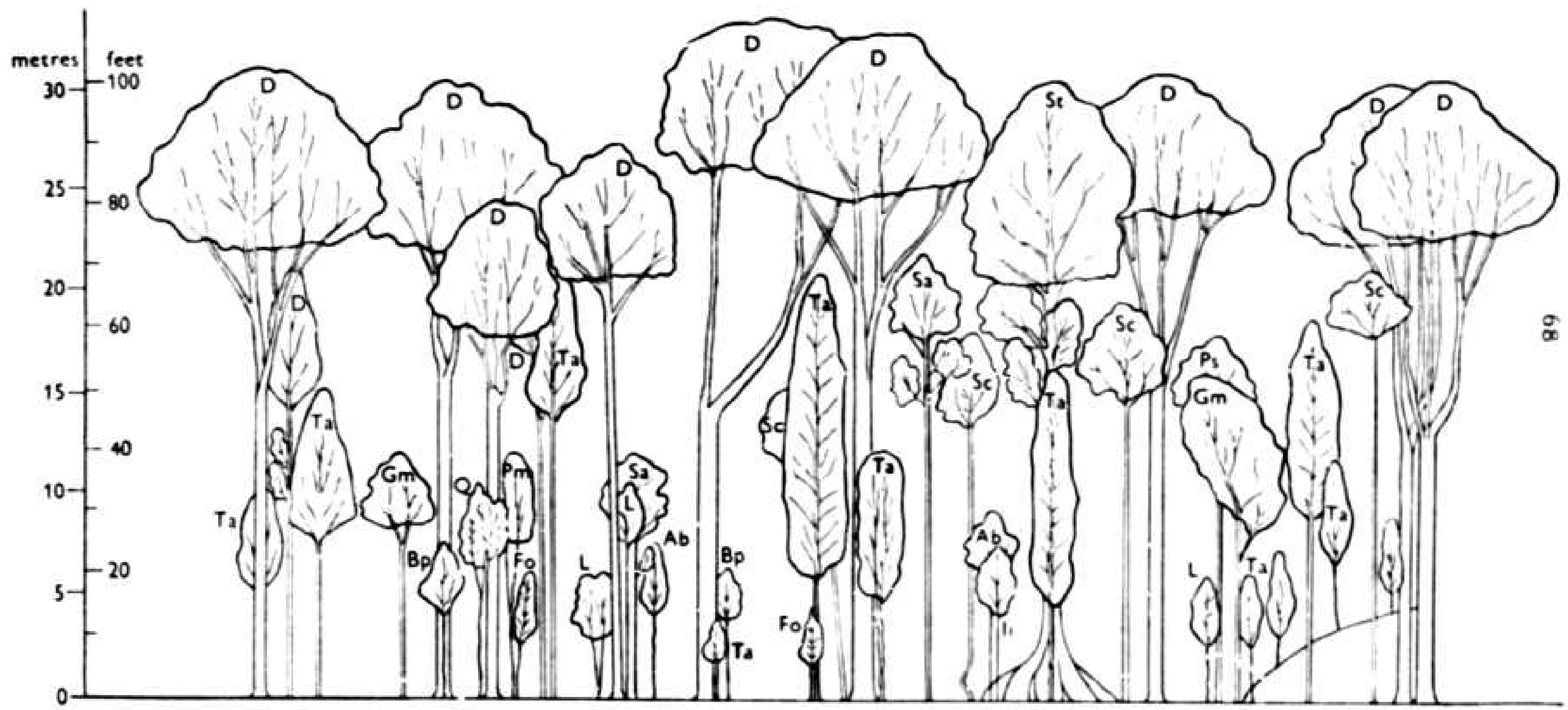

Fig. 4. Profile diagram, representing a strip 25 ft. (7.6 m.) wide, of primary Rain forest, Dacryodes-Sloanea association, Dominica, British West Indies. (After Beard (1949), Richards "Tropical Rain Forest.")

which are especially frequent in Southeast Asia, and a ground layer of herbaceous plants and seedlings.

Some emergent or predominant trees, such as "jelutong" (Dyera costulata), may reach a height of upwards of 150 ft. (50 m.), but they do not form a continuous canopy. In reality the canopy is formed by crowns of the tallest trees in the top stratum, as well as those in the lower stories. Trees in the upper layer or canopy generally attain a height of 90 to 120 ft. (30 - 40 m.); those in the second stratum may reach up to about 75 ft. (23 m.) high; while trees in the third story range from 25 to 40 ft. (8 - 12.5 m.) tall.

The dominant trees in the canopy as a rule, have long, straight, often columnar boles which usually branch only near the top. The crown varies in form from round, umbrella-shaped to irregular, or it may be tall and narrow because of limited space between the trees. Many species have small to large, thin to thick buttresses at the base. This feature is highly characteristic of Rain forest trees. Such plank-like outgrowths are little developed or may be completely lacking in Mixed Deciduous or other forest stands.

The bark of Rain forest trees may be smooth or rough, scaly or lenticular, and of variable thickness. The foliage is usually dense, and in the upper story it is almost continuous. Some trees may be deciduous for a short period or in part deciduous, but to all intents and purposes the Rain forest is constantly evergreen. Compound leaves predominate in the upper stories, while simple leaves are most frequent in the lower strata. The average leaf-size, according to Raunkiaer's leaf-size classification (1916), is mesophyll. Most of the trees have inconspicuous flowers, or at least they are difficult to recognize from the ground, and are often white to greenish. Species of tall palms, such as Livistona speciosa and the sugar palm (Arenga saccarifera) of Southeast Asia, may be present or absent, or at times are represented by small, immature palms.

In addition to mechanically independent, or autotrophic plants, mechanically dependent plants are usually present. These include climbers, lianes or woody vines, stranglers (Ficus) and epiphytes, as well as plants without chlorophyll, represented by saprophytes and parasites.

The shrub stratum is variable in density and height. Where the forest has not been disturbed, shrubby growth is seldom sufficiently dense to impede progress, and in some sites shrubs as well as herbaceous plants in the gound layer may be totally lacking. In sections of the southernmost part of peninsular Thailand, for example, rattans (Calamus) are characteristic of the lowest stratum, creeping for a considerable distance along the ground and climbing on trees. The ground layer consists of herbaceous plants a few inches to 2 or 3 ft. (60 - 90 cms.) tall, in addition to tree seedlings, which often are abundant, ferns and selaginellas. Mosses are sparse or absent on the ground.

Despite the density of the foliage, especially in the upper stories, the forest floor may be dappled with sun-flecks. But the interior of the Rain forest is usually somber, and the atmosphere at ground level is constantly humid, even at the height of the dry season. Unlike forests of temperate regions, plant growth and reproduction of leaves, flowers and fruits in the Rain forest are generally continuous, because of the constantly high humidity and temperature, with only slight seasonal variation. Although there is no well-defined periodicity of leaf-shedding, flowering, fruiting and the development of a new leaf crop, there are periods when the majority of trees are in flower or the production of new leaves is at its maximum.

Radiation appears to be less intense in the tropical Rain forest than in a similar type of high forest in temperate regions. Daylight averages about 12 hours, with slight seasonal variation. In addition to a high degree of cloudiness, especially in the early morning hours and which is greatest during the wet season, the presence of dust in the air and smoke from brush fires reduces the amount of bright sunshine.

Visibility, both horizontally and especially vertically, is minimal in the Rain forest. The canopy appears continuous as seen from above. In reality it is composed not only of the crowns of trees in the top story, but includes those in the lower stories as well. Seldom is it possible in the humid forest to see through the canopy to the ground level. However, along banks of streams the undergrowth may appear dense, but on penetrating into the interior of the forest seedlings and shrubs become less dense, and do not seriously impede progress.

Humid Mixed Hardwood Evergreen forests are well represented in the Mekong basin countries, to a limited extent in northeast Puerto Rico, but are not represented in Texas. These may be segregated into Lowland and Hill or Upper Evergreen forests. True Rain forest, with a high annual rainfall in excess of 100 inches, distributed throughout the year and with a short dry period, is limited, however, to such areas of Southeast Asia as Takuapa region in southeastern peninsular Thailand, and on the

Precipitation at Ranong, Kra Isthmus

Southwestern Peninsular Thailand 1/

Dominant Types: Rain Forest, interspersed with rolling Savanna, and Mangrove Woodland along coast.

Month	1960 mm.	1961 mm.	1962 mm.	1963 mm.	1964 mm.
January	10.1	24.9	40.7	1.1	24.0
February	17.7	17.8	2.8	2.9	9.7
March	32.7	38.1	6.2	36.3	49.4
April	67.3	239.6	131.1	62.3	76.3
May	624.4	892.3	336.2	426.8	660.6
June	749.0	587.4	572.1	681.2	662.8
July	708.7	494.3	869.7	457.8	390.2
August	789.7	832.7	595.3	667.7	894.2
September	966.8	824.7	774.4	841.4	719.6
October	371.4	466.6	354.9	563.1	352.1
November	205.2	119.0	71.0	149.9	129.9
December	41.8	43.6	18.1	81.5	72.8
Total	4,584.8 180.50 in.	4,581.0 180.35 in.	3,774.5 148.60 in.	3,972.0 156.37 in.	4,041.6 159.11 in.
Average per month	382.0 15.4 in.	381.8 15.03 in.	314.54 12.38 in.	331.0 13.03 in.	336.8 13.26 in.

1/ Data furnished by Provincial Forest Officer, Ranong.

upper slopes of the Cardamom Mountain range in western Cambodia, which receives the highest rainfall in the Indochina Peninsula.

Moist Evergreen forests, with a lower annual precipitation of 80 to 100 in. (2,030 - 2,540 mm.), and with well-defined wet and dry seasons of equal duration, have a much wider distribution in Southeast Asia. These humid forests occur in Thailand throughout most of the southern section of the Peninsula, such as at Kaochong at altitudes of 450 to 650 (140 - 200 mm.); on the island of Phuket; on the leeward slopes of the Tenasserim range along the border of Burma, in the west; in central Thailand in the Khao Yai National Forest; in the southeast, on the island Kochang and along the slopes of the Khao Sa Bap Mountain range on the border of western Cambodia. They are also frequent in Cambodia, especially in the western part; in central Vietnam; sections of Laos; and in northwestern Puerto Rico. Because of the valuable timbers, esteemed for local construction, and minor products for export, these humid forests have long been heavily exploited in the more accessible areas.

There are several areas in North America and Europe where a temperate type of Rain forest occurs. The closest analogue is the Mixed Mesophytic forest. One of the best examples of this type in the United States covers the western slopes of the Olympic Peninsula in northwestern Washington State. The winter climate in that area is unusually wet. In some sections annual precipitation may exceed 140 in. (3,550 mm.). The Peninsula is almost an island, nearly surrounded by water, and the Olympic National Park occupies its central and western part. In the western valleys of the Park, as a result of constantly high precipitation, an extraordinary type of vegetation has developed, similar in physiognomy to the tropical Rain forest.

Dominant species in this Rain forest are few in number, although some are larger in stature than those even in a tropical Rain forest. Some of the taller trees reach a height of 200 ft. (75 m.) and a diameter in excess of 8 ft. (2.5 m.). Dominants in this Temperate wet forest are Sitka Spruce (*Picea sitchensis* Carr.) and Western Hemlock (*Tsuga heterophylla* Sarg.). Western Red Cedar (*Thuja plicata* Donn) and Douglas Fir (*Pseudotsuga taxifolia*) are also prominent.

Near banks of streams Big Leaf Maple (*Acer macrophyllum* Pursh), Alder (*Alnus rubra* Bong.) and Black Cottonwood (*Populus trichocarpa* Torr. and Gray) are abundant. Moss-covered vine Maple (*Acer circinnatum* Pursh) is represented in the understory

Mosses carpet the forest floor and cover the tree trunks, while clubmoss hangs from the branches. Ferns and flowering plants also mingle with the mosses on the forest floor. No comparable tall, luxuriant forest exists in Texas.

In Puerto Rico, the Luquillo Mountains, at the northeastern end of the island, have an altitude of up to 4,400 ft. (1,450 m.). They are fully exposed to the moisture-laden trade-winds from the northeast and have the highest rainfall of any site on the island, amounting to about 120 inches and at times up to 150 in. (3,800 mm.) or more annually. There is no well-defined dry season, droughts are unknown, and there are few days without rain. Cloudiness is above the average and the vegetation is frequently drenched with condensed moisture. These conditions give rise to the development of a Rain Forest type.

Regarded as a Mixed, Moist Evergreen forest, or by some as a Lower Montane Rain forest. it is considered the best example of Rain forest in Puerto Rico and other parts of the West Indies. It now forms part of the Luquillo National Forest.

Wadsworth describes it as a heterogeneous moist tropical forest, with similar physiognomy and with many of the same species found in Hispaniola (Dominican Republic and Haiti), Jamaica and Cuba. Some affinities in composition and structure also exist between the Dacryodes-Sloanea association and the moist forest of the Atlantic slopes of Central America and northern South America.

The two key genera - Dacryodes and Sloanea - are strong components of this moist Hardwood forest of Puerto Rico and of the larger Lesser Antilles, including St. Kitts, Montserrat, Guadeloupe, Dominica, St. Lucia, St. Vincent and Grenada. The Dacryodes-Sloanea association is generally found on foothills, slopes and lower ridges of mountains, at altitudes of 490 to 2,600 ft. (150 - 800 m.) in Puerto Rico, and as high as 3,000 ft. (900 m.) in some of the Lesser Antilles. The terrain is usually very rough.

The Dacryodes-Sloanea association is not as complex, in structure or composition, as the optimum Rain forest of southern peninsular Thailand, western Cambodia, or Malaysia, for example. There are indications that, in former years, this excellent forest was culled for useful timbers for construction, and probably for fuelwood. This Rain forest is composed of the usual three strata, upper, middle and lower, which are generally discontinuous, and with a maximum tree height of about 100 ft. (30 m.). The total number of species in the association is nearly 200 if local variations in composition throughout the islands are included. In Puerto Rico about 90 species have been found in undisturbed primary stands, and an additional 80 species in more extensive secondary forests. About one-fourth of the species are in each of the upper and lower tree stories, with the remaining half in the middle story. "Tabanuco" (*Dacryodes excelsa*) is the most dominant large tree in all primary stands, and in some sites it constitutes up to 35 percent of the basal area.

Associated with tabanuco (*Dacryodes excelsa*), but less prominent, are several species of *Sloanea*, of which *S. berteriana* is the most frequent. Other timber species growing in the Puerto Rican stands are: *Guarea trichilioides*; *Buchenavia capitata*; *Homalium racemosum*; *Ocotea moschata*; *Manilkara bidentata*; *Tabebuia pallida*; and *Tetragastris balsamifera*.

The soils in which the *Dacryodes-Sloane* association appears, or once flourished, are reddish, deep laterite and derived from fine-grained igneous rock. Boulders are common on the surface as well as throughout the profile. These soils are high in clay and low in silt and sand. They are generally acid, heavy but permeable, and well drained except in sites where the rainfall is heaviest.

The climate in the tabanuco forest is cooler than that of the more extensive lowland continental Rain forest, because of elevation, oceanic influence, and possibly latitude (12 to 18° N.). In Puerto Rico the mean temperature ranges from 64 to 75° F. (21 - 24° C.), and the extremes are 54° and 90° F. (12° and 32° C.). Precipitation ranges from 80 to 120 in. (2,030 - 2,048 mm.). During the drier part of the year, from January to April, the rainfall sometimes may fall to about 3 inches (75 mm.) per month. This dry period, however, is of only slight significance to the forest. Relative atmospheric humidity, according to brief records, seldom falls below 60 percent, and is generally above 90 percent at night.

The sites where the *Dacryodes-Sloanea* association occurs is subject to occasional hurricanes, which are important in the development and structure of the climax formation. These are characterized by strong winds with a velocity of 75 to 152 miles (120 - 245 kms.) per hour, preceded or accompanied by heavy rains up to 20 in. (50 cm.) or more in 24 hours. The effect is to uproot or to fell many exposed trees and to strip branches and leaves from most of the remaining standing trees. Residual evidence of the damage may be seen years later, in broken branch stubs and reformed crowns of standing trees.

Temperate Rain Forest - Northwestern Washington State 1/

Average Precipitation

Month	Conto	Quinault	Wishkauh Headworks	Clearwater	Spruce
	Inches	Inches	Inches	Inches	Inches
January	17.07	20.25	17.79	17.41	18.39
February	11.32	14.06	13.17	14.43	13.99
March	14.82	13.44	15.60	13.48	13.47
April	7.85	8.30	9.40	8.61	8.78
May	4.29	6.26	5.92	5.76	6.10
June	3.97	4.56	4.54	4.95	4.22
July	1.87	1.65	2.06	2.10	1.94
August	2.25	2.45	2.08	2.23	2.21
September	5.77	6.70	5.70	6.05	5.33
October	10.30	12.21	11.37	11.50	11.71
November	15.22	18.02	13.94	17.85	14.50
December	18.60	20.68	20.69	18.76	21.00
Annual	113.33	128.58	122.26	123.13	121.64

1/ U.S. Department of Agriculture. U.S. Department of Agriculture Yearbook, Climate and Man. 1248 pp. 1941.

The Rain forest in Luquillo is much more complex in trees than temperate forests, but is less diverse than some main land tropical forests. Smith* lists a total of 200 species of plants at El Verde site, Luquillo National Park, Puerto Rico. "Over half of the canopy is composed of only five species. If the palm dominated areas are eliminated, Sloanea and Manilkara remain as the overwhelming dominants of the forest.

"Four species make up the overwhelming preponderance of understory species (79.1%) although the understory species themselves compose only about one-third of the understory growth. Other species in the understory are seedlings of canopy species.

"Lianes are about half as abundant as canopy trees. Although epiphytes are common, they are not a major component of the forest, and are less numerous than in some other tropical forests. Most of the epiphytes include relatively rare ferns and orchids.

"Herb level ground coverage is noticeably lacking in the forest. Some species cover rocks only. About four small plants cover each square meter, but of these only one is an herb(usually the grass Ichnanthus or the fern Dryopteris deltoidea). The others are tree seedlings. Saprophytes are common."

Canopy trees: Tree species (over 4 in. dbh) recorded by Smith in top stratum in Rain forest, El Verde site:

Species	Relative density below Pct.
Dacryodes excelsa Vahl.	18.2
Euterpe globosa Gaertn.	11.4
Croton poecilanthus Urban	9.5
Sloanea berteriana Choisy	8.1
Manilkara bidentata (A. DC.) Cher.	6.4
Miconia tetandra (Sw.) D. Don.	5.5
Cecropia peltata L.	4.6
Ormosia krugii Urban	3.1
Matayba domingensis (DC.) Radlk.	3.0

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*Smith, Robert F. 1965. Vegetation Structure of the Lower Montane Rain forest at El Verde. The Rain Forest Project Annual Report FY-65. Rio Piedras, P.R.

Species	Relative density below: Pct.
Inga fagifolia (L.) Willd. (= Inga laurina (Sw.) Willd.	2.7
Linociera domingensis (Lam.) Knobl.	2.0
Alchornea latifolia Sw.	1.9
Alchorneopsis portoricensis Urban	1.8
Sapium laurocerasus Desf.	1.7
Tabebuia pallida Miers.	1.7
Buchenavia capitata (Vahl.) Eichl.	1.6
Micropholis garciniaefolia Pierre	1.6
Ocotea leucoxylon (Sw.) Mex.	1.1
Calycogonium squamulosum Cogn	1.1
Guarea trichilioides L.	1.0
Didymopanax morototoni (Aubl.) Decne. & Planch.	1.0
Inga vera Willd. (= Inga inga (L.) Britton)	1.0

Principal understory trees which do not usually reach to the canopy:

Species	Relative density below: Pct.
Palicourea riparia Benth.	41.5
Drypetes glauca Vahl.	19.4
Cordia borinquensis Urban	10.7
Hirtella rugosa Pers.	7.4
Psychotria berteriana DC.	3.8
Myrcia ?	3.6
Trichilia pallida Sw.	3.3
Ixora ferrea (Jacq.) Benth	2.9
Lasianthus lanceolatus (Griseb.) Urban (=L. moralesii (Griseb.) C. Wright	1.9
Cassipourea guianensis Aubl. (=C alba Griseb.)	1.5

Lianes or woody vines growing up to the canopy.

Species	
Rourea glaba Griseb.	28.4
Philodendron krebsii Schott	18.0
Marcgravia rectiflora Tr.	14.0
Heteropteris laurifolia (L.) Juss. (=Banisteria laurifolia L.	13.7
Schlegelia brachyantha Griseb. (=S. portoricensis (Urban) Britton	4.9
Neorudolphia volubilis (Willd.) Britton	4.0

Species	Relative density below: Pct.
Securidaca virgata Sw. (=Elsota virgata (Sw.) Kuntze	4.0
Paullinia pinnata L.	3.4
Doliocarpus calinoides (Eichl.) Gilg.	2.0
Philodendron lingulatum (L.) C. Koch.	1.4
Cissus sicyoides L.	1.2

Some epiphytes, without terrestrial attachment, growing on other plants:

Species	Relative density below: Pct.
Trichomanes capillaceum L.	40.1
Guzmania berteroniana (R&S) Mez	28.0
Nephrolepis rivularis (Vahl.) Mett	8.0
Elaphoglossum flaccidum (Fee) Moore	5.8
Polypodium lycopodioides L.	3.7
Epidendrum spp.	3.2
Elaphoglossum dussii Underw.	2.6
Polypodium sp.	1.6
Vriesia macrostachya (Bello) Mez.	1.6
Hillia parasitica Jacq.	1.6

Most frequent herbaceous plants:

Ichnanthus pallens (Sw.) Munro ex Benth.	32.9
Pilea krugii Urban	26.6
Dryopteris deltoidea (Sw.) Kuntze	11.4
Arthrostylidium sarmentosum Pilger	8.9
Alsophila borinquena Maxon	8.2
Peperomia emarginella (Sw.) DC.	3.2
Polypodium duale Maxon	3.2
Erythrodes plantaginea (L.) Lindl.	1.9
Selaginella krugii Hieron.	1.9

An example of a Moist forest in Puerto Rico is that at Maricao, at the western end of the island. When seen from above, this forest appears to be composed of trees of various height and color, with mosaic shades of green because of variations in species and age of foliage. Few trees have trunks more than 3 ft. (1 m.) in diameter, although many species have a marked basal flare. Their crowns are narrow, sparsely branched, and the bark on most species is smooth. One of the characteristic features of the environment is the scarcity of humus. The ground is covered with a thin layer of fallen leaves and twigs, and a thin layer of humus, below which there is a layer of black soil only a few inches deep. These factors are probably caused by the gradual fall of leaves throughout the year, the rapid oxidation of organic matter, and its rapid removal by heavy rainfall. Although there are many tree species, there are few individuals of each within a given area. These are usually widely scattered throughout the forest.

The two most conspicuous trees are Lucuma multiflora and Guarea ramiflora. Although large individuals are not frequent, their seedlings are abundant. Other species of frequent occurrence are: Zanthoxylum martinicense, which has a trunk covered with stout conical thorns; Clusia rosea and C. gundlachii, with peculiar semi-epiphytic habit; the ever-present Didymopanax morototoni and Cecropia peltata, with large leaves which are brown above and white below; Coccoloba grandifolia, with very large, almost circular leaves; Piptadenia peregrina; isolated individuals of the Sierra palm (Prestoea montana). Where the cover is not too dense, the two tree ferns, Cyathea arborea and Alsophila aquilina, appear. Other trees worthy of mention are: Guarea guara, Buchenavia capitata, Nectandra patens, Amomis caryophyllata, Dendropanax laurifolium, Mayepea domingensis, Ixora ferra, Tetragastris balsamifera, Byrsonima spicata, Alchornea latifolia, and Drypetes glauca. Species of Erythrina may also be spotted when in bloom.

Piptadenia peregrina and Nageia coriacea are most often found near the bottom of valleys, near settlements or along roadsides. In the bottomland we also find the introduced "pomarosa" (Eugenia jambos). In clearings and at the edge of the forest, Miconia prasina and Cordia sulcata are abundant.

Seedlings and saplings of Guarea guara and Lucuma multiflora are very abundant everywhere, and Dendropanax laurifolium occurs in scattered patches.

In the undergrowth the bamboo-like grass, Arthrostylidium sarmentosum, appears, as well as such grass as Lasiacis divaricata and L. sorghoides, which climb over the undergrowth. The high-climbing Philodendron krebsii is frequent, as well as the climbing Marcgravia rectiflora, which is also abundant.

Epiphytes are not abundant. The most frequent is Anthurium acaule, growing on horizontal branches or in crotches of trees, on exposed rocks, stumps, and occasionally on the ground.

Herbaceous ground flora is scanty or absent. Plants which appear to be well adapted to the dense shade are: Ruellia coccinea, and two delicate grasses, Ichnanthus pallens and Pharus glaber.

As a result of reduction of light, many secondary species are represented only by a few individuals except at the edge of the forest and along the trails and roads where there is a maximum of light. Among the most characteristic species of shrubs in such places are: Miconia prasina and M. laevigata, Vitex divaricata, Calycogonium krugii, Piper scabrum, Myrcia splendens.

Number and diameter of tree species in 10 acres of Hill Evergreen Humid forest, Puerto Rico 1/

SPECIES	In. 4-6	In. 8-10	In. 12-18	In. 20+	Total No.
*Dacryodes excelsa -----------	116	53	76	63	308
Prestoea montana ------------	991	25			1,016
*Cecropia peltata ------------	214	80	37	6	337
Micropholis garciniifolia----	74	60	43	4	181
*Sloanea berteriana ----------	87	16	21	8	132
Cyrilla racemiflora ---------	4	9	11	16	40
Magnolia splendens ----------	6	5	7	15	33
*Inga fagifolia---------------	39	20	11	2	72
*Inga vera -------------------	23	18	12	2	55
*Didymopanax morototoni-------	33	24	10	1	68
Calycogonium squamulosum ----	62	16	8		96
Croton peocilanthus ---------	83	14	4		101
Alchornea latifolia ---------	31	10	5	3	49
*Alchorneopsis portoricensis--	22	9	11		42
Micropholis chrysophylloides-	12	8	4		25
Ocotea spathulata -----------	14	8	6		28
Manilkara bidentata ---------	35	5	1	1	42
Guarea guidonia -------------	20	7	2	1	30
Eugenia stahlii -------------	11	12	4		27
Matayba domingensis----------	26	8	2		36
Sapium laurocerasus ---------	26	10	1		37
Homalium racemosum ----------	5	1		2	8
Ormosia krugii---------------	6		2	1	9
Meliosma herbertii ----------	7	6	2		15
Buchenavia capitata ---------	2	2	1	1	6
Beilschmiedea pendula -------	2	1	1	1	5
Linociera domingensis -------	9	6	1		16
Andira inermis --------------	9	2	1		12
Tabebuia heterophylla--------	17	1			18
Cordia borinquensis ---------	19				19
Citharexylum fruticosum -----	9	2			11
Tetragastris balsamifera ----	6	3			9
Drypetes glauca -------------	9	1			10
Ocotea moschata -------------	4				4
31 other species ------------	193	35	12	3	243
TOTAL	2,226	487	296	131	1,140

1/ After Wadsworth (1951).

* Considered indicator species.

Species, Mostly Woody, Occurring in Evergreen Moist Forest

Kaochong, South Peninsular Thailand

Botanical Name	Family	Genus represented (X) in: Indochina	Puerto Rico
Acacia comosa	Legum.	X	X
Adenanthera pavonina	Legum.	X	X
Aglaia odoratissima	Meliac.	X	
Aglaia pirifera	Meliac.	X	
Alangium kurzii	Alangiac.	X	
Alstonia macrophylla	Apocynac.	X	X
Alstonia scholaris	Apocynac.	X	X
Anisoptera curtisii	Dipterocarpac.	X	
Arthocephalus cadamba	Rubiac.	X	X
Aporosa villosa	Euphorbiac.	X	
Aralia armata	Araliac.	X	X
Ardisia fulva	Myrsinac.	X	X
Ardisia wallichii	Myrsinac.	X	X
Arenga pinnata	Palmae	X	X
Artocarpus elastica	Morac.	X	X
Artocarpus lakoocha	Morac.	X	X
Barringtonia pedicellata	Lecythidac.	X	X
Bassia (Madhuca) grandiflora	Sapotac.	X	
Bischofia javanica	Euphorbiac.	X	X
Bouea burmannica	Anacardiac.	X	
Bouea microphylla	Anacardiac.	X	
Brownlowia sp.	Tiliac.	X	
Canthium dioicum	Rubiac.	X	
Capparis winittii	Cappardiac.	X	X
Carallia sp.	Rhizophorac.	X	
Careya sp.	Lecythidac.	X	
Castanopsis indica	Fagac.	X	
Cedrela toona	Meliac.	X	X
Chasalia chartacea	Rubiac.	X	
Cinnamomum iners	Laurac.	X	X
Cinnamomum parthenoxylum	Laurac.	X	X
Crataeva erythrocarpus	Capparidac.	X	X
Cratoxylon pruniflorum	Guttifer.	X	
Crypteronia paniculata	Sonneratiac.	X	
Curculigo latifolia	Amaryllidac.	X	X

Botanical Name	Family	Indochina	Puerto Rico
Dalbergia cochin-chinensis	Legum.	X	X
Dehaasia cuneata	Laurac.	X	
Dillenia sp.	Dilleniac.	X	X
Diospyros brachiata	Ebenac.	X	X
Diospyros buxifolia	Ebenac.	X	X
Diospyros ehretioides	Ebenac.	X	X
Diospyros ferrea	Ebenac.	X	X
Diplospora sp.	Rubiac.	X	
Dipterocarpus baudii	Dipterocarp.	X	
Dipterocarpus grandi-florus	Dipterocarp.	X	
Dipterocarpus kerrii	Dipterocarp.	X	
Duabanga sonneratioides	Sonneratiac.	X	X
Durio zebethinus	Bombacac.	X	X
Erythroxylon cuneatum	Erythroxylac.	X	X
Eugenia kurzii (syn. Syzygium fruticosum)	Myrtac.	X	X
Eugenia polyantha (syn. Acmea polyantha)	Myrtac.	X	X
Eugenia siamensis	Myrtac.	X	X
Fagraea fragrans	Loganiac.	X	
Ficus sp.	Morac.	X	X
Flacourtia sp.	Flacourtiac.	X	X
Garcinia coma	Guttifer.	X	X
Glochidion	Euphorbiac.	X	
Gnetum scandens	Gnetac.	X	
Grewia paniculata	Tiliac.	X	
Heritiera elata	Sterculiac.	X	
Heterophyragma adeno-phyllum	Bignoniac.	X	
Hibiscus macrophyllus	Malvac.	X	X
Hopea ferrea	Dipterocarp.	X	
Hydnocarpus castaneus	Flaccurtiac.	X	X
Hydnocarpus ilicifolius	Flacourtiac.	X	X
Hydnocarpus sumatranus	Flacourtiac.	X	X
Intsia bakeri	Legum.	X	X
Ixora ebarbata	Rubiac.	X	X
Knema conferta	Myristicac.	X	
Knema sphaerica	Myristicac.	X	

Botanical Name	Family	Indochina	Puerto Rico
Ligustrum confusum	Oleac.	X	X
Linociera microstigma	Oleac.	X	X
Litsea grandis	Laurac.	X	
Macaranga tanarius	Euphorbiac.	X	X
Melodorum fruticosum	Anonac.	X	
Memecylon edule	Melastom.	X	
Memecylon myrsinoides	Melastom.	X	
Mesua ferrea	Guttifer.	X	X
Millettia (Padbruggea) atropurpurea	Legum.	X	X
Mitrephora setosa	Anonac.	X	
Morinda tinctoria	Rubiac.	X	X
Murraya paniculata	Rutac.	X	X
Nauclea brunnea	Rubiac.	X	
Neolitsea zeylanica	Laurac.	X	
Nephelium sp.	Sapindac.	X	X
Neuropeltis racemosa	Convolvulac.	X	
Oncosperma horrida	Palmae	X	
Pajanelia multijuga	Bignoniac.		
Palaquium obovatum	Sapotac.	X	
Paranephelium macrophyllum	Sapindac.	X	
Parashorea stellata	Dipterocarp.	X	
Pentapetes phoenicea	Sterculiac.	X	X
Phoebe declinata	Laurac.	X	X
Phoebe lanceolata	Laurac.	X	X
Phrynium sp.	Marantac.	X	
Phyllanthus sp.	Euphorbiac.	X	X
Phyllochlamys sp.	Morac.	X	
Pluchea indica	Compos.	X	X
Pterocymbium sp.	Sterculiac.		
Pygeum lancealatum	Rosac.	X	
Saraca pierreana	Legum.	X	X
Saraca triandra	Legum.	X	X
Schoutenia peregrina	Tiliac.	X	
Semecarpus curtisii	Anacardiac.	X	
Shorea gratissima	Dipterocarp.	X	
Shorea sericiflora	Dipterocarpac.	X	
Sindora echinocalyx	Legum.	X	
Sindora fusca	Legum.	X	
Sindora siamensis	Legum.	X	

Botanical Name	Family	Indochina	Puerto Rico
Sterculia angustifolia	Sterculiac.	X	X
Sterculia companulata	Sterculiac.	X	X
Sterculia guttata	Sterculiac.	X	X
Sterculia ornata	Sterculiac.	X	X
Syzygium (Eugenia) cuneatum	Myrtac.	X	X
Syzygium (Eugenia) grande	Myrtac.	X	X
Syzygium (Eugenia) gratum	Myrtac.	X	X
Tarenna costata	Rubiac.	X	
Taxotrophis macrophylla	Morac.	X	
Terminalia triptera	Combretac.	X	X
Tetracera sp.	Dilleniac.	X	
Timonius wallichiana	Rubiac.	X	
Tournefortia intensa	Boraginac.	X	X
Vitex glabrata	Verbenac.	X	X
Vitex pinnata	Verbenac.	X	X
Walsura angulatus	Meliac.	X	
Zanthoxylon hamiltonianum	Rutac.	X	X
Zanthoxylon rhetza	Rutac.	X	X

Hill Evergreen Forest

Plateau of Pokadien, Loei Region, Northern Thailand (alt. 1,000 - 1,100 m.)

Upper Story Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus
Calophyllum sp.	-20	G
Castanopsis sp.	-20	G
Cinnamomum parthenoxylon	5+	G
Dacrydium elatum	-30	G
Diospyros sp.	-8	G
Eugenia siamensis	-10	G
Hibiscus tiliaceus	-8	S
Knema missionis	-10	G
Mitrephora vandiflora	-10	G
Peltophorum dasyrachis	-30	S
Quercus spp.	-20	G
Terminalia spp.	20+	G
Vatica odorata	-20	G
Wrightia viridiflora	10	G
Understories:		
Shrubs:		
Ardisia siamensis		G
Dracaena loureirii		S
Euphorbia sp.		G
Grewia sp.		G
Helicteres hirsuta		G
Hibiscus tiliaceus		S
Macaranga sp.		G
Memecylon pauciflorum		S
Pandanus sp.		G
Piper sp		G
Tarenna sp.		G
Climber:		
Pothos scandens		G
Ground Cover:		
Lygodium sp. (fern)		G
Rhynchospora sp.(herb)		G

EVERGREEN SEASONAL FORESTS

Within the Rain forest belt differences in the length and severity of the seasonal dry period are expressed in variations in the floristic composition and physiognomy of the vegetation. An example of this is the so-called Evergreen Seasonal forest, with 4 to 6 months of little or no rain. This formation appears to differ but little in its general appearance from the relatively non-seasonal true Rain forest, with high, rather evenly distributed rainfall. But the less favorable climate prevailing in the areas where the Evergreen Seasonal forest occurs is reflected in its diminished luxuriance and in the prevalence of deciduous trees, many of which shed their leaves during the dry season. This Formation is a type of transition from the Humid Evergreen to Deciduous Seasonal forests.

The Evergreen Seasonal forest of Southeast Asia resembles the typical Rain forest in that it consists of three stories of trees. But all the stories are generally somewhat lower in stature, less dense, and the canopy is less continuous than in the best developed Rain forest. Individual trees may reach considerable height, but those of large girth are not frequent. The general impression is of an occasional large tree in the midst of smaller growth; also, the closely spaced, columnar trunks characteristic of the Rain forest are lacking. With the exception of some of the larger species, most trees branch relatively low down the bole. Buttressing is a feature of many of the top story trees. The Formation is mainly evergreen, but some species in the top story are deciduous, others are semi-deciduous, shedding their leaves for only a few days or few weeks. The lower stories are more completely evergreen. The great majority of leaves fall into the mesophyll class of Raunkiaer (1934). Lianes and epiphytes are fairly abundant.

Evergreen Seasonal forest is also found in the Caribbean area. Beard (1944a) described this as a forest with three stories. Uppermost is a highly discontinuous layer of occasional emergent trees reaching 110 ft. (35 m.) and upwards. The middle stratum is almost continuous, though irregular in height, ranging from 45 to 90 ft. (14 - 30 m.) and forms the canopy. The lower story ranges between 10 and 30 ft. (3 - 10 m.). The canopy is lower than in the Rain forest, so that light penetrates deeper among the trees. Individual trees may attain 10 ft. (3 m.) or more in diameter, but these are very occasional. Clean boles of over 60 ft. (20 m.) are rare. Lianes are fairly abundant and epiphytes are rather well developed, growing as low as 18 ft. (6 m.) from the ground. Palms are frequent in the lower story, and have either pinnate or fan-shaped leaves. The forest is predominantly evergreen, although a good proportion of emergent species are deciduous. Compound leaves predominate in the emergent and middle strata, but simple leaves are most frequent in the lower story. Leaf size is predominantly mesophyllous. Ground vegetation is abundant.

Dry Evergreen Forest: The structural differences between the Dry Evergreen forest of Southeast Asia and that of the Caribbean appear to be so slight, so that they appear to belong to the same type of Formation.

Dry Evergreen forests are widely scattered, although not extensive, in Thailand, occurring in somewhat restricted stands between Pranburi and Chumphon in the upper Peninsula, in the eastern section between Ubon, Phibun Mangsahan and the border of Laos, and in the northeast in the region of Mukdahan, Nakorn Phanom, the region of Loei, and in other areas adjacent to the Mekong river.

Trees in the Dry Evergreen forest of Thailand include: species of *Vitex*, *Diospyros*, *Ficus*, *Eugenia*, *Aglaia*, *Walsura*, *Hopea*, *Spondias*, *Salmalia* and *Cratoxylon*. Some trees and shrubs in the understory are thorny. Other woody plants represented are species of *Hydnocarpus*, *Murraya*, *Atalantia* and *Taxotrophis*. Rattans (*Calamus*) may be present occasionally. Bamboos are represented by *Bambusa arundinacea*, *Oxytenanthera albo-ciliata* and *O. nigro-ciliata*, and the slender *Thyrsostachys siamensis*.

The association of *Mammea americana* - *Calophyllum calaba* in Puerto Rico is analogous to the Dry Evergreen forest. A number of laticiferous, resinous or aromatic trees constitute this Formation in Puerto Rico. These include: *Amomis caryophyllata*, *Calophyllum calaba*, *Hymenaea courbaril*, *Mammea americana*, *Manilkara bidentata*, *Terebraria resinosa*, also species of *Myrcia*, *Clusia* and *Ficus*. Guava (*Psidium guajava*) and pomarrosa (*Eugenia jambos*) are also found in pure stands or mixed with other species in abandoned sites. Several of these have a wide tolerance, occurring also in other formations.

Beard (1944b) describes the Dry Evergreen formation from Tobago as having a canopy between 40 to 60 ft. (13 - 20 m.) high. Below this the smaller trees are not arranged in any definable layers, but above the canopy occasional large solitary trees stand out up to 90 ft. (30 m.) in height. The forest is entirely evergreen, predominantly mesophyllous, without thorns or succulents. More than 80 percent of the individual emergent trees and 50 percent of the individuals in the lower story possess some specializations of the leaves which appear to serve to reduce transpiration. Compound leaves are virtually absent. There is no shrub layer and ground vegetation is very sparse. Beard also notes that the majority of the simple evergreen leaves are stiff and leathery, and that a high proportion furnish latex or essential oil.

Semi-evergreen Seasonal Forest: In this forest there are normally only two stories. The top layer, 60 to 80 ft. (20 - 26 m.) high, forms a fairly closed canopy, although some emergent trees may reach up to 90 ft. (30 m.); and a lower layer 20 to 45 ft. (6 - 14 m.) tall. Trees of a large girth are rare. Most of the adult trees have a straight trunk, from 12 to 26 in. (30 - 60 cm.), and average about 20 in. (50 cm.), in diameter. Branching begins low on the trunk and the crowns tend to be umbrella-shaped. The upper story consists of evergreen and deciduous species, others, according to the Association, are regularly deciduous, and the remainder in the top story are truly evergreen. But the amount of leaf-fall varies according to the intensity of wetness or the dryness of the season.

In a wet year the forest may appear to be in full foliage, whereas in a dry year the crowns begin to thin out, and at the close of the drought period they may be practically leafless. Compound, mesophyllous leaves predominate in the canopy, with simple leaves in the lower story and are mostly microphyllous.

The lower story is essentially evergreen, although it may include an appreciable number of deciduous species. The leaves of the upper story are predominantly mesophyllous, while an appreciable proportion in the lower story are microphylls.

Few trees are furnished with strong buttresses. Some trees in both stories have thorny trunks, although this feature is not constant. Leaves are well developed, and large trees have dense foliage. Epiphytes are relatively scarce.

Semi-Evergreen forest is fairly widely scattered in Thailand. In the northwestern region of Tak, for example, dominant constituents are species of: Cassia, Alangium, Erythrophloeum, Garuga, Pterocarpus, Dillenia, Wrightia, Lagerstroemia, Vitex, Dalbergia, Afzelia, Terminalia, Michelia, Dipterocarpus, Chikrassia and Hopea.

Palms are few, represented only by *Rhaphis micrantha*. *Bambusa arundinacea* is the most frequent bamboo. Climbers include *Tetrastigma* sp., *Derris scandens*, *Hoya obcordata*, *Strychnos thorelii*, *Pterolobium integerrima*, *Hiptage* sp., *Coccinea indica*, *Sarcostemma brunonianum*, *Passiflora foetida* and *Cynanchum* sp. In the ground cover the lalang grass (*Imperata cylindrica*) is frequent.

In Puerto Rico the Semi-Evergreen Seasonal Formation is represented by the *Buchenavia-Tabebuia* forest. In the West Indies, as elsewhere in tropical America, large areas where this formation occurs are favorable for tilling and pasturage, and therefore have been cut over. Beard (1944a) describes this formation in the Caribbean as a two-storied forest with a more or less closed canopy, formed by an upper story between 60 to 80 ft. (20 - 26 m.) high, and a lower story between 20 to 45 ft. (6 - 14 m.) tall. Most mature trees average 18 in. (45 cm.) in diameter. A few of the taller evergreen trees have hard, leathery leaves. Among Evergreen trees the young leaves are pale green or bright red, while deciduous trees have soft, paler green leaves, seldom shiny above, and their young leaves are pale green. The well marked lower layer is composed of hard, woody shrubs, mostly of the Myrtle Family; but ground vegetation is scanty.

Trees represented in this forest in Puerto Rico include *Tabebuia heterophylla*, an occasionally deciduous species, which is dominant numerically in a test site in the Luquillo forest; the deciduous *Buchenavia capitata* with broad spreading crown; *Cecropia peltata* and *Didymopanax morototoni*, both of which are indicators of secondary growth; *Inga fagifolia*; species of *Casearia*, *Cedrela*, *Ficus* and *Homalium*, all of which are deciduous; and *Cordia borinquensis*, *Psychotria glauca* and *P. berteriana*, *Miconia prasina*, *Drypetes glauca*, and *Guazuma ulmifolia*.

Gallery or Riparian Forest: Many rivers and streams in Southeast Asia, Puerto Rico and Texas, as elsewhere, are lined by a fringe of forest which usually differs in floristic composition from the zonal forest. Such forest, termed Riparian or Riverain and by some authors as Gallery, is found in such dry areas as northeastern Thailand, where the annual rainfall is less than 40 in. (1,016 mm.).

This type of forest is composed of low spreading trees. It is remarkably homogeneous, composed of one or few species, and has a simple structure, limited to a single stratum 10 to 40 ft. (3 - 12 m.) high, and the canopy may be either open or

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Trees represented in this forest in Puerto Rico include Tabebuia heterophylla, an occasionally deciduous species, which is dominant numerically in a test site in the Luquillo forest; the deciduous Buchenavia capitata with broad spreading crown; Cecropia peltata and Didymopanax morototoni, both of which are indicators of secondary growth; Inga fagifolia; species of Casearia, Cedrela, Ficus and Homalium, all of which are deciduous; and Cordia borinquensis, Psychotria glauca and P. berteriana, Miconia prasina, Drypetes glauca, and Guazuma ulmifolia.

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This type of forest is composed of low spreading trees. It is remarkably homogeneous, composed of one or few species, and has a simple structure, limited to a single stratum 10 to 40 ft. (3 - 12 m.) high, and the canopy may be either open or fairly dense. A shrubby or herbaceous undergrowth is often present, especially along the stream banks. This forest is subject to periodical fires so that it may be considered a fire-climax, rather than a climatic climax.

One of the most characteristic shrubs, at times attaining the size of a small tree, in periodically flooded areas in Southeast Asia is Homonoia riparia, known in Thailand as "khrai-nam" and in Vietnam "ri-ti-nuoc." It is frequent at the low water line along banks of streams and rivers, and around lakes, such as Tonlé Sap in Cambodia. It generally forms closely packed stands reaching to the waterline, with a continuous, low dark green canopy, and completely covered during the flood period. As associate of this in some areas is Eugenia ripicola, a somewhat taller tree known in Thailand as "haeo." It is partly submerged during flood periods. A palm frequent along river banks marking the high water level, is "mai-pha" (Bambusa arundinacea). This is a characteristic element of the riparian forest.

A close affinity in Puerto Rico to a Gallery forest is bamboo, which is of a secondary nature. The most common species in the riparian community, often extending from the water courses to pasture is Bambusa vulgaris. Others, such as Bambusa polymorpha and Guadua angustifolia, are also frequent. The bamboo gallery resembles the typical riparian forest, composed primarily of trees, in that the canopy is rather low, spreading and dense, and herbaceous ground cover is absent. In parts of the central Cordillera of Puerto Rico, "pomarrosa" (Eugenia jambos), introduced from the Orient, often forms a continuous fringe, with a dark green canopy, around lakes and along streams.

Dry Evergreen Forest

Pokodien, Loei Region, northern Thailand (alt. 400 - 500 m.)

Upper Story:

Trees:	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Afzelia xylocarpa	15 - 20	G
Anogeissus acuminata	10 - 20	S
Bauhinia horsfieldii	6 - 10	S
Bauhinia spp.		G
Butea superba	6 - 10	S
Calophyllum dryo-balanoides	20 - 30	S
Canarium kerrii	-18	S
Cedrela toona	30	S
Croton oblongifolius	-4	S
Diospyros variegata	-10	S
Dipterocarpus sp.	25	G
Erioglossum edule	5+	G
Gelonium multiflorum	-15	S
Glycosmis pentaphylla	-10	G
Lagerstroemia calyculata	-20	S
Litsea monopetala	5	G
Mallotus philip-pinensis	-15	S
Nephelium cappaceum		
Nephelium hypolecurm	-15	S
Picrasma javanica	-10	S
Protium serratum	20	S
Pterospermum aceri-folium	15	G
Solenospermum sp.	6	G
Sterculia lanceolata	-10	S
Strychnos spp.	-4	G
Terminalia belerica	25+	S
Terminalia tripteroides	-5	S

Understories:

Shrubs:		
Acacia insuavis		G
Albizzia myriophylla		S
Baccaurea sapida		G
Cissus adnata		G
Cryptolepis buchananii		S

Shrubs - continued:	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Laportea urentissima		S
Linociera microstigma		G
Phyllochlamys taxoides		S
Piper sp.		G
Pisonia aculenta		G
Premna collinsae		G
Symplocos longifolia		G
Climbers:		
Bauhinia spp.		G
Cocculus laurifolius		S
Palm:		
Corypha umbraculifera		G
Bamboo:		
Calamus sp.		G
Ground Cover:		
Alpinia sp. (herb)		G
Cyperus digitatus (sedge)		S
Thunbergia lancifolia (herb)		G

Dry Evergreen forest - Pranburi, upper peninsula Thailand

Based on materials gathered by Khun Amnay Keosingha and other technicians of Royal Thai Forest Department on special project for Joint Thai - U. S. Military Research and Development Center, Bangkok.

	Thailand	Represented by Species or Genus in: Indochina	Puerto Rico	Texas
Herbs:				
Abutilon indicum	X	X	X	X
Achyranthes sp.	X	X	X	
Actephila siamensis	X			
Aglaeonema sp.	X	X	X	
Cissus cf. discolor	X	X	X	X
Desmodium gangeticum	X	X	X	X
Elatostemma sp.	X	X		
Eupatorium odoratum	X	X	X	X
Kaempferia sp.	X	X	X	
Lantana camara	X	X	X	X
Munronia humilis	X	X		
Grasses:				
Digitaria sp.	X	X	X	X
Fimbristylis cyperoides	X	X	X	X
Imperata cylindrica	X	X	X	X
Saccharum fuscum	X	X	X	
Setaria sp.	X	X	X	X
Bamboo:				
Bambusa arundinacea	X	X	X	
Palm:				
Rhaphis sp.	X	X	X	

	Thailand	Indochina	Puerto Rico	Texas
Climbers:				
Acacia concinna	X	X	X	X
Albizzia myriophylla	X	X	X	X
Artabotrys siamensis	X	X	X	
Atalantia scandens	X	X	X	
Azima sarmentosa	X			
Coccinia indica	X	X	X	
Combretum procursum	X	X		
Connarus cochinchinensis	X	X		
Cyathostemma micrantha	X			
Cynanchum laeve	X	X		
Derris sp.	X	X	X	
Hiptage marginata	X	X		
Hoya obcordata	X	X	X	
Pachygone dasycarpa	X	X	X	
Passiflora foetida	X	X	X	X
Premna sp.	X	X		
Pterolobium integerrima	X	X		
Raphidophora peepla	X	X		
Sarcostemma brunonianum	X	X	X	X
Sphenodesma pentandra	X	X		
Stemona sp.	X	X		
Strychnos thorelii	X	X	X	
Tetrastigma sp.	X	X		
Tiliacora triandra	X	X		
Ventilago calyculata	X	X		
Shrubs:				
Abutilon indicum	X	X	X	X
Acacia comosa	X	X	X	X
Acalypha fruticosa	X	X	X	X
Actephila siamensis	X			
Albizzia myriophylla	X	X	X	X
Allophyllus cobbe var. limosus	X	X	X	
Aphania sp.	X	X		
Artabotrys siamensis	X	X	X	
Atalantia monophylla	X	X	X	
Atalantia scandens	X	X	X	
Azima sarmentosa	X			
Bauhinia bassacensis	X	X	X	X
Bauhinia bracteata	X	X	X	X
Bauhinia harmsiana	X	X	X	X

Shrubs continued:	Thailand	Indochina	Puerto Rico	Texas
Bridelia monoica	X	X	X	
Bridelia siamensis	X	X	X	
Buxus wallichiana	X	X	X	
Callicarpa arborea	X	X	X	
Canthium sp.	X	X		
Capparis macropoda	X	X	X	
Capparis micrantha	X	X	X	
Capparis sepiaria	X	X	X	
Capparis siamensis	X	X	X	
Capparis tenera	X	X	X	
Capparis thorelii	X	X	X	
Clausena sp.	X	X	X	
Cleistanthus heterophyllus	X	X		
Combretum quadrangulare	X	X		
Connarus cochinchinensis	X	X		
Cratoxylon polyanthum	X	X		
Croton cumingii	X	X	X	X
Croton oblongifolius	X	X	X	X
Derris scandens	X	X	X	
Desmodium gyroides	X	X	X	X
Diospyros mollis	X	X	X	X
Drypetes sp.	X	X	X	
Euonymus cochinchinensis	X		X	X
Fluggea microsperma	X	X	X	
Glossocarya sp.	X	X		
Glycosmis montana	X	X		
Harrisonia perforata	X	X		
Hesperethusa acidissima	X	X	X	
Hymenocardia wallichii	X	X		
Hymenopyramis brachiata	X	X		
Jasminum sp.	X	X	X	
Lantana camara	X	X	X	X
Lepionurus sp.	X	X		
Mallotus dispar	X	X		
Melianthus suavis	X			
Mezoneurum hymenocarpum	X	X		
Micromelum hirsutum	X	X		
Niebuhria siamensis	X	X		
Opilia sp.	X	X		
Pavetta sp.	X	X	X	
Phyllanthus sp.	X	X	X	X
Polyalthia suberosa	X	X	X	
Premna sp.	X	X		
Randia tomentosa	X	X	X	X
Scyphellandra sp.	X	X		
Solanum sp.	X	X	X	X
Tarenna longifolia	X	X		
Zizyphus cambodiana	X	X	X	X
Zizyphus oenoplia	X	X	X	X

	Thailand	Indochina	Puerto Rico	Texas
Small Trees:				
Acronychia pedunculata	X	X		
Aglaia odoratissima	X	X		
Albizzia procera	X	X	X	X
Antidesma decandra	X	X		
Artocarpus sp.	X	X		
Atalantia roxburghiana	X	X	X	
Azadirachta indica	X	X	X	
Bridelia siamensis	X	X	X	
Buchanania glabra	X	X		
Burretiodendron siamensis	X			
Caesalpinia sappan	X	X	X	X
Canangium latifolia	X	X	X	
Canthium nitidum	X	X		
Casearia cf. grewiaefolia	X	X	X	
Cassia sp.	X	X	X	X
Ceiba pentandra	X	X	X	
Celtis sp.	X	X	X	X
Cleistanthus heterophyllus	X	X		
Combretum quadrangulare	X	X		
Cordia dichotoma	X	X	X	X
Crataeva religiosa	X	X	X	
Cratoxylon polyanthum	X	X		
Croton oblongifolius	X	X		
Dalbergia nigrescens	X	X	X	
Diospyros buxifolia	X	X	X	X
Diospyros castanea	X	X	X	X
Diospyros cauliflora	X	X	X	X
Diospyros mollis	X	X	X	X
Diospyros montana	X	X	X	X
Diospyros rhodocalyx	X	X	X	X
Ehretia laevis	X	X	X	X
Erythroxylum cuneatum	X	X	X	
Euonymus carinatus	X		X	X
Euphorbia trigona	X	X	X	X
Flacourtia rukam	X	X	X	
Gardenia collinsae	X	X	X	
Garuga pinnata	X	X		
Gelonium multiflorum	X	X		
Grewia elastostemoides	X	X		
Grewia tomentosa	X	X		
Hymenocardia wallichii	X	X		
Litsea sp.	X	X		
Melia azedarach	X	X	X	X
Melianthus suavis	X			

Small Trees continued:	Thailand	Indochina	Puerto Rico	Texas
Memecylon cyaneum	X	X		
Memecylon floribundum	X	X		
Memecylon ovatum	X	X		
Mezonurum sp.	X	X		
Mitragyne parrifolia	X	X		
Mitrephora winittii	X	X		
Niebuhria siamensis	X	X		
Olea maritima	X	X	X	
Polyalthia suberosa	X	X	X	
Pseudovossia sp.	X	X		
Pterospermum littorale	X	X		
Rundia tomentosa	X	X	X	X
Rinorea sp.	X	X		
Semecarpus cf. cochin-chinensis	X	X		
Sindora maritima	X	X		
Sterculia sp.	X	X	X	
Streblus asper	X	X		
Streblus zeylanica (= S. illicifolius)	X	X		
Syzygium (Eugenia) cumingii	X	X	X	
Tarenna sp.	X	X		
Terminalia pierrei	X	X	X	
Vitex pierrei	X	X	X	X
Vitex pinnata	X	X	X	X
Walsura trichostemon	X	X		
Wrightia tomentosa	X	X		
Xanthophyllum sp.	X	X		

Medium-sized trees:

Medium-sized trees	Thailand	Indochina	Puerto Rico	Texas
Acronychia pedunculata	X	X		
Afzelia xylocarpa	X	X		
Albizzia procera	X	X	X	X
Artocarpus sp.	X	X		
Azadirachta indica	X	X	X	
Burretiodendron siamensis	X			
Canthium nitidum	X	X		
Casearia cf. grewiaefolia	X	X	X	
Cassia caretina	X	X	X	X
Celtis sp.	X	X	X	X
Crataeva religiosa	X	X	X	
Dalbergia nigrescens	X	X	X	
Dialium indicum	X	X		
Diospyros mollis	X	X	X	X
Diospyros montana	X	X	X	X

Medium-sized Trees continued:

	Thailand	Indochina	Puerto Rico	Texas
Diospyros rhodocalyx	X	X	X	X
Dysoxylum sp.	X			
Erythrina sp.	X	X	X	X
Erythrophloeum sp.	X	X		
Euonymus carinatus	X		X	X
Euphorbia trigona	X	X	X	X
Ficus altissima	X	X	X	X
Ficus callosa	X	X	X	X
Ficus curtipes	X	X	X	X
Ficus geniculata	X	X	X	X
Ficus hispida	X	X	X	X
Ficus mac-clellandii	X	X	X	X
Flacourtia rukam	X	X	X	
Garuga pinnata	X	X		
Grewia elastostemoides	X	X		
Holoptelea integrifolia	X	X		
Hydnocarpus illicifolius	X	X	X	
Hymenodicthyon excelsum	X	X		
Koompassia excelsa	X			
Lagerstroemia floribunda	X	X	X	X
Lagerstroemia loudonii	X	X	X	X
Manilkara hexandra	X	X	X	
Melia azedarach	X	X	X	X
Millettia leucantha	X	X	X	
Parkia javanica	X	X	X	
Pentace burmannica	X	X		
Pterocarpus macrocarpus	X	X	X	
Pterospermum littorale	X	X		
Putranjiva roxburghii	X	X		
Sapium insigne	X	X	X	
Semecarpus cf. cochinchinensis	X	X		
Sindora maritima	X	X		
Spondias pinnata	X	X	X	
Sterculia foetida	X	X	X	
Stereospermum fimbriatum	X	X		
Streblus asper	X	X		
Syzygium cumingii	X	X	X	
Tamarindus indica	X	X	X	
Terminalia pierrei	X	X	X	
Terminalia triopteris	X	X	X	
Tetrameles nudiflora	X	X		
Vitex pinnata	X	X	X	X
Wrightia tomentosa	X	X		

	Thailand	Indochina	Puerto Rico	Texas
Canopy Trees:				
Bombax insigne	X	X	X	
Capparis sepiaria	X	X	X	
Diospyros mollis	X	X	X	X
Euphorbia trigona	X	X	X	X
Ficus altissima	X	X	X	X
Ficus geniculata	X	X	X	X
Holoptelea integrifolia	X	X		
Koompassia excelsa	X			
Lagerstroemia floribunda	X	X	X	X
Manilkara hexandra	X	X	X	
Mezonurum sp.	X	X		
Parkia javanica	X	X	X	
Pterocarpus macrocarpus	X	X	X	
Tamarindus indica	X	X	X	
Terminalia triopteris	X	X	X	
Tetrameles nudiflora	X	X		

MONTANE FOREST

A characteristic feature of the vegetation of Southeast Asia, as in Puerto Rico, is the contrast between lowland and mountain flora. As in temperate regions, with increasing altitude there is a striking change in the vegetation of the tropics. As we ascend mountain slopes the structure of the vegetation and the physiognomy of the species change. There is also a marked increase in the percentage of small vines or lianes and a decrease in the percentage of leaves with entire margins. The tropical Rain forest gives way to the Montane Rain forest, which some ecologists term Temperate Rain forest, although it is preferable to reserve this name to formations in regions with a temperate climate.

In Thailand, as in other parts of the Indochina Peninsula, the lower altitudinal limit of the Montane Formation is not constant. In the Khao Yai forest of central Thailand, for example, it commences at about 3,600 ft. (1,100 m.). There the transition from the Upper Moist Evergreen forest (the Sub-montane forest of the Caribbean) is gradual. The Mid-mountain forest is also a mixed evergreen community. It resembles the mountain mist or cloud forest in the Andes of Venezuela, where it occurs at altitudes of 2,270 to 7,150 ft. (700 - 2,200 m.). In the Lesser Antilles, according to Beard (1942), it occurs at altitudes of 2,600 to 3,250 ft. (800 - 1,000 m.).

In the Montane or Mid-mountain forest of Khao Ya , the dominant trees are dicotyledons. There are two Associations - the Quercus - Castanopsis on the slopes, and Dacrydium - Schima on the upper ridges and flat summit. The forest is composed of two stories. Most of the trees have slender trunks and branches, and are closely spaced. Buttressed trees are absent. Lianes are few or small, and an epiphytic lichen is frequent on the crowns of trees. The undergrowth is moderately dense.

On the slopes, the most frequent species of the oak family are Quercus fleurii and Castanopsis acuminatissima. Other dominant trees on the ridges are Lithocarpus spicatus and Podocarpus neriifolia. On the flat summit of the ridges dominant trees are Schima wallichii and Dacrydium elatum, which are of larger dimensions than the trees on the upper slopes. Small, open patches of sphagnum bogs on the summit are surrounded by low gnarled trees, such as species of Olea, with their trunks and branches festooned with mosses.

In northern Thailand, in the region of Chiengmai, the upper limit of the Dipterocarp forest may be taken as the approximate dividing line between the Lowland forest and the Mountain forest. For example, the lower east slope of Doi Sutep, which has an altitude of 5,450 ft. (1,676 m.), is covered by Dry Dipterocarp forest up to about 2,300 ft. (700 m.). Between 2,300 and 3,200 ft. (700 - 1,000 m.), the vegetation is an intricate mosaic of Dry Dipterocarp and Mixed Deciduous forests, intermixed with evergreen trees of the Montane formation, with species of oak (Quercus) and chestnut (Castanopsis) as dominants. Oak trees attain a height of 50 to 65 ft. (16 - 20 m.), and a diameter of about 12 in. (30 cm.). A thin layer of humus and thick litter accumulate on the forest floor. The ground layer is composed mainly of lalang grass (Imperata cylindrica).

On the southern and southwestern slopes of Doi Sutep, reaching up to the summit, evergreen trees also predominate. These are mostly of low to medium stature. Among these are species of Quercus, Castanopsis, Lithocarpus, Dalbergia, Camellia and Melanorrhea. The vegetation in the ground layer is composed mostly of rough grasses. On the upper ridges of Doi Sutep and Doi Puy, above 4,000 ft. (1,200 m.), the Quercus - Castanopsis Association, is gradually supplanted by stands of the 3-needled pine (Pinus khasya), with fern forming the most common component of the ground cover.

On the summit most of the trees are dwarfed, with twisted trunks, and seldom more than 25 to 30 ft. (8 - 10 m.) tall. This plant community suggests the elfin woodland of Puerto Rico. During February the white flowers of a Rhododendron are conspicuous in the canopy. An epiphytic Vaccinium is noteworthy, and a species of Gnetum, with reddish fruit containing edible seed.

Montane forest is represented in Puerto Rico by the Colorado type in the Luquillo mountains in the northeast. It is found also in Cuba, Hispaniola, Jamaica, St. Kitts, Nevis, Monserrat, Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent and Grenada.

This type contains two not well marked strata. The canopy layer is fairly uniform and does not exceed 45 or 50 ft. (14.5 - 16 m.) in height. The second stratum ranges from 6 to 20 ft. (2 - 6 m.) high. The understory is suppressed almost to the point of disappearance. All the trees are evergreen. The leaves are microphyllous and are typically thick and leathery. Buttressed trees and vines are not common. Many of the trees are typically short and crooked. The crowns are low and the branches are stout. The ground is generally covered by leaves, and in some places by a thick, organic surface layer. Sphagnum moss abounds in wet places. Grasses, sedges and a small bamboo are found in openings. From the standpoint of physiognomy, Montane forest of northeastern Puerto Rico is analogous to the Lower Montane forest in the Khao Yai National Forest of central Thailand.

Species representative of this formation occurring in Puerto Rico, as tabulated by Wadsworth (1951) include: Cyrilla racemiflora, Micropholis garciniifolia, M. chrysophylloides, Ocotea spathulata, Ficus citrifolia and F. sintenisii, Cordia borinquensis, Inga fagifolia, Ilex nitida, Cecropia peltata, Sapium laurocerasus, Sloanea berteriana and others.

Growth rate in the Montane formation is slow. Wadsworth (1951) estimated that trees 12 in. (30 cm.) in diameter in this formation averaged 230 years old. Natural regeneration may take more than 50 years.

According to Wadsworth and Bonnet (1951), the mean temperature in the Montane (Cyrilla) forest ranges between 69° and 73° F., compared with 73° to 76° F. in the humid tabanuco (Dacryodes) forest, at lower altitude. Mean annual rainfall in the Montane forest ranges from 100 to 180 in. (2,500 - 4,500 mm.). Cloudiness and relative humidity also increase with altitude.

Soils in the Montane (Cyrilla) forest differ from those of the tabanuco (Dacryodes) in the Rain forest in that they are thicker, have a wetter organic layer, and the subsoil is relatively impervious. The wetness of the soil is due to impeded drainage. The poorly aerated organic soil inhibits root penetration and water absorption by plants. This accounts, in part, for the difference in structure between the Montane (Cyrilla) forest and the humid tabanuco (Dacryodes) forest at lower altitudes.

Montane Forest

Summit of Pokadien Range, Loei Region, Northern Thailand (alt. 1,200 m.)

Upper Story:

Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Aglaia polystachya	-30	S
Broussonetia papyrifera	5+	S
Castanopsis acuminatissima	25	S
Diospyros variegata	-10	S
Erythrina stricta	-12	S
Garuga pinnata	-30	S
Linociera microstigma	-10	G
Litsea monopetala	5+	G
Nephelium sp.	15+	G
Pinus merkusii	25+	S
Ternstroemia sp.	-15	S

Understories:

Shrubs:		
Ardisia sp.		G
Melastoma malabaricum		S
Nepenthes mirabilis		G
Rhododendron simsii		S
Phyllanthus sp.		G
Vaccinium sp.		G

Climber:		
Capparis horrida		S
Smilax sp.		G

Ground Cover:

Asparagus acerosus (herb)		S
Costus speciosus (herb)		S
Eriocaulon sp. (herb)		G
Syzygium gratum (herb)		G
Themeda sp. (herb)		G
Zingiber sp. (herb)		G

Representative trees and their diameter in 10 acres of Montane forest[1] in Puerto Rico

SPECIES	In. 4-6	In. 8-10	In. 12-18	In. 20+	Total No.
*Cyrilla racemiflora ----------	29	22	43	82	176
*Micropholis garciniifolia ----	228	120	111	15	474
Calycogonium squamulosum -----	239	122	81	3	445
Prestoea montana -------------	873	12			885
*Micropholis chrysophylloides--	165	79	51	4	299
Cecropia peltata -------------	47	12	9		68
Magnolia splendens -----------	22	7	6	11	46
Croton poecilanthus-----------	210	36	3		249
*Ocotea spathulata ------------	62	33	13		113
Tabebuia heterophylla --------	27	10	13		50
Dacryodes excelsa ------------	7	7	10	2	26
Ilex nitida ------------------	29	6	10	1	46
Inga fagifolia ---------------	18	2	8		28
Sapium laurocerasus ----------	13	7	4	1	25
Sloanea berteriana -----------	14	5	3		22
Matayba domingensis ----------	22	5	2		29
Eugenia stahlii---------------	7	10	2		19
Homalium racemosum -----------	4		5		9
Linociera domingensis --------	11	4	3		18
Didymopanax morototoni -------	9	7	2		18
Cordia borinquensis ----------	39	1			40
Ocotea moschata --------------	2	1	1	1	5
Alchornea latifolia ----------	19	4			23
Hirtella rugosa---------------	14		1		15
Ditta myricoides -------------	17	2			19
Ficus citrifolia -------------	5	3	1		9
Ficus sintenisii -------------	7	1			8
30 other species -------------	159	30	22	1	212
TOTAL	2,298	548	408	122	3,376

1/ After Wadsworth (1951).

* Considered indicator species.

MOSSY FOREST

The upper slopes of the Luquillo Mountains and the summit of El Yunque, in northeastern Puerto Rico, are populated by Mossy or Cloud forest. The term Mossy forest is applied to this association because one of its characteristic features is the luxuriance of mosses and selaginellas. Some ecologists call it Elfin woodland or thicket. The latter is generally found on the upper slopes exposed to constant wind, while the Mossy forest occurs on the leeward side, protected from the wind. At the lower limit the forest floor in great part is carpeted with mosses, which develop also along the base of tree trunks. At the upper limit the ground is covered with a dense mat of Selaginella, also climbing on tree trunks. This forest association occupies the peaks and descends to an elevation of about 2,300 ft. (700 m.), covering exposed wind-swept ridges. The Mossy forest at high altitudes, in northeastern Puerto Rico, is somewhat analogous to the mossy forest occasionally found in Thailand on the mountain ridges of Khao Yai National Forest and on the high peak of Inthanon in the north.

This forested area has the highest rainfall and highest atmospheric humidity in the Luquillo Mountains. Throughout almost the entire year, the peaks are wrapped in fog or cloud, raising humidity almost to the point of atmospheric saturation, with the result that rain falls almost daily, accompanied by an appreciable reduction of sunshine. Clouds gather during the night and cover the upper eastern slopes of the mountains at an elevation of about 2,000 ft. (600 m.). During the daytime these clouds, driven by winds, ascend the slopes and cross the upper ridges, enveloping the peaks in cold mist or drenching rains, finally moving westward where they evaporate under the tropical sun. The temperature is considerably reduced, usually from 7° to 11° F. lower than at sea level.

The Elfin woodland, is composed of scattered, branchy trees up to 40 ft. (12 m.) high, rising out of scrubby growth. Dominant trees in this community are Cyrilla racemiflora and Micropholis chrysophylloides, of fairly large dimensions. Massive and gnarled, they are almost invariably stag-horned, with topmost branches having died away, accounting for the open character of this community. Apparently, soil conditions are responsible for this unusual type. The soil is red, compact, impermeable, developed over granite, and the topography is somewhat sloping.

As a result of high atmospheric humidity and heavy precipitation, the soil of the Mossy forest is generally water-soaked and the plants almost constantly drip with moisture. The soil is a wet muck, usually thin, and is covered with fallen leaves, dead twigs, superficial roots and prostrate trunks.

The moist trade-winds, blowing constantly over the peaks of the Luquillo Mountains, have a pronounced mechanical effect on the plants. In sites exposed to constant wind the trees are limited in height to about 10 ft. (3 m.). The trees are stocky and branchy, with trunks seldom straight for more than 6 feet, and the crowns are flat. In the Elfin woodland, on the windward slopes, the surface of the canopy is flat, uniform in height, and frequently the uppermost twigs are dead. The trunks lean over, and the branches often bend away from the wind. The trees are all evergreen, the leaves generally microphyllous, thick, and largely confined to the tip of the branches. Some species common to other forest types have smaller leaves here than elsewhere. One tree story is usually present. Larger trees are about 12 in. (30 cm.) in diameter, and the average is from 2 to 4 in. (5 - 10 cm.). One vine, a species of Marcgravia, and numerous species of epiphytes are common. Mosses are very prominent, and cover trunks, branches, twigs, and even the leaves. Roots are generally a superficial mass, and aerial roots are common. The forest normally has little undergrowth, but grasses and sedges are found in openings.

Four tree species constitute the bulk of the arborescent vegetation in the Mossy forest of Puerto Rico, namely: Weinmannia pinnata, Ocotea spathulata, Tabebuia rigida and Eugenia borinquensis, constituting about 75 percent of the vegetation. These do not occur in the Rain forest or, at best, appear only as rare, widely isolated individuals. Other trees represented are: Clusia krugiana, Cyrilla borinquensis, Haenianthus obovatus, Calycogonium squamulosum, Micropholis garcinifolia and Tabebuia schumanniana.

In addition to mosses and selaginellas, ferns are common, the larger species growing on the ground, while smaller ones appear indiscriminately on the ground or as epiphytes. Grasses (Arthrostylidium sarmentosum and Isachne angustifolia) also develop in open sites.

Mossy forest occurs also in the Central Cordillera of Puerto Rico, but differs in several respects from that of the Luquillo Mountains. There, the influence of wind is reduced. Small trees and shrubs are not bent over or shorn off to an even canopy, but are erect and usually have rounded crowns. Mosses are reduced to a thin layer on sheltered trunks or lacking, and selaginellas are completely absent. Bromeliads are few, inconspicuous. The environment is less rigorous, indicated by the presence of many shrubs characteristic of the Rain forest, and by more luxuriant development of herbaceous plants.

Of the four dominant tree species growing in the Luquillo Mountains, only two - *Weinmannia pinnata* and *Octotea spathulata* - are present in the Mossy forest of the Central Cordillera. Ferns are numerous, represented by species of *Dicranopteris*, forming brakes on the peaks, *Elaphoglossum*, *Odontcsoria*, *Hymenophyllum*, *Trichomanes* and *Polypodium*. Dominant shrubs are more sparse, but under-shrubs and herbaceous plants are more abundant than in the Luquillo Mountains. The grasses found in this forest type in the Luquillo Mountains - *Arthrostylidium sarmentosum* and *Isachne angustifolia* - are also well represented in the Central Cordillera.

CONIFEROUS FORESTS

Although they are represented by several genera, including Pinus, Podocarpus, Keteleeria and Dacrydium, Conifers actually represent a relatively minor fraction of the vegetation of most parts of Southeast Asia. In Puerto Rico, also, there is only a single genus, Podocarpus, native to the country, although several other genera of Conifers have been introduced and propagated successfully. In Texas, on the other hand, Conifers are well represented by 5 genera, and in some sections constitute a major part of the vegetation.

In Thailand, Conifers form less than 1 per cent of the total forested area of the country. The most frequent genus is pine, of which there are two species - the 3-needled Pinus khasya, with furrowed bark, at higher altitudes; and the 2-needled P. merkusii, with scaly bark, somewhat at lower elevations.

In Thailand, the most extensive pine forests occur in the north, particularly in the upland region around Chiengmai. West of this city, they are found at altitudes from 2,000 to 5,200 ft. (600 - 1,620 m.) on the upper ridges of the mountains Sutep, Puy and Inthanon; also on the summit of Chiengdao range, and northward toward the border of Burma. On the plateau of Bo Luang, southwest of Anka range, also in northern Thailand, there is an extensive pure stand of the 3-needled Pinus khasya, at an elevation of 3,000 to 4,000 ft. (910 - 1,200 m.), surrounded by Moist Deciduous forest. To the northwest, towards the border of Burma, pines form rather large stands between Chiengmai, Mae Hongson and Mae Sariang. In the northeast of Thailand, pines are dominant in the Pokodien mountains, on the plateau of Loei. The trees are rather widely spaced, so that the pine forest is usually open, and visibility, both horizontal and vertical, is favorable. The ground cover is composed of grasses, especially Imperata, and ferns.

The 2-needled Pinus merkusii is found as low as 1,300 ft. (400 m.) in the province of Phetchabun, at the northern end of the central plain. It occurs at still lower altitudes in the region of Phibun Mangsahan, in eastern Thailand, where it may be mixed with Dipterocarp forest.

Other Conifers represented in Thailand are 4 species of Podocarpus, widely distributed but nowhere abundant. One of these, P. imbricatus, is said to grow in the evergreen forest in the province of Chantaburi, in the southeast. P. latifolia occurs in the region of Mae Hongson, in the northwest. P. neriifolia has a wider distribution, from the region of Chiengmai and Chiengrai, in the north, to Ubon, in northeastern Korat Plateau.

In South Vietnam, between the plateau of Darlac and the lower foothills, there is a mountainous area. This is the Plateaux Montagnards du Sud, with an area of about 3,000 sq. miles, varying in altitude from 3,280 and 6,560 ft. (1,000 - 2,000 m.). In the subtropical to temperate climate that prevails at these altitudes, the 2- and 3-needled pine (Pinus merkusii and P. khasya) constitute the dominant trees, with broadleaf species and bamboos predominant in the lower valleys and ravines.

In central Vietnam Conifers, Pinus khasya and P. merkusii in particular, are scattered over wide areas. Some of the stands are found in remote regions, which are sparsely populated and have few roads. Other softwoods occurring in this region are species of Chamaecyparis, Cunninghamia, Taxus and Thujopsis. These are found either in pure stands or mixed with other species. The province of Lang Bian is said to contain large stands of pine, but these are difficult to reach and have thus been little exploited. Cunninghamia siamensis grows naturally in Vietnam and is found also in South China.

In upper Laos, from Paksane northward toward Xieng Khouang, there are stands of the 2-needled pine (Pinus merkusii). Stands of this pine extend into the uplands northeast of Thakkek, on the Mekong river, toward the border of North Vietnam. Stands of Keteeleria are also found in northeastern Laos, near the border of North Vietnam, while stands of the 3-needled pine occur in an area northeast of Vientiane.

The pines are not represented in Puerto Rico by any native or naturalized species. At least 11 species have been introduced, some of which proved successful. The only native Conifer is Podocarpus coriaceus. In Puerto Rico this is a forest tree, at times 60 ft. (20 m.) tall, with spreading branches. It grows in the mountain forests and wooded valleys in the western part. It is found also in St. Kitts, Montserrat, Guadeloupe, Dominica, Martinique, Trinidad, and extends into northern South America.

In Texas, pines, particularly loblolly, shortleaf, longleaf, and slash, are the major commercial timbers in the Piney Woods, of the extreme eastern part. They occur on gently rolling to hilly forested land, at elevations of 200 to 500 (60 - 150 m.), where the annual rainfall ranges between 35 and 50 in. (875 - 1,250 mm.), and is fairly well distributed throughout the year.

Humidity and temperatures are usually high. Hardwoods, such as oaks, hickory and maple, are also present in the top story. This formation is regarded as a fire disclimax or subclimax. The Pine-Hardwood region covers about 12.5 million acres in 45 counties.

In addition, pines are represented in other formations by the Mexican pinyon (*Pinus cembroides*), shortleaf pine (*P. echinata*), Colorado pinyon (*P. edulis*), timber pine (*P. flexilis*), longleaf pine (*P. palustris*), ponderosa (*P. ponderosa*), and loblolly pine (*P. taeda*).

The genus *Cupressus* is represented in Texas by Arizona cypress (*C. arizonica*). In addition, there are 8 species of junipers; Douglas fir (*Pseudotsuga taxifolia*); and baldcypress, represented by *Taxodium distichum* and *T. mucronatum*.

SWAMP WOODLAND

Vegetation in swamps or marshlands is a characteristic feature of the landscape in Southeast Asia, Puerto Rico, Texas, as in other tropical and temperate areas. In tropical and subtropical regions, this shows a gradation from the Mangrove forest in saline soil around estuaries and in deltas along the coast, to a distinctive vegetation type in brackish water, and finally to characteristic plants occurring in freshwater swamps. Consequently, Swamp or Marshland forests may be segregated into: Mangrove forest, and Freshwater woodland.

Mangrove forest: This evergreen plant community, controlled by soil or edaphic factors, forms the most homologous type of vegetation, from the standpoint of structure and to a degree floristically, occurring in Southeast Asia, Puerto Rico, and other tropical regions. Mangrove woodland is a specialized association forming a narrow coastal belt of varying width, flourishing in deltaic and estuarine areas below high tide mark. It is the result of constantly changing conditions brought about by the accumulation of alluvium transported and deposited by streams and rivers, by tidal movement of salty or brackish water around estuaries, and by the effect of wave action on the deposition of silt, sand and mud along seacoasts.

The effect of climate on the development of Mangrove forest is less marked than on the Evergreen Rain or Moist forests, for example. The general level of the land gradually rises away from the sea, as accretion seaward takes place, resulting from the continuous deposition of soil carried downstream, especially in areas with high rainfall. As a rule, the soil along the edge of the mangrove forest contains a high clay fraction, often compact, bluish, and low in organic content.

Several identical genera are native to both hemispheres. While some stands of Mangrove in Thailand and South Vietnam may be taller than those along the north and south coasts of Puerto Rico, the physiognomy and life-forms of this Forest type are analogous. The canopy is generally of uniform height, continucus, and the foliage ranges from light to dark green, according to species. So that a Mangrove woodland, and its extent, are readily distinguishable from the air by the general hue of the foliage.

The dominant species have special life-forms and structural adaptation to withstand alternating periodical flooding and physiological dryness, and salinity of the water. For example, some Rhizophora species have stilt roots; species of Bruguiera have "knee" roots; while those of Sonneratia, Avicennia and Xylocarpus send up asparagus-like pointed pneumatophores. Some dominant trees, both in Southeast Asia and Puerto Rico, are also characterized by a tendency toward vivipary, in which the seeds germinate before falling. Another feature of the Mangrove forest is the zonation of tree species, with definite delineation of the dominants. This is often distinguishable from the air by the hue of the foliage. In Southeast Asia, for example, Sonneratia alba is a pioneer tree in the Mangrove forest. Later, as mangrove develops along the seaward margin, it becomes mixed with Avicennia. Species of Rhizophora grow on somewhat higher ground, while species of Bruguiera develop on the landward margin, often extending to the extreme limit of tidal reach.

The Mangrove forests of Southeast Asia consist of up to 20 species of trees and shrubs forming a characteristically dense, seemingly difficult to penetrate, tangled evergreen mass of trees, ranging in height from 10 to 50 ft. (3 - 16 m.), occasionally more.

A great part of the 1,250 miles (2,000 kms.) coastline of Thailand is covered by stands of mangrove. The total area of the Mangrove forest in that country is estimated to be 625 sq. miles (1,620 sq. kms.). Of this area, 286 sq. miles are located along the southeast coast, especially in the region of Khlung and Trat, and continue along the coast into Cambodia; and 337 sq. miles in the Peninsula, particularly on the southwest coast from the Kra Isthmus to the Malaysian border.

The most frequent and characteristic woody species constituting the Mangrove woodland in Thailand include: "kongkangbai-yai" (Rhizophora mucronata), "ta-bun-khao" (Xylocarpus obovatus), "pra-sakdaeng" (Bruguiera sexangula), "prong" (Ceriops roxburghiana), and "pho-ta-le" (Thespesia populnea).

Limited stands of Mangrove, composed of tall trees, occur sporadically along the coast of Cambodia. In South Vietnam, Mangrove forest covers much larger areas, amounting to about 1,600 sq. miles, along the south coast from Pointe de Camau to Cap St. Jacques. In North Vietnam, this forest covers a much smaller area, of about 360 sq. miles, and is confined to the coastal deltaic area, mostly northeast of Haiphong, and almost reaching to the border of China. Mangrove woodland, of course, does not occur in Laos.

In South Vietnam the principal trees in the Mangrove woodland is composed of the following, most of which are represented either by genus or species in Thailand:

Botanical Name	Viet. Name	Thai Name
Aegicerus majus	Trú	Lep-mu-nang
Avicennia marina	Mắm den	Sa-mae
Avicennia officinalis	Mắm	Sa-mae-dam
Bruguiera caryophylloides	Vet Dú	Rui
Bruguiera eriopetala	Vet	Pra-sakdueng (B. sexangula)
Carapa obovata (=*Xylocarpus obovatus*)		Ta-bun-khao
Ceriops candolleana	Da Voi	Prongdaeng (C. tagal)
Ceriops roxburghiana	Dà oanh	Prong
Excoecaria agallocha	Gia	Ta-tum
Kandellia rheedii	Dà	Rang-ka-tnae
Lumnitzera coccinea	Coc	Fat-daeng (L. littorea)
Rhizophora conjugata	Duoc	Kong-kan-bai-lek
Rhizophora mucronata	Dung	Kongkang bai-yai

Mangrove forests, dominated by species of Red mangrove (*Rhizophora*), are found on silting shorelines of Puerto Rico, as elsewhere in tropical America. Mangroves are usually lacking on open exposed sandy beaches, steep, rocky shores, and in many dry areas where no silt-laden streams enter the ocean. In tropical America, as in Africa, species of *Rhizophora* are generally the seaward, pioneer plants of Mangrove woodland, with species of *Avicennia* being relegated to the landward or "back (post) mangrove." The converse is usually the case in Asia. Many of the Asian trees also are usually taller and the species are more numerous than in the American Mangrove woodland. Pure stands of *Rhizophora* and *Avicennia* are widespread in tropical America.

Rhizophora, or Red Mangrove, type of tropical America is a one-layered, level-topped, evergreen, well-spaced forest, up to 75 ft. (25 m.) tall, in which herbs, vines and shrubs are rare or absent; stilt roots form an interlocking, almost impenetrable maze; numerous capillary roots spring from stilt roots immediately below the surface of the soil. Under optimum conditions, *Rhizophora* forms pure stands, with few epiphytes present. As the salinity of the soil decreases, other mangrove species become mixed with the Red Mangrove.

Avicennia, or Black Mangrove, type is also a one-layered, flat topped, evergreen, also well-spaced forest. It is almost devoid of understories and epiphytes. Avicennia is often found in pure stands, especially in lagoons behind newly formed beaches.

White Mangrove, Laguncularia, is a common constituent of the back mangrove of tropical America and Africa, but it is apparently lacking in Asia. There, its role is apparently played by species of Bruguiera or Sonneratia. In Puerto Rico, along the Mona Island, and elsewhere in the Antilles, white mangrove is often the most frequent species in this type of woodland. It also forms pure stands in Florida under not very well defined conditions. The maximum height of Laguncularia is 60 ft. (20 m.), and the maximum diameter 20 in. (50 cm.). From the air, white Mangrove may be recognized from red and black Mangrove by its light green, more open canopy.

As in Southeast Asia, mangroves are of economic value in tropical America as sources of products with a wide range of domestic uses. The timber of white mangrove (Laguncularia) is used for poles, fence posts, house frames, fuel and charcoal of inferior quality. The bark contains 10 - 17 percent (dry weight) of tannin, used for tanning leather.

Thickets associated with Mangrove woodland are of pantropical occurrence. They appear in sites where the saline mangrove soils grade into drier sands with reduced salinity. In Thailand, for example, frequent trees and shrubs appearing between the swamp and dry land include: Hopea helferi, Xylocarpus moluccensis, Bruguiera cylindrica, Excoecaria agallocha, Sonneratia caseolaris and S. alba, Hibiscus tiliaceus, which is of pantropical distribution, Intsia retusa, Lumnitzera littorea, Avicennia officinalis and A. alba. Other frequent plants in the undergrowth in Southeast Asia are: the pantropical and typical mangrove fern Acrostichum aureum, Taenitis blechnoides, nipa palm (Nipa fruticans), species of Chrysanthemum sp., a climber, Flagellaria indica, Columnella trifolia, Acanthus ebracteatus and A. ilicifolius, and a small palm (Phoenix paludosa).

Frequent plants growing in Mangrove thickets in Puerto Rico include: buttonwood (Conocarpus erecta), which has the same distribution as white mangrove (Laguncularia) and is characteristic of the back or post mangroves of America and Africa, but is lacking in Asia. Mahoe (Hibiscus tiliaceus), a cosmopolitan shrub or small tree found also in Southeast Asia, is a frequent associate of Conocarpus in tropical America. It is tolerant of saline water and is especially frequent, forming dense thickets, in back mangrove as well as in dryland moist forest. *Suriana maritima* is another element in the evergreen, often tangled mangrove thicket in Puerto Rico.

Nipa palm (*Nipa fruticans*). Known as "chac" in Thailand and "dua nuoc" in Vietnam, this palm has a short, prostrate trunk, and pinnate leaves up to 15 or 20 ft. (5 - 6.5 m.) long. It is native to Asia, and has a wide distribution from the Ganges to Australia, although it is somewhat difficult to determine its precise natural distribution, because of the fact that it is often cultivated. In Thailand, as in other parts of Southeast Asia, Nipa palm often forms small clumps in rice fields, or extensive, pure stands usually along the landward side of mangrove forest. It attains its best development in brackish estuarine areas, where fresh water mixes with slightly saline water. In some areas it grows in association with certain trees characteristic of the Mangrove forest, such as *Sonneratia*. The Nipa palm association is one of a series of typical semi-mangrove communities in the Eastern tropics. Nipa palm does not occur in the American or African tropics, but there are analogous communities. For instance, the *Manicaria saccifera* swamps of northeastern South America and a *Pandanus* community on the west coast of Africa are comparable plant communities.

Nipa palm plays a fairly important part in the domestic economy of Southeast Asia. A skillful use made of the leaves is to fold them around a hardwood pole or bamboo. When dried, they are stitched to form a thatch material, which is both light and effective. These "ataps" as they are known in Malaya are much used in fishing villages for sides, partitions, and roofs of houses. In addition, Nipa palm leaves are utilized for such other purposes as umbrellas, sun hats, raincoats, coarse baskets, and for mats and bags as in the Philippines. In Thailand, also, the young unopened leaves are used for cigarette-wrapper. The young seed, when boiled, is edible and slightly sweet. Mature seed is very tough and hard, and seems to have no particular use, although some thought has been given to crushing the ripe seed to furnish cattle feed ar as base material to make buttons.

Mangrove Fern: On the landward margin of Mangrove forest, along the north coast of Puerto Rico, one of the most familiar plants is the tall Mangrove fern, *Acrostichum aureum*. Normally it grows as scattered individuals in sites where the soil is somewhat dry, because of exposure to wind and sun, and is less impregnated with salt. But if mangrove trees are cleared, and the site is slightly above sea level, this fern soon grows in crowded masses 3 ft. (1 m.) or more in height, forming almost pure stands several acres in extent. This fern is also found in Thailand, where it is known as "prong-tha-le," and in other parts of the Mekong basin countries, growing in similar habitat where mangrove occurs.

Post Mangrove: The most characteristic tree in back Mangrove swamps in Southeast Asia, inland from the Mangrove woodland, is "cajeput" or "paper-bark" (Melaleuca leucadendron), of the Myrtle family. Known as "med" or "samet" in Thailand and "tram" in Vietnam, this tree, native to Asia, is of small to medium size, from 10 to 30 ft. (3 - 10 m.) in height. It forms small to rather extensive stands in open, sandy moist soil or sites subject to periodical floods, and often close to, but not mixed with, the mangrove forest. Some ecologists consider the Melaleuca association as the climax of the mangrove formation.

Cajeput is an extremely vigorous and resistant tree, crowding out other plants, and cannot be easily exterminated by cutting or burning. It is rather widely distributed in Southeast Asia. In Thailand it grows scatteringly along the southeast coast, forming fairly extensive stands between Chantaburi and Trat, close to the Cambodian border. In the Peninsula it occurs in small stands in the Kra Isthmus, in plains and low valleys near the coast. These stands are protected for the firewood they provide, when mangrove wood is not available.

In addition to Melaleuca leucadendron, other trees in swamps with brackish water in Southeast Asia are species of Xylocarpus and Intsia.

In Texas, according to Thorne (1954), salt marshes are best developed along the more protected temperate shores in the northern part of the Gulf of Mexico, and become less extensive in the south because of competition from mangrove. These salt swamps consist of dense masses of narrow-leaved sub-aquatic plants, growing closely together. These intergrade with fresh-water herbaceous swamps, and some species are common to both.

The salt marsh supports species of Carex, Cyperus, Juncus, Scirpus, several cordgrasses (Spartina), seashore salt-grass (Distichlis spicata) and millet (Zizaniopsis miliacea).

The coastal marsh (Spartina - Sporobolus Associes) occupies a narrow strip between the coastal prairie and the Gulf, following the sinuous coastline. Action of waves on the beach builds up a sand and shell ridge 3 to 4 feet high, behind which the marsh gradually rises to the coastal prairie. Dominants of the

Association are Spartina spartinae and Sporobolus virginicus. Important Associates are species of Batis, Dondia, Juncus, Salicornia, Scirpus, Limonium, Pluchea, Borrichia, Iva, Baccharis, and Lycium.

Freshwater Swamps: In fresh-water lakes, ponds and the lower reaches of rivers the land constantly tends to encroach on the water. In the process of new land forming from water, vegetation plays an important part both in temperate and tropical regions. Aquatic plants resist water movement, slowing it down, and thus increase the rate of deposition of suspended matter. Later aquatic plants help to consolidate the sediments, to which their dead remains are added, and thus change the texture of the soil and increase the bulk. This leads to a general rise in the level of the ground relative to that of the water. Accompanying this rise there is a plant succession, or hydrosere, starting with various types of aquatic vegetation and usually ending in a type of forest similar to, although perhaps not exactly identical with, the Climax. During the course of the transition there is a gradual change from open water to relatively dry conditions, and the vegetation itself tends to produce a mesophytic environment.

Examples of hydroseres are plentiful in Southeast Asia, Puerto Rico and elsewhere in the tropics, as well as in Texas and other temperate regions. The hydrosere tends to be similar in widely separated regions, not only in the general course of events, but in the structure and physiognomy of successive phases. In the earlier phases of the hydrosere herbaceous plants are generally dominant. Later they are replaced by woody plants. Both in temperate and tropical hydroseres manocotyledons play an important part in the intermediate stages. In temperate regions they dominate the reed swamp state. In the tropics a reed swamp stage is often present, but palms are more constantly dominant. The last phase of the succession is a tall forest dominated by dicotyledonous trees. In this the water level is at, or near, the soil surface, even during the dry season. The final stage of the hydrosere is dominated by tall woody species, in which a shrub stratum and ground vegetation are relatively sparse.

The Freshwater swamp forest of tropical America is described as a forest of a single tree stratum, from 60 to 90 ft. (20 - 30 m.) high, and rather open underneath. The ground is waterlogged or just covered with water for over half the year. The trees show root specialization, such as sinuous plant buttresses or stilt roots. There is little or no ground vegetation. Leaves are compound, mesophyllous. There is a tendency to purity of stand.

In Puerto Rico, a dominant tree in freshwater swamps, and which is somewhat homologous to cajeput (Melaleuca leucadendron) of Southeast Asia, is "swamp bloodwood" or "palo de pollo" (Pterocarpus officinalis). This tree is limited to the American tropics and is found in Jamaica, Cuba, as well as Puerto Rico, throughout most of Central America, and in northern South America as far as the estuary of the Amazon river. Another species of this genus, "pra-du" (P. macrocarpus), is widely distributed in Thailand, but occurs only in dry soils in teak and other forest types, far distant from the coastal Mangrove swamps.

In Puerto Rico, swamps in which Pterocarpus is dominant and forms pure stands occur in three localities: north of Mayaguez; near Dorado beach; and close to Humacao beach.

Only limited ecological studies have been made on fresh-water swamp vegetation in the interior of Thailand, as well as in the other Mekong basin countries. In most swamp forest sites the number of tree species is relatively restricted, with a tendency for one or a few species to be dominant.

Swamp woodland, usually of low stature is found in the southern Peninsula, in the northeastern section of Korat plateau, such as in the area of Borabué, Kalasin, Sakhorn Nakhorn, and Nakorn Phanom; and in the Central Plain, as in the region of Nakorn Sawan.

In the southern Peninsula, one of the most characteristic woody species in sandy soils is Alstonia spathulata, a small laticiferous tree. Associated with this are Fagraea fragrans, Lagerstroemia speciosa, Barringtonia aculeata, a species of Saraca, and occasionally rattan (Calamus). Around freshwater swamps in central Thailand frequent trees are: Hydnocarpus anthelminthicus, Xanthophyllum glaucum, Lagerstroemia speciosa, Albizzia procera, Butea monosperma, and species of Barringtonia and Nauclea. In sections of northeast Thailand, long drought and flash floods hinder the development of forest growth. As a result, extensive grass-covered plains, "thung," develop. During the dry season the water level in the lakes and deeply cut stream beds is 15 to 20 ft. (4.5 - 6.5 m.) below the level of the plains. In the rainy season, however, the river beds and lakes fill quickly and flood over wide expanses. The stream channels are indicated by low trees, shrubs and clumps of bamboos growing along the natural levees. Here and there, stands of trees, composed especially of Dipterocarpus obtusifolius, appear above the flood waters. These grassy swamps are found along lake Nong Han, at Sakhon Nakhon, and near Borabué, in the northeast; around the lake at Phyao, north of Lampang; and near Nakhon Sawan, in the central plain.

Cypress - Tupelo swamp is found in parts of the lower Mississippi river delta. This lies under water of fluctuating levels except during rare periods of prolonged drought. Cypress and tupelo appear to be the only tree species able to tolerate prolonged flooding. Hence, they occur in pure stands of either species or a mixture of the two. Included in such areas are hummocks and narrow ridges, subject to annual flooding, which may be occupied by water oak, pecan, willow and other hardwood species characteristic of wetter sites of normal bottomland.

From mucky cypress swamp with its tremendous amount of organic matter and silt and its maximum of water content, there is a broad bottom land or flood plain zone which connects the swamp with the adjacent uplands. According to Tharp (1926), as the soil surface of a cypress swamp gradually rises the water decreases continuously until a point is reached where its surface gradually becomes more firm as elevation continues to increase. The gentle slope continues to the sterile sandy uplands, inhabited by the climax pine forest.

Beginning with the outer edge of Cypress swamp, the numerous components of this zone, in order of appearance, include: Group A - Carpinus caroliniana, Carya cordiformis, C. aquatica and C. leiodermis, Diospyros virginiana, Fraxinus caroliniana, Gleditsia aquatica, Nyssa aquatica, and Salix nigra. Group B - Carya pecan, Celtis laevigata, Cercis canadensis, Fraxinus americana and F. pennsylvanica var. lanceolata, Gleditsia triacanthos, Liquidambar styraciflua, Magnolia grandiflora, Populus deltoides, species of Prunus, Quercus and Ulmus, also Nyssa sylvatica. Group C - Acer rubrum, Alnus rugosa, Bumelia lanuginosa, Castanea pumila, Persea borbonia, and species of oak. It is in these broad transition zones that the vast hardwood forests of the Pine Association in Texas occur as final stages in the hydrosere, leading spatially to the pine forest climax.

In several localities east of the Colorado river in Texas there are extensive marshy areas populated by Typha latifolia and T. angustifolia and Scirpus lacustris. Along stream courses and in other bodies of semi-fresh water Arundo donax, Phragmites communis and Zizaniopsis miliacea grow in abundance. Dominant herbaceous plants in this habitat include: species of Acuan, Ambrosia, Argemone, Aster, Batis, Borrichia, Cyperus, Distichlis, Dondia, Erigeron, Gaillardia, Heliotropium, Iva, Juncus, Salicornia and Sporobolus.

DECIDUOUS OR SEASONAL FORESTS

These are the type in which some or all the trees shed their leaves, either entirely or in part, and usually during some period of the dry season. Some Evergreen trees, of course, are mixed with the Deciduous.

The designation "Seasonal" is aptly applied in Puerto Rico, as in other tropical American regions, because such factors as leaf production and shedding, and flowering and fruiting are largely dependent upon climatic conditions. In Southeast Asia the term "Monsoon forest" is generally used, as the phenomena of leaf shedding and production are influenced by the periodic entry of dry and rainy seasons, controlled by the shift of the prevailing northeast and southwest winds.

The character of Deciduous forests in Southeast Asia is variable, influenced to a large degree by the amount of available moisture. They range from moderately dense to open, and are composed of two or three stories. Often there is a dense underbrush of shrubs and undershrubs, some of which are thorny, and herbaceous plants. Grasses are usually abundant, in addition to small palms and cycads.

The structure and composition of Deciduous forests are usually less complex than the Humid (Rain or Moist) Evergreen forests. The trees vary in dimensions, according to microclimate, site and soil conditions. They range from medium height to fairly tall, and at times attain large girth. Their root system is well developed and often deep. Usually the trees are not heavily buttressed and are of moderate taper. The branches of most trees forming the topstory are stout, and the crowns are irregularly shaped to rounded. The leaves, usually abundant, vary in size from mesophyllous to macrophyllous and are often coriaceous. As in tropical America, in Southeast Asia Deciduous forests occur on plains and hill-slopes and are not selective as to soil types and elevation, although they seldom reach an altitude of 3,000 ft. (900 m.).

Deciduous Seasonal forest, analogous to the Monsoon forest of Southeast Asia, is widespread in the West Indies and on the Pacific slope of Central America. Beard (1946a) describes it as a two-storied forest with the canopy formed by the lower stratum between 9 and 30 ft. (3 - 10 m.), and an upper layer of scattered trees up to 60 ft. (20 m.). There are a few stout trees, 20 in. (0.5 m.) being about the largest diameter. Stems fork or branch low down and tend to be bent or crooked. Many of the lower story species have a tendency to clumped growth. Deciduous Seasonal forest occurs in Puerto Rico on several soil types, such as Ponce limestone, shale hills near La Parguera, and on serpentine soils near Yauco. An example of this in Puerto Rico is the Bucida-Bursera forest of the Ponce limestone area, on the south coast. Annual rainfall and temperatures are such that this forest may be placed in dry to very dry Life Zones.

Prominent species in this formation in Puerto Rico are. Adelia ricinella, Amyris elemifera, Bourreria succulenta, Bucida buceras, Bursera simaruba, Capparis cynophallophora, Ceiba pentandra, Citharexylum fruticosum, Coccoloba latifolia, Cordia collococca, Exostemma caribaeum, Ficus laevigata, Guaiacum officinale, Guazuma tomentosa, Krugiodendrum ferreum, Pisonia albida, Schaefferia frutescens, Tabebuia heterophylla, Trichilia hirta, and Zanthoxylum monophyllum.

The Deciduous forests of the Indochina Peninsula may be separated into 2 broad categories: (A) Mixed Deciduous, and (B) Deciduous Dipterocarp forest.

(A) Mixed Deciduous Forest:

This forest type is widely distributed in Thailand, as in other parts of Southeast Asia. It is one of the most valuable assets of Thailand, as a source of timbers, particularly teak (Tectona grandis).

Mixed Deciduous forest may again be divided into 2 subtypes: Moist Mixed Deciduous; and Dry Mixed Deciduous forest.

Moist Mixed Deciduous forest: This forest is fairly dense and tall, but less luxuriant and complex than the Rain forest. In Southeast Asia, it occurs in areas with an annual precipitation of 50 to 80 in. (1,270 - 2,030 mm.). The dry season is well marked, at least by a brief leafless period. This subtype shows a tendency toward dominance by a single genus or species. Typical of this is teak (Tectona grandis). In northwestern and northern Thailand, teak constitutes the most characteristic tree, although it may not be dominant numerically.

Dry Mixed Deciduous forest: In this subtype, the annual rainfall is less than 50 in. (1,270 mm.), falling mostly in the wet season, followed by 6 months or more of dry to very dry period. In general, this forest is definitely less luxuriant than the Evergreen Rain or Moist Mixed Deciduous forests. It is relatively simple in structure, with 1 or 2 stories, and dominants measure 50 to 75 ft. (16 - 22m.) tall. The canopy is uneven, and not dense. Many of the dominant trees have straight, clean trunks of rather large dimensions. Others are twisted, with low branches and flat or umbrella-shaped crown. Most of the woody species are leafless, with some evergreen trees present. Plank buttresses and stilt roots are almost always absent. Woody vines, epiphytes and ferns are few. Leaves are small to large, finely-pinnate or simple digitate, and many are leathery. Bamboos are frequent in the lower story, especially Bambusa arundinacea, Dendrocalamus strictus and Thyrsostachys siamensis.

The most characteristic and commercially valuable tree in this subtype of forest in northern Tahiland is teak (Tectona grandis). Trees associated with teak include: Acacia catechu, Adina cordifolia, Afzelia xylocarpa, Anogeissus latifolia, Cassia fistula, Dalbergia bariensis, D. dongnaiensis and D. oliverii, Diospyros mollis, Erythrophloeum succirubrum and E. Teysmannii, Nauclea orientalis, Pterocarpus macrocarpus, Tetrameles nudiflora, Vitex peduncularis and Xylia kerrii. Many of these furnish useful timbers long used in domestic trade.

(B) Deciduous Dipterocarp Forest:

This forest type is characteristic of the Mekong countries, where, in addition to Malaysia, it attains its greatest development. It is not represented in Puerto Rico or elsewhere in tropical America or Africa.

In Thailand, there are vast tracts of Dipterocarp forest in the east, northeast, north and northwestern sections, but it is absent in the southern part of the Peninsula, although species occur in the Humid forest. It covers about 57,000 sq. miles (142,000 sq. kms.), equivalent to about 45 percent of the country's total forested area. This forest is also predominant and the most extensive type in Vietnam, Laos and Cambodia. In general it is of open nature, composed of small to medium-sized trees, and widely spaced. It corresponds to what French ecologists and foresters, who have studied the vegetation of Indochina, classify as "forêts claires." The soils are generally sandy, gravelly or lateritic, and have a profound effect on the composition and structure of this forest type. Grasses are abundant. Vertical and horizontal visibility are favorable.

The tree species are mixed, although there is a tendency toward gregariousness, with dominance by one or a few species. Dominant Dipterocarp trees, of which some attain great development, include: Dipterocarpus intricatus, D. obtusifolius and D. tuberculatus, Pentacme siamensis and Shorea obtusa.

Other trees of large dimensions, several of which have long figured in the domestic market and in international trade, are: Dipterocarpus alatus, Anisoptera cochinchinensis, Afzelia xylocarpa, Irvingia malayana, Sindora siamensis, Terminalia tomentosa and Shorea floribunda.

Extensive areas, with Dipterocarp forest, have been cleared for rice culture. Also, the constant demand, over many decades, for durable timbers for heavy construction and railroad ties, and as source of fence posts and firewood, has been a heavy drain on this forest. In addition, a series of minor forest products are furnished by species occurring in this forest. Among these are: dammar resin from Shorea obtusa and Pentacme siamensis; wood oil, for torches, from Dipterocarpus alatus, D. obtusifolius and D. intricatus; nux-vomica from the seeds of Strychnos nux-vomica; oil from the seeds of Parinarium annamense; and a viscid oleo-resin from Melanorrhea usitata.

Dry Dipterocarp forest: Also known as Dwarf Dipterocarp forest, this occupies regions where the annual precipitation is low, and the physical conditions are such that only a fraction of the rainfall becomes available to the trees.

In Thailand, Dry Dipterocarp forest is frequent along the margin of the western plains in the region of Banpong and Kanchanaburi; in the basin of the Kwae Noi and Kwae Yai rivers; along the border of the upper plain in the region of Tak and between Thoern and Lampang; in the triangle between Chiengmai, Mae Hongson and Mae Sariang, in the northwest; in the Korat plateau, in the northeast; and in the region of Surin and Ubon in the east. It is not present in the Peninsula.

In East Texas Deciduous Forest Formation is represented by the Quercus - Carya Association. The oak-hickory association extends as a narrow strip, seldom more than 60 miles (96 kms.) wide, between the pine-oak forest and the prairie, extending northward to the Red river, and then gradually narrows to a vanishing point. Numerous stands of this association appear elsewhere whenever there are outcrops of sandy soil underlaid by red clay and gravel.

This forest flourishes on rolling hills, ranging in altitude from 250 to more than 1,000 ft. (77 - 307 m.). The soil is uniformly sandy, underlaid by red or yellowish, sometimes grayish, clay. While not excessively rich, the soil of the oak forest is more fertile than that of the pine-oak formation, so that a larger proportion of it is under cultivation.

Extremes of rainfall vary appreciably, from 30 to 45 in. (762 - 1,143 mm.). While the area near the coast benefits from the moisture-laden southeast sea breezes, these become considerably drier before they reach the northwest.

The dominant tree throughout this association is post oak (*Quercus stellata*). This is usually, but not always, associated with blackjack (*Quercus marilandica*), and throughout much of its distribution by hickory (*Carya buckleyi*).

Small trees in the lower story of this formation include: *Crataegus apiifolia* and *C. spathulata*, *Ilex decidua* and *I. vomitoria*, *Viburnum rufidulum* and *Rhus copallina*. Shrub socies are composed of *Croton argyranthemus*, *Koellia albescens*, *Lantana horrida*, *Rhus aromatica*, and species of *Myrica*, *Callicarpa*, and *Symphoricarpos*.

Herbaceous vegetation includes species of *Commelina*, *Cracca*, *Delphinium*, *Elephantopus*, *Eupatorium*, *Indigofera*, *Tradescantia*, *Verbena*, *Vernonia*, *Vincetoxicum* and other genera.

Lianes are not frequent in the oak-hickory forest. The only one of importance is *Smilax bona-nox*. Other vines present are: *Ampelopsis arborea* and *A. quinquefolia*, *Berchemia scandens*, *Tecoma radicans*, and *Vitis cinerea* and *V. candicans*. The last-named, especially, is widespread in the climax growth throughout the whole area of the association.

Dry Mixed Deciduous Forest

Pokodien, Loei Region, Northern Thailand (alt. 400 - 500 m.)
Soil sandy, silty.

Upper Story:

Trees	Height Range (meters)	Affinity in Vietnam Cambodia and/or Laos (S = species; G = genus)
Albizzia lebbekoides	-20	S
Anogeissus acuminata	-20	S
Berrya mollis	15 - 20	S
Bridelia retusa	15 - 20	S
Cassia fistula	-12	S
Cassia garretiana	-10	S
Combretum quadrangulare	-12	S
Cordia obliqua	-10	S
Cratoxylon formosum	-20	
Cratoxylon nerii-folium	12 - 15	S
Dalbergia foliacea	-10	G
Dillenia pulcherrima	-20	G
Diospyros ehretioides	-10	S
Diospyros mollis	-10	S
Diospyros rhodocalyx	-10	G
Dolichandrone spatha-cea	15 - 20	S
Gardenia erythroclada	4 - 8	
Garuga pinnata	-35	S
Gelonium multiflorum	-15	S
Heterophragma sul-fureum	-10	G
Holarrhena densiflora	-20	G
Lagerstroemia balansae	6+	S
Lagerstroemia calyculata	10	S
Lagerstroemia tomentosa	20+	S
Lagerstroemia undulata	10	S
Millettia brandisiana	-20	S
Millettia buteoides	15+	S
Millingtonia hortensis	25	S
Mitragyne spp.	15+	G
Pterocarpus macrocarpus	-15	S
Randia tomentosa	-10	S
Salmalia (Bombax) in-signis	-15	S
Schleichera oleosa	15 - 20	G

Trees - continued	Height Range (meters)	Affinity in Vietnam Cambodia and/or Laos (S = species; G = genus)
Sindora siamensis	-25	S
Sterculia thorellii	-20	S
Sterculia angusti-folia	-10	S
Stereospermum sp.	-30	G
Strychnos nux-vomica	-12	S
Terminalia mucronata	25+	S
Vitex canescens	-10	G
Wrightia tomentosa	-10	G
Xylia kerrii	-18	S

Understories:

Shrubs:

Antidesma decandrum	G
Antidesma sp.	G
Bauhinia bracteata	S
Barleria cristata	G
Bridelia retusa	S
Capparis sepiaria	S
Celastrus paniculata	S
Cissus rheifolia	G
Desmodium sp.	G
Desmos dumosus	G
Desmos sp.	G
Grewia sp.	G
Harrisonia perforata	G
Helicteres isora	S
Helicteres lanata	S
Helicteres obtusa	G
Mitragyne spp.	G
Paederia pilifera	S
Uvaria sp.	G
Walsura trichostemon	S

Bamboos:

Bambusa arundinacea	S
Bambusa tulda	S
Dendrocalamus membranaceus	S
Oxytenanthera albo-ciliata	S

	Affinity in Vietnam Cambodia and/or Laos (S = species; G = genus)
Ground Cover - Herbs unless otherwise indicated.	
Colonia sp.	G
Costus sp.	G
Dioscorea sp.	G
Emilia sonchifolia	S
Eriosema sp.	G
Eupatorium odoratum	S
Lygodium flexuosum (fern)	S
Tylophora rotundifolia	G
Vetiveria sp.	G

Dry Mixed Deciduous Forest with Teak Dominant [1/]

Trees in forest surrounding Teak plantation at Maetek, Ngao District, Province of Lampang, Northern Thailand (alt. 600 m.)

Upper Story:

Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Anogeissus acuminata	10 - 20	S
Bauhinia variegata	6	S
Cananga latifolia	25	S
Cratoxylon pruniflorum	6 - 12	S
Diospyros montana	15+	S
Eugenia caneura	12+	G
Heterophragma adenophyllum	-10	G
Holarrhena antidystenterica	-10	G
Hymenodictyon excelsum	8 - 15	S
Lagerstroemia balansae	5 - 6	S
Lagerstroemia villosa	10 - 15	S
Milletia brandisiana	-20	S
Milletia brevispina	-15	G
Salmalia (Bombax) insignis	-15	S
Tectona grandis	20+	S
Xylia kerrii	-18	S
Zizyphus oenoplia	-5	S

Understories:

Shrubs:

Acacia oxyphylla	G
Allophylus sootepensis	G
Anomianthus dulcis	S
Combretum deciduum	S
Erioglossum rubiginosum	S
Flemingia stricta	S
Harrisonia perforata	G

1/ Based on studies made by Professor Doenchai Ratanawongse, School of Forestry, Prae, Northern Thailand.

Shrubs - continued:	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Holarrhena densiflora	G
Phyllanthus sp.	G
Scyphellandra pierrei	S
Strobilanthes auriculatus	G
Toxocarpus vallaris	G
Trema orientalis	G
Zizyphus oenoplia	S
Climbers:	
Atherolepis pierrei	S
Buettneria pilosa	S
Butea superba	S
Capparis horrida	S
Dalbergia volubilis	S
Parameria barbata	G
Smilax macrophylla	S
Bamboos:	
Bambusa tulda	S
Oxytenanthera albo-ciliata	S
Ground Cover - Herbs unless otherwise indicated:	
Alangium salvifolium	G
Andropogon micranthus (grass)	G
Carex indica	S
Colonia flagrocarpa	G
Costus globosus	G
Dalbergia cana	G
Dalbergia maymensis	G
Desmodium triflorum	S
Desmodium velutinum	G
Eupatorium odoratum	S
Jasminum sootepense	G
Pachyrrhizus erosus	S
Stemona aphylla	G

Dry to Moist Mixed Deciduous Forest

Panokchao, Loei Region, Northern Thailand (alt. 400 - 500 m.)

The following listings indicate the species constituting the various strata in this forest type, located in the middle Mekong basin, close to the border of upper Laos. 1/

Upper Story:

Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Adina cordifolia	8 - 35	S
Adina parvula	20+	G
Albizzia lebbekoides	20	S
Anogeissus acuminata	10 - 20	S
Aporosa villosa	-10	S
Artocarpus lakoocha	15+	G
Azadiracta indica	8 - 15	S
Bauhinia sp.	10+	G
Berrya mollis	15 - 20	S
Bridelia retusa	-20	S
Buchanania latifolia	-10	S
Canarium kerrii	-18	S
Careya arborea	-25	S
Castanopsis acuminatissima	-25	S
Cordia obliqua	5 - 10	S
Cratoxylon formosum	-20	S
Cratoxylon neriifolium	12 - 15	S
Cratoxylon pruniflorum	6 - 12	S
Dalbergia bariensis	15 - 20	S
Dalbergia cultrata	10 - 20	S
Dalbergia dongnaiensis	15 - 30	S
Dalbergia nigrescens	10 - 20	S
Dialium cochinchinense	15 - 25	S
Dillenia pulcherrima	-20	G

1/ Based on data compiled by Mr. Doenchai, Instructor in the School of Forestry, Prae, northern Thailand.

Trees - continued:	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Diospyros cho-boensis (?)	-15	S
Diospyros montana	-15	
Dipterocarpus in-tricatus	20 - 30	S
Dipterocarpus tuber-culatus	15 - 20	S
Erythrophloeum suc-cirubrum	-30	S
Gardenia obtusifolia	-3	S
Grewia asiatica	5+	S
Holarrhena anti-dyenterica	15+	G
Holoptelea integri-folia	25+	S
Irvingia malayana	20+	G
Ixora sp.	-6	G
Lagerstroemia sp.	25+	G
Mallotus paniculatus	-12	G
Mangifera caloneura	20	G
Morinda tinctoria	-5	S
Odina wodier	10 - 20	S
Parinarium anamense	-30	S
Pentacme siamensis	-25	S
Phyllanthus emblica	-10	S
Quercus sp.	10+	G
Salmalia (Bombax) in-signis	-12	S
Schleichera oleosa	15	G
Shorea buchananii	-15	G
Shorea obtusa	-30	S
Shorea talura	-15	G
Sindora siamensis	20	S
Symplocos laurina	15+	G
Terminalia chebula	-20	S
Ternstroemia sp.	10+	G
Turpinia cochin-chinensis	10+	
Turpinia pomifera	10+	
Vitex sp.	15	G
Xylia kerrii	20+	S
Zanthoxylum brudringa	-10	G
Zizyphus oenoplia	-8	S

Understories:	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Shrubs:	
Acacia concinna	S
Agapetes parishii	G
Croton tomentosus	S
Desmodium insigne	S
Desmos dinensis	S
Desmos cochinchinensis	G
Desmos dumosus	S
Flacourtia pudica	G
Gardenia coronaria	S
Gardenia erythroclada	S
Gardenia obtusifolia	S
Glochidion sp.	G
Gmelina asiatica	G
Gonocaryum subrostratum	S
Helicteres elongata	G
Hibiscus lampas	G
Hoya kerrii	G
Indigofera elliptica	G
Ixora sp.	G
Maesa indica	S
Melientha suavis	S
Memecylon scutellatum	G
Mitragyne hirsuta	G
Mitrephora vandiflora	G
Murraya siamensis	G
Osbeckia chinensis	S
Randia tomentosa	G
Terminalia tripteroides	S
Ternstroemia sp.	G
Turpinia pomifera	
Climbers:	
Acacia concinna	S
Afgekia sericea	
Bauhinia bracteata	S
Butea superba	S
Celastrus paniculata	S
Combretum trifoliatum	S
Dalechampia falcata	S
Desmodium insigne	S
Ecdysanthera rosea	G

Climbers - continued:	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Mallotus philippinensis	S
Opilia amentacea	S
Oxystelma esculentum	S
Randia tomentosa	S
Rourea stenopetala	S
Smilax sp.	G
Spatholobus parviflorus	G
Streptocaulon sp.	G
Tetrastigma cruciatum	S
Toddalia aculeata	S
Palm:	
Wallichia sp.	G
Bamboo:	
Arundinaria pusilla	S

Ground Cover - Herbs unless otherwise indicated.

Aganosma marginata	G
Andropogon micranthus (grass)	G
Arthrosiphon grandiflorus	
Begonia inflata	G
Capparis flavicans	G
Cassia pumila	S
Crinum sp.	G
Curcuma sp.	G
Cycas immersa (cycad)	S
Desmodium triangulare	G
Desmodium triflorum	G
Dioscorea glabra	S
Dioscorea myriantha	S
Dioscorea pierrei	S
Echinochloa colona	S
Emilia sonchifolia	S
Euphorbia hirta	G
Globba sp.	G
Gymnopetalum cochinchinense	S

Ground Cover - continued	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Gynura pseudochina	S
Helicteres elongata	G
Helicteres lanata	S
Heterostemma wallichii	G
Hydrocotyle sibthorpioides	G
Hymenodictyon excelsum	S
Ipomoea sp.	G
Leonotis nepelaefolia	G
Litsea sebifera	S
Melastoma villosum	S
Melothria heterophylla	S
Polygonum sp.	G
Stemona sp.	G
Urena sinuata	S
Vernonia cinerea	S
Xanthium strumarium	S

Mixed Broadleaved Forest

Pakthongchai, Korat Province, Northeast Thailand (alt. 300 - 350 m.)

Upper Story:

Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Acacia comosa	-5	G
Adenanthera pavonis	7-16	S
Adina polycephala	15 - 25	S
Aglaia pirifera	-10	S
Antidesma sp.	-5	G
Bauhinia cultrata	-5	G
Bauhinia horsfieldii	5+	G
Butea sp.	-10	G
Cananga sp.	20 - 25	G
Diospyros montana	-10	S
Erioglossum sp.	-5	G
Gardenia tubifera	-5	S
Homalium sp.	10+	G
Hopea ferrea	-25	S
Hydnocarpus ilicifolius	-10	G
Litsea chinensis	-7	G
Macaranga perakensis	-10	G
Mallotus argyratus	-10	G
Ochna sp.	5 - 6	G
Pterospermum semisagittatum	-25	S
Randia siamensis	-5	G
Randia wittii	-7	S
Shorea sericiflora	15+	G
Zizyphus sp.	-8	G

Understories:

Shrubs:		
Alyxia sp.		G
Amomianthus dulcis		G
Antidesma sp.		G
Bridelia sp.		G
Canthium sp.		G
Capparis siamensis		G
Casearia grewifolia		G
Clerodendron serratum		G
Coelodiscus sp.		G
Connarus sp.		G
Desmodium oblatum		S

Understories:

Shrubs - continued:	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Goniothalamus sp.	G
Grewia disperma	G
Helicteres sp.	G
Ixora sp.	G
Linociera microstigma	G
Melodorum fruticosum	G
Memecylon ovatum	G
Micromelum sp.	G
Murraya paniculata	G
Mussaenda uniflora	S
Opilia sp.	G
Phyllanthus sp.	G
Strychnos sp.	G
Symplocos sp.	G
Taxotrophis macrophylla	G
Tetrastigma sp.	G
Tourneforia intensa	G
Uraria sp.	G
Urena speciosa	G
Walsura angulata	G
Climbers:	
Diploclisia (Cocculus) glaucescens	G
Dunbaria longeracemosa	S
Gnetum siamensis	G
Palm:	
Wallichia sp.	G
Ground Cover:	
Aporosa sp. (herb)	G
Aristida balansae (herb)	S
Centotheca lappacea (herb)	S
Colania sp. (herb)	G
Costus sp. (herb)	G
Cyanotis sp. (herb)	G
Dioscorea sp. (herb)	G
Drymaria quercifolia (herb)	G
Globba sp. (herb)	G
Kaempferia sp. (herb)	G
Peliosanthes sp. (herb)	G
Swertia sp. (herb)	G
Vernonia cinerea (herb)	S

Also species of Zingiberaceae and Rubiaceae.

Dry Dipterocarp Forest

Pokodien, Loei Region, Northern Thailand (alt. 400 - 500 m.)

Upper Story: Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S - species; G = genus)
Buchanania reticulata	-8	S
Garcinia obtusifolia	-10	G
Pentacme suavis	20+	S
Phyllanthus emblica	-2	S
Shorea obtusa	-25	S
Symplocos racemosa	-10	G
Understories:		
Shrubs:		
Bunchosia reticulata		
Cissus repens		S
Clausena guillauminii		G
Desmodium dunii		G
Ixora sp.		G
Memecylon pauciflorum		S
Morinda tinctoria		S
Murraya siamensis		G
Rourea stenopetala		S
Symplocos racemosa		G
Climbers:		
Pachygone dasycarpa		S
Smilax sp.		G
Bamboo:		
Arundinaria pusilla		S
Ground Cover:		
Ecdysanthera rosea (herb)		G
Elephantopus scaber (herb)		S
Streptocaulon sp. (herb)		G
Panicum sarmentosum (grass)		S

Fig. 5. Profile diagram, representing a strip 200 ft. (61 m.) wide, of primary Mixed Dipterocarp forest, Mt. Dulit, Borneo. Only trees upwards of 25 ft. (7.6 m.) high are shown. (From Richards' "Tropical Rain Forest.")

Dipterocarp Forest in Teak Area of

Maetek, Ngao District, Lampang Province, Northern Thailand (alt. [illegible] m.)

Upper Story Trees	Height Range (meters)	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus
Anogeissus acuminata	10 - 20	S
Bridelia retusa	15	S
Casearia grewiaefolia	-6	S
Cratoxylon pruniflorum	-3	S
Dalbergia nigrescens	-20	S
Dillenia aurea	-12	S
Dipterocarpus tuber-culatus	-25	S
Holigarna kurzii	10	G
Kydia calycina	-5	S
Lagerstroemia balansae	-6	S
Pentacme suavis	-30	S
Randia longispina	-3	G
Shorea obtusa	15 - 30	S
Symplocos laurina	-5	G
Terminalia mucronata	20+	S
Vitex limonifolia	5+	G

Understories:

Shrubs:		
Antidesma diandrum		S
Bridelia retusa		S
Clerodendron serratum		G
Desmodium velutinum		G
Indigofera sootepensis		S
Phyllanthus emblica		S
Strobilanthes auriculatus		G
Trema nudiflora		G

Climber		
Smilax macrophylla		S

	Affinity in Vietnam, Cambodia and/or Laos (S = species; G = genus)
Ground Cover - Herbs unless otherwise indicated.	
Abutilon graveolens	S
Andropogon micranthus (grass)	G
Carex indica	S
Centella asiatica	G
Colonia flagrocarpa	G
Cycas siamensis	S
Eupatorium odoratum	S
Hibiscus lampas	G
Lygodium flexuosum (fern)	S
Melothria affinis	G
Pogostemon glaber	G

COASTAL VEGETATION

Littoral woodland or Coastal thickets occur on many exposed, well drained sandy shores in tropical regions, where Mangrove woodland is absent, and in temperate zones. The zonation of this coastal vegetation is similar in almost all areas. Along the seaward margin there is usually a colony of low-growing, trailing plants which are halophytic. They thrive on the beaches in sandy soil with high salt content and are not affected by frequent submergence. The most constant plant on such open seashores is Ipomoea pes-caprae, which has a pantropical distribution. Associated with this are species of Canavalia and Spinifex.

Behind the Pes-caprae formation in Southeast Asia, as in other parts of western Pacific, a narrow belt of littoral woodland develops along exposed shores, in which Barringtonia speciosa and B. racemosa are dominant trees. The Barringtonia formation is best developed in areas with sparse population. Some of the most constant trees associated with Barringtonia, several of which have a pantropical distribution, are: Calophyllum inophyllum, Terminalia catappa, and Thespesia populnea; also Hibiscus tiliaceus, Tournefortia argentea, and Pandanus tectorius. Australian pine (Casuarina equisetifolia) also is often grown as windbreak, and develops spontaneously on rapidly accreting shores, on sand spits, and around river estuaries. Another species of Casuarina, C. junghuhniana, is also planted occasionally to arrest erosion along exposed shores and the formation of dunes.

Along the southeast coast and in the Peninsula of Thailand much of the littoral woodland, except Mangrove and other forest trees, has been cleared for agricultural use or to supply fuelwood. An example of undisturbed coastal woodland is found at Huay-Yang, between Prachuab Khirikhan and Chumphon, in the east-central section of the Peninsula. In some sites it forms a continuous belt with a rather low canopy or where a clearing has been made it appears in small stands, with intervening exposed spaces covered with a dense growth of Imperata and other rough grasses. The trees measure about 30 ft. (9.5 m.) in height, are closely spaced, and the undergrowth is dense. Their trunks are often gnarled, the bark scaly and rough and most of the trees have a heavy, hard and durable wood. Dominant trees in this Beach woodland are: Manilkara hexandra, Terminalia pierrei and T. mucronata, Odina wodier, Cratoxylon formosum, Garcinia cornea, Pterospermum semisagittatum, Diospyros variegata and D. ehretioides, and Cordia dichotoma.

Adjacent to, and inland from, this coastal fringe at Huay-Yang, the evergreen pantropical Acacia comosa forms a low, continuous stand. This small, leguminous tree soon invades areas which have been cleared for cultivation, and constitutes a seral stage between the Beach woodland and Mixed Semi-evergreen forest farther inland. In this forest, extending westward to the foothills, dominant trees are: Dipterocarpus alatus, Afzelia xylocarpa, Dialium cochinchinensis, Lagerstroemia tomentosa, Melanorrhea usitata, Fagraea cochinchinense, Garcinia cornea, Mangifera caloneura, Salmalia (Bombax) insignis, Erythrophloeum succirubrum, Stereospermum fimbriatum, Spondias pinnata, and Wrightia tomentosa.

Pes-caprae occurs along the shores of the West Indies, including Puerto Rico. As in the eastern tropics, Canavalia is almost as constant as Ipomoea pes-caprae. Behind this colony there is a narrow zone of woody vegetation, resembling the Barringtonia formation of Southeast Asia and other tropical areas of Asia. On exposed coasts this may be a mere thicket or scrub, or it may reach 20 to 40 ft. (6 - 12 m.) high, interlaced with vines. Usually this is a two-storied woodland, with low, open or dense canopy and the undergrowth is dense or sparse. The dominant tree here is the small sea grape (Coccoloba uvifera), either forming a nearly pure stand or intermixed with other species. Almost equally as characteristic are Hippomane mancinella and Chrysobalanus icaco. Farther inland other trees, shrubs and herbs appear. Such subordinate woody species as Terminalia catappa and Thespesia populnea, which occur also in the Asian Barringtonia Formation, are represented in the Coccoloba community in the West Indies. In Puerto Rico Associates of Coccoloba are: Eugenia axillaris, Rauwolfia tetraphylla, Erithalis fruticosa, Dodonaea viscosa, and some members of Cactus scrub, which invade the Littoral thicket, especially on the southern coast. In the landward facies, associates of Chrysobalanus icaco are Eugenia jambos and Psidium guajava, which appear in the canopy and undergrowth; also Ouratea littoralis, Byrsonima spicata, Myrcia splendens and M. citrifolia. The armed palm, Acrocomia aculeata, appears occasionally in the back thicket.

In East Texas the low sand and shell ridges between the beach and coastal marsh, according to Tharp (1926), are thickly covered with vegetation composed of a surprising number of species. Dominants among consocies east and west of the Brazos river, listed by Tharp, include: Batis maritima, Heliotropium curassavicum, Monanthochloa littoralis, Salicornia bigelovii and S. perennis, Sesuvium portulacastrum, and Sporobolus virginicus.

Subordinate associates are: Desmanthus acuminatus and D. illinoensis Ambrosia psilostachya, Aster spinosus, Atriplex arenaria, Borrichia frutescens, Chamaecrista littoralis, Rhynchosia minima, Eragrostis secundiflora, Erythrina herbacea, Indigofera leptosepala, Ipomoea trifida, Iva frutescens, Limonium angustratum, and Rubus trivialis. Colonies are also formed by Ipomoea littoralis and I. speciosa, Iva lanceolata, species of Chamaesyce, Coreopsis, Croton, Galactia, Oenothera, Scutellaria, Spartina, Tidestraemia and, west of the Brazos river, a species of Yucca.

In East Texas there is also a fairly rapid invasion of the coastal prairie by woody plants. Chief of these is Acacia farnesiana, frequent on old sand and shell ridges. Asociated with this are species of Colubrina, Eysenhardtia, Aloysia; also Prosposis juliflora var. glandulosa and Celtis pallida forming a dense cover.

Other woody invaders of the coastal prairie to the northwest of the chaparral are species occurring in the transition zone between the coastal prairie and the climax formation to the north. The principal of these is live oak (Quercus virginiana), usually in the form of a shrub. Post oak (Quercus stellata) is another oak invader of coastal prairie, but is of less importance than Q. virginiana. It is limited to sandy ridges and in the vicinity of flood plains. Loblolly pine (Pinus taeda) is the most important woody invader along the line of contact between the pine - oak forest and coastal prairie. Other trees of importance in some sites are sweet gum (Liquidambar styraciflua) and especially green hawthorn (Crataegus viridis), which covers large low-lying tracts, especially adjacent to bayous and rivers.

S A V A N N A

A savanna may be described as a plant community in which there is a virtually continuous, ecologically dominant stratum of more or less xeromorphic herbaceous plants, of which grasses and sedges constitute the principal components, and widely spaced shrubs, trees or palms are present, or they may be entirely absent. Some savannas may be considered seral stages; others are apparently stable climaxes. Those in which trees are dominant, and with or without a continuous ground cover of grasses, may be classed as climatic climaxes. Others, formed by repeated burning of Deciduous or Semi-deciduous forests, may be regarded as fire-climaxes. Savannas which are treeless grasslands, or in which trees are scattered or form only small stands, may have developed as the result of excessive cultivation and repeated burning. In some areas savannas may be edaphic climaxes, in which instance the environmental and soil conditions are unfavorable for the development of a closed forest. Because of the generally open nature of a savanna, whether wooded or treeless, constant dominants are the grasses and other plants forming the ground stratum.

As a rule there is a sharp contrast in the floristic composition, as well as in physiognomy, between a savanna and the surrounding closed forest. Most of the dominant and subordinate species differ in the two communities. But several genera, which are related taxonomically but differ sharply in physiognomy, may be present in both formations.

The strong contrast between the vegetation of the savanna and the closed forest may be influenced by several environmental differences. One important factor is fire. The humid Evergreen forest is immune to fire, or at least it will not burn as readily as a drier Deciduous forest, whereas some savannas are subjected to periodic fires, either spontaneous or deliberately set. Usually only a few plants in the savanna are able to withstand repeated burning. As a rule aboveground vegetation of grasses, small palms, cycads, seedlings and even shrubs are destroyed. The trees, also, may be damaged, resulting in their deformed or dwarfed appearance, so that the vegetation of the savanna is often a question of fire-resistance and selection.

Savannas are much more widespread in tropical America, especially in Central and northern South America, than in Southeast Asia. Although true savanna is of limited occurrence in Puerto Rico, such as isolated, small patches in upper Luquillo Mountains, it is frequent in the other West Indian islands. In tropical America typical examples of savannas are the great "Llanos" of southern Venezuela; the "campos firmes" and "caatingas" of Brazil; and the "oak ridge," "pine ridge" or "pimento swamp" of British Honduras. The so-called Acacia-Prosopis savanna of Puerto Rico belongs more properly to the Thorn woodland, because the herbaceous stratum is not dominant.

In the Orinoco basin of Venezuela, for example, woody species of frequent occurrence and characteristic of the savanna are: Anacardium occidentale, Byrsonima crassifolia, and Curatella americana. These small, often gnarled, trees are also found in Puerto Rico. In Trinidad, Byrsonima verbascifolia is typical of some savannas, while in others species of Myrcia and Roupala are dominants. In the island of Hispaniola (Haiti and the Dominican Republic), Miconia rubiginosa enters into the savanna flora. In Central America, as far south as Nicaragua, and in Cuba and the island of Hispaniola, pine savanna is the most prevalent. But in the southern section of Central America pine is supplanted by various fan palms.

In Thailand savannas occur under a variety of climatic conditions, and likewise vary in physiognomy. They occur in areas with an annual rainfall of about 20 in. (500 mm.), as in eastern Thailand where the dry season may last 7 or more months; and in west central Peninsula, where the annual rainfall exceeds 100 in. (2,500 mm.), with a relatively short dry season. Some small savannas, such as on the mountains of the Pacific islands, reflect a rain-shadow effect as they cover the leeward slopes of mountain ranges, and are protected from the dominant trade winds. The "campos cerrados" of the Amazon basin, for example, are attributed to the drying effect of the trade winds as they pass over the mountains of the Guiânas. Compared with the vast open Llanos of Venezuela or eastern Colombia, the "campo firme" of Brazil, and the "pampas" of Argentina, open grass or wooded savannas are of somewhat limited extent in Southeast Asia.

Short bunch-grass savanna tends to prevail in areas with less than 40 in. (1,000 mm.) of annual precipitation; tall bunch-grass savanna where there is 40 to 80 in. (1,000 - 2,000 mm.), and sedge savanna where the rainfall is more than 80 in. (2,000 mm.) annually.

Patches of open rolling or flat grassland savanna occur in Thailand south of the Kra Isthmus in the region of Ranong, on the western side of the central Peninsula, and flanked along its southern margin by a high Rain forest. The ground cover is composed of low grasses, herbaceous plants, and occasional tufts of small shrubs. Some of these are probably biotic grasslands, which have developed after the destruction of patches of Evergreen or Deciduous forests for shifting agriculture, and usually followed by periodical burning.

In Thailand, the closest analogue to the wooded savanna of tropical America is that in which dwarf, widely spaced trees of the wood-oil family (Dipterocarpaceae) are dominant numerically. The most characterisitic of these are Shorea obtusa, Pentacme siamensis, and Dipterocarpus obtusifolius. These savannas appear to be a fire-climax. As in other parts of Southeast Asia, it is customary in Thailand to burn the savannas each year, usually during the dry months of January to March. The three species cited, as well as a low cycad (Cycas siamensis), and the ever present "lalang" grass (Imperata cylindrica), appear to be fire resistant. This is probably the reason for their preponderance in the wooded savannas.

Wooded savannas are more widespread in Thailand than the open grassland type. The soil is generally impoverished. On dry sites, lacking in humus, the soils are usually deep to bed rock, and sandy, but frequently with laterite or hardpan near the surface. As a rule, the trees are of small dimensions, seldom exceeding 30 ft. (10 m.) in height. They are widely dispersed and the canopy is always open, so that the general landscape often has a park-like appearance.

Stretches of wooded savanna occur in eastern Thailand, in the region of Surin, Ubon, Phibun Mangsahan, and extend eastward to the border of southern Laos. In the northeast they occur in limited patches between Konkaen and Kalasin, and continue northward from Konkaen to Udon, as far as Nongkhai in the middle Mekong river basin. Other areas of wooded savanna are distributed in the north between Tak, Thoern and Lampang, and between Chiengmai and the border of Burma. In western Thailand they occur on rolling hills around Banpong, Kanchanaburi, and in the basins of the Kwae Noi and Kwae Yai rivers, in places mixed with Thorn scrub. Farther to the northwest, they are found between Mae Sariang and Mae Hongson, along the border of Burma.

The Post Oak savanna of Texas is comparable to a degree to the wooded savanna of tropical regions. The topography of this area is gently rolling to hilly, with an elevation of 300 to 800 ft. (90 - 246 m.) above sea level, and an annual rainfall of 35 to 45 in. (875 - 1,145 mm.). Soils in the bottomlands are light-brown to dark-gray and acid, ranging in texture from sandy loams to clays. On the uplands the soils are light-colored, acid sandy loams or sands.

Some authorities consider the Post Oak savanna as a part of the oak-hickory or Deciduous forest formation, based on the fact that the understory vegetation is typically tall grass. Others prefer to class it as a part of the tree prairie association of the Grassland Formation. Gould maintains that, according to evidence, brush and tree densities have increased tremendously from the virgin condition.

The top-story is composed primarily of post (Quercus stellata) and blackjack oak (Q. marilandica). Climax grasses include species of Andropogon, Panicum, Tridens and Uniola, as well as such invading plants as bullnettle (Cnidoscolus texanus), yaupon (Ilex vomitoria), and green briar (Smilax bona-nox).

The Grassland Formation of East Texas, represented by the Andropogon-Stipa Association may be compared to tropical grassland savanna. This extends from the southwest as a narrow strip, less than 20 miles (32 kms.) wide, until it reaches the Red river, when it widens out to more than 150 miles (240 kms.). The area is almost flat in the northeast, but becomes increasingly rolling to the south and west, ending abruptly along the Balcones Escarpment, which, south of the Colorado river, delimits the junction of the prairie and oak-cedar-mesquite woodland. Elevations range between 400 - 900 ft. (123 - 277 m.).

The soils are black clay derived from decomposed limestone. Oak forest invariably appears wherever there are outcrops of sandy, gravelly red clay soil. The fine texture of the soil, the presence of considerable humus and the limestone substrata contribute to the increased water-holding capacity of the soil. The first two factors are of specieal importance to herbaceous vegetation, enabling it to withstand periods of drought than is normally possible in the coarser surface sands of the oak forest. Annual rainfall ranges from more than 30 in. (762 mm.) along the western edge, to nearly 50 in. (1,270 mm.) in the extreme northeast. Temperature extremes vary more in the northern part than in the southern section.

Because of such biotic factors as grazing and agricultural practice, it is difficult to pinpoint the true dominance in the association. Railroad right-of-ways perhaps furnish the best sites for climax vegetation, because of greater protection. But these, also, are subject to annual burning to reduce fire hazard. Protected areas are inhabited by a number of grasses, of which the most common and widespread are species of *Andropogon* and *Stipa*. Herbaceous plants, often with showy flowers, include: *Pentstemon tubiflorus*, *Physalis subglabrata*, *Rosa foliosa* and *R. setigera*, and *Siphium laciniatum*.

An alternate of the grassland is the oak forest prairie. This begins at the Brazos river opposite the oak-hickory forest association and extends to the southwest. Alternating strips several miles wide of typical oak and prairie generally run in a northeast to southwest direction. As a rule the grassland is confined to calcareous clay soil, while the oak forest is found in sand or gravel underlain by reddish or yellowish clay. This suggests that the distribution is controlled by edaphic factors.

The grassland or post oak (*Quercus stellata*) savanna of the Gulf Prairie of Texas has been invaded by mesquite (*Prosopis juliflora* var. *glandulosa*), species of oak (*Quercus*), *Acacia*, including huisache (*A. farnesiana*), and pricklypear (*Opuntia* spp.). The primary plants are tall bunch grasses, represented by species of *Andropogon*, *Muhlenbergia*, *Panicum*, *Tripsacum* and others.

THORN WOODLAND

This Formation is more widespread in the Caribbean and mainland tropical America than in Southeast Asia. It is particularly abundant in Venezuela along the north coast and the offcoast islands, also on the northern edge of the Llanos, and in the Guajira peninsula to the west. The caatingas of Brazil also contain some thorn woodland and cactus scrub.

The Thorn woodland is a scrubby type of evergreen, spiny trees, 10 to 30 ft. (3 - 10 m.) high, varying from fairly open to somewhat closed, with hard, microphyllous leaves, although some microphyllous species are not evergreen. In addition to reduction in size, the leaves show other adaptations for decreasing transpiration. Ground vegetation is practically absent, except some rare bromeliads and succulents. The tree flora is poor, sometimes composed of less than 30 species, and most of the thorn trees belong to the Mimosaceae and Caesalpiniaceae. Some usually dwarfed species, of the Deciduous Seasonal forest, intermingle with the more characteristic components of Thorn woodland.

A typical example of this community in Puerto Rico is the vegetation between Ponce and Guánica, on the south coast. There the coves and non-saline flats are occupied by Thorn woodland, while the slopes and ridges are populated by cactus scrub. Near Susua and Guánica the dry season may be interrupted by a short wet period, usually in May. This probably results in two periods of refoliation, in May and again in August-September.

Among characteristic trees in the Thorn woodland in Puerto Rico are: Acacia farnesiana, Cordia angustifolia, Guaiacum officinale, Haematoxylon campechianum, Leucaena leucocephala, Moringa oleifera, Parkinsonia aculeata, Pithecollobium dulce and Prosopis juliflora, in addition to the ubiquitous weed, Lantana camara. Prosopis became naturalized in Puerto Rico many years ago and has invaded the forests covering dry limestone hills of the southwest coast. Natural reproduction is usually abundant. It often forms open park-like stands, along with other species, particularly the pantropical Acacia farnesiana, which is also found in Southeast Asia. The annual precipitation in this site, of about 36 in. (900 mm.), and the mean annual temperature of 97° F. (36° C.) indicate that this formation is a transition from Tropical Very Dry to Tropical Dry Formation.

Thorn woodland is well developed in sections of Thailand, as in the other Mekong basin countries, although it does not cover such extensive areas as in parts of tropical America. It occurs in areas with high temperatures, annual rainfall of less than 40 in. (1,000 mm.), and long periods of drought. The soil is usually sandy, infertile and almost bare. The vegetation is composed of dense clumps of small trees, shrubs, bamboos, and occasionally cacti. As in Puerto Rico, many of the plants characteristic of this formation are armed with sharp spines. They are abundant on plains and well-drained slopes. They are frequent along trails and around habitations, whereas thornless plants are few or absent in such sites. One probable reason for this is that buffalo- or ox-drawn carts move constantly along trails, and only the armed plants are able to survive constant browsing.

In Thailand, Thorn woodland covers fairly extensive areas in the upper Peninsula, in the region of Banpong, Kanchanaburi, and the lower Kwae Noi basin, in the west. It is also scattered throughout the central plain, in the Korat plateau in the northeast, and toward the border of Cambodia and southern Laos.

Characteristic trees, all of which are deciduous, in the Thorn woodland are: Azadirachta indica, Bombax (Salmalia) insigne, Chukrassia velutina, Croton hutchinsonianus, Spondias pinnata, Terminalia glaucifolia, Zizyphus cambodiana and Vitex spp. Dominant shrubs, mostly armed, are: Randia tomentosa, with long, sharp spines; Feroniella lucida, a slender shrub with small, but very sharp spines; Flacourtia indica; and a species of Bauhinia. Usually intermixed with the shrubs and trees are bamboos, well adapted to long droughts, and which often form small, dense, almost impenetrable clumps. The most frequent of these is the thorny "phai-pha" (Bambusa arundinacea), up to 15 or so (4.5 m.) tall. Another common bamboo, forming small clumps, is "mai ruak" (Thyrsostachys siamensis). Cacti, especially species of the "pricklypear" (Opuntia), are often present in the upper Peninsula and in the northeast.

In Texas the plant association most analogous to the Thorn woodland of Southeast Asia and Puerto Rico is the so-called brush. Most of the species represented in this plant community are armed with spines. According to Smith and Rechenthin (1964), brush is the most serious problem on rangeland. A survey made a few years ago by range conservationists of the Soil Conservation Service showed that 88.5 million acres, or 82 percent, of "Texas' once luxuriant grasslands are now infested with one or more low-value or worthless woody plants."

About 50 percent of this acreage is so densely covered and grass is so suppressed that little improvement can be expected without reduction of the brush competition.

Brush is almost always present on poor condition grasslands, and generally the root system is very well developed. Research in Arizona indicated that mesquite trees use about 1,725 pounds of water to grow one pound of dry matter, and catclaw (*Acacia greggii*) about 2,000 pounds. It has been estimated that brush, cacti and weeds in Texas use about 146 million acre-feet of water annually, equivalent to approximately 40 percent of the State's total use. Smith and Rechenthin consider that brush infestation is light when it forms less than 10 percent of the canopy; medium when it forms 10 to 20 percent; and thick, when it forms 20 percent or more of the canopy.

Probably the most prolific is mesquite (*Prosopis juliflora* var. *glandulosa*). It is estimated that it now covers more than 56 million acres in Texas, and is growing denser each year on infested land. Mesquite is a prolific seed producer, and livestock and wild animals relish the mature leaves. The seed germinates more rapidly when it has passed through the digestive system of livestock. As a result the seeds are spread over wide areas, and soon become established on falling on bare or denuded areas.

Huisache (*Acacia farnesiana*) and retama (*Parkinsonia aculeata*), both of pantropical distribution, were introduced into Texas during pioneer times for use as ornamentals and shade trees. They have escaped and are now widespread in grassland in South Texas. Macartney rose (*Rosa bracteata*), a native of South Chi[illegible] was also introduced about 100 years ago, but has escaped and is rapidly increasing.

Other woody plants, some of which are armed, and are acute problems in sections of Texas include: creosotebush (*Larrea divaricata*), tarbush (*Flourensia cernua*), and lecheguilla (*Agave lecheguilla*) in the Trans-Pecos; yucca (*Yucca* spp.) and catclaw acacia (*Acacia greggii*) on sandy soils of the High and Rolling Plains; lotebush (*Condalia obtusifolia*), widespread in southern and western Texas; flame-leaf sumac (*Rhus copallina*) develops in heavily used, burned-over, or brush-treated grasslands in the central part; coyotillo (*Karwinskia humboldtiana*), a poisonous shrub of Southwest Texas; and others that constitute the chaparral of South Texas, such as amargosa (*Castela texana*), species of *Condalia*, granjeno (*Celtis pallida*) and guayacán (*Porlieria angustifolia*).

There are about 78 species of cacti in Texas, but only 5 have become a serious problem. They grow throughout the State, with the exception of the Piney-woods of East Texas. Cacti spread rapidly on grasslands of low stature or where the cover is sparse and become readily established on bare ground through the medium of birds or animals.

BAMBOOS

Bamboos are conspicuous in the landscape of Southeast Asia and constitute a characteristic feature of the vegetation of that area. These giant grasses, represented by such genera as Bambusa, Dendrocalamus, Gigantochloa and others, are generally spontaneous or wild, but sometimes planted, and are widely utilized locally for economic rather than for ornamental purposes. Some smaller bamboos, such as species of Bambusa and Thyrsostachys, are gregarious over large areas and are often planted for hedges. Larger species, such as Bambusa blumeana, may form large clumps and are often planted for shade and windbreak around homes and hamlets. The basal part of certain species of Bambusa have numerous spiny branches, forming dense thickets, and which protect the clumps against depredations of animals. Young tender shoots of most bamboos are edible.

Puerto Rico has only a limited number of native bamboos, but several species have been introduced from Southeast Asia and elsewhere. Some of these, such as Bambusa vulgaris and B. tulda, have become firmly established and are now widely distributed throughout the island, along highways and banks of streams, and invade pastures. In Texas only one species of bamboo, the giant cane (Arundinaria gigantea), is represented, usually in moist sites.

In Indochina Peninsula bamboos represent one of the most gregarious, and economically the most important group of plants, serving the daily needs of the people of Thailand, Cambodia, Laos and throughout Vietnam. Several genera are extremely tolerant and are found under a variety of climatic and soil conditions. Some species flourish in humid (Rain or Moist) Evergreen forests, others in Dry and Moist Mixed Deciduous, and Gallery forest, and still others in Thorn woodland, and Coastal thickets.

There are at least 10 genera of bamboos in Thailand, of which the most frequent are: Bambusa, Cephalostachyum, Dendrocalamus, Gigantochloa, Oxytenanthera and Thyrsostachys. Individual genera have well defined habitat. In a particular brake there is usually only one dominant species of bamboo, and the habit and general appearance of the brake remain essentially constant. For this reason bamboos are valuable indicators of forest and soil types.

The graceful "phai-si-suk" (Bambusa blumeana) is often grown in the central plain around farmyards and along canals, or "khlongs." The armed "phai-si-suk" (Bambusa blumeana) is tolerant, growing abundantly on alluvial stretches along watercourses as well as on impoverished soils, and frequently forms small clumps in rice fields. "Mai-khai" (Oxytenanthera albo-ciliata) occurs on hills or low plains on lateritic or sandy soils. Dendrocalamus strictus is characteristic of Dry Mixed Deciduous Teak forest, while Bambusa polymorpha and Cephalostachyum pergracile are typical bamboos of Moist Teak forest.

The slender "mai-ruak" (Thyrsostachys siamensis) is one of the most widespread species in continental Thailand, growing in well-drained soils on plains and steep slopes, low in plant nutrients, such as in cutover Teak forests in the north. It is frequently planted as live fences and around farmyards.

Brakes of Bambusa arundinacea are most extensive in the upper Peninsula, and extend to the northwest along the basin of the Maekiong river, formed by the union of the Kwae Yai and Kwae Noi rivers. Along these rivers this armed bamboo forms a fringe, indicating the high-water level in the riparian forest. Its graceful culms, 40 to 50 ft. (12 - 16 m.) long, often arch over the water. On steep, well-drained slopes, with calcareous soil, the gregarious "mai ruak" (Thyrsostachys siamensis) is the dominant bamboo. On level land, in Mixed Deciduous forest, in the middle and upper reaches of the Kwae Yai river, the "mai pak" (Oxytenanthera nigro-ciliata) or the "mai khai" (Oxytenanthera albo-ciliata) are the most frequent species.

In cutover Mixed Deciduous forests of northern Thailand Bambusa arundinacea, Thyrsostachys siamensis and Dendrocalamus strictus soon develop in sites cleared in the forest.

As a rule, bamboos are ready colonizers. Some are fire resistant, and difficult to eradicate, although they can be chemically controlled to some extent. Following clear cutting or burning of forest, the site is soon restocked by new bamboo culms developing from the subsurface rhizomes that have survived fire or other damage. To promote natural regeneration of the forest, the bamboos have to be cut repeatedly or eradicated by means of herbicides.

Certain bamboo species also invade clearings which have remained fallow following shifting agriculture, the "ray" system long and widely practiced in Southeast Asia. Because of their vigorous growth, they suppress other plants, including the hardy and ubiquitous Eupatorium odoratum and the widespread lalang grass (Imperata cylindrica), and even tree species.

Clearing of Evergreen Rain or Moist forest also creates conditions favorable for the establishment of bamboo, especially brakes of Bambusa species. In these forests bamboos and rattans often dominate the undergrowth.

The growth of a bamboo brake is generally uniform, and usually reaches its maximum height in a very short period. Rejuvenation is continuous. A typical bamboo in the dry forest blossoms after a vegetative growth of 20 to 30 years. Soon after flowering and seeding the old culms of most species wither, then break off as a result of decay, which usually occurs during the wet season. The brake regenerates from new culms sprouting from the underground rhizomes or from seedlings that develop in the succeeding rainy season. Thus, a regular rhythm characterizes the development and replacement of the bamboo brake.

For comparative purpose, the following is a list of bamboos which are represented either by genus or species in the Mekong basin countries, and, through introductions, in Puerto Rico.

	Thailand	Indochina 1/	Puerto Rico 2/
Arundinaria baviensis Balansa		X	X
Arundinaria ciliata A. Cam.	X	X	
Arundinaria falcata Nees	X	X	X
Arundinaria pusilla Chev. & Cam.	X	X	
Arundinaria sat Balansa		X	
Arundinaria suberecta Munro	X		
Bambusa affinis Munro	X		
Bambusa agrestis Poiret		X	
Bambusa arundinacea Retz	X	X	X
Bambusa balcooa Roxb		X	
Bambusa blumeana Schultes	X	X	
Bambusa flexuosa Munro		X	
Bambusa latiflora Kurz	X		
Bambusa longispatha Gamble	X		

1/ Includes Cambodia, Laos, North and South Vietnam.
2/ Represented by species or genus, introduced.

	Thailand	Indochina	Puerto Rico
Bambusa macroculmis A. & C. Riv.			X
Bambusa nana Roxb.	X	X	X
Bambusa nutans Wallich		X	
Bambusa pallida Munro	X	X	
Bambusa polymorpha Munro	X		X
Bambusa procera A. Chev.		X	
Bambusa schizostachyoides Kurz		X	
Bambusa tonkinensis Baill.		X	
Bambusa tulda Roxb.	X	X	X
Bambusa tuldoides Munro		X	
Bambusa vulgaris Schrad.	X	X	X
Bambusa vulgaris Schrad. var. striata Gamble		X	
Bambusa wrayi Stapf		X	
Cephalostachyum longbianense A. Chev.		X	
Cephalostachyum pergracile Munro	X		
Cephalostachyum virgatum Kurz		X	
Dendrocalamus asper Back.	X		
Dendrocalamus brandisii Kurz	X	X	
Dendrocalamus flagellifer Munro		X	
Dendrocalamus giganteus Munro	X	X	
Dendrocalamus hamiltonii Nees	X	X	
Dendrocalamus hookeri Munro		x	
Dendrocalamus latiflorus Munro		X	
Dendrocalamus longifimbriatus Gamble		X	
Dendrocalamus longispathus Kurz	X		
Dendrocalamus membranaceus Munro	X	X	
Dendrocalamus nudus Pilger		X	
Dendrocalamus patellaris Gamble		X	
Dendrocalamus sericeus Munro		X	
Dendrocalamus strictus Nees	X	X	X
Dinochloa mac-clellandii Kurz		X	
Dinochloa sp.	X		
Gigantochloa ater Kurz		X	
Gigantochloa cochinchinensis A. Cam.		X	
Gigantochloa compressa Parkins	X		
Gigantochloa kurzii Gamble	X		
Gigantochloa ligulata Gamble	X		

	Thailand	Indochina	Puerto Rico
Gigantochloa scribneriana Merrill		X	
Gigantochloa verticillata Munro		X	
Melocalamus compactiflorus Benth.	X	X	
Oxytenanthera albocilata Munro	X	X	
Oxytenanthera densa G. Cam.		X	
Oxytenanthera dinhensis A. Cam.		X	
Oxytenanthera hayatae A. Cam.		X	
Oxytenanthera hosseusii Pilger	X	X	
Oxytenanthera nigrociliata Munro	X	X	
Oxytenanthera parvifolia Brandes	X	X	
Oxytenanthera poilanei A. Cam.		X	
Oxytenanthera sinuata Gamble		X	
Oxytenanthera stocksii Munro		X	
Oxytenanthera tenuispiculata A. Cam.		X	
Schizostachyum aciculare Gamble	X	X	
Schizostachyum blumei Nees		X	
Schizostachyum chilianthum Kurz		X	
Schizostachyum tenue Gamble		X	
Schizostachyum zollingeri St.		X	
Thyrsostachys oliveri Gamble	X		
Thyrsostachys siamensis Gamble	X	X	

P A L M S

Palms constitute an important element in the vegetation of Southeast Asia. In Puerto Rico, however, there are far fewer species, whether native or introduced. But such palms as the mountain cabbage (Prestoea) figure prominently and form extensive stands in sections of the island. Palms are represented in Texas by only two species, the dwarf palmetto (Sabal minor) and Texas palmetto (S. texana). The latter forms fairly large stands in coastal region of Texas, south of Brownsville.

In Puerto Rico, at elevations above the Rain forest belt on the Luquillo mountains and in the west-central highlands, there is a distinct change in the vegetation in the massing of the mountain cabbage or sierra palm (Prestoea montana, syn. Euterpe globosa). Its lowest altitudinal limit in the Luquillo Mountains is approximately 2,000 ft. (600 m.), compared with about 3,000 ft. (900 m.) in the Central Cordillera. The change from Rain forest to palm brake may be influenced by differences in precipitation, atmospheric moisture, wind exposure, temperature and other factors. The palm brake is probably a seral stage in the successional development of plant cover following the elimination of the original or primary growth.

In the Rain forest in Puerto Rico the sierra palm occurs as scattered individuals in the understory. But at higher altitude it forms a continuous, almost pure stand along the upper slopes of the Luquillo Mountains and particularly in the mountains of Toro Negro in the central part. The transition from Rain forest to palm brake is sharp and well demarcated, and a complete change may take place within a short distance.

Above the Montane forest region, the sierra palm becomes intermixed with elements of the Elfin woodland or Mossy forest. The line of mergence of the two plant communities is less defined than at lower elevation along the upper edge of the Rain forest.

The sierra palm is readily recognized at a distance by the form and size of the leaves, and its pale green foliage. It has a straight, erect, cylindrical trunk, rarely more than 6 inches (15 cm.) in diameter, and up to 30 ft. (10 m.) or so in height. The pinnate leaves, from 6 to 8 ft. (2.0 - 2.5 m.) long, provide a dense shade. The fruit is globose.

Invasion by other species, either from the Mossy forest above or Rain forest below, is hindered by fallen palm leaves which tend to smother the vegetation developing underneath. However, there are occasional specimens of the "yagrumo" tree (Cecropia peltata), a tree fern (Cyathea arborea) and Clibadium erosum, all of which are considered weed plants of the Rain forest. There are also scattered individuals of such trees as Clusia rosea, Cordia borinquensis, Cananga blainii, Alchornea latifolia, Guarea guara and Miconia tetrandra. Shrubs are usually poorly represented. Of these, Psychotria berteriana is the most abundant, attaining a height of 18 ft. (6 m.); also P. uliginosa, and P. maleolus, Duchartrea sintenisii and Daphnopsis philippana, which are of smaller size and are less frequent.

Two woody vines, species of Marcgravia, found in the Rain forest, reach their best development in the Sierra palm brakes. In addition, there are climbing aroids; a climbing bamboo (Arthrostylidium sarmentosum), and epiphytic bromeliads are more abundant than in the Rain forest. Peperomia rotundifolia is frequent along the base of palm trunks. Ferns found in the Rain forest, such as species of Struthiopteris, Hymenodium, Polypodium and Vittaria, are also abundant along the borders of trails.

Herbaceous plants are limited in the number of species as well as of individuals. The most conspicuous is a begonia (Begonia decandra), which finds optimum conditions in the Palm forest, and appears in abundance wherever there is sufficient light. Other herbaceous species in the Sierra palm forest are: Peperomia alata, Sauvagesia erecta, Crantzia ambigua, Physurus plantagineus, Carex polystachya, Alsophila quadripinnata and Lycopodium cernuum.

In Thailand there are about 75 species of palms, scattered throughout the country. Likewise, there are a large number of palm species in the adjoining countries to the east. Of these, the only species in those areas growing in stands, comparable to the extensive brakes of Sierra palm in Puerto Rico, is the Nipa palm (Nipa fruticans), which is characteristic of tidal areas in the Mangrove woodland along the coast of Thailand, South Vietnam, and in limited areas in North Vietnam and Cambodia. The endosperm around the immature seed of the Nipa palm is much esteemed during the dry months, and the leaves are used on a considerable scale for thatch and partitions.

A number of species in the Mekong basin countries are of local importance and are propagated as source of food, or provide materials for thatch or construction. One of the most characteristic palms around homes and hamlets, especially in the southern Peninsula, is the tall, slender and handsome areca or betel palm (Areca catechu), known in Thailand as "mak" and "cau" in Vietnam. Mixed with lime and wrapped in "phlu" leaf (Piper betel), of the pepper family, the dried kernel is widely used in the Indochina Peninsula for chewing.

A characteristic element of the landscape of the rice-growing plains of the Mekong basin countries is the "palmyra palm" (Borassus flabellifer). Known in Thailand as "tanta-not," "thot-lot" in Vietnam, it grows as isolated individuals or in small stands, especially in rice fields, where it is protected. Its inflorescence is tapped as a source of a sap used as a beverage when fermented, and processed to furnish a sugar.

Palms of Thailand and affinity in Indochina and Puerto Rico

	Thailand	Indochina	Puerto Rico*
Adonidia merrillii Becc.	X		
Areca catechu L.	X	S	G
Areca laosensis Becc.	X	S	
Areca triandra Roxb.	X	S	
Arenga pinnata Merr.	X	G	G
Arenga westerhoutii Griff.	X	S	
Borassus flabellifer L.	X	S	
Borassus machadonis Ridl.	X	G	
Calamus caesius Bl.	X	G	
Calamus findlayianum Lindl.	X	G	
Calamus floribundus Griff.	X	G	
Calamus gracilis Roxb.	X	G	
Calamus insignis Griff.	X	G	
Calamus latifolius Roxb.	X	G	
Calamus ornatus Bl.	X	G	
Calamus rotang L.	X	G	
Calamus scipionum Lour.	X	G	
Calamus tenuis Roxb.	X	S	
Calamus trigrinus Kurz	X	G	
Calamus viminalis Willd.	X	G	
Caryota mitis Lour.	X	S	
Caryota urens L.	X	S	G
Cyrtostachys lakka Becc.	X		G
Cocos nucifera L.	X	S	S
Chrysalidocarpus madagascariensis Becc.	X	G	G
Corypha lecomtei Becc. (?)	X	S	G

* = introduced; G = genus; S = species

	Thailand	Indochina	Puerto Rico
Corypha umbraculifera L.	X	G	G
Daemonorops brachystachys Furt.	X	G	G
Daemonorops callicarpus Mart.	X	G	G
Daemonorops didymophyllus Becc.	X	G	G
Daemonorops elongatus Becc.	X	G	G
Daemonorops grandis Mart. var. megacarpus Furt.	X	G	G
Daemonorops kunstleri Becc.	X	G	G
Daemonorops schmidtii Becc.	X	G	G
Didymosperma sp.	X	G	
Elaeis guineensis Jacq.	X	S	S
Eugeissona tristis Griff.	X	S	
Hyophorbe verschaffeltii H. Wendl.	X		S
Iguanara sp.	X		
Korthalsia sp.	X	G	
Licuala glabra Griff.	X	G	G
Licuala grandis Wendl.	X	G	G
Licuala spinosa Wurb.	X	S	G
Licuala triphylla Griff.	X	G	G
Livistona chinensis R. Br.	X	S	G
Livistona rotundifolia Mart.	X	G	G
Livistona sarious Merr.	X	G	G
Livistona speciosa Kurz	X	G	G
Martinezia sp.	X		G
Nipa fruticans Wurmb.	X	S	
Oncosperma horrida Scheff.	X	G	
Oncosperma tigillaria Ridl.	X	G	
Phoenix acaulis Ham.	X	G	G
Phoenix dactylifera L.	X	G	G
Phoenix humilis Royle	X	S	G
Phoenix loureiri Kunth	X	G	G
Phoenix paludosa Roxb.	X	G	G
Phoenix sylvestris Roxb.	X	G	G
Pinanga disticha Bl.	X	G	G
Pinanga hookeriana Becc.	X	G	G
Plectocomia griffithii Becc.	X	G	
Pritchardia pacifica Seem. & Wendl.	X		G
Ptychosperma macarthurii Wendl.	X		G
Rhapis excelsa Henry	X	G	G
Rhapis humilis Bl.	X	G	G
Roystonea regia Cook	X	S	S
Stevensonia grandifolia Dunc.	X		
Teysmannia sp.	X		
Thrinax excelsa Lodd. & Griseb.	X		G
Verschaffeltia splendida H. Wendl.	X		

	Thailand	Indochina	Puerto Rico
Wallichia caryotoides Roxb.	X	G	
Wallichia disticha Anders.	X	G	
Zalacca conferta Griff.	X	G	
Zalacca edulis Reinw.	X	G	
Zalacca secunda Griff.	X	C	
Zalacca wallichiana Mart.	X	S	

SUCCESSIONAL GROWTH

While the primary forest - the humid evergreen, mangrove, deciduous or seasonal forest - is of importance to the ecologist, forester and other specialists, another equally important phase of vegetation to be considered is the secondary or successional growth that develops following partial or complete destruction of the original forest. Many species of plants that grow in the primary forest do not appear in secondary growth. Likewise, the majority of plants that thrive in the successional phase do not occur in virgin forest. Some stands of second growth thickets, especially those containing spiny shrubs and small trees, grasses with sharp leaf-edges, or bamboos, are often more difficult to penetrate than even the most dense undergrowth in a virgin humid forest.

It is astonishing to see how rapidly a clearing opened in a forest or even in abandoned land is occupied by weeds and shrubbery. It is well known that in the humid tropics plant growth is exceedingly rapid, but the rapidity of its development can be appreciated only by actual observation. Trails cut through the forest, unless kept open, are closed within a few weeks or months. If rubber plantations, such as those of South Vietnam, southeast and southern peninsular Thailand, are not constantly kept free of plant pests the ground is soon covered with coarse weeds and grasses, shrubs and vines. When cultivated land is left to itself during the wet season, in the course of a couple of months it will be so densely covered with tall, lusty herbs that it is practically impossible to force a way through without the use of a bush-knife. An idea of the rank nature of vegetation in such sites may be gained by inspecting the thickets of giant ragweed (Ambrosia trifida), found in rich alluvial soil in the Mississippi Valley.

In Puerto Rico there is a large number of weedy plants that grow almost throughout tropical America and many are pantropical in distribution, but are seldom, if ever, found in primeval forest and savanna. Almost all of these are American in origin. Their widespread distribution, abundance, vigor and diversity are probably the result of long association with the human race. If man abandoned a region for a few centuries, it is probable that most of these weedy plants would gradually disappear.

In tropical America and Southeast Asia the successional pattern of second-growth development is essentially the same, although species in the respective areas may be distinct. Wherever banana plantations in tropical America are abandoned, the banana plants persist for several years, but there is a gradual diminution in fruit production, until finally they are choked by coarse herbs, shrubs, and quick-growing trees. Similarly there are extensive patches which at one time were cleared for manioc, corn, or pasture, but are now abandoned. Untilled land is soon populated by aggressive herbaceous plants, most of which do not exist in the virgin forest. Dominant second-growth herbs are pokeweed (*Phytolacca rivinoides*), *Neurolaena lobata*, *Eupatorium macrophyllum*, *Acalypha costaricensis* and *Pavonia rosea*.

A host of shrubs later flourish in these sites. Some grow as rapidly as herbs, and a few quickly attain the size and habit of small trees. Common shrubs or small trees in tropical America are: *Lantana camara* (found also in Thailand) *Hamelia patens*, *Eupatorium odoratum* (also widespread in Thailand), *Baccharis trinervis*, *Cestrum nocturnum*, *Solanum diversifolium*, *Piper aduncum* and *P. multinervium*, *Bursera simaruba*, *Acalypha diversifolia*, *Cordia ferruginea*, *Malvaviscus grandiflorus*, and species of *Gliricidia*, *Trema*, *Gouania*, *Heliocarpus*, and *Triumfetta*. In these sites also there is an abundance of *Cecropia* trees which, throughout tropical America, are always at their best in second-growth, although they are frequent also in the primeval forest. Several plants armed with spines abound in second-growth thickets. One of the worst pests in banana plantings in Central America is "zarza hueca" (*Byttneria*), often forming dense interlacing tangle in exposed thickets. *Mimosa hondurana*, armed with fine, closely set and recurved spines, climbs over other shrubs, and attaches to one's clothes in a fiendish manner. Wherever *Mimosa invisa* grows abundantly it is a formidable barrier, almost impossible to force a way through.

In the West Indies secondary communities of different ages are very frequent. In Guadeloupe, according to Stehlé, the first colonizers of open sites in forests at low and medium altitudes, comparable to lower Montane forest, are such weeds as species of *Ageratum*, *Hyptis*, *Ipomoea*, *Lantana*, etc. Stehlé recognized two types of older secondary communities in the middle region. Where the original humus layer still exists, the plant community consists of trees of the genera of *Cecropia*, *Hibiscus*, *Ochroma* and *Oreopanax*. In this community, also tree ferns, mostly species of Cyathea and Gleichenia sp., are found. The last named fern is common in secondary communities in humid tropical regions. In sites, at lower altitudes, at one time tilled and where the humus layer had been destroyed, there develops a scrub dominated by species of Croton and Miconia.

Kenoyer reconstructed the sequence of succession on old clearings in Barro Colorado Island, Panama. In the first stage of colonization the dominant plants are grasses, represented by about 20 species, and sedges (species of Scleria and Cyperus). Short-lived dicotyledonous herbs, of the families Amaranthaceae, Compositae, Euphorbiaceae, Mimosoidae, Solanaceae, etc., are also frequent. After one year heliconias and the panama-hat palm (Carludovica palmata) appear, and numerous seedlings of shrubs and trees dominate the next stage. These include species of Apeiba, Cecropia, Cordia, Ochroma, etc., and some herbaceous plants which do not develop during the first year. Woody vines appear later, and the vegetation by now, up to 5 or 6 feet tall, forms an almost impenetrable tangle. After two years, a young secondary forest is formed, in which trees such as species of Cecropia, Ochroma limonense (balsawood), and the palm Attalea gompnococca are conspicuous, and become dominant. This community still persists after 15 years and gradually becomes richer with the appearance of other species. Trees represented by species of Ficus, Inga, Protium, also melastomaceous trees and shrubs, and many others develop. Woody vines are numerous, including the ribbon-like Bauhinia excisa. Herbaceous and shrubby undergrowth is abundant. In later years a number of species present in the primary forest become established, so that the plant community becomes much denser and more difficult to penetrate than the primary forest. According to indications, the successional growth would eventually lead to the development of a climax forest.

The grasslands of Texas, according to H. N. Smith of the U. S. Soil Conservation Service, were once among the most luxuriant in the nation, and the base for a great livestock industry. Early travelers and writers mention trees scattered through the State, as bands or mottes of trees and other woody growth, along watercourses and on rocky or gravelly hills. Mesquite and other undesirable woody plants undoubtedly grew in small stands and produced seed which, if unchecked, were capable of spreading over the grasslands. Heavy use of grassland, coupled with drought, brought about a change in the natural grass cover, resulting in serious infestation by hardier but undesirable woody plants, which may be classed as second-growth. Fifty percent of this area is so densely infested that satisfactory forage production cannot be obtained without some form of brush control to reduce competition.

Smith and Rechenthin consider the following as the major undesirable woody plants, or brush, that have developed as secondary growth on rangeland in Texas:

Blackbrush Acacia - Acacia rigidula Benth.: Genus (Acacia) well represented in Puerto Rico and Southeast Asia.

Cactii - species of Opuntia, Echinocactus, Echinocereus, etc.: Abundant in tropical dry areas.

Creosote bush - Larrea divaricata Cov.: Does not occur in Puerto Rico or Southeast Asia.

Guajillo - Acacia berlandieri Benth.: Genus (Acacia) well represented in Puerto Rico and Southeast Asia.

Huisache - Acacia farnesiana (L.) Willd.: Occurs also in Southeast Asia and Puerto Rico.

Junipers (Cedars) - Juniperus spp.: Genus represented by introduction in Puerto Rico.

Macartney rose - Rosa bracteata Wendl.: Introduced from South China.

Mesquite - Prosopis juliflora var. glandulosa (Torr.) Cock.: Frequent in Puerto Rico.

Oak, blackjack - Quercus marilandica Muenchh.: Oaks are well represented in Southeast Asia by distinct species; several Asiatic and North American species have been introduced into Puerto Rico.

Oak, live - Quercus virginiana Mill.

Oak, post - Quercus stellata Wangh.

Oaks, shin - Quercus mohriana Buckl., etc.

Salt cedar - Tamarix gallica L.: This species has been introduced into Puerto Rico from Europe.

Sand sagebrush - Artemisia filifolia Torr.: This genus is represented by introductions in Puerto Rico and is found also in Southeast Asia.

Tarbush - Flourensia cernua DC.: Not represented in the other countries.

White brush - Aloysia ligustrina Small: Genus represented in Puerto Rico and other parts of tropical America.

Winged elm - Ulmus alata Michx.: The elm family occurs in Puerto Rico and Southeast Asia.

Yaupon - Ilex vomitoria Ait.: There are many species of this in Puerto Rico, and the genus is also represented in Southeast Asia.

In the tropical Rain forest climate, soil, vegetation, and fauna are factors that contribute to the maintenance of equilibrium in a very complex plant community. But when one of these components, such as the primary forest is disturbed by felling and/or burning the other components, in turn, undergo a radical change. Removal of the canopy increases the illumination at ground level from a small fraction to daylight. The range in temperature increases while the minimum atmospheric humidity is lowered. Exposure to sun and air alter the properties of the soil. Where there are steep slopes, erosion will commence to remove the surface soil layers, and increase in soil temperature leads to a rapid disappearance of humus. The subsequent vegetation that develops becomes adjusted to the microclimate, the altered soil conditions, and to the changed conditions of the habitat.

The first phase of successional growth following the disturbance of dense, humid forest, whether in tropical America or Southeast Asia, is usually dominated by weeds and grasses. These are generally short-lived, often less than one year. The next phase may be dominated by shrubs, followed by small, soft-wooded trees. Or the succession may lead almost directly from the herbaceous stage to tree dominance. This secondary forest is usually composed in great part of trees, which are soft-wooded, of fast growth, and are wind- or animal-dispersed.

Little is known of the time needed in the tropics for the secondary or successional stages to develop into a climax forest. Chevalier states that the forest surrounding the famous temple of Ankor Vat in western Cambodia was probably destroyed 500 to 600 years ago. The forest now existing in that area resembles the original primeval forest, but certain differences are still noticeable.

In Thailand, as in other Mekong basin countries, among the initial herbaceous plants that appear most frequently following the destruction of a patch of forest, are the common weed (Eupatorium odoratum), introduced from this Hemisphere, and the ubiquitous Imperata cylindrica grass. Both plants are light-loving and cannot thrive under shrubs or trees. These weeds also occur in abundance wherever land has been tilled for one or two crops and afterwards abandoned. Later the ground is colonized by shrubs such as species of Melastoma and Lantana. The shrub stage is followed by the development of a typical secondary forest, in which trees of the genera Bombax (Salmalia), Dillenia, Grewia, and Vitex appear, as well as species of wild bananas (Musa). But very often in Thailand, as in the other Mekong basin countries, the weeds, grasses and woody plants are gradually dominated by bamboos, particularly species of Bambusa, Thyrsostachys and Oxytenanthera, which may even suppress the development of tree species.

In the American tropics the successional growth in Rain forest is similar in structure to secondary Rain forest in the Old World, although it is quite different, of course, in floristic composition. The grass Imperata cylindrica, so frequent in secondary growth in the Old World tropics, does not occur in tropical America except in Chile, but I. brasiliensis and other grasses play an analogous part. Intertwining sedges of the genus Scleria, with sharp-edged leaves, often form an almost impenetrable tangle in secondary forests of northern South America.

Weeds of the following genera are frequent throughout tropical America. Many of these, and even identical species, occur in Texas and Southeast Asia:

Aeschynomene	Cuphea	Iresine	Phyllanthus
Ageratum	Cyperus	Mimosa	Piper
Alternanthera	Desmodium	Jussiaea	Priva
Amaranthus	Digitaria	Melanthera	Pseudelephantopus
Asclepias	Drymaria	Melothria	Rivina
Axonopus	Echinochloa	Miconia	Salvia
Bidens	Eragrostis	Mikania	Scleria
Blechum	Eclipta	Momordica	Setaria
Boerhaavia	Erechtites	Neurolaena	Scoparia
Borreria	Euphorbia	Oplismenus	Sida
Cassia	Fimbristylis	Panicum	Solanum
Chamissoa	Gomphrena	Paspalum	Tridax
Commelina	Hyptis	Pavonia	Triumfetta
Crotalaria	Indigofera	Petiveria	
Croton	Ipomoea	Phaseolus	

In addition to these, other woody species appear in secondary growth, as well as many coarse grasses of low food value.

In the more humid parts of tropical America the soft-wooded trees of the genus Cecropia are a characteristic element of young secondary forest. These trees may form almost pure stands, especially along river banks. In Puerto Rico, "yagrumo hembra" (Cecropia peltata) is the most frequent, and is found almost throughout the island. It propagates naturally, and at first growth is rapid (2 - 3 inches in diameter in one year), but requires nearly full sunlight. Another typical tree component of the secondary forest in the island is "yagrumo macho" (Didymopanax morototoni), scattered in forests especially of the lower moist coastal and moist limestone regions. Even the large stands of the mountain cabbage palm (Prestoea montana) in some areas, as in the highlands of Toro Negro, may be considered to be seral, having invaded sites previously occupied by primary forest.

Successional growth - Luquillo Rain Forest

Studies made during June 1966 in a series of plots at (a) El Verde and (b) Jiménez, in the Luquillo National Forest of Puerto Rico, indicated that no matter what form of disturbance may take place, either by felling, clearing, burning, or by the adoption of other techniques, the regrowth is essentially similar throughout. The rate of development and density of species occurring in the new growth are indicative of their adaptability to the modified micro-climate and other altered environmental conditions. Species that occur in the primary growth gradually reappear in the ground layer of the successional growth. It is apparent that the development of successional growth and recovery of a Tropical Rain forest proceeds at a more rapid rate than in a Temperate Rain forest.

(a) In the Jiménez site, eight months after treatment, the ground layer in 6 one-acre plots, covered from 40 to 100 percent of each plot area, and measured from 6 to 24 inches in height, but some grasses reached up to 6 feet high. The average height of the canopy ranged between 50 and 70 feet. The following species, representative of the various layers in the primary growth, were most frequent in the overall plots: 1/

Top Story:

Alchornea latifolia - f
Byrsonima spicata - ff
Banisteria laurifolia - ff
Cecropia peltata - vf
Cordia berteriana - o
Cordia borinquensis - o
Cordia sulcata - o
Dacryodes excelsa - o
Daphnopsis caribaea - o
Didymopanax morototoni - vf

1/ vf = very frequent; f = frequent; ff = fairly frequent; if = infrequent; o = occasional.

Top Story - continued:

Didymopanax gleasonii - o
Drypetes glauca - o
Eugenia borinquensis - o
Eugenia stahlii - o
Guarea trichilioides - ff
Hirtella rugosa - o
Hirtella triandra - o
Homalium racemosum - f
Inga fagifolia - vf
Inga vera - o
Linociera domingensis - vf
Manilkara nitida - f
Matayba domingensis - vf
Myrcia deflexa - vf
Myrcia splendens - vf
Ocotea leucoxylon - o
Ormosia krugii - o
Rapanea ferruginea - o
Sapium laurocerasus - f
Tabebuia heterophylla - f

Middle and Lower Stories:

Casearia sylvestris - o
Comocladia glabra - ff
Ixora ferrea - vf
Lasianthus lanceolatus - o
Miconia spp. - o
Palicourea riparia - f
Piper treleasenum - o
Psychotria berteriana - f
Senegalia wetteniana - o
Solanum torvum - f
Trema micrantha - o
Trichilia pallida - f

Lianes:

Cissampelos pareira - o
Philodendron krebsii - o
Rajania sp. - o
Rourea glabra - o
Smilax coriacea - ff

Undergrowth - herbaceous:

Alsophila borinquena - if
Dryopteris sp. - o
Elephantopus sp. - o
Heliconia bihai - f
Heliconia caribaea - o
Ichnanthus sp. - ff
Paspalum virgatum - f
Philodendron ligustrum - o
Phytolacca rivinoides - o

(b) In 20 plots, each 80 x 100 feet, at El Verde site, also checked eight months after treatment, the new ground layer covered from 40 to 80, and where grasses were abundant up to 100, percent of the plot area; ranging from 12 to 24 inches in height, and up to 6 feet tall in the case of some grasses. Seedlings of the following species were recorded:

Top Story:

- Alchornea latifolia - f
- Andira inermis - o
- Beilschmiedia pendula - o
- Buchenavia capitata - o
- Casearia arborea - o
- Casearia guianensis - o
- Casearia sylvestris - vf
- Cecropia peltata - vf
- Croton poecilanthus - f
- Dacryodes excelsa - f
- Daphnopsis caribaea - o
- Didymopanax morototoni - vf
- Drypetes glauca - o
- Guatteria blainii - if
- Guarea trichilioides - vf
- Guettarda scabra - f
- Hirtella rugosa - f
- Hirtella triandra - o
- Inga fagifolia - f
- Manilkara bidentada - o
- Matayba domingensis - vf
- Myrcia deflexa - f
- Myrcia splendens - vf
- Ocotea leucoxylon - vf
- Ocotea portoricensis - if
- Ormosia krugii - vf
- Prestoea montana - vf
- Roystonea borinquena - f
- Sapium laurocerasus - vf
- Sloanea berteriana - f
- Tabebuia heterophylla - vf
- Tetragastris balsamifera

Middle and Lower Stories:

- Ardisia glauciflora - o
- Banisteria latifolia - o
- Banisteria laurifolia - vf
- Byrsonima coriacea - o
- Byrsonima spicata - o
- Comocladia glabra - vf
- Cordia borinquensis - vf
- Cyathea arborea - o
- Elephantopus sp. - o
- Eugenia borinquensis - o
- Eugenia stahlii - o
- Gomedesia lindeniana - f
- Guarea ramiflora - f
- Heliconia bihai - f
- Heliconia caribaea - f
- Inga vera - o
- Ixora ferrea - f
- Lasianthus lanceolatus - o
- Linociera domingensis - vf
- Miconia prasina - f
- Miconia tetrande - f
- Ocotea floribunda - vf
- Ocotea tetrandra - if
- Palicourea riparia - vf
- Palicourea rigida - o
- Piper aduncum - vf
- Prestoea montana - vf
- Psychotria berteriana - vf
- Rapanea ferruginea - if
- Rourea glabra - f
- Rourea surinamensis - f
- Solanum torvum - f
- Trichilia hirta - if
- Trichilia pallida - vf
- Trichilia virgata - if

Lianes:

- Philodendron spp. - f
- Rourea glabra - o
- Smilax coriacea - o

Undergrowth - herbaceous:

- Chloris sp. - o
- Elephantopus sp. - o
- Ichnanthus sp. - f
- Paspalum virgatum - vf
- Paspalum spp. - vf

AERIAL SURVEYS OF VEGETATION

In his first Report on the "Vegetation of Southeast Asia" (CR 49-65, December 1965), the author emphasized the practical value of aerial surveys to complement ground studies of vegetation, to expedite the task of making forest inventories, to evaluate the distribution and extent of forest types or formations, and to assess the effect of herbicides in the control of vegetation.

Aerial photographs also facilitate the identification of many individual plants, which may be indicative of the soil and habitat in general, by studying certain characteristics of trees, such as height, form and size of the trunk, color of the bark, crown diameter and coverage, thickness of the branches, color and density of foliage, and whether a tree is evergreen or deciduous.

The best time to take aerial photographs in Thailand, and probably in the other Mekong basin countries, is during the dry season, from the middle of November to the end of March. During this period most of the forests, especially the Deciduous, are in their driest state. I found that the most satisfactory interpretation is obtained from photographs taken at an oblique angle of about 30°, opposite to the direction followed by the plane, and at an altitude of 1,000 to 2,000 ft. (300-600 m.), depending of course on weather conditions and the amount of haze or smoke in the atmosphere, which naturally affects the depth of visibility.

Of dryland forests, such obvious types as Semi-evergreen and Dipterocarp forests, and savannas can be readily recognized. In Mangrove or swampland forests, the gradual change in species from the seaward fringe to the landward side are readily recognizable from the air; also stands of Nipa palm (Nipa fruticans), and cajeput (Melaleuca leucadendron) in post-mangrove areas, with brackish water, can be readily spotted. While the perpetually dark green canopy of the humid (Rain or Moist) forest is very distinctive, identification of individual trees is oftentimes somewhat difficult. Because of the absence of even small stands of any particular species, the forest appears as a monotonous, almost solid blanket of green. On closer study, however, it appears as a mosaic of several shades, varying with the species and light.

In Thailand, it was observed that certain individual tree species have some distinguishing features which are recognizable when seen from the air at low altitudes. For example, the round, light-colored trunk of "yang-khao" (Dipterocarpus alatus) is distinguishable from the almost white, fluted bole of "tabaek" (Lagerstroemia calyculata). Many species of wild fig trees (Ficus) have widespreading, umbrella-shaped crowns, and corpulent branches. Teak trees (Tectona grandis) can be readily spotted in the northern forests of Thailand during the months of January and February by the gray tone of their crowns which are practically leafless at that time. Plantations of Pará rubber (Hevea brasiliensis) are recognizable from the air, by the pattern of planting, often rectangular; in January by the yellowish tint of old leaves about to fall, and later by the slender, grayish trunks visible through the almost leafless crowns with slender branches.

In Puerto Rico, also, Duke made some interesting observations on the identification of forest formations and individual tree types as seen from the air. In flying over the Luquillo National Park, the heterogeneous, uneven, mosaic of many shades of green distinguishes the Rain forest at medium elevation from the Montane woodland, palm brakes, and Elfin thicket on the upper slopes. The high frequency of the semi-deciduous crowns of "roble" (Tabebuia heterophylla) is noticeable from the air, especially in April, when the trees are leafless. At that time the pink flowers make this tree even more striking as seen from above. The broad spreading crowns of the deciduous Buchenavia capitata are also quite striking. But the dark green, flat canopy of stands of Calophyllum, often with a bronze hue, is somewhat difficult to distinguish from the Montane woodland of Cyrilla.

By means of aerial photographs, taken on a windy day, it is possible to estimate the frequency of Cecropia, with its large leaves silvery beneath, in relation to Didymopanax, also with large leaves but gold-colored on the underside. Similarly the relative proportion of the palms, Prestoea and Roystonea, may be evaluated. Roystonea is distinguished from Prestoea by its darker green leaves, without a yellowish tinge, and with finer divisions of the fronds.

The dark green canopy of stands of Cyrilla - Micropholis in the Luquillo forest makes this formation readily detectable in aerial survey. The Elfin thicket is also distinguishable by its wind-swept, low grayish-green canopy often interrupted by rocks.

In Puerto Rico, as in Thailand, vertical visibility is best in the Seasonal Semi-evergreen forest during the dry season. Among deciduous or semi-deciduous trees near the test plots, the following could be recognized: Buchenavia capitata, Gliricidia sepium, Guazuma ulmifolia, Homalium racemosum, Tabebuia heterophylla and species of Casearia, Cedrela, Cordia, and Ficus.

During the dry season, the somber gray of the Deciduous Seasonal forest, when the trees are leafless, is quite conspicuous. Some plants that can be spotted are the large cactus, Pilocereus royeni, Bursera simaruba tree with its reddish trunk, and Bucida, on account of its characteristic crown and a few persistent yellowish leaves. At low altitude, Cactus scrub may be recognized by the columnar cacti overtopping the maze of bramble. A checkerboard pattern is produced in plots treated with herbicides. Cactus scrub varies from open sparse stands to thickets in which vertical visibility is hampered by leaves and stems.

Open park-like stands of Prosopis and Acacia trees near the southwest coast are easily distinguished because of their light green, fairly broad crowns dotting the semi-bare ground. However, when the canopy is closed it is not easy to distinguish the Thorn woodland from Cactus scrub.

It is difficult to delineate from the air the Pterocarpus swamps from Icaco thickets, such as those occurring in brackish water along Dorado beach on the north coast. But during the dry season, the Pterocarpus tree is conspicous, especially in April, when the orange-yellow flowers appear. Coconut groves and stands of Australian pine (Casuarina equisetifolia) along the coast, readily recognizable from the air, indicate a type of terrain that is more easily trafficable than in other coastal forest associations.

During April and May, the young copper-colored leaves of wind-swept thickets of Coccoloba uvifera are very distinctive from the air. The darker red young leaves of Terminalia catappa, and the conical form of its crown, are recognizable on the landward side of thickets.

Low, wind-swept vegetation on dry coastal sands appears from the air as a coastal hedge. These littoral hedges usually have a dense foliage, but their generally low stature does not impede vertical visibility.

It is not easy to distinguish between natural savannas and the Prosopis - Acacia orchards. Thorn savannas appear to offer better emergency, and even permanent, landing strips than natural savannas. In the savannas of Southeast Asia, for example, grass between trees gives the entire area a light tone. Individual trees with foliage stand out as dark spots, but when they are devoid of leaves they appear as light spots. In Puerto Rico natural savannas are very limited in area and do not represent any significance in aerial photographs. However, in the West Indies and Central America, palm and pine savannas can be distinguished from aerial photographs. In areas where the palms have fan-shaped leaves, the ground is usually firmer than in areas where pinnate-leaved palms predominate.

In the Mangrove woodland of Puerto Rico, as in Southeast Asia, it is important for persons making aerial surveys to be familiar to some degree with the various species as seen from the air, because the problems of mobility and trafficability vary appreciably even within a limited area. Red mangrove is almost impenetrable, while black mangrove has a more open aspect. Stands of red mangrove are limited in Puerto Rico, generally confined to the seaward margin, but there are extensive stands of Rhizophora in the delta areas of Southeast Asia. White mangrove, which is common in Puerto Rico, is difficult to distinguish from red and black mangrove. Its stilt roots cannot be seen through the light green canopy, and the trunk is not as dark as red mangrove. The central part of the swamps is largely occupied by white mangrove, often mixed with the black species. Buttonwood (Conocarpus) and the pantropical mahoe (Hibiscus tiliaceus) frequently have a yellowish hue, and appear as scattered individuals along the landward side of swamps.

In Puerto Rico, as in Southeast Asia, circular pads in or near the mangrove woodland, usually on the landward side, are occupied by the swamp fern (Acrostichum aureum). A dark green strip separating the dryland forest from the mangrove swamp is a characteristic pattern created by this large fern. This should not be confused with the Nipa palm (Nipa fruticans), which usually has short leaning trunk and large, somewhat feathery fronds, and light-colored when seen from the air.

The dense, dark green, narrow belts of riparian or gallery forest so familiar along watercourses are readily distinguishable from the air in both temperate and tropical regions. However, bamboos are somewhat difficult to recognize on small-scale photographs. On scales upwards of 1:10,000 bamboo brakes resemble clusters of feathers rising high above the ground, and the tone is generally lighter than other trees in the stand.

The aquatic plant of swamps and coastal marshes, Montrichardia, can be spotted from the air from its large vertically orientated leaves. Species of tall grasses and sedges, which occupy the same habitat, are difficult to distinguish, and have a general resemblance to sugar cane. Of herbaceous plants in swamps, it is possible to recognize *Typha angustifolia*, *Colocasia esculenta*, water lilies, as well fruiting cattails at low altitudes.

PLANTS FOR SURVIVAL

The function that plants serve as sources of food, water and shelter is of considerable importance to the military in the field, especially when operating in remote, sparsely populated areas or during periods of emergency.

There are numerous plants throughout the tropical and temperate regions of the New and Old World that are useful to man in some form or other. Many food plants have been introduced from the American tropics to Southeast Asia. Likewise, a number of plants of the Old World which furnish edible fruits or seeds, have been brought into the New World tropics, have become naturalized and grow spontaneously. They are grown usually in well populated areas, sometimes in open sites, such as rice fields, but seldom do they escape into the primary forest.

Most plants are harmless and may be eaten with safety when cooked. Fortunately, only a small proportion may be considered toxic or injurious. In addition to plants cultivated around abodes and in populated areas, tropical forests contain, during some period or other of the year, a variety of fruits, seeds, and underground tubers that are edible. Also, the terminal buds of most palms or the pithy interior of certain species of palms may be eaten and a large number of plants may be used as potherbs. For example, the inhabitants of northeastern Thailand have long resorted during periods of famine to gathering "wild" or spontaneous plants in the surrounding forests, to supplement their meager supply of rice.

It is often difficult for the man in the field to determine whether a plant or fruit is edible or poisonous. This is particularly true in unfamiliar tropical surroundings. A few simple rules should be followed: (a) Do not eat plants that have a bitter taste or offensive odor. (b) Avoid contact with any plant that exudes a milky sap, and do not eat any parts of such plants except those that are familiar such as papaya fruit. (c) It is generally assumed that any food eaten by monkeys is safe for human consumption, but it should be taken only in minimal quantities at first to determine the reaction.

Some leaves, flowers, fruits, seeds, bulbs and roots may be eaten raw; others should be boiled or fried. Such plants as cassava or manioc require repeated cooking and several changes of water to eliminate the toxic substance present and to render them non-toxic. The well-known cashew nut, in the fresh state, should be thoroughly roasted. Taro root also requires thorough cooking to eliminate the needle-like crystals which may cause irritation to the throat. If one is uncertain about a plant, the best step is to cook it thoroughly, change the water at least once, and eat only a small quantity at least in the beginning.

There follows a brief description of some of the principal sources of food plants in Southeast Asia.

Grass family: To this large group belong our cultivated cereals, such as corn, rice, rye, millet, sorghum, bamboos, sugarcane, all of which are distributed in tropical regions, in addition to wheat, barley, oats and rye, which are important crops of temperate areas. A wild species of sugarcane (Saccharum spontaneum), a coarse-leaved grass, known as "phong" (Thai) or "lau" (Viet.), and up to 9 ft. (3 m.) tall, is frequent in Southeast Asia in rich soil in valley bottoms. In some areas the hearts of the young shoots are frequently eaten raw or cooked.

Some of the wild grasses have fairly large seeds, and are produced in abundance. Freed of chaff, these may either be boiled or roasted. Other wild grasses, again, have smaller seeds than our cultivated cereals, such as oats, barley, wheat or rye. They are perfectly safe to eat, and are actually used by the natives in time of emergency.

Coix lachryma-jobi. Job's tears; Du'ai (Thai); Cuo'm-gao (Viet.). A coarse grass, up to 3 ft. (1 m.) high, abundant especially in open sites. The large seeds may be eaten raw boiled or roasted.

Setaria spp. Khao-fang (Thai). A coarse grass up to 6 ft. (2 m.) high, abundant in old clearings, on old plantations, along shaded ravines and forest borders. Hearts of young shoots may be eaten raw or cooked. The numerous small seeds may be boiled or roasted and are used as famine food.

Ferns: The number of species of ferns in tropical regions is very great. Some are small or insignificant; others, like tree ferns, may be relatively large in size. While their food value may be somewhat low, parts of ferns may be useful for survival when other foods are not available. The parts most commonly used are the "fiddle heads" or the young unfolding leaves. These may be eaten either raw or cooked. Some fiddle heads are tough, others are bitter or otherwise distasteful. But so far as is known no ferns are actually poisonous when eaten.

Tree ferns (Cyathea) are found chiefly in the Rain forest, although they may sometimes be found in abandoned clearings in somewhat moist sites. The young leaves as they begin to uncurl, or fiddle-heads, are tender and may be eaten raw or cooked. The terminal head or "cabbage" may also be eaten. There are several species of tree ferns reported in the Mekong basin countries.

Palms: There are many species of palms scattered throughout Southeast Asia, tropical America and elsewhere. They vary greatly in size and habit. Some are low and shrubby, others like the betel nut palm (Arenga), are tall and slender, and still others are gigantic in size. Some species grow along seashore, such as coconut (Cocos nucifera); others, like the nipa palm (Nipa fruticans), near the seacoast within reach of tidal waters. The "tanna" palm of Thailand (Borassus flabellifer) is protected in rice fields or open areas. Some palms grow in thickets or secondary growth, and still others are found in high forest. Representatives of several genera of palms (Corypha, Arenga and Caryota) of Southeast Asia store up great quantities of starch in their trunk. This starch is a valuable food. Generally the terminal bud or "cabbage" of most palms is edible and may be eaten raw, boiled or roasted. This bud is found deep in the terminal crown of leaf stalks. Except in cases where it may be too bitter, palm cabbage is an excellent vegetable.

Except for the coconut and a few other palms, the fruits of many of the Southeast Asian palm species are not edible. In fact those of the betel-nut palm (Arenga) and fishtail (Caryota) contain minute stinging crystals which cause intense pain on contact with the mouth or tender skin.

Metroxylon spp. Sago palm; sa-khu (Thai). This palm is usually found in freshwater swamps. It grows up to 25 to 30 ft. (8 - 10 m.) high. The trunk is rich in starch, the source of commercial sago, and which is the basic food of the natives in parts of Malaysia. The terminal buds or cabbage may be cooked and eaten as a vegetable.

Calamus spp. Rattan; Wai-hin, wai-chang, wai-khom (Thai); May, may soc, may min (Viet.). There are many species of rattan palms, found chiefly in the moist high evergreen forest. They grow for considerable length along the ground and climb to a great height. The leaf stalks and leaves are armed with claw-like spines. The leaf tips are greatly extended and also armed with sharp spines. In many species the basal part of the stem is slightly swollen and contains some starch. This lower part may be roasted and the cooked starch eaten. The stems also yield a somewhat potable but tasteless water.

Corypha spp. Caryota fishtail; Buri, lan, tao-rang (Thai); Cay la buon, dung-dinh (Viet.). Like sago palm, these palms store up great quantities of starch in their trunk, which may be used as food. The tender leaf tips or cabbage may also be cooked and eaten.

Borassus flabellifer. Palmyra or sugar palm; Tanna or tanta-not (Thai); Thot-lot (Viet.). This tall palm is widely distributed and frequent in Thailand and other parts of Southeast Asia, especially in rice fields, where it is protected. The sap tapped from the base of the inflorescence is used as a beverage, and to some extent as source of sugar.

Cocos nucifera. Coconut; Ma-phrao (Thai); Duà (Viet.). This is one of the most commonly cultivated palms in tropical regions. The large terminal leaf buds, or cabbage, is one of the finest vegetables, and may be eaten in quantity, either raw or cooked. The nut yields the best drinking water, while the meat may be eaten in any stage of development.

Nipa fruticans. Nipa palm; Chak (Thai); Dừa nuoc, dừa la (Viet.). This stemless palm, up to 15 ft. (5 m.) high, grows along tidal streams back of mangrove swamps, where it is within reach of the influence of salt or brackish water. The solitary dark brown, rounded heads of fruit is about 1 ft. (30 cm.) or more in diameter. The large white seeds may be eaten when immature and resemble coconut in flavor. When fully mature the seed is hard and has to be crushed or grated if eaten.

Some edible fruits of Southeast Asia:

Achras zapota: Sapodilla; La-muat-farang (Thai): Xa-bo-che, (Viet.). A medium-sized tree, up to 25 ft. (8 m.) or more tall, exuding a milky sap. Introduced from tropical America, it is cultivated and grows spontaneously in Southeast Asia, but not in the high forest. The fruit is grayish to brown, round to oval. Reddish-brown to pinkish-white pulp is sweet, somewhat granular and edible; the large, black smooth seeds are not eaten.

Anona muricata: Sour sop; Thu-rian-khaek (Thai); Mang-cau xiem (Viet.). A tree about 15 ft. (15 ft. (5 m.) high, generally cultivated, but sometimes wild; usually near settlements, but does not grow in the forest. The large greenish fruit has a good flavor and is always eaten raw.

Anona reticulata: Custard-apple, Noi-nong (Thai); Cay-bình bát (Viet.). A tree, about 15 ft. (5 m.) tall, similar to sour sop. Grows chiefly under cultivation, but not in the high forest. The large fruit has a good flavor and is eaten raw.

Anona squamosa: Sugar-apple; Noi-na (Thai); Mang-cu dat (Viet.). This small tree, about 15 ft. (5 m.) high, is found in cultivation and wild, near settlements, but not in high forest. The pale green, medium-sized fruit has an excellent flavor and is eaten raw.

Artocarpus spp. There are several species of Breadfruit or Jakfruit (Artocarpus) in Southeast Asia and tropical America. All yield abundant milky sap, which is harmless, and the seeds of all of them are edible when cooked. Among the most frequent species are the following:

Artocarpus altilis: Breadfruit; Sa-ke (Thai); Xa-kè (Viet.). A large tree up to 40 ft. (12 m.) or so high. The leaves are rather large, lobed, and the fruit is large, nearly round, green or brownish green. It is a basic food plant in parts of Malaysia and South Pacific and in Southeast Asia, where many varieties are cultivated. Seedless form is boiled, baked or roasted. The large seeds in the seeded form, boiled or roasted, furnish an excellent food, as do the seeds of other species.

Artocarpus champeden: Champedak; Cham-pa-da (Thai). A large tree, with large, cylindrical fruit, but smaller than in the jakfruit, and has a strong odor. The pulp is edible and the seeds also when boiled or cooked.

Artocarpus heterophylla: Jakfruit; Kha-nun (Thai); Mit (Viet.). A large tree, generally cultivated. The fruit is greenish or yellowish green, up to 3 ft. (1 m.) long, and sometimes weighs up to 40 pounds. The pulp may be eaten raw, while the many large seeds furnish excellent food when boiled or roasted.

Averrhoa carambola: Carambola; Ma-fuang (Thai); Khé (Viet.). Averrhoa bilimbi: Bilimbi, ta-ling-pring (Thai); Khé tàu (Viet.). These are small trees, 12 to 15 ft. (4 - 5 m.) tall. The greenish fruit is very acid and may be eaten either raw or cooked. Bilimbi fruit resembles a small cucumber, borne on the trunk and larger branches, while Carambola fruit is star-shaped, 5-angled, and borne on the branchlets. Both species are cultivated and grow spontaneously, but not in the high forest.

Carica papaya: Papaya, papaw; Ma-la-ko (Thai); Du-dủ (Viet). This soft wooded, fast growing, normally unbranched tree, from 6 to 15 ft. (2 - 5 m.) high is of pantropical distribution, and frequently cultivated. The large, melon-like fruit, borne on the trunk, furnishes an excellent food. Green unripe fruit may be cooked or eaten. The leaf-stems, young leaves and flowers are also eaten as greens when cooked, with several changes of water to remove the bitter taste and certain harmful substances present.

Cynometra cauliflora: Nang-ai (Thai); Mot, lá-lua (Viet.). A small tree, up to 12 ft. (4 m.) tall. Generally found around abodes, but not in the high forest. Flowers and fruits are borne on tubercles on the trunk and branches. Fruit 1-seeded, yellowish to greenish. Pulp surrounding the seed is yellowish white, juicy, edible and has a sweet sour taste.

Eugenia spp.: There are many species of Eugenia in forested regions of Southeast Asia. They are of small to medium stature. These include: Jambolan (E. cumini), known in Thai as wa; Malay apple (Eugenia malaccensis), chomphu-sa-raek (Thai), and Dieu-do (Viet.); and rose apple (Eugenia jambos), chomphu-nam-dokmai (Thai); Bô-dao (Viet.). Their fruits may be eaten with safety, although some have little pulp.

Lansium domesticum: Lansone; Lang-sat (Thai); Bôn-bon (Viet.). A cultivated tree with pale yellow fruit, borne on the trunk and larger branches below the leaves. It is considered one of the best of tropical fruits.

Lycopersicon esculentum: Wild tomato; Ma-khua-thet (Thai); Ca to-mách (Viet.). A wild form of the common cultivated tomato, this erect branched herb, up to 3 ft. (1 m.) tall, is common in thickets and clearings, but does not occur in the forest. The small, red fruit is eaten raw.

Mangifera indica: Mango; Mamuang (Thai); Xoà-i (Viet.). This tree is of pantropical distribution, and furnishes one of the best of tropical fruits. There are many varieties. Those in Southeast Asia mostly have yellow fruit. On rare occasions an individual may be allergic to mango fruit, in which case a skin rash may develop. Certain individuals may also be allergic to the leaves. Other species of *Mangifera*, growing wild and furnish an edible fruit, exude an irritating sap, which affects the skin as does poison ivy. The recommended treatment is the same as for poison ivy.

Musa spp. Banana, plantain; Kluai-pa, etc. (Thai); Chuoi (Viet.). There are several species and scores of varieties of the common banana. For all practical purposes plantain cannot be distinguished from edible banana, except that all banana varieties may be eaten raw, while plantain should be boiled, fried or roasted. Green bananas may also be cooked. Many wild forms occur in forested regions, especially where clearings have been made. All types of bananas, whether cultivated or wild, are safe to eat when boiled or roasted. The fruits of wild species usually contain a small quantity of pulp and numerous seeds, which may also be cooked or eaten. Other parts of the banana plant may be used as source of food, especially the terminal flower bud. This may be boiled or plaeed in hot ashes, and certain varieties make excellent vegetable. Others are bitter because of tannic acid present, but this substance may be eliminated by cooking in several changes of water. The soft inner part of the somewhat thick root and the tender heart at the base of the stem may be cut into small pieces, boiled and eaten. Even the small shoots from the lower parts of the plant may be cooked and eaten in time of emergency.

Nephelium lappaceum: Rambutan; Ngo (Thai); Chom-chom (Viet.). *Nephelium mutabile*: Pulsuan; Ngo-khonsan (Thai). These are medium-sized trees, usually cultivated, although Pulsuan sometimes grows in forests. The fruits are red, one-seeded, and contain a pulp of good flavor. Both fruits are considered among the best tropical fruits.

Pandanus tectorius: Pandan or screw pine; Lamchink (Thai); Dua, Dua gai (Viet.). This is a frequent plant in Southeast Asia, up to 12 or 15 ft. (4 - 5 m.) high, growing usually near the sea, and at times forming a fairly dense thicket. It is characterized by the prop roots, and long spiny leaves arranged spirally at the end of the branches. The terminal leaf-bud or "cabbage" may be eaten either raw or cooked. The thin pulp in the fruit and the small seeds are also edible.

Physalis spp.: Ground cherry; Lhung-theny (Thai); Thu-lu canh(Viet.). These are erect branched herbs with white or yellow flowers. Growing in open sites, often near the seashore. The round fruit, red when ripe, borne inside an inflated husk, resembles a small tomato, and may be eaten raw.

Psidium guajava: Guava; Fa-rang (Thai); Oi (Viet). This shrub or small tree, of pantropical distribution is often in abandoned cultivated land, but never found in high forest. It has pale greenish or yellowish green, smooth, many-seeded fruit. This may be eaten out of hand or cooked and has an excellent flavor.

Sandoricum koetjape: Santol; Ka-thon (Thai); Sau sau dỏ (Viet.). A medium-sized tree, about 30 ft. (10 m.) tall. It is often cultivated and grows spontaneously. The fruit is round, yellowish, 2 to 5 in. (5 - 12 cm.) in diameter, covered with short hairs, and contains 2 - 5 large seeds. These are enclosed in a soft, whitish, juicy, sour-sweet, edible pulp. Seeds are not eaten.

Spondias dulcis: Otaheite apple; Makok-fa-rang (Thai); Cóc (Viet.). This medium-sized tree is widely distributed and widely planted in Southeast Asia. The fruit is plum-like, yellowish or yellowish green. The thin pulp around the large seed has an excellent flavor. Another species, Spondias pinnata, and known in Thai as "ma-kok," also has a fruit with edible pulp.

Tamarindus indica: Tamarind; Ma-kham (Thai); Me (Viet.). A large tree, of pantropical distribution, often planted in populated areas, occasionally spontaneous in Southeast Asia in rice fields, but does not grow in the high forest. Has light brown fruit. The pulp surrounding the seeds is edible, acid, and mildly laxative. Young leaves and flowers may be cooked and eaten as greens.

Some edible seeds of Southeast Asia:

Aleurites moluccana: Candle-nut tree; Pho-thi-sat (Thai); Dan lai (Viet.). A small to medium-sized tree with characteristic pale green foliage and greenish white flowers. The fruit contains one hard-shelled seed, rich in oil, and which may be eaten after roasting.

Anacardium occidentale: Cashew; Ma-muang-himma-phan (Thai); Dào-lon-hot (Viet.). A small tree up to 15 ft. (5 m.) tall, frequent in populated areas, but not in high forest. The pulp of the fruit (hypocarp) is yellow to purplish, very juicy and refreshing, although somewhat astringent. Caution: The single seed at the tip of the fruit is the cashew nut of commerce and should be eaten only after being boiled or roasted.

Arachis hypogaea: Peanut; Thua-li-song (Thai); Ban-Phong, loc (Viet.). The common peanut is often planted in Southeast Asia, especially in sandy soils. The fruit, borne underground, is nutritious and the seeds may be eaten raw or cooked.

Cajanus cajan: Pigeon pea; Thua-rae (Thai); Dau-saeng (Viet.). This is a small shrub up to 6 ft. (2 m.) tall. Sometimes cultivated, it is more often wild, frequent in open areas, but not found in the forest. The beans are edible but must be thoroughly cooked.

Canarium spp. Ka-na, ma-kok-lu'am (Thai). There are a number of species of this genus in Southeast Asia and Malaysia. They are forest trees, mostly of large size. The bark exudes a sticky, aromatic resin. The single, fairly large, oily seed has a good flavor, and may be eaten either raw or roasted.

Cycas circinnalis and other species of Cycads. Ma-phrao (Thai); Thien-tuế (Viet.). These palm-like plants, with a rather rough stem and stiff leaves, grow in the forest and often near the seashore. The young leaves of C. circinnalis may be eaten cooked like asparagus. The trunk yields a type of sago, but its extraction is difficult. The seeds of some species are used as food in times of emergency, but they are highly poisonous unless properly prepared. The meat should be grated or crushed and soaked in water, with frequent changes of water, and the process is repeated during a period of several days. The soaked material may be baked and made into cakes. Caution: It is advisable to consult the natives, whenever possible, to determine which species may be used as food.

Dolichos lablab: Hyacinth bean; Thua-paep (Thai); Dau-móng-chim (Viet.). This vine, often cultivated and frequent in thickets, has pink or reddish pods. The seeds are yellowish white with black dots, or black with white dots. The young pods, when cooked, furnish an excellent vegetable. Young leaves and flowers are also eaten after being cooked.

Gnetum spp. Mu'ai duk, krai'a-ma-mu'ai (Thai). Small trees or woody vines, growing in the forest, and some species are cultivated. Their seeds may be eaten raw, roasted or boiled, and the young leaves make excellent greens.

Nelumbium nelumbo: Lotus; Bua-luang (Thai); Sen (Viet.). Nymphaea spp. Water lily; Bua-daeng (Thai); Sun do (Viet.). These plants occur in shallow freshwater lakes, in slow streams, and in man-made canals of Southeast Asia. The large seeds of the lotus are excellent when boiled or roasted, and the large roots, submerged in the mud, may be cooked and eaten. The numerous small seeds of the water lilies may also be cooked and eaten, as well as the thick root.

Phaseolus lunatus: Lima beans; Thua-ratcha-mat (Thai). This vine, often cultivated and naturalized, occurs in thickets. Young tender pods may be cooked and eaten like string beans. Ripe seeds of wild forms should be thoroughly cooked with several changes of water.

Sterculia foetida: Sam-rong (Thai); Cay trom-hoi (Viet.). This is a fairly tall tree with large, red fruit. The numerous, almost black seeds are rich in oil, and have a flavor suggesting beechnut. The seeds may be eaten either raw or roasted. Other species of this genus grow in the forests, and the seeds of all species are edible.

Terminalia catappa: Indian almond; Hu-kwang (Thai): Bàng bien (Viet.). This tree of medium size, has a pantropical distribution. It is generally found along the seashore, but sometimes planted inland as a shade tree. Some of the leaves are usually red. The fruit contains a single seed with excellent flavor. Other species of Terminalia grow in the forest, and their seeds are likewise edible.

Edible tubers:

Alocasia macrorrhiza. Elephant ear; Pu'm-pu (Thai); Khoai-s'ap (Viet.). A large plant 3 to 12 ft. (1 - 4 m.) tall, growing in forests and open places. It has a fairly tall trunk and the juice from it is very acrid, because of oxalate of lime present, which may cause irritation to the mouth and nose. During emergency the softer part of the trunk, which contains starch, may be cooked and eaten. It should be cooked very thoroughly after several changes of water.

Colocasia antiquorum. Bon-khieo (Thai); Khoai-cao, Khoai-min (Viet.). This plant, brought to America from the Old World, is commonly planted in sandy soils in the Caribbean. When thoroughly boiled or baked the large underground tuber, resembling Irish potatoes, has a good flavor and is nutritious. The tender leaves also may be cooked and eaten like spinach. Caution: If eaten raw the tuber is poisonous or at least dangerous.

Colocasia esculenta: Taro; Phu'ak (Thai); Mon-nuớc Mon-nuớc (Viet.). This is one of the most commonly cultivated food plants in Polynesia, Malaysia, and in parts of Indochina Peninsula, and has been introduced into Puerto Rico. The tuber is rich in starch and may be eaten either boiled or roasted. It is an excellent substitute for potato. Young leaves are eaten as greens, but should be thoroughly cooked to destroy the irritating crystals.

Dioscorea spp. Yams: Man-nam, Man-sao, Man-thian (Thai). Several species of yams are found, often in cultivation, in Thailand, Vietnam and in Puerto Rico. They are twining vines, usually with large tuberous rootstocks. The meat varies from white to purplish, and provides an excellent food when boiled or roasted. Caution: Some species, such as wild yam, are considered poisonous, and should be thoroughly cooked beforehand.

Eleocharis dulcis: Water chestnut; Haeo-song-ka-thiam (Thai); Cu'nong (Viet.). This tufted plant, 2 to 4 ft. (0.60 - 1.25 m.) high, grows in open freshwater swamps. The nearly round, hard tuber is excellent to eat when boiled or roasted.

Ipomoea batatas. Sweet potato; Man-thet (Thai); Lang (Viet.). This is widely cultivated throughout Southeast Asia, and in other tropical regions. The tuber is a staple article of food. The leaves and young shoots make a good pot herb as substitute for spinach.

Manihot esculenta. Cassava, yuca, manioc; Man-sampa lang (Thai); Mi (Viet.). This is one of the most important food plants of the tropics, and is the source of tapioca. The large tubers are rich in starch. There are two main varieties - the bitter and sweet cassava - which cannot be distinguished other than by taste. Caution: Bitter cassava is poisonous when eaten raw. Cooking or roasting eliminates the poisonous principle (hydrocyanic acid). The tuber is crushed or grated, washed with several changes of water, and then cooked or roasted thoroughly. Young leaves may be boiled and eaten like spinach.

Maranta arundinacea. Arrowroot; Man-arrowroot, cha'khu (Thai); Huynh-tinh, mi-tinh (Viet.). This is the commercial arrowroot, and is found only in cultivation. The thick, scaly root may be cooked and eaten, or it may be crushed, and the abundant starch washed out and eaten.

Mechanically hazardous plants are discussed in "Some Harmful Plants of Southeast Asia (Mimeographed Report), recently issued by the U. S. Medical School of the Department of the Navy. This Report, prepared under the supervision of Lt. Commander Albert J. Oakes, contains a description of 37 species of plants, with corresponding outline drawings, that cause contact injury, their habitat and the injurious nature of the plant.

Plants as source of water: Thirst is just as much of a problem to the lost serviceman as starvation. Throughout tropical America and Southeast Asia there are a number of plants that contain a sap which may serve as a safe substitute for water. Among these are the organ cactus and coconut "milk." Other plants in this group found in the Caribbean include:

Vitis tiliifolia. Wild grape, Bejuco de agua. The small wild grape vine is frequent in thickets and forests in West Indies and Central America. Its fruit is edible but sour. The thick stem may be tapped for its abundant sap.

Tetracera sp. Water vine, Bejuco de agua. This large woody vine is present mostly in dry brushland where it climbs on the crowns of trees. The leaves are stiff, thick, with the texture of sandpaper. Long sections of the larger stems contain a substantial amount of colorless sap that is potable.

Ravenala madagascariensis. Traveler's palm; Kluai farang (Thai); Chuoi-rê-quat (Viet.). This plant is widely distributed in tropical countries, and occurs in Southeast Asia and Puerto Rico as an ornamental. The fleshy leaf petiole, when punctured with a sharp knife, exudes a fairly abundant watery sap which is drinkable.

Plants to stupefy fish: In widely scattered areas of the world, especially in remote tropical regions, different species of plants are used to poison or stupefy fish. The methods vary, but the usual procedure is to crush the part of the plant to be used, mix it with water, and throw a sufficient quantity of the macerated mass into a stagnant pool or slow flowing stream. In some areas a dike or obstacle is built to impede the fish from escaping. The plant material paralyzes the gills, but in no way does it affect the flesh, and the fish thus secured can be eaten with safety.

<u>Barringtonia asiatica</u>: Chik-le (Thai); Chiec bang (Viet.). This is a medium-sized tree growing on the seashore. It has smooth leaves, large pink flowers, and large fruits which are square on cross section, with a single large seed. The crushed seeds are used for poisoning fish in pools.

<u>Derris elliptica</u>: Kalampho (Thai); Day thuoc-ca (Viet.). This is the most efficient fish poison, and is widely used in Southeast Asia to capture fish in slow streams, lakes and tidal pools. There are other species of this genus, and some are more potent than others. All species of <u>Derris</u> are woody vines, with flowers resembling that of the bean, and with narrowly winged pods. The part used is chiefly the crushed roots, but crushed branches and leaves may also be used.

<u>Tephrosia purpurea</u>: Cha-khram (Thai); Doan-kiem do (Viet.). This is a small shrub or woody herb growing in open sites, and has small purplish flowers. It is widely used as a fish poison by crushing the whole plant and throwing the mass into ponds.

Some seeds of Southeast Asia edible when roasted

Most of the plants cited have a number of local names, varying from one region to another. The vernacular name given is the one most generally used.

Acacia aneura: Acacia, Wild tamarind (English); Sompoi (Thai).
Anacardium occidentale: Cashew (Eng.); Dào-lôn-hôt (Viet.); Ma-muang-himma-phan (Thai).
Artocarpus spp.: Breadfruit, Jackfruit (Eng.) Xa-kê, Mitnài, choay (Viet.); Khan-nun (Thai).
Careya arborea: Ka-don (Thai).
Coix lachryma-jobi: Job's tears (Eng.); Bo-bo (Viet.); Du'ai (Thai).
Cycas revoluta (considered dangerous): Cycad, Sago palm (Eng.); Thiên-tuế (Viet.); Prong-yi-pun (Thai).
Entada phaseoloides: Bám-bàm leo (Viet.); Sa-ba (Thai).
Nelumbium nelumbo: Bua-luang (Thai).
Nephelium lappaceum: Rambutan (Eng.); Chôm-chôm (Viet.): Ngo (Thai).
Nipa fruticans (immature seed only): Nipa (Eng.); Dùa nuốc, Dà lố (Viet.); Chak (Thai).
Nymphaea spp.: Water lily (Eng.); Bua-daeng, Bua-phuan (Thai).
Phyllanthus emblica: Myrobalan (Eng.): Chùm-ruôt nui (Viet.). Ma-kham-pom (Thai).
Psophocarpus tetragonolobus (considered dangerous): Black bean (Eng.): Dấu rong (Viet.); Thua-phu (Thai).
Setaria parviflora: Mary grass (Eng.); Ma-ranti (Thai).
Sterculia foetida: Cây trôm-hôi (Viet.); Sam-rong (Thai).
Terminalia catappa: Indian almond (Eng.); Bàng Bien (Viet.); Hu-kwang (Thai).
Trapa bicornis: Water chestnut (Eng.); Äu (Viet.); Ka-chap (Thai).

Summary of Survival Plants of Southeast Asia

(English name, when known, in parentheses)

Botanical Name and Use	Thai Name	Viet. Name
Acacia concinna Tender leaves for potherb.	Sompoi	
Acacia insuavis Tender leaves for potherb.	Chaom	
Achras sapota (Sapodilla) Fruit edible.	La mut-fa rang	Xa-bȯ-chè
Acrostichum aureum (Mangrove fern) Fiddlesticks for potherb.	Prong-tha-le	Ráng làm chõi
Adenia pierrei Fruit edible; new leaves for potherb.	Nang-nun	
Aegle marmelos Juice from fruit.	Ma-tum	
Afzelia xylocarpa Endosperm.	Ma-kha-yai	
Aleurites moluccana (Candlenut) Candles.	Pho-thi-sat	Dầu-lai
Allium cepa (Onion) Vegetable.	Hom-yai	Hành
Alocasia macrorrhiza (Elephant ear) Tuber.	Kra-dat	Khoai-mòn
Alternanthera repens Tender leaves for potherb.		Diêc-bò
Amaranthus viridis Young leaves for potherb.	Phak-khom	Dén xanh
Amomum sp. Fruit edible when cooked.	Ka-wan	
Amomum villosum Fruit edible when cooked.	Reo-dong	
Ampelocissus martini Fruit edible.	Thao-prieo	Nho-rùng
Anacardium occidentale (Cashew nut); roasted seed edible; cashew apple or <u>hypocarp</u> also edible.	Ma-muang-humma-phan	Dào-lõn-hòt
Anacolosa ilicoides Seed edible.	Ko-sae	
Ananas comosus (pineapple) Fruit edible.	Sappa-rot	Khom
Annona muricata (Sour sop) Fruit edible.		Măng-cáu-xièm

Botanical Name and Use	Thai Name	Viet. Name
Annona reticulata (Custard apple) Fruit edible.	Noi-nong	Binh-bát
Annona squamosa (Sweet sop) Fruit edible.	Noi na	Mảng-cau-dai
Antidesmus bonius Fruit edible.		Ko-liên-tú
Antigonon leptopus (Coral vine) Tuber.	Phuang-chom-phu	Hieu-nu
Arachis hypogaea (Peanut) Nut edible.	Thual-li-song	Dau-phong, lac
Ardisia sp. Berry edible.		Cóm-nguoi
Arenga saccharifera (Sugar palm) Seed and shoots edible; sugar from inflorescence.	Luk-chit	Coac
Artocarpus altilis (Bread fruit) Vegetable.	Sa-ke	Xa-kè
Artocarpus heterophyllus (Jack fruit) Vegetable	Kha-nun	Mit
Artocarpus integrifolia Fruit and seed edible.	Kha-nun	
Artocarpus masticata Vegetable		Choay
Averrhoa bilimbi (Bilimbi) Fruit edible.	Ta-ling-pring	Khe-tàu
Averrhoa carambola (Carambola) Fruit edible.	Ma-fu'ang	Khè
Baccaurea sapida Fruit edible.	Ma-bai	
Bambusa arundinacea (Bamboo) Vegetable.	Phai-pa	Tre gai
Bambusa spp. Young shoots, seed edible.	Phai-pa, phai-si-suk	
Barringtonia asiatica Fish poison.	Chik-le	Chiec bang
Basella rubra (Spinach vine) For potherb.	Phak-prang	Mống-toi
Bauhinia purpurea Young leaves cooked.	Sieo-dokdaeng	
Begonia inflata Leaves for potherb.	Somkungbok	
Bixa orellana (Anatto) Pulp around seed for condiment.	Kham-thai	Siêm-phung
Boerhaavia diffusa (Hog weed) Vegetable	Phak-bia-yai	Nam-sam

Botanical Name and Use	Thai Name	Viet. Name
Borassus flabellifer Seed, fruit, beverage from fruit; young shoots for pot-herb, and sugar from inflorescence.	Tanta-nut	Thot lot
Bouea burmanica Fruit edible.	Ma-prong	
Bouea microphylla Fruit edible.	Ma-prang	
Brassica chinensis (Chinese cabbage) Vegetable.	Phak-katkhao	Cai-r'o
Brassica oleracea (Cabbage) Vegetable.	Phak-kha-na	Su-hao
Caesalpinia mimosoides Young leaves for potherb.	Cha-lu'at	Diep trink-nu
Cajanus indicus (Pigeon pea) Vegetable.	Thua-rae	Dau sang
Calamus spp. (Rattan) Water from stems.		Mây
Canarium kerrii Fruit edible when ripe.	Ma-kok-lu'am	
Capsicum frutescens (Hot pepper) Vegetable.	Phrik-chi-fa	Ot
Capsicum annuum (Chile pepper) Fruit edible.	Phrik	
Carica papaya (Papaya) Fruit edible.	Ma-la-ko	Du-dú
Caryota mitis (Fishtail palm) Starch	Tao-rang	Dủng-dinh
Caryota urens Young shoots for potherb.	Tao rang	
Cassia fistula Young fruit.	Chaiya-phru'k	Muong bo-cap
Cassia siamea Flowers and young leaves for potherb.	Khi-lekyoi	Muong xiem
Castanopsis tribuloides Seed edible.	Ko-du'ai	De
Ceratopteris thalictroides (Water-fern) For potherb.	Phakkutnam	Rang gac nai
Chrysophyllum cainito (Star apple) Fruit edible.		Vú-sữa
Citrus sinensis (Sweet orange) Fruit edible.	Som-chin	Cam

Botanical Name and Use	Thai Name	Viet. Name
Citrus spp. (Lime, lemons) Fruit edible.		
Cleome viscosa Vegetable.	Phak-sian-phi	Mang
Coccoloba uvifera (Sea-grape) Fruit edible.		Nho-biển
Cocos nucifera (Coconut) Fruit meat as pulp and "milk" as substitute for water.	Ma-phrao	Dứa
Coix lachryma-jobi (Job's tear) Seed edible.	Du'ai	Bo-bo
Colocasia esculenta (Taro) Tuber.	Hu	Mon-nuớc
Commelina communis (Wandering Jew) For potherb.	Ap-chicb	Rau-Trai
Commelina spp. For potherb.	Phak-prap	
Corypha lecomtei Starch.		Lá-buon
Cosmos sulphureus (Cosmos) Tender leaves for salad.	Dao-kra-chai	Chuon-chuồn vàng
Crataeva roxburghii Young leaves for potherb; fruit edible.	Kum-nam	
Curcuma longa (Turmeric) Condiment.	Kha-min	Nghệ
Cyathea latebrosa (Tree fern) Fiddlesticks for potherb.		Phuong sí, rang
Cycas spp. (Cycad) Sago from rhizome.		Thiên-tuế
Dendrocalamus spp. (Derris) Tender shoots for potherb.	Mai-lamma-lok	Tam-vong
Derris elliptica (Rotenone) Fish poison.	Khru'a-lai-nam	Thuốc-cá
Dialium cochinchinense Fruit edible.	Khleng	
Dillenia indica Fruit edible.	Ma-tat, san plao	So ba
Dillenia pentagyna Fruit edible.	Sanna	
Dioscorea alata Tuber.	Man-chao-ma phrao	Khoai mai
Dioscorea bulbifera (Yam) Tuber.	Man-kha-min	Khoai-nhật

Botanical Name and Use	Thai Name	Viet. Name
Dioscorea burmanica Tuber	Manchuak	
Dioscorea esculenta Tuber.	Man-mu'-su'a	
Dioscorea glabra Tuber	Man-chai	
Dioscorea hispida Tuber.	Man kloi	
Dioscorea myriantha Tuber	Man-sao	
Dioscorea pentaphylla Tuber.	Man-khan khao	
Dioscorea pierrei Tuber	Man-nam	
Diospyros mollis Endosperm.	Ma-klu'a	Mac-mu'a
Diospyros rhodocalyx Fruit edible.	Ta-ko-na	
Diospyros siamensis Fruit edible.	Ma-phlap yai	
Dolichos lablab (Hyacinth bean) Vegetable.	Thau-paep	Dau ban trang
Duabanga sonneratioides Emergency food.	Tumten	Bảng-lảng-bàn
Durio zibethinus (Durian) Fruit edible.	Thu-rian	Sầu-riêng
Ehretia buxifolia Fruit edible.		Cùm-rum
Eichornia crassipes (Water hyacinth) For potherb.		luc-binh
Elaeagnus latifolia Fruit edible.	Salottrao	
Elaeocarpus madopetalus Fruit edible.	Ma-kok-nam	
Eleocharis dulcis (Water chestnut) Tuber.		Cu-nang
Eleocharis tuberosa (Water chestnut) Tuber.		Mã-thầy
Emilia sonchifolia For potherb.		Hồng-khô-thái
Enterobldbium saman (Rain tree) Young seed used for food.	Kampu	Pheo-heo

Botanical Name and Use	Thai Name	Viet. Name
Erioglossum rubiginosum Fruit edible.	Ma-huat	
Eryngium foetidum For potherb.		Ngò-ta
Erythrina suberosa Young leaves for potherb.	Thong-lang-bai mon	
Eugenia jambos (Rose apple) Fruit edible.	Chom-phu-khao	Bồ-đào
Eugenia spp. Fruit edible.	Wa, Wa-nam	
Feronia elephantum Fruit edible.	Ma-khwit	
Ficus religiosa (Bot tree) Fruit edible.	Pho	Bo-dế
Flacourtia jangomas (Indian plum) Fruit edible.	Ta-khop-thai	Hồng-quàn
Garcinia cowa Fruit edible; new leaves used for potherb.	Cha-muang	
Garcinia mangostana (Mangosteen) Fruit edible.	Mang-khut	Măng-cut
Garcinia vilersiana Fruit edible.	Ma-phut	
Grewia asiatica Berry.	Lai	Cỏ'ke
Guazuma tomentosa Berry		Thuc-dia
Heracleum burmanicum Fruit edible when cooked.	Ma laep	
Hibiscus esculentus (Okra) Vegetable.	Ma-khu'a-mon	Bấp-chả
Hodgsonia capniocarpa Endosperm edible seed oil.	Ma-king	
Hydnocarpus anthelmintica Fruit juice.	Ka-bao	Cay-chum Cao
Hydrocotyle asiatica Leaves for potherb.	Bua-bok	
Hydrolea zeylanica Vegetable	Sa-dao-din	Thuy bich

Botanical Name and Use	Thai Name	Viet. Name
Ipomoea aquatica (Water morning glory) For potherb.	Phak bung	Rau-muong
Ipomoea batatas (Sweet potato) Tuber.	Ka-bok	Khoai-lang, lang
Ipomoea pes-caprae (Seaside morning glory) Food in time of shortage.	Phak-bang-tha le	Rau-muong bien
Irvingia malayana Seed edible.	Ka-bok	
Jussiaea repens Young shoots edible.	Phaeng phuai	Rau dua trau
Lagenaria siceraria Vegetable.	Nam tao	Bau
Lansium domesticum Fruit edible.	Langsat	Bòn-bon
Lantana camara (Lantana) Berry.	Pha-ka-krong	Thom-ổi
Leucaena leucocephala (Jumpy beans) Vegetable.	Tha-thin-ban	Cay-bo-chet
Limnocharis flava (Velvet-leaf) For potherb.	Nang-kwak	Nè-thao-vàng
Lucuma mammosa Fruit edible.		Lu-cu-ma
Luffa cylindrica (Sponge gourd) Vegetable.	Buap klom	Muớp huong
Lycopersicon esculentum (Tomato)	Ma-khua-thet	Ca to màch
Madhuca pierrei Oil from seed.	Ma sang	
Mangifera caloneura Fruit edible.	Ma-muang-pa	
Mangifera indica (Mango)	Ma-muang	Xoái
Manihot esculenta (Cassava, manioc) Tuber	Man-sampa-lang	Khoai-mi, mi
Maranta arundinacea (Arrowroot) Starch	Man-arrowrot	Hoang-thanh, mi-tinh
Memecylon edule Fruit edible.	Phlong-dan	Sâm ngot
Memecylon ovatum Fruit edible.	Phlong-kin luk	
Metroxylon sagu Starch from pith.	Sa-khu	

Botanical Name and Use	Thai Name	Viet. Name
Monocharia hastata For potherb.	Phak-top-thai	Rau-mac
Monocharia vaginalis For potherb.	Phak-khiat	Rau mac la-ong
Morinda citrifolia (Indian mulberry) Fruit edible.	Yo ban	Nhau-thuong
Moringa oleifera (Horseradish tree) For food.	Ma Rum	Chùm-ngay
Morus alba Fruit edible.	Mon	Dau tam
Mucuna pruriens (Cow-itch) Fruit in emergency.	Ma-mui	Mat-meo
Muntingia calabura (Capulin) Berry.	Ta-kap-farang	Mát-sám
Murraya paniculata Fruit edible.	Kaeo	Nguyet-quý
Musa X paradisiaca (Banana & plantain). Fruit edible.	Khuai kok	Chuoi gia
Musa spp. (Plantain) Vegetable.	Kluai pa, klua-bua	Chuoi
Nelumbo nucifera (Water lotus) Nuts edible.	Bua luang	Sen
Nephelium hypoleucum Fruit edible.	Kho-laen	
Nephelium lappaceum (Rambutan) Fruit edible.	Ngo	Chòm-chòm
Nephelium litchi Juice from fruit.	Lin-chi	
Nephelium longana Fruit edible.	Lam-yai	
Neptunia oleracea Young leaves edible.	Phak-ka-chet	
Neptunia prostrata For potherb.		Rau-nguc
Nipa fruticans (Nipa palm) Endosperm, ground immature seed edible.	Chak	Dua la
Nymphaea lotus var. pubescens Stalk edible when cooked.	Bua-daeng	Sun do
Nymphaea stellata (Water lily) Emergency food.	Bua-phuan	Sun co
Nymphaea tetragona (Water lily) Food during famine period.		Sun vuong

Botanical Name and Use	Thai Name	Viet Name
Olax scandens Young leaves for potherb, and fruit edible.	Ka-thok-rok	
Opuntia dilleni (Prickly pear) Fruit edible.	Se-ma	Vot gai, luoi-rong
Oryza sativa (Rice) Cereal.	Khao	Lua, nep
Oroxylum indicum (Pods) Edible when cooked.	Phe-ka	Cay-san-dau
Pachyrrhizus erosus (Yam bean) Tuber.	Man kaeo	Cu-san
Pandanus tectorius (Pandan) Fruit edible.	Lam chiak	Dừa lop
Parkia speciosa Seed edible.	Sa-to	
Passiflora quadrangularis (Passion flower) Fruit edible.	Su-khontha rot	Chùm-bao-dua
Phaseolus mungo (Mungo bean) Vegetable.	Thua-thong	Dau xanh
Phaseolus vulgaris (Kidney bean) Vegetable.	Thus khaek	Dau-hồ-a-lan
Phoenix acaulis Fruit edible.	Peng-bok	Chà-la
Phyllanthus distichus (Star apple) Fruit edible.	Ma-yom	Chùm-ruot
Phyllanthus emblica (Myrobalan) Fruit edible	Ma-kham-pom	Chùm ruot núi
Phyllostachys bambusoides (Bamboo) Vegetable.		Tre tro
Physalis angulata (Ground cherry) Fruit edible.		Thú-lú canh
Physalis peruviana (Gooseberry) Fruit edible.	Gooseberry	Thú-lù-tròn
Piper sarmentosum New leaves cooked for potherb.	Cha-phlu	
Piper spp. Seed edible during emergency.	Phlu, Prik-thai	
Pistia stratiotes (Water lettuce) Tender leaves for potherb.	Chok	Bèo-cái
Pithecolobium dulce (Manila tamarind) Fruit edible.	Ma kham thet	Me-keo
Pithecolobium jiringa Seed edible.	Cha-niang	

Botanical Name and Use	Thai Name	Viet. Name
Podocarpus neriifolia Berry edible.	Phaya-mai	Bachnien-tung
Portulaca oleracea (Purslane) Tender leaves for potherb.	Phak-bia-yai	Rau-sam
Prunus persica (Peach) Fruit edible.	Tho	Dao
Psidium guajava (Guava, guayaba) Fruit edible.	Fa-rang	Oi
Pteridium aquilinum Young leaves for potherb.	Kut-kia	Dai-duc
Punica granatum (Pomegranate) Fruit edible.	Thap-thim	Lúu
Randia spp. Used for fish poison.	Khlet, tumka	Gang trang
Raphanus sativus (Radish) Vegetable	Phak-khathao	Ra-di
Rhizophora mucronata (Mangrove) Source of food during famine.	Kongkang bai	Duoc Nhon
Rumex acetosella (Sheep sorrell) Young leaves for potherb.		Toan-thao
Saccharum arundinaceum (Sugar cane) Source of sugar.	Khaem	Lach
Saccharum officinarum (Sugar cane) Source of sugar.	Oi	Mia
Sagittaria sagittifolia (Chinese arrowhead) Vegetable.	Ka-khiat	Tù cò
Sandoricum indicum (Santol) Fruit edible.	Kra-hut	Sấu
Schleichera trijua Fruit edible.	Ta-khro	
Selaginella pubescens Young shoots for potherb.	Fu'ai nok	
Sesamum indicum (Sesame) Seed edible.	Nga	Mè
Sesbania grandiflora (Sesbania) Vegetable.	Khae-ban	So-dùa
Setaria italica (Foxtail millet) Cereal.	Khao-bang	Ke
Solanum torvum Fruit edible.	Ma-khu'a phuang	
Sonchus oleraceus (Sow weed) Young leaves for potherb.	Phak kat-hom	Bach-nhũ-cuc

Botanical Name and Use	Thai Name	Viet. Name
Sonneratia caseolaris Fruit edible.	Lam-phai	Ban chua
Sphenoclea zeylanica For potherb.	Phak-pumpla	Xà-bong
Spilanthes acmella (Para cress) Young leaves for potherb.	Phak-khrat	Cúc-áo
Spondias dulcis (Ambarella) Fruit edible.	Ma-kok-farang	Cóc
Spondias pinnata Fruit edible, young leaves for potherb.	Ma-kok	
Stenochlaena palustris Emergency food (Fiddlesticks served as vegetable).	Prong suan	Dây chay
Sterculia foetida (Java olive) Nut edible.	Sam-rong	Trom hoi

Some Hazardous Plants of the Caribbean Area and Southeast Asia

It is important that those who come in contact with plants should be able to recognize the most common plants that are liable to cause irritation or inflammation on contact with the body. The following are a few common toxic or dermatogenic plants found in the Caribbean area and in the Mekong basin countries. Some have been introduced from this Hemisphere and are now naturalized in Southeast Asia.

Cameraria latifolia. Local name: White Poisonwood.

This shrub or small tree is found only in sections of the West Indies. It is considered to be one of the most poisonous of tropical American plants.

Cecropia spp. Local names: Yagrumo, Trumpet-tree.

This medium-sized tree is abundant in the lowlands of tropical America. The hollow branches are inhabited by small ants that sting painfully when a leaf or branch is touched. The long cord-like spines of the fleshy fruit may be eaten, although a poor food substitute.

Comocladia sp. Local names: Guao, Maíz pelado.

The sap of some species of this shrub or small tree causes blistering and prolonged inflammation of the skin, similar to that caused by poison ivy.

Coriaria thymifolia. Local name: Maco tinto.

This shrub grows in the mountains of Guatemala, at altitudes of 7,000 to 8,000 feet. The fruit is a small, juicy, reddish purple berry, which is highly poisonous.

Croton ciliato-glandulosus. Local names: Ciega-vista; in Thailand a common name for some species is "plao."

This shrub grows among underbrush in dry localities and is common in parts of Mexico and Central America. The entire plant is covered with sticky hairs that cling to the hand when handled. In contact with the eyes, this sticky substance may cause severe inflammation.

Dieffenbachia spp. Local names: Rábano, Dumb Cane; Wan-mú-npi (Thai).

When the stems or leaves are broken, the milky sap that exudes may cause severe blistering and inflammation of the skin. The plant is common in lowlands and wet ground of Central America and southward. When cut, the plant gives off an offensive skunk-like odor.

Euphorbia cotinifolia. Local names: Yerba lechera, Poison spurge; Sa-lat-dai-pa (Thai); Xuong-rang (Vietnam).

On contact with the skin the milky sap causes blisters and intense inflammation similar to that resulting from poison ivy. It is most common in lower mountain regions in Cuba and from Mexico to northern South America; it is often planted for fence posts.

Hippomane mancinella. Local names: Manzanillo, Machineel.

The milky sap causes blistering and severe inflammation of the skin in some persons. Smoke from burning wood may injure the eyes. This plant grows along the seacoast, where it forms dense thickets. Its fruit resembles a small green apple.

Hura crepitans. Local names: Jabillo, Sandbox tree; Pho-sri-ma-ha-pho (Thai); Ma-dau (Vietnam).

The milky sap of this large tree is liable to cause severe irritation to the skin, and particularly on contact with the eyes. Its woody fruit is dangerous to handle because when dry it explodes, scattering the seeds violently. The seeds are poisonous. The milky sap, mixed with other substances, is sometimes used to stupify fish.

Jatropha curcas. Local names: Pinon, Physic nut; Sa-bu-dam (Thai); dau-lai, Ba-dau (Vietnam).

A shrub or small tree commonly found in lowlands of the entire Caribbean region, where it is often planted for hedges or live fenceposts. The raw seeds or nuts are poisonous, or at least violently purgative, and at times may be fatal. But after being thoroughly roasted, they are sweet and edible. However, it is best not to eat them under any circumstances.

Jatropha urens. Local names: Pringamoza, Stinging spurge; in Thailand a common name for some species is "ma-la-ko-fa'rang."

This plant should be handled with caution. It is thickly covered with stiff hairs which sting severely and cause pain and inflammation, often with numbness lasting for several days. There is no special treatment for this condition.

Karwinskia calderonii. Local name: Huilihuiste.

The small, almost black fruit of this tree is juicy and attractive in appearance. But the juice and pulp, while harmless, should not be eaten. The seeds also are highly poisonous. Several species of this tree are found from southwestern Texas through Mexico to western Nicaragua.

Metopium toxiferum. Local name: Black Poisonwood.

This tree is common in parts of the West Indies. The sap causes blisters and prolonged inflammation similar to the effect produced by poison ivy. The smoke from the burning wood is also dangerous.

Mucuna pruriens. Local names: Pica-pica, Cowitch; Ma-mu, mamuy (Thai).

This plant, closely related to "manuy" of Thailand, is frequent in the Caribbean Islands. Its hard pods are covered with stiff hairs or bristles that separate easily. They penetrate the skin and cause intense itching and irritation that may last for some time. Caution should be taken that the hairs do not lodge in the eyes, as they may cause serious trouble. Thickets where cowitch is plentiful should be avoided whenever possible.

Rhus striata. Local names: Hinchador, Poison Sumac; Somphot (Thai).

This shrub or small tree belongs to the same family (Anacardiaceae) as the poison oak, poison ivy, and the poison sumac growing in swamps of the United States. It grows at fairly high elevations on exposed hills in Central America. Contact with the leaves or sap causes blistering or swelling that may persist for weeks.

Ricinus communis: Local names: Castor oil plant; La-hung (Thai); Thau-dau (Vietnam).

This erect shrub with large lobed leaves is frequently cultivated, and grows spontaneously in open sites and thickets. The seeds are considered poisonous and purgative. They should not be eaten.

Laportea spp. Local names: Tree-nettle; Tam-yae-thang (Thai); also found in Vietnam.

These shrubs or small trees grow in thickets, secondary growth, and at times in high forest. All parts of the plants are furnished with numerous, minute stinging hairs containing an intensely irritating sap. On contact with the skin they produce the sensation of hot iron, apparently caused by formic acid present. Although painful, the sting is normally not dangerous. Some species are more irritating than others.

Semecarpus spp.: Local names: Rak-pa, rak-khao, hakkhi-mu (Thai).

These shrubs or small trees, of the poison ivy or poison oak family (Anacardiaceae), at times grow to a height of 30 ft. (10 m.). They occur chiefly in thickets and secondary growth. Some species are reported to cause severe skin eruption on contact, or from the sap when the trees are felled. Treatment is the same as that indicated for poison ivy. The swollen basal part of the fruit is fleshy, usually dark purple, and can be eaten with safety.

Sapium spp. Local names: Lechecillo, Olivo: Kra-hut (Thai).

The milky sap of some species of these trees is considered very poisonous. In parts of Central America the Indians use it to poison arrows. Elsewhere, the coagulated sticky sap serves to catch small birds.

Triplaris americana. Local name: Ant-tree.

Hollow twigs are inhabited by vicious stinging ants.

Urera baccifera. Local names: Chichicaste, Nettle tree.

There are several species of this plant, some stinging more severely than others. As a precaution, it should be remembered that if the leaves or branches strike the body, intense pain is produced with irritation that may last a day or more. No permanent injury is caused, and there is no special treatment. The most dangerous nettles are the shrubby tree-like ones, but contact with some of the low, soft-stemmed nettles may cause intense pain for a short time. It is often planted for hedges and is frequent at low and medium altitudes.

COMMERCIAL TIMBER TREES OF VIETNAM, CAMBODIA, LAOS, THAILAND, AND PUERTO RICO

THEIR PROPERTIES AND USES

Adina cordifolia Benth. & Hook. Family Rubiaceae. Vernacular names: Gáo vàng, Dàng dè (Vietnam); Khvao, Kdol (Cambodia); may Taptao, may Cang lyong (Laos).

A third grade timber, produced commercially in Cambodia, South and Central Vietnam; logs 5 to 10 m. in length, and 40 to 50 cm. in width. Wood orange yellow, with a fine grain; moderately hard and somewhat light to fairly heavy; easy to work and takes a good polish; shrinks slightly and is resistant to water. Its fine grain and attractive color make it useful for turnery and carving.

Aglaia gigantea Pellegrin. Family Meliaceae. Vernacular names: Gôi (Vietnam); Beng kheou (Cambodia); may Phamay (Laos).

A second class timber, produced in North Vietnam; logs 10 to 12 m. long and 50 to 60 cm. in diameter. Wood pinkish, gradually turning to pale red, and has a fine grain; is slightly flexible and resistant to insects and moisture; soft to fairly hard and light to moderately heavy. It is considered suitable for furniture manufacture, also for boat and shipbuilding and wagons. Formerly it was esteemed for making airplane propellers.

Alstonia scholaris R. Br. Family Apocynaceae. Vernacular names: Mò cua, Sữa (Vietnam).

Classed as third grade, this timber is produced in South and Central Vietnam; logs measure 5 m. in length and from 45 to 50 cm. in diameter. Wood yellowish white and has a fairly fine grain, with no demarcation between sapwood and hardwood; is soft and white; shrinks slightly and is perishable in water and very susceptible to insect attacks. Used for packing cases and for making wooden shoes; having only a slight shrinkage and a regularly uniform trunk, it is suitable for plywood.

Anisoptera cochinchinensis Pierre. Family Dipterocarpaceae. Vernacular names: Vên vên, Vin vin (Vietnam); Phdiec (Cambodia); may Bac (Laos).

A second grade timber, produced in South Vietnam and Cambodia; logs 15 to 20 m. in length, and 1 m. to 1.50 m. in width. Wood yellowish white, homogeneous, has a fairly fine grain; is soft and light in weight; subject to appreciable shrinkage, easy to work, but soon dulls the saw because of fine grains of calcium oxalate present; is only fairly durable and preserves well when exposed to moisture; used in carpentry for interior use, and is much esteemed for the manufacture of inferior grade furniture; it may be used for plywood, because of its width, from 1 to 1.5 m., free of knots and 10 m. or more in length; drying on the spot reduces considerably its density and tendency to shrink; considered the best "white wood" for export and formerly exported to France in blocks.

Calophyllum spp. Family Guttiferae. Vernacular names: Còng (Vietnam); Phaong (Cambodia).

A third grade timber, produced in South and Central Vietnam and Cambodia; logs 10 to 15 m. long and 35 to 40 cm. in diameter. Wood pinkish brown with fine streaks, and medium grain; is soft, moderately hard and fairly heavy; easy to work, resistant to moisture, insects, teredo and exposure to air; used for decks, ribs and masts of ships; also in carpentry and cabinetmaking.

Canarium spp. Family Burseraceae. Vernacular names: Chám, Chim den, Trang, Cana (Vietnam); may cuòm, may Bày

A second grade timber, produced commercially in North and northcentral Vietnam; bole 10 to 12 m. long and 50 to 60 cm. in width. Wood grayish white or pinkish, homogeneous; has a fine grain; sapwood and hardwood are differentiated; subject to slight shrinkage and does not preserve well in water; is soft and light in weight, is subject to rapid attack by destructive agents; used for packing cases and matchboxes; furnishes a resin much sought for in North Vietnam for the manufacture of joss sticks and for caulking boats.

Cassia siamea Lam. Family Leguminosae. Vernacular names: Muồng (Commercial); Muồng, Muồng den (Vietnam); Angkanh (Cambodia); may Xa thone (Laos).

A first grade timber, produced in Central Vietnam and Cambodia; logs 10 to 12 m. long and 25 to 30 cm. in diameter. Wood dark or almost black, with yellow or brownish streaks; is very hard and heavy; is resistant to insect attacks and weathering; the heartwood, known as "partridge wood", furnishes attractive material for cabinetwork. It rarely attains large dimensions, but grows rapidly during the first years. For this reason it is often propagated for artificial reforestation or to establish stands to furnish good quality firewood within a short period.

Cassia timoriensis DC. Family Leguminosae. Vernacular names: Muồng tia, Muồng dỏ (Vietnam); may ki lep pa (Laos).

A third grade timber, produced in North Vietnam, North-central Vietnam and Laos; logs measure 5 to 8 m. long. and 50 to 6C cm. in diameter. Wood reddish, and has a coarse grain; subject to slight shrinkage and preserves well in water; is fairly hard and moderately heavy; suitable for crates and boxes, general construction and ordinary furniture.

Chikrassia tabularis A. Juss. Family Meliaceae (Mahogany). Vernacular names: Lát hoa, Chua khèt (Vietnam); may Dun hin (Laos).

A first class timber, produced in north-central Vietnam and North Vietnam. Logs from 10 to 12 m. in length, and 40 to 50 cm. in diameter. Wood streaked, grayish brown with a yellowish tinge, and a coppery hue; and has a fine grain; shrinks slightly and preserves well in water; is moderately hard and heavy; easy to work and takes a good polish; is resistant to insect attacks and to weathering. Because of its luster and streaks, this wood is much esteemed for fine carpentry and high grade furniture. It is much sought in Tonkin for the manufacture of high grade furniture like Gò do (Pahudia cochinchinensis) in South Vietnam.

Cinnamomum spp. Family Lauraceae. Vernacular names: Rè (Vietnam); Kantuyvé chmol (Cambodia).

Classed as second grade timber, produced in North Vietnam and northcentral Vietnam; logs 5 to 10 m. long and 50 to 60 cm. in diameter. Wood light brown with grayish tinge, and has a fine grain; is soft, light in weight and not durable; subject to slight shrinkage and preserves well in moisture. It is suitable only for boxes, crates and cabin trunks.

Dalbergia bariensis Pierre. Family Leguminosae. Vernacular names: Cẩm lai (Vietnam); Néang nuong, Léang (Cambodia); may Nuon, may Camphi (Laos).

Considered a luxury wood, exploited in Cambodia and South and Central Vietnam; logs from 5 to 10 m. long and 30 to 60 cm. in diameter. Wood deep violet red, with pronounced black streaks, of medium texture, takes an attractive polish; is durable, hard and very heavy; easy to work; resistant to moisture and weathering and is almost incorruptible. This species is considered one of the most attractive woods for fine furniture in Southeast Asia. It is utilized in the manufacture of high grade furniture, arm-chairs and closets.

Dalbergia cochinchinensis Pierre. Family Leguminosae. Vernacular names: Trắc (Vietnam); Kranhung (Cambodia); may Kanhoung (Laos).

Regarded as a luxury wood, produced in South and Central Vietnam, Cambodia and Laos; logs 4 to 5 m. long and 30 to 35 cm. in width. Wood reddish with fine dark or almost black streaks; is close-textured, very durable, hard and heavy and is much esteemed for high-grade furniture.

Dialium cochinchinensis Pierre. Family Leguminosae. Vernacular names: Xoay (Vietnam); Kralanh (Cambodia); may Mac kheng (Laos).

A first grade timber, produced commercially in South Vietnam, Cambodia and Laos; bole from 5 to 10 m. in length, and from 25 to 40 cm. in diameter. Wood reddish brown, and has a very fine grain; shrinks appreciably on drying and preserves well in moisture; is hard and very heavy; is somewhat difficult to work and splits readily under pressure; is very resistant to insect attacks and teredo and to weathering; it is an excellent hardwood, utilized above all in the manufacture of rolls or drums to crush sugarcane; also for hubs of wagons and rudders.

Diospyros mun (A. Chev.) H. Lec. Family Ebenaceae. Vernacular names: Mun (Vietnam); Angkot khmau (Cambodia); may Mac kủa (Laos).

Classed as a luxury timber, this is produced in Central Vietnam and Cambodia; logs measure 4 to 6 m. in length and 35 to 45 cm. in diameter. Wood greenish black, and has a fine grain; is very hard and heavy; takes a beautiful polish and is easy to work, but does not take nails; is resistant to insect attacks and weathering; much esteemed for cabinetwork; also used for the manufacture of walking sticks, boxes, harpoons for fishing, and is suitable for javelins, but has been heavily cutover and is now somewhat rare.

Dipterocarpus spp. Family Dipterocarpaceae. Vernacular names: Dau, Conrai, Mit, Sonnang, Trabeng, Long, Son (Vietnam); Chhoeuteal, Bai, Thom, Tuk, Bankoucy, Chhngar (Cambodia); may Nhang, may Sabeng, may Cung (Laos).

A second grade timber; produced in South Vietnam; logs 20 to 25 m. long and 100 to 150 cm. in diameter. Wood reddish, with somewhat coarse grain; is resistant to water; somewhat soft, but moderately hard and heavy; is easy to work and takes paint and varnish well; it is not very resistant to insect attacks or to weathering. It is useful for general construction, for the same purposes as fir, and for planks in the construction of river boats or sampans. Its large dimension, ease of working, absence of defects make this wood useful for veneers for plywood and for the interior construction of houses, such as ceiling and wainscot. Some species of Dau, such as Dipterocarpus alatus, Dau conrai, and D. dyeri, Dau song nang, are moderately durable and are not resistant to weathering. But D. artocarpifolius, Dau mit, D. intricatus, Dau long, and D. obtusifolius, Dau tra ben, are resistant to weathering and especially termites, especially D. intricatus and D. artocarpifolius. For this reason they are much esteemed for weathering.

Erythrophleum fordii Oliver. Family Leguminosae. Vernacular names: Lim, Lim xanh (Vietnam); may Lem (Laos).

A first class timber; logs measure from 6 to 12 m. in length, and 60 to 80 cm. in diameter. Wood light brown, often streaked and lustrous, with a coarse grain; it shrinks appreciably when used green, and preserves well in water; is hard and very heavy; the presence of cross grain makes it difficult to work and to take polish; is almost incorruptible when exposed to weathering. Considered an excellent wood for construction, and has multiple uses, such as in carpentry, for railroad crossties, wharfs, planks for decks and floors, in bridge construction, wagons, doors and windows, heavy furniture and shelves. It may be used for paving streets. It is much esteemed in North and Central Vietnam especially in heavy construction, and takes the place of Sao (Hopea odorata) extensively used in South Vietnam.

Garcinia spp. Family Guttiferae. Vernacular names: Trai, Trai lý (Vietnam); may Lay, Lý (Laos).

A first grade timber, produced in North and Central Vietnam; logs 12 to 15 m. long and 35 to 40 cm. in width. Wood yellowish brown; has a very fine grain; is very hard and very heavy; takes a good polish, resistant to insect attacks and is almost incorruptible. It is suitable for fine carpentry, turnery, carving, general construction and railroad crossties.

Hopea dealbata Hance and H. odorata Roxb. Family Dipterocarpaceae. Vernacular names: Sao, Den, Xanh (Vietnam); Koki, Mosau, Dek (Cambodia); may Ken, Kheng (Laos).

A first grade timber, produced commercially in South Vietnam; logs from 15 to 20 m. long, and about 80 cm. in diameter. Wood yellow or sometimes greenish, turning rapidly to reddish brown; has a fine grain; moderately hard to hard and fairly heavy to heavy; takes paint and varnish well; is subject to slight shrinkage and preserves well in water; is easy to work. It is very resistant to weathering, and is regarded as the best timber in Southeast Asia for durable, heavy construction. Comparable to oak (Quercus), it is more flexible and lighter in weight than most of the other useful local timbers. It is used for a wide range of purposes, including carpentry, flooring, doors and windows, tables, cupboards, shelves and railroad crossties; also in naval construction for ribs and decks of ships (junks) and for making agricultural vehicles.

Hopea pierrei Hance. Family Dipterocarpaceae. Vernacular names: Kiền kiền (Vietnam); Koki khsach (Cambodia).

A first class timber exploited in Central Vietnam; logs 10 to 15 m. long, and 50 to 60 cm. in diameter. Wood light brown, turning rapidly to darker brown, and somewhat streaked; has a fine, straight grain; has slight shrinkage and preserves well in water; when seasoned it becomes very hard and is somewhat difficult to work; is resistant to insect attacks, especially termites, and to weathering. It is especially esteemed for durable construction, such as posts and pillars for wharfs, bent work, planks, masts and decks in shipbuilding. This timber, found only in Central Vietnam, is used for the same purposes as Lim (Erythrophloeum fordii) in North Vietnam and Sao (Hopea odorata and H. dealbata) in the South.

Lagerstroemia spp. Family Lythraceae. Vernacular names: Bằng lang, Thao lao, Sang lẻ (North-central Vietnam); Sra lao, Entranel (Cambodia); may puo'i (Laos).

A second grade timber; produced commercially in the southern part of South Vietnam, Central Vietnam, Cambodia and Laos; logs 10 to 15 m. long and 60 to 80 cm. in width. Wood brownish with a grayish tinge; has a fine grain; does not shrink much and preserves well when exposed to moisture. This is one of the best woods for building boats, as it bends well and is resistant to insects, termites, and vibration; also considered suitable for general construction. It is much utilized in the building of fishing boats and junks, rafters and beams of roofs, ribs of hull, and for making tool handles; also for furniture and interior construction. Unfortunately larger logs often have heart rot.

Litsea vang H. Lec. Family Lauraceae. Vernacular names: Bồi lồi (Vietnam); Beloi (Cambodia); may Bóng nang (Laos).

A first grade timber exploited in South and Central Vietnam, and Cambodia; logs 10 to 12 m. long, and 50 to 60 cm. in width. Wood is lustrous, yellowish brown; fragrant when fresh; resistant to insect attacks and weathering; preserves well when immersed in water. It is suitable for making furniture, carpentry and cabinetwork.

Lophopetalum duperreanum Pierre. Family Celastraceae. Vernacular names: Sáng trắng, Ba khía (Vietnam).

A third grade timber, exploited commercially in South Vietnam; bole from 10 to 12 m. in length, and about 60 cm. in diameter. Wood is white with grayish streaks, turning brownish on exposure to air; has a fine grain; is soft and light in weight; liable to check and is not durable; is subject to slight shrinkage and preserves well in water. It is suitable for packing boxes, shoes and clogs, matches and is utilized also for packing crates to transport tobacco and petroleum cans.

Mallotus cochinchinensis Lour. Family Euphorbiaceae. Vernacular names: Vang, Vang trứng (Vietnam); Champou prey (Cambodia).

A third grade timber, produced commercially in North Vietnam and North-central Vietnam; logs 10 to 21 m. in length, and 40 to 45 cm. in width. Wood is yellowish white; has a somewhat coarse grain; is very soft, light in weight, but fairly durable; easy to plane but subject to check. It is suitable for the manufacture of footwear, in cooperage, for making boxes and crates and matchboxes; appears to be suitable also for plywood.

Manglietia glauca Blume. Family Magnoliaceae. Vernacular names: Mỡ vàng tâm (Vietnam); may Luong khom, Ham khòm (Laos).

A first class timber, with centers of production located in North Vietnam, north-central Vietnam and Laos; logs 5 to 10 m. long, and 50 to 60 cm. in diameter. Wood is yellowish, turning to pale brown on exposure to light; has a fine grain; is fragrant when fresh; is light in weight, soft and resistant to insect attacks and weathering; it retains paint and varnish well. It is much esteemed locally for carving and for the manufacture of high grade furniture.

Melanorrhoea laccifera Pierre. Family Anacardiaceae. Vernacular names: So'n (Vietnam); Kroeul (Cambodia); may Nam kieng (Laos).

Considered a luxury timber, this is exploited in South and Central Vietnam and Cambodia; logs 5 to 8 m. long, and 30 to 35 cm. in diameter. Wood is mahogany red, very homogeneous; has a fine grain; is hard, heavy, takes an attractive polish, but does not resist weathering when exposed for prolonged periods. Unfortunately it is liable to stain and to become brittle when in contact with moisture. It is used in cabinetwork and is also suitable for turnery, carving and pillars of pagodas.

Melia spp. Family Meliaceae. Vernacular names: Xoan, Sau dau (Vietnam); Sdau, Anlok, Khmoch (Cambodia); may Hiên (Laos).

A second grade timber, produced in North Vietnam and Laos; logs 8 to 10 m. long and 40 to 50 cm. in width. Wood is pinkish; has a somewhat coarse grain; is soft, light in weight and fairly durable; does not preserve well in water; easy to work and takes paint and varnish well; utilized for boxes and crates, carpentry, and especially for posts and pillars in house construction, and inferior grade furniture.

Mesua ferrea L. Family Guttiferae. Vernacular names: Vấp (Vietnam); Bosréack (Cambodia); may Ka thang (Laos).

A first grade timber, produced in South Vietnam, Cambodia and Laos; logs from 5 to 10 m. in length, and 25 to 55 cm. in width. Wood has a dark mahogany color; has a rather fine grain; is hard, very heavy; durable and resistant to teredo; subject to appreciable shrinkage and preserves well in water. It is easy to work when freshly cut, but difficult to saw when dried; used mostly for pillars in wharf construction and beams for wagons.

Pahudia cochinchinensis Pierre. Family Leguminosae. Vernacular names: Gõ dỗ, Gõ tò te (Vietnam); Beng (Cambodia); may Suc (Laos).

A first class timber, produced in Cambodia, South Vietnam, South-central Vietnam, Cambodia and Laos; logs from 5 to 10 m. in length, and 60 to 80 cm. in diameter. Wood is light brown with a yellowish tinge; has a rather coarse texture; takes an attractive luster when polished; is very resistant to weathering. It is much esteemed for carving and the manufacture of high-grade furniture.

Parashorea stellata Kurz. Family Dipterocarpaceae. Vernacular names: Chô chi (Vietnam); may Háo (Laos).

A second grade timber, produced in North Vietnam, Central Vietnam and Laos; logs from 15 to 20 m. long, and 80 cm. to 1 m. in diameter. Wood gray with a yellowish to pinkish tinge, and turns brown on exposure to air; has a somewhat coarse grain; is very durable and preserves well in water but is less durable when alternating between humid and dry soil. Its tendency to darken when exposed to sun limits its use for the manufacture of furniture. It is suitable for construction, especially for boat and shipbuilding, and is best used in contact with water, such as hulls of ships.

Parinarium anamense Hance. Family Rosaceae. Vernacular names: Câm (Vietnam); khlonk (Cambodia).

Considered a third class timber; produced commercially in South and south-central Vietnam and Cambodia; logs 5 to 10 m. long and 50 to 60 cm. in width. Wood yellowish when freshly cut, gradually turning to light brown or pinkish; resistant to moisture; is moderately hard and heavy; somewhat difficult to work; saws with difficulty and does not take a high polish. It is suitable for interior carpentry, although little exploited.

Pasania fissa Oerst. (=Quercus fissa Champ.). Family Fagaceae. Vernacular names: Sói bôp (Vietnam).

A second grade timber, produced in North Vietnam; logs 5 to 10 m. long, and 60 to 80 cm. in diameter. Wood white to yellow, occasionally with characteristic short streaks, and no demarcation between sapwood and heartwood; has a slight shrinkage and preserves well in water; is soft, light in weight and durable; it is suitable for joinery, panels and for the manufacture of window blinds.

Pinus khasya Royle. Family Coniferae. Vernacular names: Pin a 3 feuilles (Commercial); Thông, Ngo (Vietnam); may Pec (Laos).

Three-needled pine, classed as second grade timber; this is produced on the plateau of Lang-bian, Dalat region, South Vietnam; logs measure from 8 to 10 m. in length, and 50 to 60 cm. in diameter. Wood is heterogeneous in properties; the sapwood, sharply defined from the heart, is white or yellowish white, while the heartwood is light brown and has a strong odor of turpentine when freshly cut; is hard and heavy; shrinks appreciably and has a high saturation point. It is suitable for interior construction and for making packing cases; the 3-needled pine in the Dalat area replaces Dau (Dipterocarpus) for joinery.

Pinus merkusii Jungh. Family Coniferae. Vernacular names: Pin a 2 feuilles (Commercial); Thong (Vietnam); Sral (Cambodia); may Pe, Pec (Laos).

The 2-needled pine, considered a second grade timber, is produced commercially in Cambodia and South-central Vietnam; logs 10 to 15 m. long, and 50 to 60 cm. in diameter. Wood is heterogeneous in color, with the sapwood ranging from white to yellowish white or reddish, while the sharply demarcated heartwood suggests pitchpine, and varies from yellowish white to yellowish with reddish streaks; is hard to very hard, shrinks appreciably and preserves well in water. It is suitable for interior construction, joinery and packing cases. The 2-needled pine growing in Cambodia is more strongly streaked and less odorous than that of Central and North Vietnam; commonly called "pitchpin", it is used for the interior of railroad cars and general furniture. The wood of 2-needled pine presents variable characteristics according to the tree; some boles have a dense wood, and very durable because of abundant resin present, so that the timber can be used for outdoor construction and other uses exposed to weathering.

Pterocarpus pedatus Pierre. Family Leguminosae. Vernacular names: May douk (Commercial); Dang huong (Vietnam); Thnong (Cambodia); may Dúk (Laos).

Considered a luxury wood, produced in South and Central Vietnam, Cambodia and Laos; logs from 10 to 16 m. in length and 50 to 60 cm. in diameter. Wood is orange yellow, reddish or reddish brown, well streaked and occasionally mottled; exudes a fragrance suggesting sandal or rosewood; has a fine grain; is hard and heavy; takes a good polish; is susceptible to slight shrinkage and preserves well in water; but the presence of its cross grain makes it somewhat difficult to give it a high finish; is resistant to insect attacks and weathering. It is considered an excellent wood for the manufacture of high-grade furniture and is much sought also for fine carpentry and cabinetwork. It is sometimes exported under the name of rosewood.

Pygeum arboreum Endl. Family Rosaceae. Vernacular name: Xoan dào (Vietnam).

A second grade timber, produced commercially in North Vietnam; logs 10 to 12 m. long, and 40 to 45 cm. in width. Wood pale mahogany color with pinkish gray sapwood, not sharply demarcated from the heartwood; has a fine grain and silky luster; and easy to work; shrinks slightly and has a tendency to rot in water and is not resistant to weathering; is soft and light in weight. It is used in joinery and carpentry, also in coach-building, the manufacture of barrels to store cement, and for rifle butts.

Quercus (Pasania) spp. Family Fagaceae. Vernacular names: Giẻ, Sồi (Vietnam); Krang, Khos (Cambodia); may Cổ (Laos).

A second grade timber, expoloited in North and Central Vietnam and Laos; logs 5 to 10 m. long and 60 to 80 cm. in diameter. Wood is pinkish or pale reddish gray; has a cross grain; shrinks appreciably, preserves well in water, but is subject to checking when dried. It is suitable for general construction, and is used in North Vietnam for a variety of purposes, including tool handles, construction of farm houses, wheelbarrows, wagons and wheels. Because of its susceptibility to insect attack, it is best adapted for interior construction.

Sandoricum indicum Cav. Family Meliaceae. Vernacular names: Sâu (Vietnam); Kompeang reach (Cambodia).

Considered a third grade timber, produced in South Vietnam and Cambodia; logs 10 to 12 m. long, and about 60 cm. in diameter. Wood is pale red; has a faint camphor-like odor; rather coarse grained; is soft and light in weight; resistant to weathering. It is used for making footwear, in general carpentry and is suitable also for the manufacture of pencils.

Shorea cochinchinensis Pierre. Family Dipterocarpaceae. Vernacular names: Sến mủ, Xến mủ (Vietnam); Popel, Mosau, Thmar (Cambodia).

A first grade timber, produced in South Vietnam; logs 15 to 20 m. long, and about 80 cm. in diameter. Wood is yellow, turning to reddish brown, and has an oily touch on the flat surface; is moderately hard and heavy; and easy to work. Although less durable, it is used for the same purposes as Sao (Hopea). It is suitable for the building of boats, but does not last more than 10 years when in contact with saline water; is also suitable for interior construction.

Shorea hypochra Hance. Family Dipterocarpaceae. Vernacular names: Sen bobo (Vietnam); Lumbor, Koki luong (Cambodia).

A second class timber, produced commercially in Cambodia under the name of Lumbor; logs from 15 to 20 m. in length, and 50 to 80 cm. in diameter. Wood is light yellow and has a faint luster, turning brownish on long exposure to sunlight; has a fairly fine grain; is moderately heavy and fairly hard. This timber is similar in properties to Sao (Hopea), except that it susceptible to termites and does not withstand moisture well. It is abundant in Cambodia. As a result of extensive cutting of Hopea, it is used extensively in that country to make crates for shipping rubber and other products.

Shorea obtusa Wall. Family Dipterocarpaceae. Vernacular names: Cà chắc (Vietnam); Phchek (Cambodia); may chich (Laos).

A first grade timber, produced mainly in Cambodia; logs 15 to 20 m. long, and 50 to 60 cm. in diameter. Wood is reddish brown; has a fine grain; preserves well when exposed to moisture; is easy to work, bends well, but is somewhat difficult to polish. It is considered excellent for heavy construction and is much sought for naval construction. It is often used for railroad crossties, and telephone and telegraph poles, because of its resistance to teredos and to weathering.

Shorea vulgaris Pierre. Family Dipterocarpaceae. Vernacular names: Chai (Vietnam); Chorchong (Cambodia); may Hång (Laos).

Considered a second grade timber, produced in South Vietnam, south-central Vietnam and Laos; logs from 15 to 20 m. long, and 60 to 100 cm. in diameter. Wood is grayish pink and has a yellowish tinge; has a fairly fine texture and is cross-grained; moderately hard and fairly heavy; and is resistant to moisture. It is more durable and resistant to weathering than Dau (Dipterocarpus). Although exploited only to a limited extent, it is suitable for construction, especially for boat and ship building. The wood contains an abundance of resin (up to 40 or 50 liters per tree) which is used for caulking boats.

Sindora cochinchinensis Baill. Family Leguminosae. Vernacular names: Go mât (Vietnam); Krakas (Cambodia); may Te (Laos).

A first grade timber, produced in Cambodia, South and Central Vietnam and Laos; logs from 5 to 10 m. long, and 80 to 100 cm. in diameter. Wood is yellowish brown when fresh, turning rapidly to reddish brown and often streaked; has a fine grain; hard and very heavy; takes a good polish; shrinks slightly and preserves well in water; is durable because of the resin present. It is considered an excellent wood for general construction, furniture manufacture, and can be carved and turned without difficulty. In Cambodia, where it has been exploited extensively, it is used in carpentry, for columns of pogodas and for building expensive houses. In South and Central Vietnam it is much esteemed for fine furniture, cabinetmaking and carpentry.

Styrax sp. Family Styracacese. Vernacular names: Bồ dề (Central Vietnam); may Nhan (Laos).

A third grade timber, produced in North Vietnam, north-central Vietnam and Laos; logs from 8 to 12 m. long and 30 to 40 cm. in width; wood is white; has a fine grain; is not durable, subject to slight shrinkage but preserves rather well when immersed in water. It is used mainly for making match boxes.

Talauma duperreana Finet & Gagnep. Family Magnoliaceae. Vernacular names: Giổi (Vietnam); may Ham (Laos).

A first class timber, produced in North Vietnam, north-central Vietnam and Laos; logs 10 to 12 m. long and 40 to 60 cm. in diameter. Wood is lustrous yellow, fragrant; has a very fine grain; shrinks slightly and preserves well in water; is easy to work; takes paint and varnish well; it is resistant to insect attacks and is almost incorruptible. It is utilized for carpentry, joinery, cabinetmaking, boxes and crates, for building sampans and is especially useful for making carved furniture.

Tarrietia cochinchinensis Pierre. Family Sterculiaceae. Vernacular names: Huynh (Vietnam); Spon, Bey sanlek (Cambodia); may Hhom pa (Laos).

A second class timber, produced in South and Central Vietnam, Cambodia and Laos; logs measure 10 to 15 m. long, and 50 to 60 cm. in diameter. Wood is reddish with a violet tinge, often streaked; has a coarse grain; shrinks slightly and does not preserve well in water; is soft but fairly heavy; although rather easy to work it does not take a good polish; although resistant to insect attacks, it does not withstand weathering well: it is used mainly for interior carpentry, wheelwright, wainscotting, partitions and flooring. It is often utilized with Dau (Dipterocarpus) in the manufacture of ordinary furniture, closets, desks, with Dau forming the frame and Huynh the panels. It is also suitable for plywood, but unfortunately larger logs often have heartrot.

Tectona grandis L. Family Verbenaceae. Vernacular names: Teck (Commercial); Giá ty (Vietnam); May sac (Cambodia); may Sac (Laos).

A first grade timber, with center of commercial production in northwest Laos; logs 5 to 10 m. in length, and from 60 to 80 cm. in diameter. Wood is yellowish brown and slightly streaked; has a fine grain, with a characteristic odor and an oily feel; is moderately light in weight and very durable; is subject to slight shrinkage, preserves very well in water; is resistant to insect attack and teredo; preserves well when exposed to weathering and moisture. This well known wood is considered an excellent timber for durable construction, high-grade carpentry, the manufacture of furniture, and especially for naval construction.

Tetrameles nudiflora R. Br. Family Datiscaceae. Vernacular names: Tung (Vietnam); Sampong (Cambodia).

Classed as fourth grade timber, commercial production centered in South Vietnam and Cambodia; logs from 10 to 15 m. long, and 1 to 1.50 m. in width. Wood is yellowish white; has a rather fine grain; is easy to work, subject to slight shrinkage, and absorbs a large amount of moisture; susceptible to insect attacks; liable to check and is brittle. It is used for boxes and crates; its lack of shrinkage and uniformity of logs make it suitable for panels.

Terminalia spp. Family Combretaceae. Vernacular names: Chiêu liêu (Vietnam); Sramar (Cambodia); may Kheo nua (Laos).

A second grade timber, produced in South Vietnam and Cambodia; logs 15 to 20 m. long and 50 to 80 cm. in diameter. Wood is grayish, with a greenish yellow tinge; has a fine grain; is easy to work and takes an attractive polish; is resistant to moisture. It is much esteemed for cabinetwork, wheelwright work, agricultural implements, ribs of boats and oars.

Toona febrifuga M. Roem. Family Meliaceae (Mahogany). Vernacular names: Xoan moc, Xuong mot (Vietnam); Chom cha (Cambodia); may Nhum (Laos).

A second grade timber, produced commercially in all the Mekong basin countries; logs from 15 to 20 m. in length, and 80 cm. in diameter. Wood is pinkish, turning to mahogany brown; is very fragrant; has a somewhat coarse grain; subject to slight shrinkage, and does not preserve well in moisture; is soft; is light in weight and easy to work. It is used especially for the manufacture of cigar boxes, and is suitable also for joinery, wainscotting, partitions and furniture making; but is little used for general construction.

Vatica spp. Family Dipterocarpaceae. Vernacular names: Lâu táu (Vietnam); Chramas, Tralak (Cambodia); may Chich dèng (Laos).

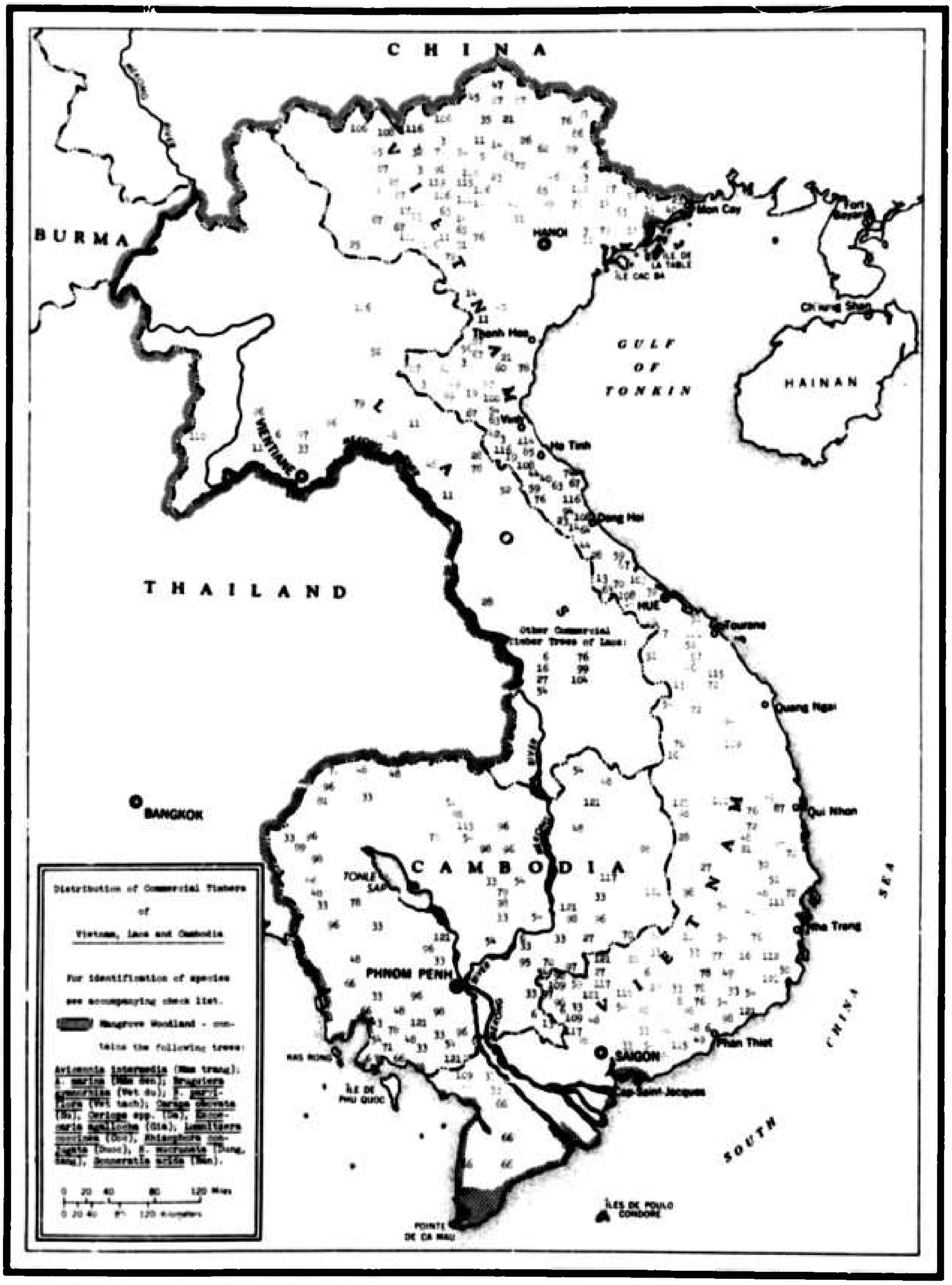
A first class timber, produced in South Vietnam and Cambodia; logs from 10 to 15 m. long and 30 to 35 cm. in diameter. Wood is creamy white with a greenish tinge, and turning gradually to yellowish brown; has an interwoven grain; is hard and heavy; has a rather good shrinkage and preserves well when exposed to moisture; is resistant to insect attacks, except teredo. It is often used for pillars, in carpentry, building boats, especially those used for fishing.

Wrightia sp. Family Apocynaceae. Vernacular names: Lòng mú'c (Vietnam); Choeu day khla (Cambodia); may Muc (Laos).

A third class timber, produced in North and South Vietnam, Cambodia and Laos; logs measure from 5 to 8 m. in length, and 35 to 40 cm. in diameter. Wood is uniformly white; has a fine grain; is rather durable; is soft and light in weight; shrinks slightly and does not preserve well in water. It is used for making shoes, turning and carving. On account of its light weight it is also suitable for boxes and crates.

<u>Xylia dolabriformis</u> Benth. Family Leguminosae. Vernacular names: Cẩm xe (Vietnam); Sokram (Cambodia); may Dèng (Laos).

A first grade timber produced in South Vietnam; logs from 8 to 10 m. long and 60 to 80 cm. in diameter. Wood is reddish brown; has a fine grain; is very hard, heavy and impregnated with resin; easy to work when freshly sawed, but becomes more difficult on seasoning and is almost incorruptible. It is considered an excellent wood for naval construction, marquetry, wheelwright, railroad crossties, telephone and telegraph poles.


CHINA
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CAMBODIA
HANOI
Mon Cay
ÎLE CAC BA
GULF OF TONKIN
HAINAN
Thanh Hoa
Ha Tinh
Dong Hoi
VIENTIANE
HUE
Tourane
Quang Ngai
Qui Nhon
Nha Trang
BANGKOK
TONLE SAP
PHNOM PENH
SAIGON
Phan Thiet
Cap Saint Jacques
ÎLE DE PHU QUOC
POINTE DE CA MAU
ÎLES DE POULO CONDORE
SOUTH CHINA SEA
Other Commercial Timber Trees of Laos:
Distribution of Commercial Timbers of Vietnam, Laos and Cambodia
For identification of species see accompanying check list.
Mangrove Woodland - contains the following trees:

Map 3

Distribution of Commercial Timber Trees

in

Vietnam, Cambodia and Laos 1/

(See accompanying map for identification of species)

Botanical Name	Local Commercial Name
1. Actinodaphne chinensis	Re mit
2. Adina cordifolia	Gáo
3. Aglaia gigantea	Goi
4. Albizzia lucida	Bang xe
5. Alstonia scholaris	Mò cua
6. Anisoptera cochinchinensis	Vên vên
7. Antiaris toxicaria	Sui
8. Aquilaria agallocha	Gió bâu
9. Artocarpus hirsuta	Mit nài
10. Artocarpus masticata	Chay
11. Bassia pasquieri	Sèn
12. Boehmeria nivea	Gai
13. Calophyllum spp.	Công
14. Canarium spp.	Châm
15. Carallia lucida	Sang mà
16. Cassia siamea	Muông
17. Cassia timorensis	Muông tía
18. Cassia sp.	Muông trang
19. Castanopsis indica	Cà ôi
20. Casuarina equisetifolia	Filao
21. Chikrassia tabularis	Lát hoa
22. Cinnamomum iners	Háu phat
23. Cinnamomum spp.	Re
24. Commersonia echinata	Thung
25. Cunninghamia sinensis	Samou
26. Dacrydium elatum	Hoang dan

1/ Source: Maurand, P. 1943. L'Indochine Forestière. 252 pp. Hanoi.

	Botanical Name	Local Commercial Name
27.	Dalbergia bariensis	Cẩm lai
28.	Dalbergia cochinchinensis	Trac
29.	Dialium cochinchinense	Xoay
30.	Diospyros mun	Mun
31.	Diospyros siamensis	Cẩm thi
32.	Dipterocarpus sp.	Chò nau
33.	Dipterocarpus spp.	Dầu
34.	Dolichandrone rheedi	Quao
35.	Duabanga sonneratioides	Phay
36.	Dysoxylum loureiri	Huỳnh duờng
37.	Engelhardtia chrysolepis	Cheo
38.	Eriodendron anfractuosum	Gòn
39.	Erythrina indica fordii	Vông
40.	Erythrophleum fordii	Lim
41.	Eugenia spp.	Tram
42.	Excoecaria agallocha	Giáo
43.	Fagraea fragrans	Trai
44.	Ficus spp.	Sung, Sộp
45.	Fokienia hodginsii	Pemou
46.	Garcinia sp.	Trai lý
47.	Heynea trijuga, var. microcarpa	Sang
48.	Hopea dealbata	Sao
49.	Hopea ferrea	Sang dá
50.	Hopea odorata	Sao
51.	Hopea pierrei	Kiền kiền
52.	Keteleeria davidiana	May hinh
53.	Knema corticosa	Sang mau
54.	Lagerstroemia spp.	Bằng lang
55.	Linociera macrophylla	Hỏ bí
56.	Liquidambar formosana	Thâu
57.	Litsea longipes	Du
58.	Litsea polyantha	Bời lời nhot
59.	Litsea vang	Bời lời
60.	Lophopetalum duperreanum	Sang trăng
61.	Lophopetalum wightianum	Ba khia
62.	Machilus odoratissima	Khảo
63.	Mallotus cochinchinensis	Vang
64.	Manglietia glauca	Mo vâng tâm
65.	Markhamia (Dolichandrone) stipulata	Dinh
66.	Melaleuca leucadendron	Trầm
67.	Melia spp.	Xoan
68.	Mesua ferrea	Vắp
69.	Nephelium chryseum	Truờng chua
70.	Pahudia cochinchinensis	Gõ dỏ

	Botanical Name	Local Commercial Name
71.	Palaquium obovatum	Gomme gutte, (Gutta percha)
72.	Parashorea stellata	Chò chi
73.	Parinarium annamense	Càm
74.	Payena elliptica (Madhuca elliptica)	Viêt
75.	Peltophorum ferrugineum	Lim xet
76.	Pentace burmanica	Nghiên
77.	Pinus khasya	Pin a 3 feuilles
78.	Pinus merkusii	Pin a 2 feuilles
79.	Pinus spp.	Pin
80.	Podocarpus cupressina	Xun pemou
81.	Podocarpus neriifolia	Thông tre, Faux pemou
82.	Pometia pinnata	Tru'ong
83.	Pterocarpus pedatus	Maydouk
84.	Pterocarya stenoptera	Co'i
85.	Pygeum arboreum	Xoan dâo
86.	Quercus (Pasania) fissa	Sôi bòp
87.	Quercus (Pasania) spp.	Giẻ
88.	Rhizophora conjugata	Duo'c
89.	Salmalia (Bombax) malabarica	Gao
90.	Sandoricum indicum	Dou
91.	Sapium sebiferum	Soi
92.	Schima crenata	Trò sót
93.	Semecarpus sp.	Léo heo
94.	Shorea cochinchinensis	Sèn mú
95.	Shorea hypochra	Lumbor
96.	Shorea obtusa	Cà chàc
97.	Shorea vulgaris	Chai
98.	Sindora cochinchinensis	Gò mât, Sèn mú
99.	Sindora tonkinensis	Gu
100.	Spatholobus sp.	Ràng ràng
101.	Spondias lakonensis	Giâu gia
102.	Shorea thorellii	Sèn cho chai
103.	Sterculia lychnophora	Uo'i
104.	Stereospermum annamense	Ké
105.	Strychnos nux-vomica	Co chi
106.	Styrax tonkinensis	Bò dé
107.	Swietenia sp. (?)	Giai ngua
108.	Talauma sp.	Giôi
109.	Tarrietia cochinchinensis	Huỳnh
110.	Tectona grandis	Teck
111.	Terminalia catappa	Bàng
112.	Terminalia tomentosa	Câm liên

Botanical Name	Local Commercial Name
113. Terminalia spp.	Chiều liêu
114. Tetrameles nudiflora	Tung
115. Toona febrifuga	Xoan moc
116. Vatica sp.	Tàu
117. Vatica spp.	Làu táu
118. Vitex pubescens	Bình linh
119. Wrightia sp.	Lòng mức
120. Xanthophyllum sp.	Sang ót
121. Xylia dolabriformis	Càm xe
122. Xylia kerrii	Dà dá

Timbers and Other Forest Products of Thailand

The forests of Thailand contain a wealth of timber trees and other forests products, which represent an important source of revenue for the country. Principal of these timbers, of course, is teak (Tectona grandis), concentrated mainly in the northern Mixed Hardwood forests. For many decades Teak figured as the principal timber used within the country and for export. In recent years, however, exports of other timbers, particularly those of the Dipterocarp family, have equaled those of Teak. Because of over-cutting in former years, and destruction caused by shifting agriculture and fire, there is a need for a systematic program to restore the teak forests as well as some of the other more important commercial trees.

The following trees are indicative of the variety of timber species in Thailand and their uses. For simplification, these are grouped according to their local application.

Botanical Name	Thai Name 1/
Construction:	
Adenanthera microsperma	Ma-kam-ton
Adenanthera pavonina	Ma-kiam-ta-chang
Afzelia xylocarpa	Ma-kha-yai
Artocarpus calophylla	Kha-nun-pan
Artocarpus lanceifolia	Kha-nun-pa
Chukrasia tabularis	Siat-ka
Chukrasia velutina	Yom-hin
Dipterocarpus alatus	Yang-khao
Dipterocarpus costatus	Yang-daeng
Dipterocarpus dyeri	Yang-klong
Dipterocarpus grandiflorus	Yang, Yang-yung
Dipterocarpus intricatus	Krat
Dipterocarpus obtusifolius	Hiang
Hopea ferrea	Ta-khian-nu
Hopea odorata	Ta-khian
Hopea pierrei	Ta-khian-sai
Lagerstroemia calyculata	Ta-baek-yai
Myristica spp.	Chan-thet
Nephelium lappaceum	Ngo

1/ Most of the species listed have several vernacular names, varying from one region to another. The one cited, in most cases, is that in common usage.

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1/ Most of the species listed have several vernacular names, varying from one region to another. The one cited, in most cases, is that in common usage.

Botanical Name	Thai Name
Construction - continued:	
Palaquium gutta	Chik-nom
Palaquium obovatum	Kha-nun-rok
Pterocarpus spp.	Pra-du
Syzygium (Eugenia) spp.	Wa
Terminalia triptera	Tan-deang
Terminalia tripteroides	Pu-chao
Xylia kerrii	Daeng
Xylia xylocarpa	Daeng
Xylocarpus moluccensis	Ta-bun-dam
Posts, Poles and Pillars:	
Acacia catechu	Si-siat-nu'a
Acacia siamensis	Ka-thin-pa
Adenanthera microsperma	Ma-kam-ton
Adenanthera pavonina	Ma-klam-ta-chang
Afzelia retusa	Lumpho-tha-le
Avicennia spp.	Sa-mae
Azadirachta indica, var. siamensis	Sa-dao
Berria ammonilla	Liangman
Berria mollis	Liangman
Boschia griffithii	Thu-riannok
Bruguiera cylindrica	Rui
Bruguiera gymnorhiza	Pra-sakdaeng
Bruguiera parvifolia	Rangka-thae
Bruguiera sexangula	Pra-sakdaeng
Cassia fistula	Chaiya phruk
Casuarina equisetifolia	Sontha-le
Ceriops roxburghiana	Prong
Ceriops tagal	Prongdaeng
Cratoxylon spp.	Taeo
Crypteronia griffithii	Miang-am
Crypteronia paniculata	Khap
Cynometra spp.	Mangkha
Dehaasia cuneata	Hae-ra-cho
Dialium cochinchinense	Khleng
Dialium indum	Ka-yi-khao
Diospyros spp.	Ta-ko-pha-nom, Ri-phao
Elateriospermum tapos	Pra
Erythroxylon cuneatum	Krai-thong
Fagraea fragrans	Kan-krao
Garcinia cornea	Pha-wa

Botanical Name	Thai Name
Posts, Poles and Pillars - continued:	
Helicia spp.	Mu'at-khon-tua-mae
Heritiera javanica	Ngon-kai
Heritiera sumatrana	Ngon-kai
Hopea pierrei	Ta-khian-sai
Hopea recopei	Chan-phu
Hydnocarpus anthelmintica	Ka-bao
Hydnocarpus kurzii	Ka-bao
Kandelia rheedei	Rang-ka-thae
Lagerstroemia floribunda	Ta-baek-na
Lagerstroemia loudonii	Sa-lao-bai-yai
Lagerstroemia macrocarpa	In-thanin-bok
Lagerstroemia tomentosa	Sa-lao-bai-lek
Litchi chinensis	Lin-chi
Litsea petiolata	Tham-mang
Lumnitzera littorea	Fat-daeng
Lumnitzera racemosa	Fat-khao
Madhuca pierrei	Ma-sang
Melaleuca leucadendron	Sa-met
Morinda coreia	Yo-pa
Morinda elliptica	Sa-lakpa
Neolitsea zeylanica	Ian
Ochrocarpus harmandii	Sara-phi
Ochrocarpus harmandii	Sara-phi
Ochrocarpus siamensis	Sara-phi-dok-yai
Oncosperma horrida	Lao-cha-on-khao
Oncosperma tigillaria	Lao-cha-on
Padbruggea spp.	Khi-mu
Payena spp.	Phi-kunpa, Phi-khun thu'an
Persea americana	A-wo-kha-do
Phoebe spp.	Khang-khok
Pithecolobium bubalinum	Niangnok
Pithecolobium jiringa	Ma-niang
Premna pyramidata	Sak-khi-kai
Protium serratum	Ma-faen
Pterospermum diversifolium	Cham-pi-khaek
Rhizophora mucronata	Kongkangbai-yai
Saccopetalum lineatum	E-raet
Schleichera trijuga	Ta-khro
Scorodocarpus boreneenis	Ka-thiam-ton
Sindora echinocalyx	Ma-kha
Stereospermum spp.	Khae-hin
Strychnos nux-vomica	Sa-laeng-chai
Styrax benzoides	Kam-yan
Terminalia alata	Rokfa

Botanical Name	Thai Name
Posts, Poles and Pillars - continued:	
Terminalia chebula	Sa-mo-thai
Terminalia citrina	Sa-mo-di-ngu
Terminalia mucronata	Ta-baek-lu'at
Terminalia pierrei	Ta-baek-khon
Thespesia populnea	Pho-tha-le
Vatica cinerea	Sak-hin
Vitex canescens	Sa-mo-ka-nom
Vitex limonifolia	Sa-wong
Vitex pinnata	Tin-nok
Xylocarpus obovatus	Ta-bun-khao
Flooring:	
Afzelia bakeri	Lum-pho
Aglaia pirifera	Khang-khao
Aglaia pyramidata	Chan-cha-mot
Bouea burmanica	Ma-prang
Canarium kerrii	Ma-kok-lu'am
Canarium venosum	Ma-koem
Carallia brachiata	Chiang-phra-nang-ae
Dillenia spp.	Sandin, Sanhing
Dracontomelum mangiferum	Phra-chao-ha-phra-ong
Heritiera littoralis	Ngon-kai
Homalium damrongianum	Phi-kun-pa
Homalium tomentosum	Kha-nang
Hymenodictyon excelsum	Som-kop
Koompassia excelsa	Yuan
Lagerstroemia balansae	Ta-baek-kriap-daeng
Lagerstroemia duperreana	Ta-baek-plu'a-kbang
Lagerstroemia speciosa	In-tha-nin-nam
Lophopetalum duperreanum	Song-sa-lu'ng
Madhuca esculenta	La-mut-si-da
Madhuca grandiflora	La-mut-si-da
Madhuca pierrei	Ma-sang
Mangifera spp.	Ma-muang
Mansonia gagei	Chan-khao
Melanorrhoea laccifera	Nam-kiang
Melanorrhoea usitata	Rak-yai
Michelia spp.	Champa
Nauclea brunnea	Khi-min
Nauclea orientalis	Kan-lu'ang
Neesia altissima	Thu-rian-phi
Parkia javanica	Ka-riang

Botanical Name	Thai Name
Flooring - continued:	
Peltophorum dasyrachis	Nonsi
Peltophorum inerme	Nonsi
Pentace burmanica	Si-siat-plu'ak
Podocarpus imbricata	Phaya-mai
Podocarpus latifolia	Khun-mai
Podocarpus neriifolia	Phaya-mai
Protium serratum	Ma-faen
Sandoricum indicum	Ka-thon
Schima wallichii	Tha-lo
Schoutenia hypolenca	Daengsa-mae
Sterculia foetida	Sam-rong
Swintonia schwenckii	Kan-thong
Tarenna hoanensis	Chan-khao
Terminalia belerica	Sa-mo-phi-phek
Panels and Partitions:	
Azadirachta indica, var. siamensis	Sa-dao
Cedrela microcarpa	Si-siat-hom
Cedrela toona	Yomhom
Dipterocarpus tuberculatus	Phluang
Hopea helferi	Ta-khian
Lagerstroemia collinsae	Ta-baek-bai-lek
Mitragyna brunonis	Kwao-tum
Odina wodier	Oi-chang
Parashorea stellata	Khiansai
Parinarium anamense	Mak-mok, Mak-mu
Tectona grandis	Sak
Zanthoxylum budrunga	Luk-ra-mat
Furniture:	
Afzelia xylocarpa	Ma-kha-yai
Dalbergia bariensis	Pha-yungklaep
Dalbergia cochinchinensis	Pha-yung
Dalbergia cultrata	Ka-phi-khao-khwai
Dalbergia dongnaiensis	Ketdaeng
Dalbergia oliveri	Chingchan
Diospyros discolor	Ma-rit
Diospyros mollis	Ma-klua
Pterocarpus spp.	Pra-du
Tectona grandis	Teck, Sak

Botanical Name	Thai Name
Boat and Shipbuilding:	
Adina cordifolia	Kwao
Albizzia procera	Thon
Anisoptera spp.	Ka-bak
Artocarpus chaplasha	Kha-nun-nok
Artocarpus lakoocha	Hat
Aquilaria spp.	Mai-hom
Calophyllum floribundum	Tagnhan
Dipterocarpus alatus	Yang-khao
Dipterocarpus costatus	Yang-daeng
Eugenia (Syzygium) cumingii	Wa
Hopea ferrea	Ta-khian nu
Hopea odorata	Ta-khian
Mesua ferrea	Bun-nak
Michelia spp.	Champa
Palaquium gutta	Chik-nom
Palaquium obovatum	Kha-nun-nok
Tectona grandis	Sak
Railroad Crossties:	
Mesua ferrea	Bun-nak
Pentacme siamensis	Rang
Shorea curtisii	Sa-ya-daeng
Shorea faquetiana	Ka-lo
Shorea farinosa	Ka-bak-khao
Shorea floribunda	Pha-yom
Shorea glauca	Aek
Shorea gratissima	Suai
Shorea guiso	Sa-ya-daeng
Shorea hypochra	Pha nong
Shorea leprosula	Ta-yom
Shorea obtusa	Teng
Shorea parvifolia	Ma-ranti
Shorea talura	Pha-yomdong
Shorea thorelii	Yang-mok
Shorea sericea	Ta-khiansai
Sindora maritima	Ma-kha-ling
Sindora siamensis	Ma-kha-tae

Botanical Name	Thai Name
Agricultural Vehicles (Wagons):	
Acacia leucophloea	Cha-laep-daeng
Albizzia odoratissima	Khang-daeng
Albizzia procera	Thon
Eugenia (Syzygium) cumingii	Wa
Homalium tomentosum	Kha-nang
Irvingia malayana	Ka-bok
Irvingia oliveri	Ka-bok
Kydia calycina	Liang-fai
Milletia leucantha	Ka-phi-khao-khwai
Tools and Tool Handles:	
Anogeissus acuminata	Ta-khian-nu
Cassia garrettiana	Sa-mae-san
Cratoxylon spp.	Taeo
Memecylon ovatum	Phlong-yai
Mimusops elengi	Phi-kun
Murraya paniculata	Kaeo
Rhizophora mucronata	Kongkangbai-yai
Terminalia triptera	Tan-daeng
Terminalia tripteroides	Pu-chao
Walsura spp.	Kaeo-lao, Kat-lin
Fuelwood and Charcoal:	
Bruguiera sexangula	Pra-sakdaeng
Hydnocarpus castanea	Ka-bao-dong
Rhizophora mucronata	Kongkangbai-yai
Schleichera trijuga	Ta-khro
Xerospermum intermedium	Kho-hia
Carving and Turning:	
Adina cordifolia	Kwao
Albizzia lebbek	Cham-chu-ri
Cinnamomum siamense	Ta-khrai-ton
Dalbergia cochinchinensis	Pha-yung
Diospyros buxifolia	Ri-phao
Diospyros spp.	Lamit, Phapchin
Gardenia collinsae	Phut
Gardenia obtusifolia	Khom khwan
Gmelina arborea	Mao
Holarrhena antidysenterica	Mok-yai
Hydnocarpus castanea	Ka-bao-dong

Botanical Name	Thai Name
Carving and Turning - continued:	
Hydnocarpus illicifolia	Ka-bao
Litsea grandis	Ka-thang
Murraya paniculata	Kaeo
Wrightia tomentosa	Mok-man
Boxes and Crates:	
Acrocarpus fraxinifolius	Kang-khi-mot
Alstonia scholaris	Tin-pet
Amoora polystachya	Ta-su'a
Canangium latifolium	Sa-kae-saeng
Canarium kerrii	Ma-kok-lu'am
Canarium venosum	Ma-koem
Cedrela microcarpa	Si-siat-hom
Cedrela toona	Yomhom
Cinnamomum iners	Op-choei
Cinnamomum parthenoxylon	Thep-tha-ro
Cinnamomum siamense	Ta-khrai-ton
Fagraea fragrans	Kan-krao
Ficus spp.	Krang, etc.
Garuga pinnata	Ta-khram
Hymenodictyon excelsum	Som-kop
Litsea spp.	Ka-thang
Manglietia insignis	Champi-pa
Millingtonia hortensis	Pip
Nauclea orientalis	Kan-lu'ang
Pinus khasya	Son-sambai
Pinus merkusii	Son-song-bai
Sterculia campanulata	Po-e-keng
Sterculia foetida	Sam-rong
Sterculia lychnophora	Phung-tha-lai
Spondias pinnata	Ma-kok
Terminalia belerica	Sa-mo-phi-phek
Tetrameles nudiflora	Som-phong

Botanical Name	Thai Name	Utility
Special Uses:		
Amoora polystachya	Ta-su'a	Plywood
Ailanthus fauveliana	Ma-yom-pa	Matches
Alangium salviifolium	Pru	Rifle stocks
Anisoptera spp.	Ka-bak	Cement molds
Anthocephalus cadamba	Ka-thum	Match and toothpicks
Castanopsis spp.	Ko-yum, Ko-ti, Ko-du'ai	Shingles
Corypha lecomtei	Lan	Fiber for hats
Erythrophloeum spp.	Sak	Construction of sugar mills.
Holoptelea integrifolia	Ka-chao	Mortar and pestles to pound rice.
Lithocarpus spp.		Shingles
Manilkara hexandra	Ket	Shuttles and looms for spinning and weaving.
Melaleuca leucadendron	Sa-met	Leaves yield a volatile oil.
Nipa fruticans	Chak	Leaves for thatch and young leaves to wrap cigarettes.
Planchonella spp.	Tan-sian, Tannom	Rice mills
Quercus spp.	Ko-dang, Ko-nok	Shingles
Salmalia spp.	Ngao-pa	Cement molds
Sterculia colorata	Po-fai	Fiber for rope
Sterculia fulgens	Po-khao	Fiber for rope
Sterculia guttata	Po-kka-nun	Bark fiber for rope.
Sterculia ornata	Po-tup-fai	Bark fiber for rope and hats.
Sterculia versicolor	Po-chaek	Wood suitable for pulp.
Tetrameles nudiflora	Som-phong	Cement molds
Minor Forest Products:		
Balanocarpus heimii	Ta-khian-chan-ta-maeo	Resin
Cudrania javanensis	Kae-lae	Yellow dye
Caesalpinia sappan	Fang	Dye
Cassia bakeriana	Kalpa-phruk	Tannin
Cassia javanica	Kai-phruk	Tannin
Corypha lecomtei	Lan	Fiber for making hats.

Botanical Name	Thai Name	Utility
Minor Forest Products - continued:		
Diospyros siamensis	Ma-phlapyai	Tannin
Dyera costulata	Thinpet-daeng, Lutong	Latex furnishes an insoluble gum.
Garcinia hanburyi	Rong	Yellow dye; gamboge tree.
Hydnocarpus anthelmintica	Ka-bao	Chaulmoogra oil to treat leprosy.
Madhuca spp.	Ma-sang	Latex furnishes an insoluble gum.
Palaquium gutta	Chik-nom-hin	Yields a gum as source of insoluble gum.
Palaquium obovatum	Khanun-nok	Yields a grade of gutta percha.
Rhizophora spp.	Kong khangka-bai	Source of tannin.

Bamboos:

As in other parts of Southeast Asia, Bamboos are probably the most abundant and most indispensable plants in the everday life of the natives. They are used for a multiple of purposes, such as for the construction of houses, to provide shade and fences around farm houses and hamlets, to form gutters, to irrigate rice paddies or other cultivated patches, to arrest soil erosion, provide raw material for paper pulp, while many species furnish shoots which are considered a delicacy.

Rattans:

Several species of Rattans (Calamus) are frequent in the Rain forest, usually in moist sites or along banks of streams, especially in the southern part of the Peninsula and in the Khao Yai National Forest in the central region. They are used domestically for the manufacture of furniture, cables in the construction of swing bridges, and split to lash timber rafts. For many years rattans have also been exported in considerable quantities to Singapore, Hongkong and other ports.

Useful Timbers and other Products of Puerto Rico[1/]

Acrocomia aculeata. Corozo, Gugru.
Hard wood from outer part of trunk used for flooring or turned into walking sticks. Hard-shelled seeds are edible, with flavor suggesting coconut, and contains an oil.

Albizzia lebbek. Acacia amarilla, Lebbek.
Wood moderately hard, strong, coarse-grained; useful for furniture, paneling, veneering, turnery and general construction. Often planted along roadsides in lowlands of Puerto Rico; occurs also in Southeast Asia

Alchornea latifolia. Achiotillo.
Posts and fuel; suitable for temporary cement forms, veneer and bent parts.

Andira inermis. Moca, Cabbage angelín.
High-grade furniture and cabinetwork; wood used chiefly for posts and poles.

Artocarpus altilis. Breadfruit, Panapen.
Wood sometimes used for interior partitions, and is suitable for boxes, crates and light construction, and surfboards. In periods of drought the leaves provide forage for cattle. The sticky sap serves as birdlime. Fruit gathered before maturity when roasted or boiled serves as a starchy vegetable. Young fruits can be sliced and fried, seeds are edible when boiled or roasted. A dessert and preserve can be prepared from the male flower clusters.

Artocarpus heterophyllus. Jaca, Jackfruit.
Wood suitable for carpentry and cabinetwork. Large fruit edible when cooked, furnishing a starchy vegetable, with a peculiar flavor and is less palatable than breadfruit.

Bambusa vulgaris. Common Bamboo.
Besides for use as an ornamental and for shade, roots and leaf litter check erosion on roadside banks and slopes. Poles are utilized for fence-posts, ladders, tool handles, and stakes. When split, stems are woven into baskets, also for furniture, fishing rods, mats, etc. Tender tips of bamboo shoots are edible after boiling, and are also prepared in meat stews and salads.

Beilschmiedia pendula. Guajón.
Wood hard, strong, heavy, but susceptible to damage by dry-wood termites; suitable for shipbuilding, general construction, flooring, furniture, cabinetmaking, carpentry.

1/ Source: Little, Jr., E.L. and F. H. Wadsworth. 1964. Common Trees of Puerto Rico and the Virgin Islands. 548 pp.

Buchenaxia capitata. Granadillo.
Wood suitable for furniture, cabinetwork, construction, framing, flooring, plywood, veneer, interior trim, boatbuilding and turnery.

Bucida buceras. Ucar, Gregre.
Heaviest available wood of Puerto Rico; suitable for heavy duty, such as workbenches, machinery platforms, heavy construction; elsewhere for marine piling, crossties, house posts, bridge timber and charcoal.

Bursera simaruba. Almácigo, Turpentine-tree.
Boxes, crates, cement frames, interior carpentry, light construction, fuelwood and charcoal. Aromatic resin exuding from the bark used as glue, varnish, incense and to coat canes.

Byrsonima coriacea. Maricao.
Fancy furniture and for cabinetmaking, turnery, interior trim, decorative uses.

Calophyllum brasiliense. María, Santa María.
Chiefly for construction, posts, elsewhere used for furniture, cabinetmaking, planing, shingles, interior construction, shipbuilding, house framing, agricultural implements, handles, vehicles, structural timbers, poles and crossties.

Calycogonium squamulosm. Jusillo.
Posts and poles; also suitable for furniture, pattern-making, veneer and plywood, farm implements, tool handles, heavy duty turnery, boat parts, heavy construction and bridge timber.

Cananga odorata. Ylang-ylang.
Flowers contain a volatile or essential oil, utilized in the manufacture of perfumes.

Casuarina equisetifolia. Casuarina, Australian beefwood.
Fence-posts and poles, beams but not underground, oxcart tongues, charcoal and fuel; bark used for tanning and to extract a red or blue-black dye. Tree frequently planted in Southeast Asia for windbreak and to arrest erosion in sand dunes.

Cecropia peltata. Yagrumo hembra, Trumpet tree.
Excelsior; combined with cement, it is processed into a type of insulation board for partitions and light interior construction; matchsticks, boxes and crates, interior boarding, paper pulp; hollow stems used to make floats and fish nets and life preservers, and split to serve as water troughs and gutters. Wood ignites easily from friction and serves as tinder.

Cedrela odorata. Cedro hembra, Spanish cedar.
Wood suitable for general construction, carpentry, furniture, cabinetwork, doors and frames, and other purposes.

Ceiba pentandra. Ceiba, Silk-cotton tree.
Boxes, slack cooperage, light construction, patternmaking, utility-grade plywood; dugout canoes.

Coccoloba pubescens. Moralón.
Wood durable, resistant to dry-wood termites, suitable for construction and furniture.

Coccoloba uvifera. Seagrape, Uva de playa.
Wood hard, moderately heavy, suitable for turnery, furniture and cabinetwork; fresh thick leaves used by early Spanish settlers as substitute for paper.

Coccoloba venosa. Calambrena. Chicory-grape.
Egg-shaped fruit has fleshy calyx lobes which are sweet and edible.

Cocos nucifera. Palma de coco, Coconut palm.
The trunk serves for posts. The leaves furnish thatch for roofs and shelters, or made into lattice screens and fences. Shells used for kitchen utensils and for high-grade charcoal. Coconut fiber, or coir, made into mats, ropes, brooms and brushes.

Conocarpus erectus. Mangle botón, Button mangrove.
Takes a fine polish and generally very durable; fence-posts, cross-ties, turnery and boatbuilding; makes good charcoal.

Cordia alliodora. Capa, Capa prieto.
Used extensively throughout Tropical America for furniture, cabinetwork, millwork and in general construction; also for bridge timber, flooring, ship decking, boat parts, oars and crossties.

Cyathea arborea. Arbol de helecho, Tree fern.
Although not a solid wood, the hard trunk is durable, resistant to decay and termites; useful for posts, framework of houses, and as water bars for drainage along mountain trails. Carib Indians used the stems to preserve fire, which can be maintained for hours without smoke or flame.

Dacryodes excelsa. Tabonuco.
Susceptible to decay and dry-wood termites; suitable for furniture, carpentry and general construction.

Didymopanax morototoni. Yagrumo macho, Matchwood.
Suitable for match-sticks and match-boxes, plywood, pulp, and as a substitute for balsa wood.

Eucalyptus robusta. Eucalipto, Beakpod eucalyptus.
Underground piling, poles and fence posts; elsewhere for general construction, especially when exposed to weathering.

Eugenia stahlii. Guayabota.
General construction, crossties, oxcart tongues, poles and posts; suitable for furniture, cabinetwork and turnery.

Genipa americana. Jagua, Genipa.
Suitable for furniture, tool handles, carts; also for shoe-lasts, plows, tool handles, barrel hoops, chests, vehicles, shipbuilding, cabinetwork, flooring, interior trim and decorative veneer.

Guaiacum officinale. Guayacán, Lignumvitae.
Wood durable, heavy and resistant; suitable for special uses in trimmings and brushing blocks for propeller shafts of ships, pulley sheaves, mallets, bowling balls and turnery.

Guarea trichilioides. Guaraguao.
Fine furniture and cabinetwork, resembles mahogany and Spanish cedar, takes high polish; construction, carpentry, implements, cooperage.

Guatteria blainii. Haya minga.
Wood hard, heavy, and formerly used for construction but now only chiefly for posts.

Hernandia sonora. Mago.
Light boxes, crates, fishing floats, temporary boarding and interior construction.

Homalium racemosum. Caracolillo.
General construction, tool handles, agricultural implements and boat parts.

Hyeronima clusioides. Cedro macho.
Wood heavy and attractive; suitable for furniture and construction.

Hymenaea courbaril. Algarrabo, West Indian Locust.
Good quality, but limited in quantity; suitable for carpentry, general construction, cartwheels, posts and railroad crossties.

Inga laurina. Guamá.
Furniture, cabinetwork, tool handles, interior trim, general and heavy construction, crates, boxes, flooring, veneer and plywood.

Inga vera. Guaba.
Posts, fuel and charcoal; suitable for light construction, general carpentry and utility furniture.

Eucalyptus robusta. Eucalipto, Beakpod eucalyptus.
Underground piling, poles and fence posts; elsewhere for general construction, especially when exposed to weathering.

Eugenia stahlii. Guayabota.
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Good quality, but limited in quantity; suitable for carpentry, general construction, cartwheels, posts and railroad crossties.

Inga laurina. Guamá.
Furniture, cabinetwork, tool handles, interior trim, general and heavy construction, crates, boxes, flooring, veneer and plywood.

Inga vera. Guaba.
Posts, fuel and charcoal; suitable for light construction, general carpentry and utility furniture.

Laguncularia racemosa. Mangle blanco, White mangrove.
Posts, fuelwood, charcoal, and sometimes for tool handles; elsewhere for general construction.

Licaria salvifolia. Canelilla.
Wood heavy, used for poles, posts and fuel.

Licaria triandra. Palo de misanteco, Gulf licaria.
Wood yellow, heavy, strong, used in Puerto Rico for posts; is suitable for interior construction, matches and match-boxes.

Magnolia portoricensis. Jaguilla.
Wood hard, heavy, fine-textured, has spicy fragrance, but susceptible to drywood termites; suitable for furniture and cabinetwork.

Magnolia splendens. Laurel sabino.
Wood used for furniture and cabinetwork, suitable also for veneer, plywood, millwork, turnery, construction, carpentry and boat planking. Spicy leaves serve as a condiment.

Mammea americana. Mamey, Mammee-apple.
Hard, heavy, strong but susceptible to dry-wood termites; used for fence-posts and fuel; elsewhere for carpentry, piling and general construction.

Mangifera indica. Mango.
Meat chopping blocks and fuel wood in Puerto Rico; elsewhere it is utilized for furniture, carpentry, flooring, construction, carts, plywood and cooperage.

Manilkara bidentata. Ausubo, Balata.
Hard, heavy, durable, suitable for construction, furniture, cabinetwork, crossties, utility poles, tool handles, heavy construction, flooring and bridges.

Matayba domingensis. Negra lora.
Posts and poles when treated; suitable for furniture, cabinetwork, turnery, interior trim, flooring, agricultural implements, vehicle handles, light and heavy construction.

Meliosma herbertii. Aguacatillo.
Of limited local supply in Puerto Rico; used for construction, carpentry, furniture, cabinetwork, paneling, interior trim, boxes and crates.

Micropholis chrysophylloides. Caimitillo.
Suitable for construction, furniture, cabinetwork, interior trim, flooring, farm implements, tool handles, veneer, plywood, and general carpentry.

Micropholis garciniaefolia. Caimitillo verde.
Posts and in construction; suitable for veneer, plywood, furniture, cabinetmaking, turnery, trim, flooring, farm implements, tool handles, and general carpentry.

Montezuma speciossima. Maga.
Now scarce in Puerto Rico; suitable for furniture; occasionally used for turnery, musical instruments posts and poles.

Nectandra coriacea. Laurel avispillo. Jamaica nectandra.
Wood used in carpentry, cabinetwork and for poles. Leaves, twigs and bark spicy.

Ochroma pyramidale. Balsa, Guano.
Lightest of commercial woods; used for life-rafts, lifebelts, insulation, floats for fishnets and substitute for cork.

Ocotea cuneata. Canelón.
Wood used for posts and is suitable for construction.

Ocotea floribunda. Laurel espada.
Wood white, light-weight, easily worked, used mostly for posts and fuel, occasionally in the construction of farm buildings.

Ocotea leucoxylon. Laurel geo.
Wood moderately soft, of light weight, used for posts, also in carpentry and construction; suitable for low grade furniture, in cabinetwork, interior trim, light construction, boxes and crates, plywood, sheathing, concrete forms, and shingles. Fruits said to be a valuable food for hogs.

Ocotea moschata. Nuez moscada.
Attractive timber formerly used for cabinetwork; suitable for turnery, furniture, cabinetmaking, light and heavy construction, bridge timbers, and packing crates.

Ocotea spathulata. Nemocá.
Wood suitable for furniture, cabinetmaking, paneling, turnery, boat planking, farm implements, handles, heavy construction, and bridge timbers.

Ormosia krugii. Palo de matos.
Fuel, furniture, millwork, construction, boxes, crates and general carpentry.

Petitia domingensis. Capá blanco.
Furniture, light and heavy construction, posts and piling, crossties, and rollers for coffee-milling; suitable for turnery, cabinetmaking, farm implements and bridges.

Pisonia subcordata. Corcho blanco, Water mampoo.
Wood soft, white, porous, not durable, used for net-floats for fishing and as fuelwood.

Pithecollobium saman. Samán, Raintree.
Takes beautiful polish, cross-grained and difficult to work; suitable for furniture, interior trim and general construction.

Podocarpus coriaceus. Caobilla, Podocarp.
Wood suitable for fine cabinetwork and furniture, although trees in Puerto Rico are usually small and of poor form.

Pouteria multiflora. Tácana.
Principally for construction and furniture; elsewhere used for house framing, bridge work and posts.

Prestoea montana (*Euterpe globosa*). Palma de Sierra, Mountain cabbage palm.
Beneficial on steep mountain slopes to maintain protective cover for watershed and in preventing soil erosion.

Prosopis juliflora. Bayahondá, Mesquite.
Wood tough, strong and resistant to decay; fence posts and crossties; abundant in Texas.

Rhizophora mangle. Mangle colorado, Mangrove.
Useful for posts, poles, fuelwood and charcoal; larger sizes for marine piling, wharves and shipbuilding.

Roystonea borinquena. Palma real, Royal palm.
Boards hewn from hard outer part of trunk used for siding and flooring in rural areas; dry leaf blades serve as thatch for roofs, and the broad sheaths spread out to make sides of buildings. Fruit considered a good food for hogs.

Sabal causiarum. Sabal.
Straw hats made from young leaves, after curing, bleaching and drying; leaf fiber woven into baskets, mats and hammocks; old leaves serve as thatch.

Salix humboldtiana. Sauce, Humboldt willow.
Wood suitable for posts, fuel, boxes and in cabinetmaking; slender flexible branches woven into baskets and wicker furniture.

Sideroxylon foetidissimum. Amarillo, Tortugo, False-mastic.
Useful for construction; suitable also for boats, heavy planking, furniture and house posts.

Sloanea berteriana. Motillo.
Used sparingly in Puerto Rico for furniture and heavy construction; sutiable for farm implements, handles, heavy-duty and boat parts.

Spondias mombin. Jobo, Hogplum.
Fenceposts, fuel, packing boxes and crates; furnishes pulp for white paper, and is suitable for plywood.

Stahlia monosperma. Cóbana negra.
Wood hard, durable and suitable for furniture; resistant to dry wood termites.

Swietenia macrophylla. Caoba hundureña, Honduras or Central American Mahogany.
Furniture, cabinetmaking, veneer, interior trim; limited supply of small logs obtained from local plantations, and most of lumber is imported into Puerto Rico from Mexico.

Tabebuia heterophylla. Roble blanco.
Construction, posts and poles; suitable for furniture, cabinetwork, interior trim, veneer, flooring, paneling, boatbuilding, and yokes for draught animals.

Tectona grandis. Teca, Teak.
Introduced into Puerto Rico from Southeast Asia; most valuable timber for furniture and shipbuilding; thinnings from plantations used for posts.

Terminalia catappa. Almendra, Indian Almond.
Posts and fuel; millwork, furniture, veneer and cabinetwork; used elsewhere for general construction, boat-building, bridge timbers, crossties and flooring.

Tetragastris balsamifera. Masa.
Furniture, cabinetwork, paneling, interior construction, flooring, millwork and oars.

Trema micrantha. Guacimilla, Florida trema.
Wood useful for posts and fuel; bark yields a strong fiber used for cordage.

Trichilia hirta. Tinacio, Broomstick.
Resistant to dry-wood termites; useful for posts and fuel.

Triplaris americana. Triplaris, Ant-tree.
Wood is suitable for general construction; hollow twigs are inhabited by vicious stinging ants.

Vitex divaricata. Higuerillo, White fiddlewood.
Framework of houses, fenceposts, construction, cabinetwork, shingles; suitable for tool handles, boats and flooring.

Zanthoxylum flavum. Aceitillo, Yellow heart.
High grade West Indian satinwood, supply now exhausted; used for decorative furniture, cabinetmaking, inlaid work, veneer, and turnery.

Zanthoxylum martinicense. Espino rubial, White prickle.
Wood seldom used as only few small trees remain in Puerto Rico; suitable for lowgrade furniture, construction and concrete frames.

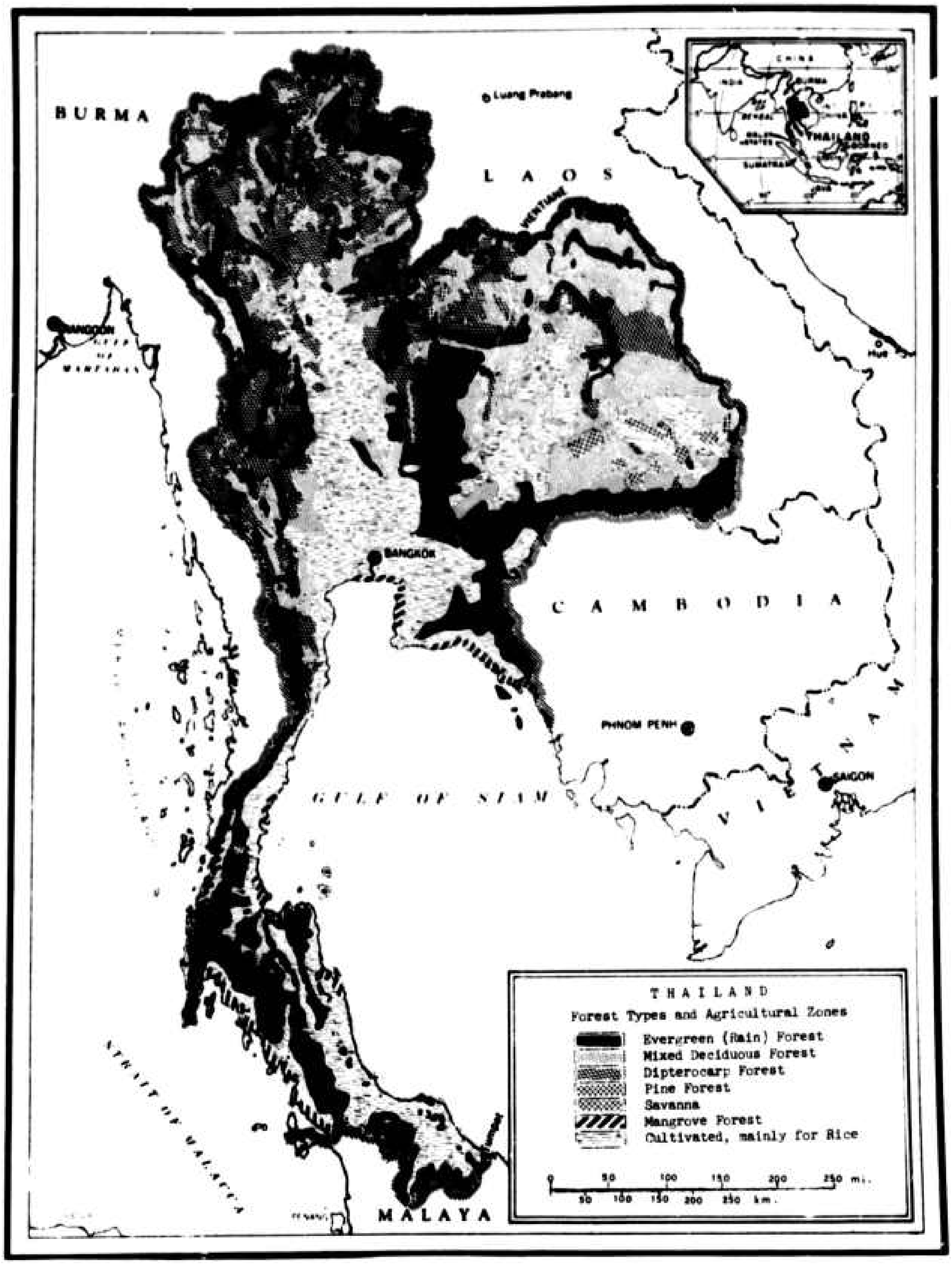
M A P S and I L L U S T R A T I O N S

The maps, reproduced in the following pages, indicate the distribution of the principal types of forests in Thailand, North and South Vietnam, Laos, Puerto Rico and Texas. Other maps depict land use in Thailand and the adjacent Mekong basin countries in relation to the forest zones, in addition to soil groups in Thailand and Cambodia.

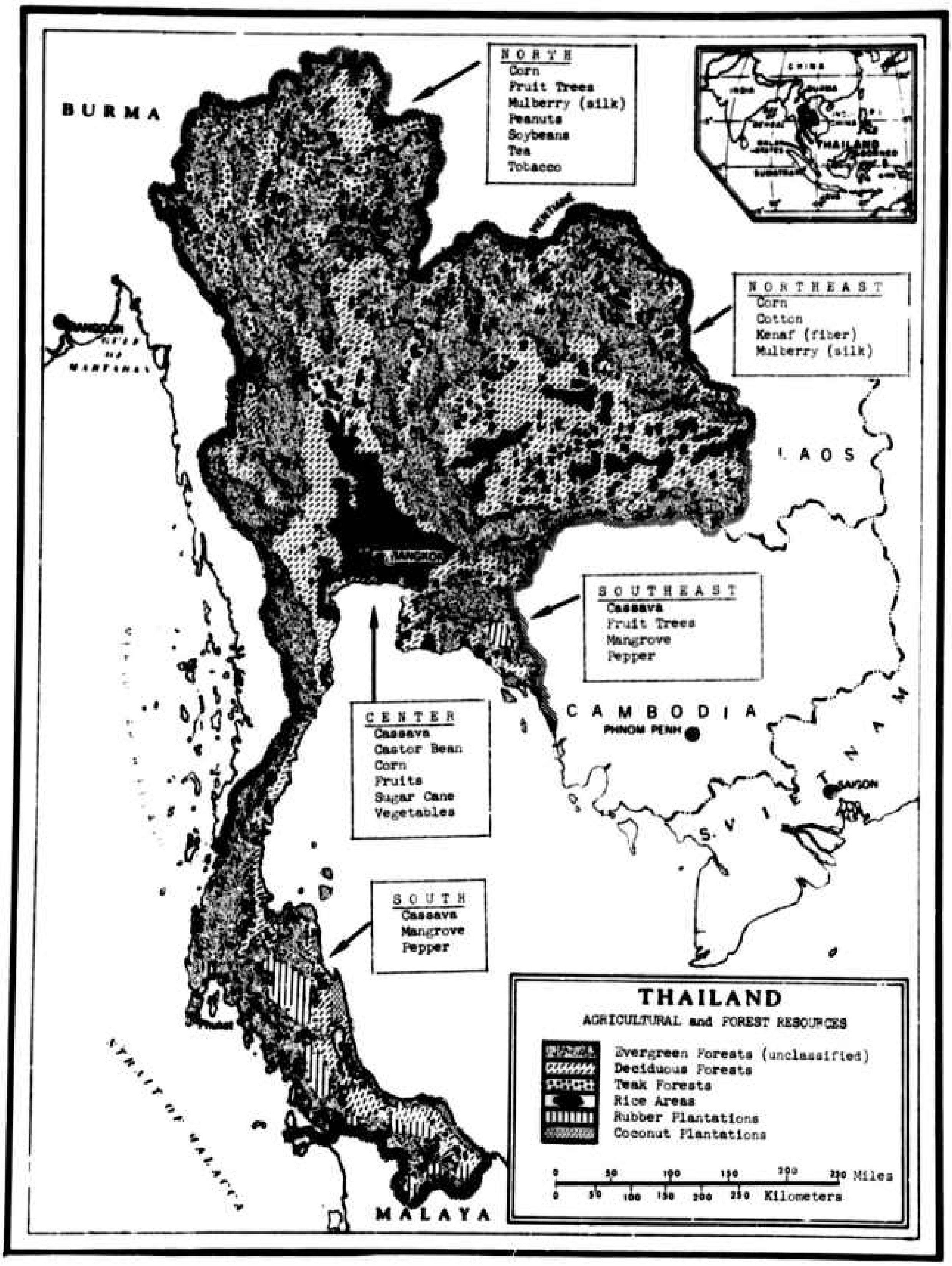
The principal primary and secondary types of forests or formations, occurring in Southeast Asia, Puerto Rico and Texas, are illustrated by a series of photographs. Unless otherwise indicated, these were taken by the author in the course of the Project.

The outline figures of survival plants are reproduced by permission of the Bureau of Medicine and Surgery, U. S. Navy, and others through the courtesy of the U. S. Army.

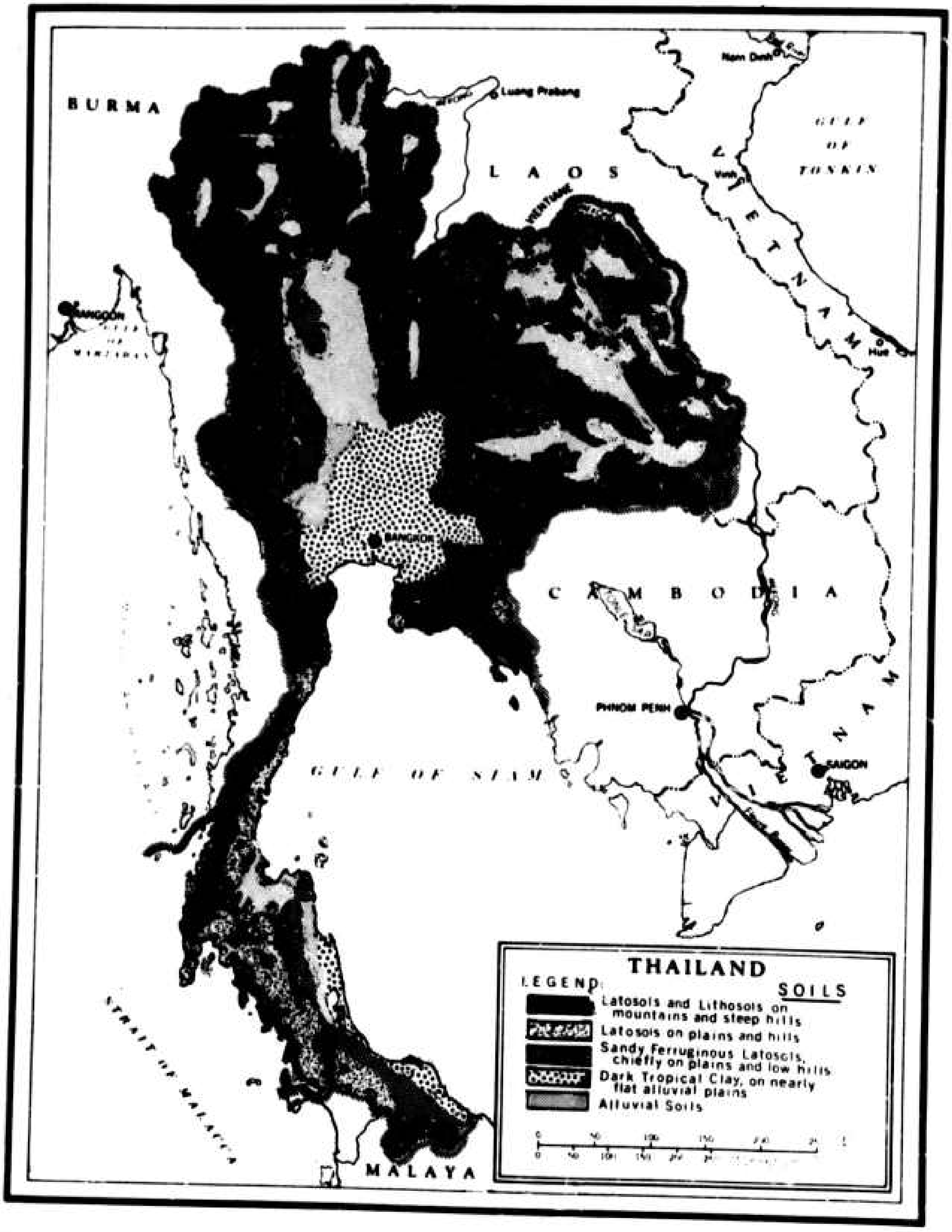
Additional maps and illustrations of the forests of Southeast Asia are included in U. S. Department of Agriculture Publication (CR 49-65) "Vegetation of Southeast Asia: Studies of Forest Types - 1963-1965." compiled by the author.


THAILAND
Forest Types and Agricultural Zones
Evergreen (Rain) Forest
Mixed Deciduous Forest
Dipterocarp Forest
Pine Forest
Savanna
Mangrove Forest
Cultivated, mainly for Rice
0 50 100 150 200 250 mi.
50 100 150 200 250 km.
BURMA
Luang Prabang
LAOS
RANGOON
BANGKOK
CAMBODIA
PHNOM PENH
SAIGON
VIETNAM
GULF OF SIAM
MALAYA

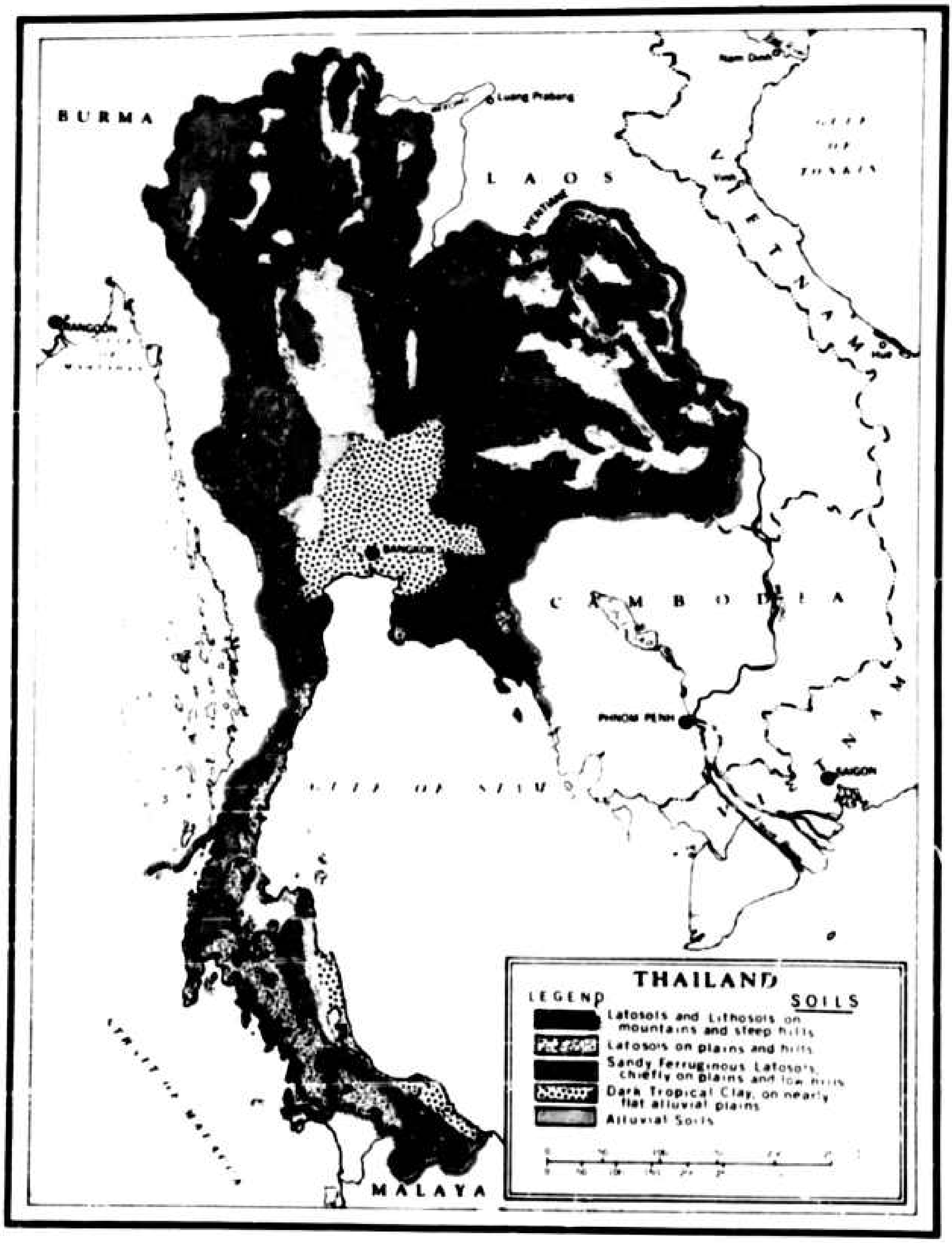
Map 4


BURMA
NORTH
Corn
Fruit Trees
Mulberry (silk)
Peanuts
Soybeans
Tea
Tobacco
NORTHEAST
Corn
Cotton
Kenaf (fiber)
Mulberry (silk)
LAOS
SOUTHEAST
Cassava
Fruit Trees
Mangrove
Pepper
CAMBODIA
PHNOM PENH
CENTER
Cassava
Castor Bean
Corn
Fruits
Sugar Cane
Vegetables
SOUTH
Cassava
Mangrove
Pepper
VIETNAM
SAIGON
MALAYA
THAILAND
AGRICULTURAL and FOREST RESOURCES
Evergreen Forests (unclassified)
Deciduous Forests
Teak Forests
Rice Areas
Rubber Plantations
Coconut Plantations
0 50 100 150 200 250 Miles
0 50 100 150 200 250 Kilometers

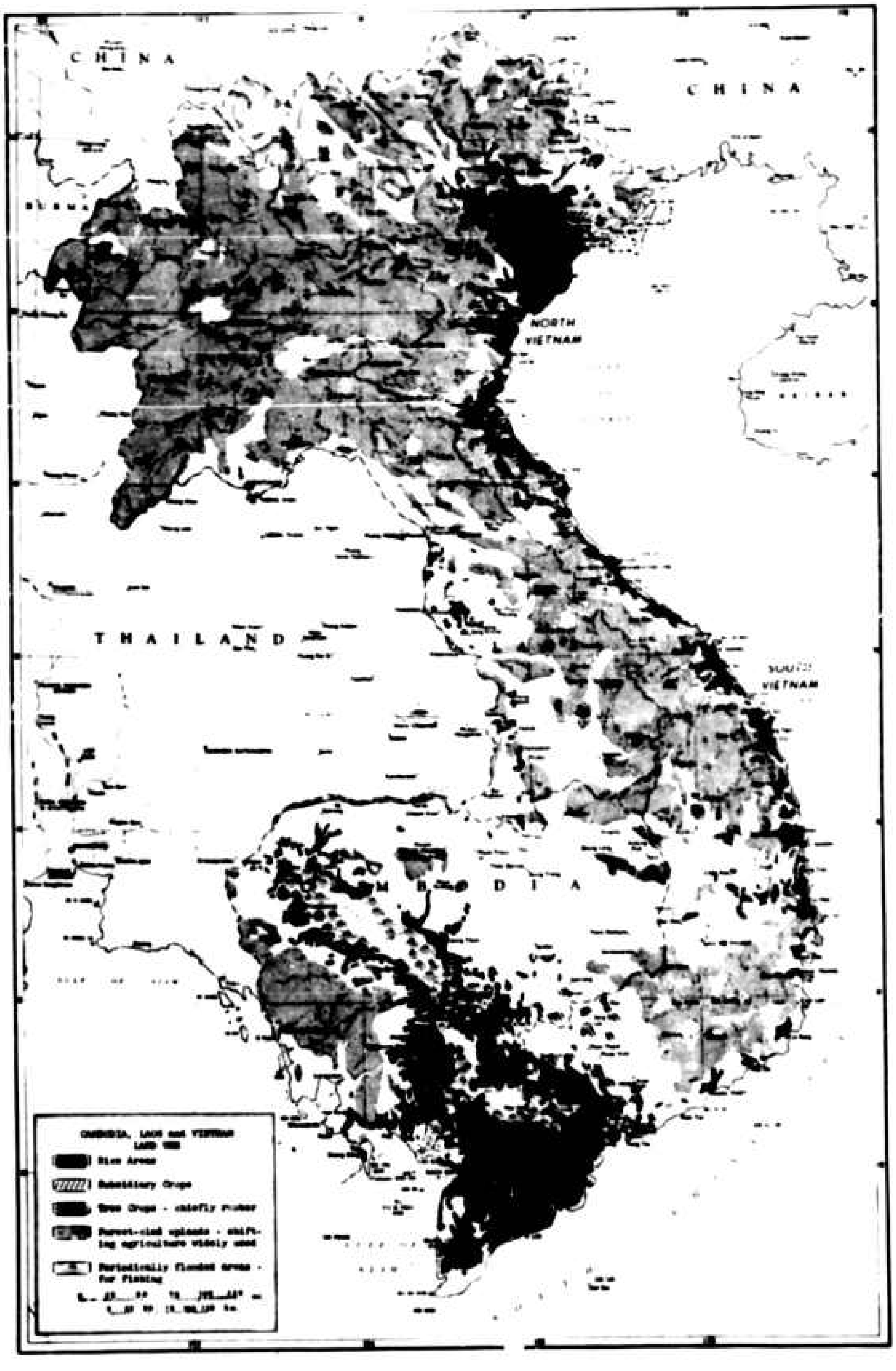
Map 5



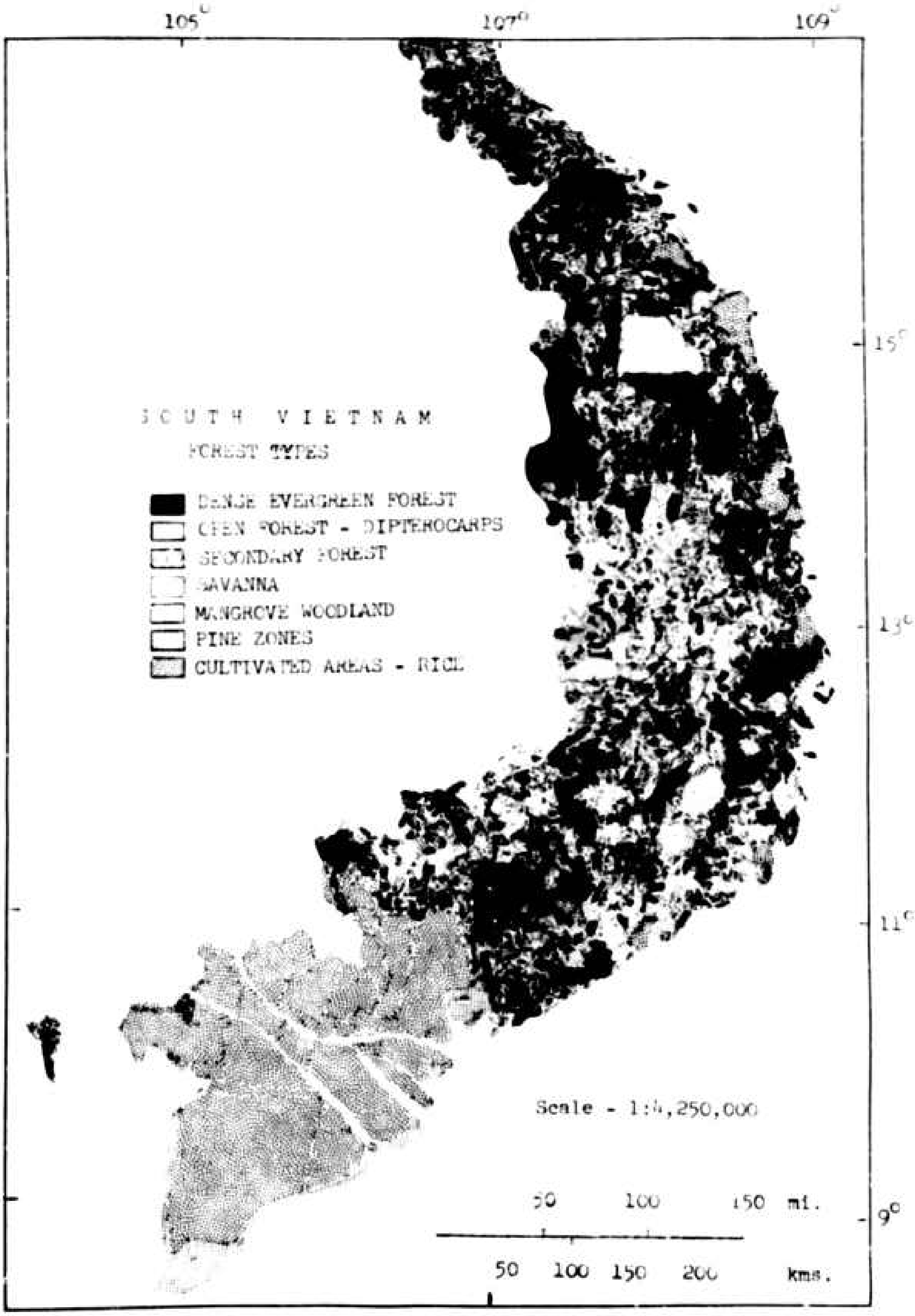
Map 6. Distribution of principal soil types in Thailand. (Adapted from data furnished by World Soil Geography, USDA.)



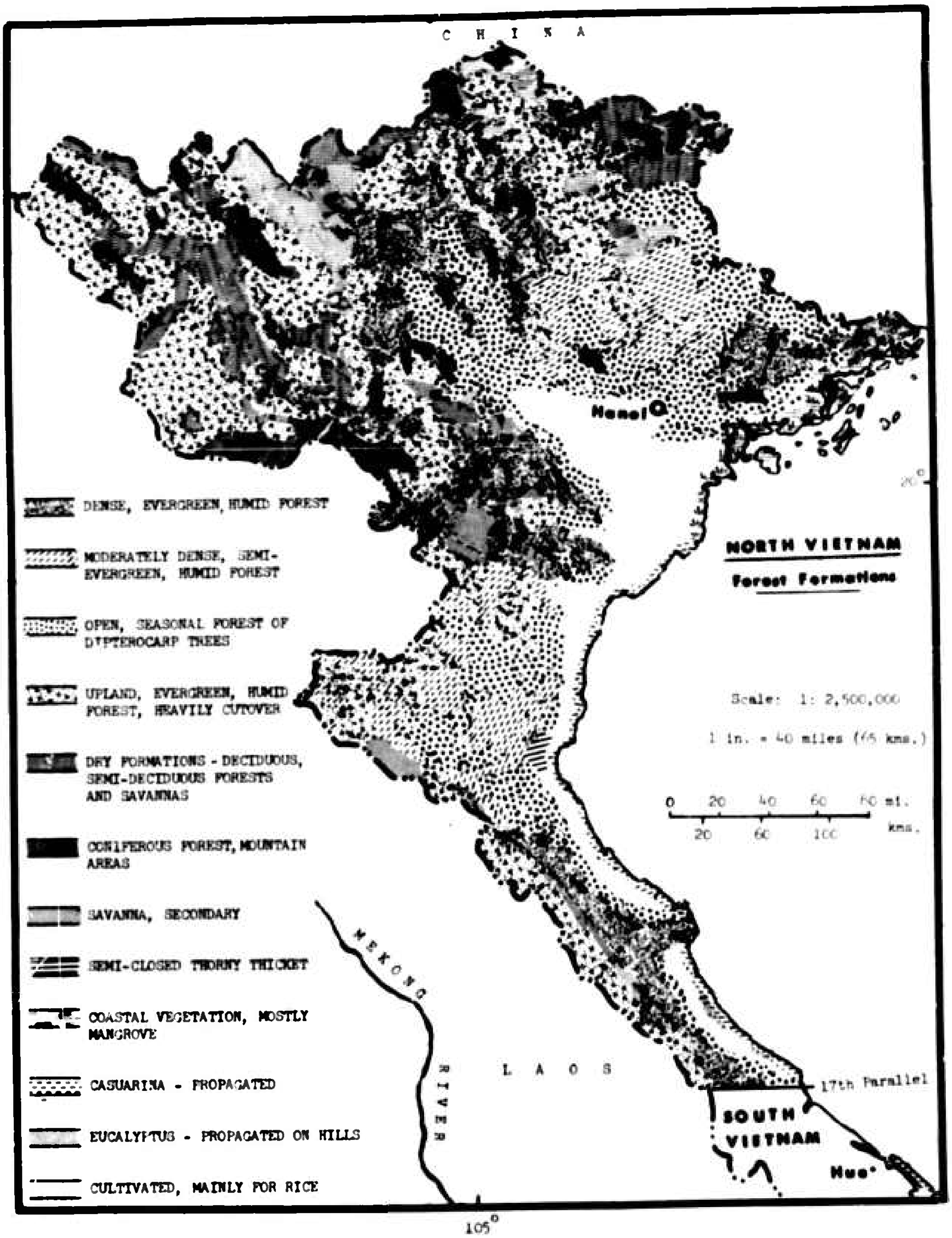
Map 6. Distribution of principal soil types in Thailand. (Adapted from data furnished by World Soil Geography, USDA.)



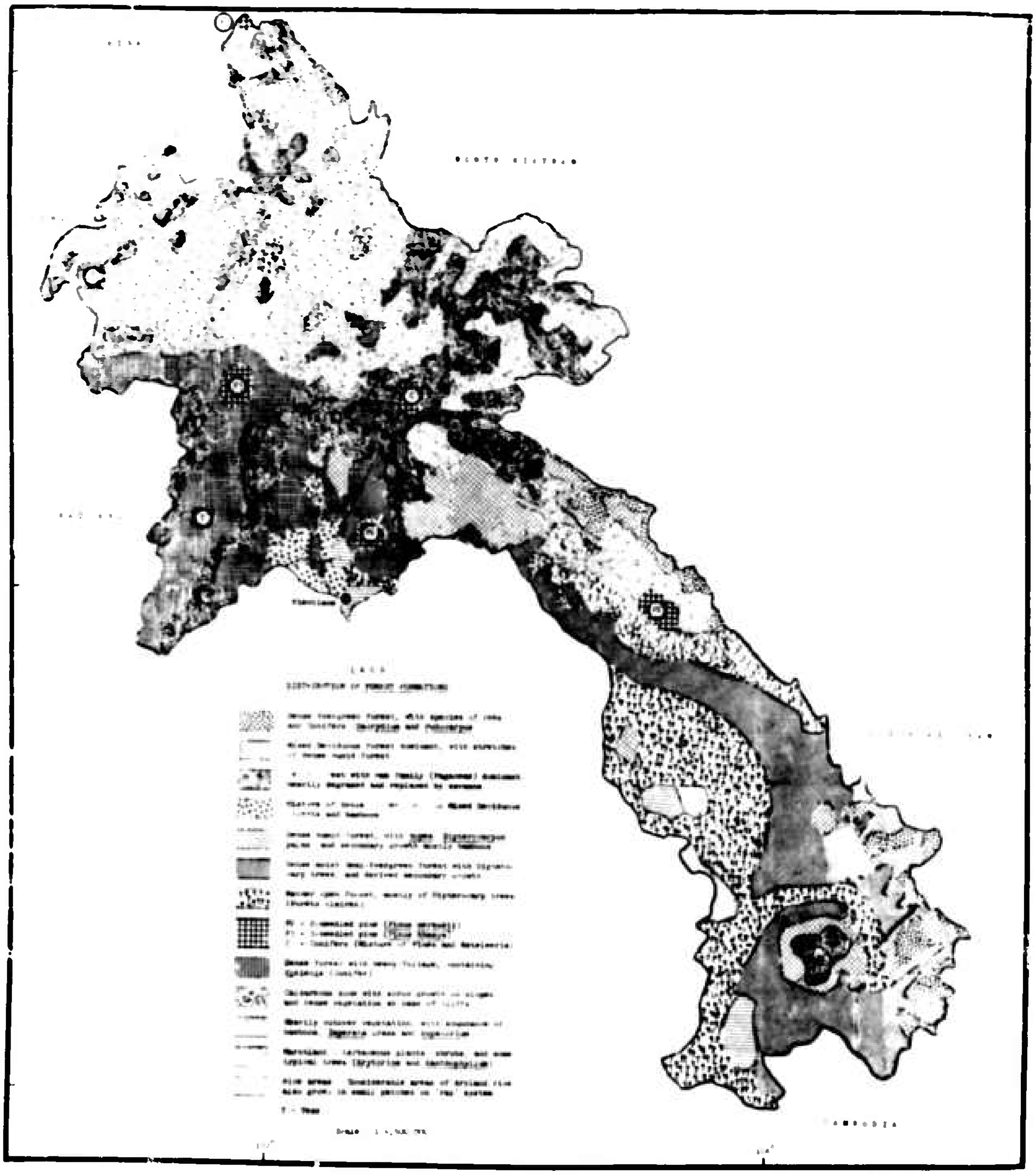
Map 7


105°
107°
109°
15°
13°
11°
9°
SOUTH VIETNAM
FOREST TYPES
DENSE EVERGREEN FOREST
OPEN FOREST - DIPTEROCARPS
SECONDARY FOREST
SAVANNA
MANGROVE WOODLAND
PINE ZONES
CULTIVATED AREAS - RICE
Scale - 1:4,250,000
50 100 150 mi.
50 100 150 200 kms.

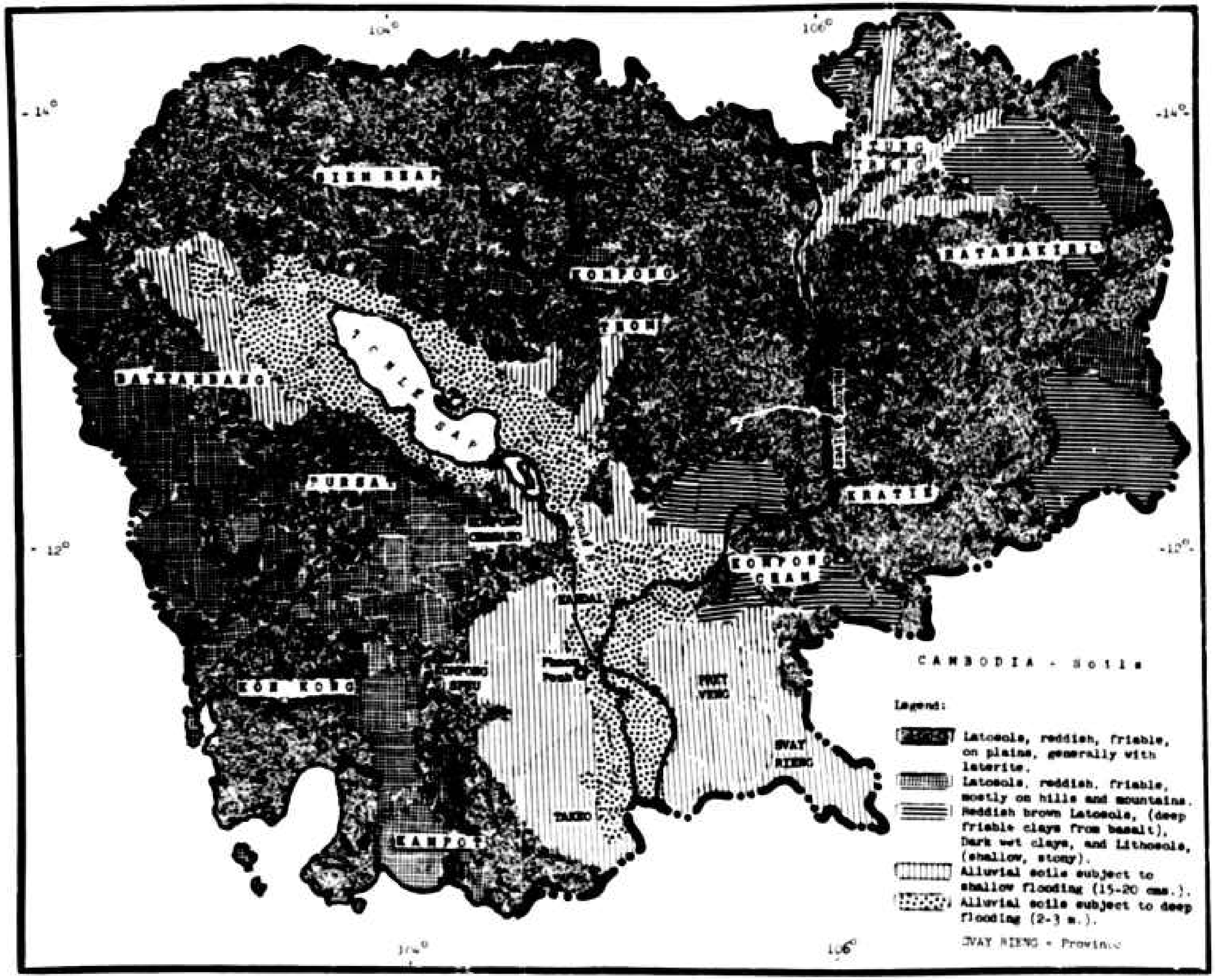
Map 8


C H I N A
Hanoi
NORTH VIETNAM
Forest Formations
Scale: 1: 2,500,000
1 in. = 40 miles (65 kms.)
0 20 40 60 80 mi.
20 60 100 kms.
DENSE, EVERGREEN, HUMID FOREST
MODERATELY DENSE, SEMI-EVERGREEN, HUMID FOREST
OPEN, SEASONAL FOREST OF DIPTEROCARP TREES
UPLAND, EVERGREEN, HUMID FOREST, HEAVILY CUTOVER
DRY FORMATIONS - DECIDUOUS, SEMI-DECIDUOUS FORESTS AND SAVANNAS
CONIFEROUS FOREST, MOUNTAIN AREAS
SAVANNA, SECONDARY
SEMI-CLOSED THORNY THICKET
COASTAL VEGETATION, MOSTLY MANGROVE
CASUARINA - PROPAGATED
EUCALYPTUS - PROPAGATED ON HILLS
CULTIVATED, MAINLY FOR RICE
MEKONG
RIVER
L A O S
17th Parallel
SOUTH VIETNAM
Hue
105°
20°

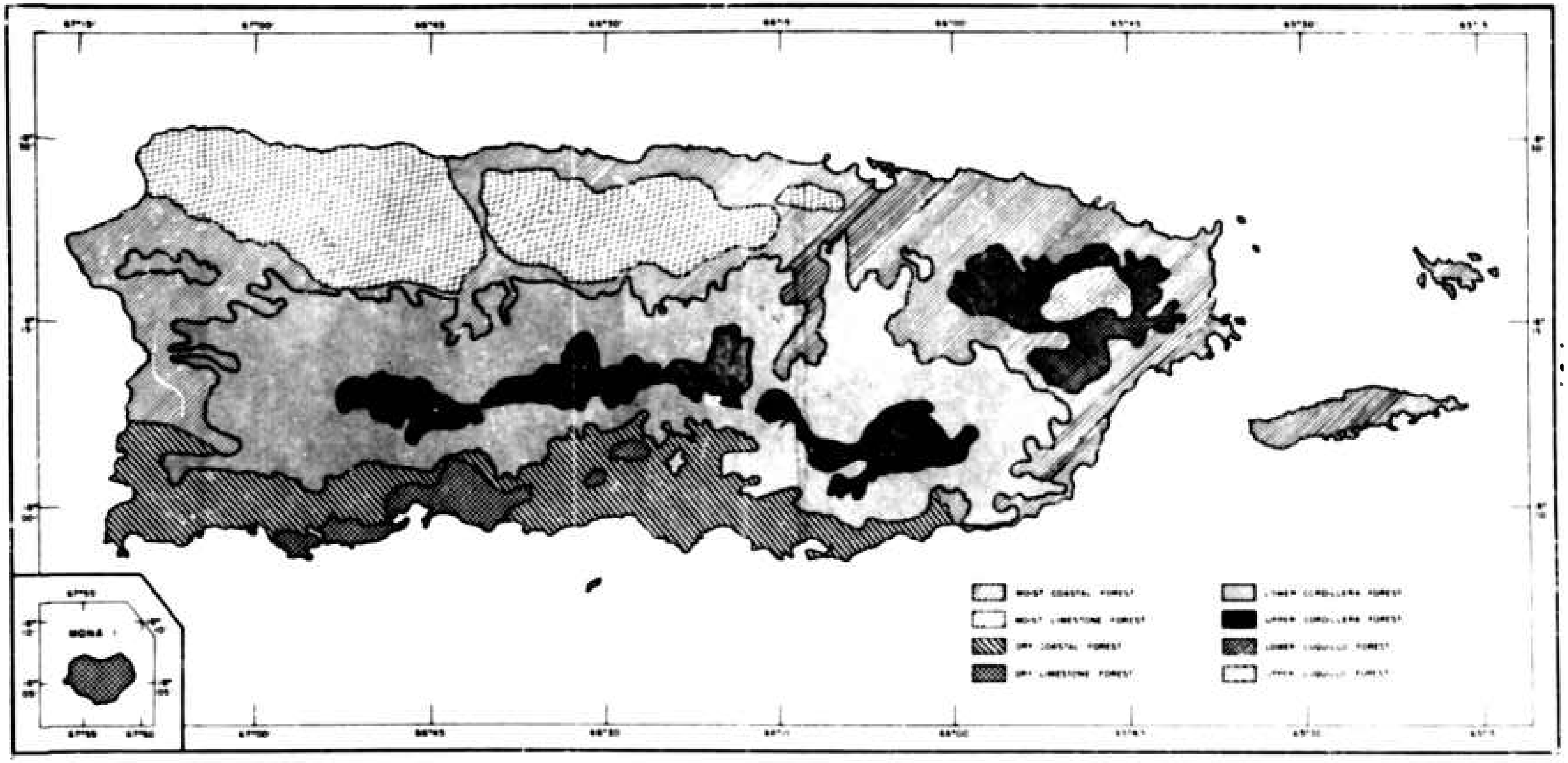
Map 9



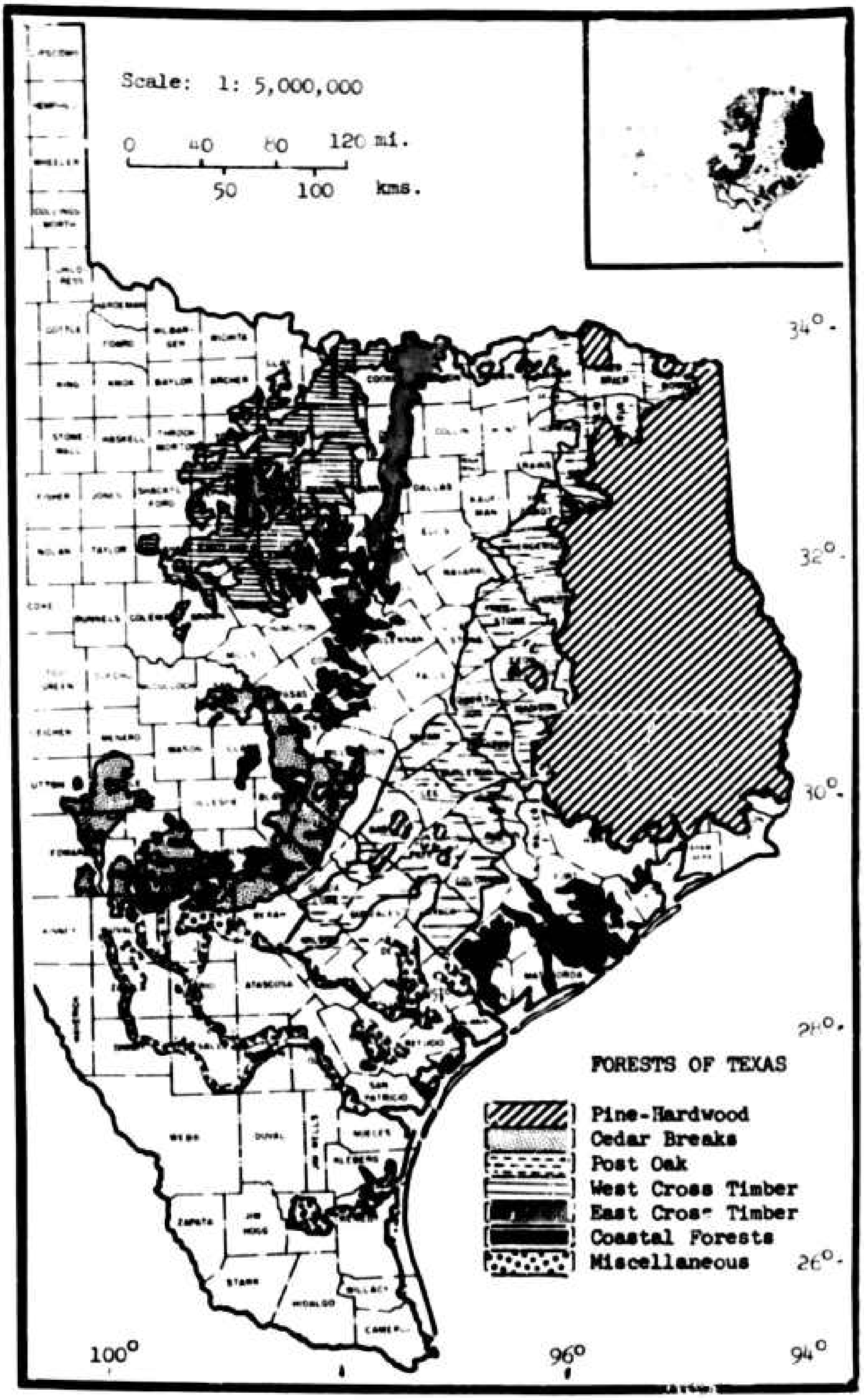
Map 10


CAMBODIA - Soils
Legend:
Latosols, reddish, friable, on plains, generally with laterite.
Latosols, reddish, friable, mostly on hills and mountains.
Reddish brown Latosols, (deep friable clays from basalt).
Dark wet clays, and Lithosols, (shallow, stony).
Alluvial soils subject to shallow flooding (15-20 cms.).
Alluvial soils subject to deep flooding (2-3 m.).
SVAY RIENG - Province
SIEM REAP
KOMPONG
THOM
BATTAMBANG
TONLE SAP
PURSAT
KOH KONG
KAMPOT
TAKEO
PREY VENG
SVAY RIENG
KOMPONG CHAM
KRATIE
RATANAKIRI
STUNG TRENG
14°
12°
104°
106°

Map 11



Map 12. Forest types of Puerto Rico. (From Little and Wadsworth USDA Agricultural Handbook No. 249.)


Scale: 1: 5,000,000
0 40 80 120 mi.
50 100 kms.
34°
32°
30°
28°
26°
100°
96°
94°
FORESTS OF TEXAS
Pine-Hardwood
Cedar Breaks
Post Oak
West Cross Timber
East Cross Timber
Coastal Forests
Miscellaneous

Map 13

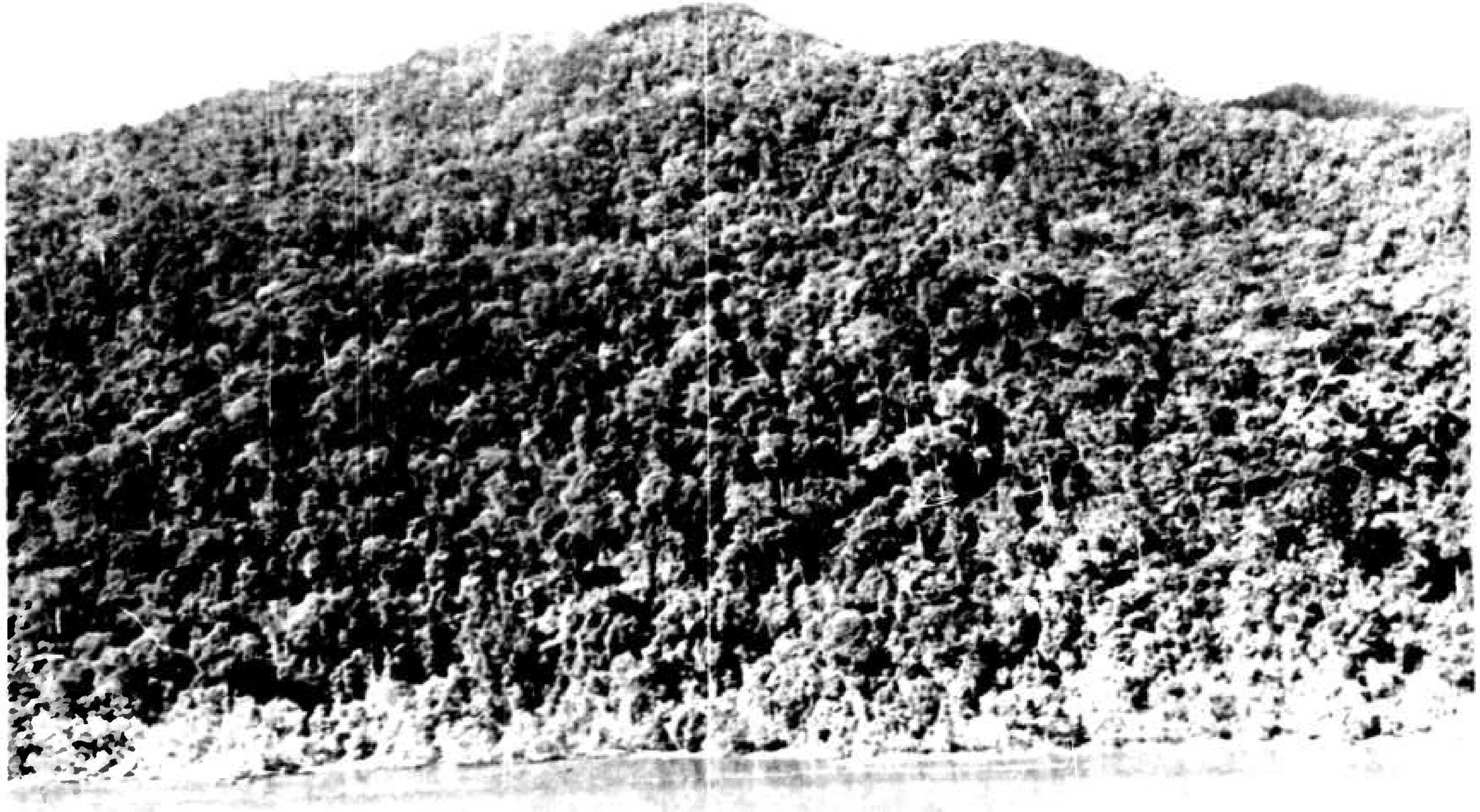


Fig. 6. Rain (Evergreen) forest, island of Kochang, southeast Thailand.

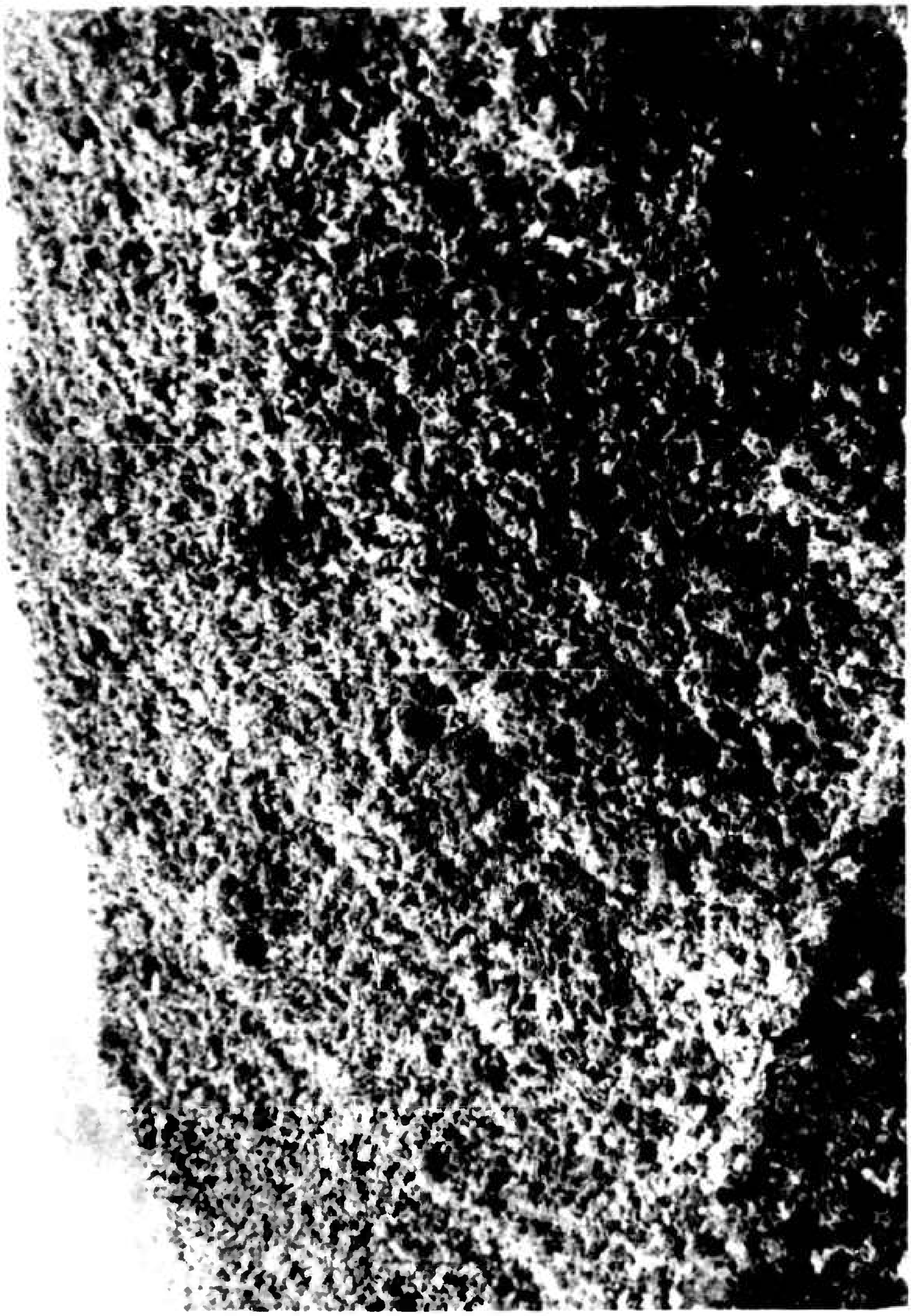


Fig. 7. Rain (Evergreen) forest, Luquillo National Forest, Puerto Rico.

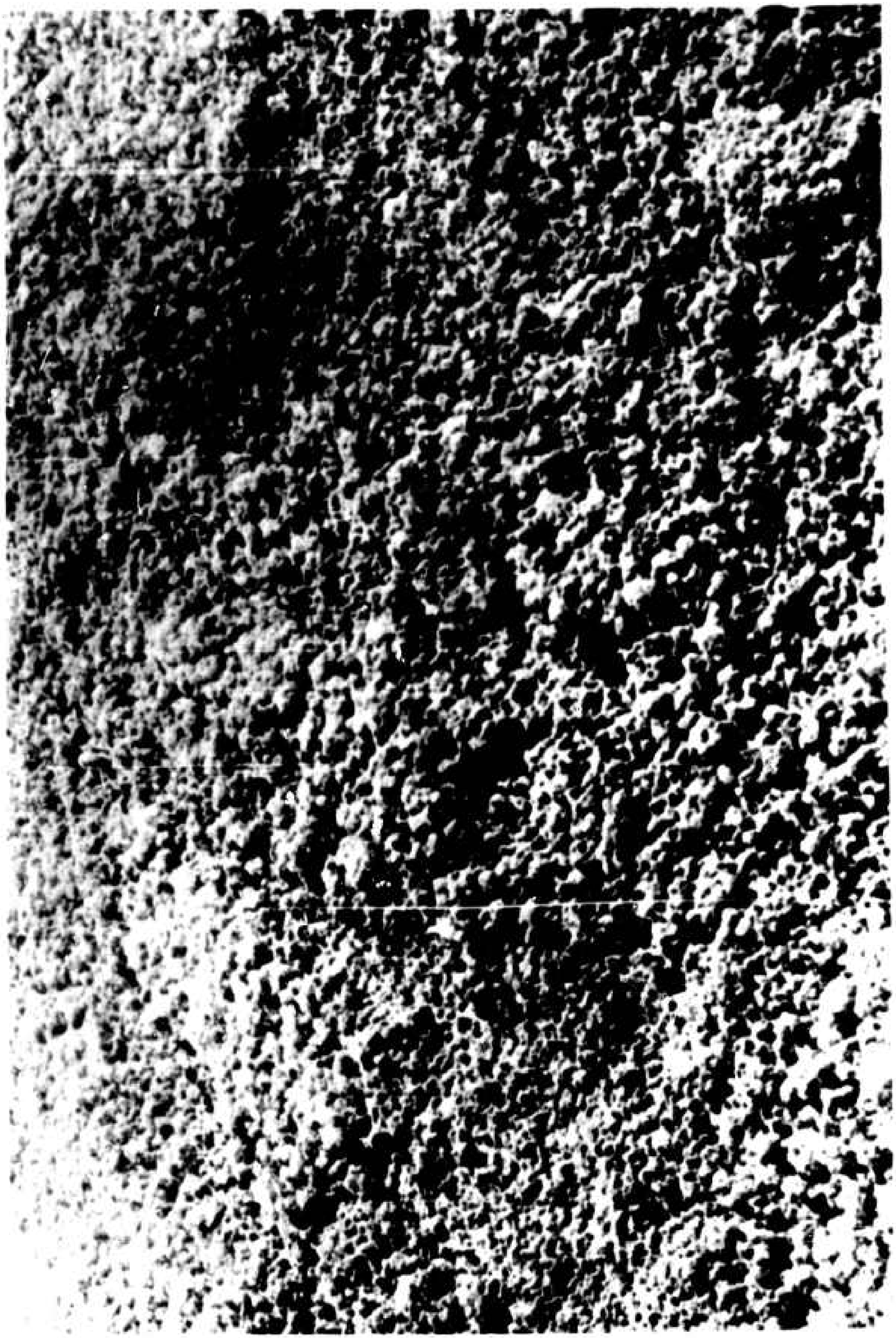


Fig. 8. Monsoon Evergreen forest, northern Thailand.

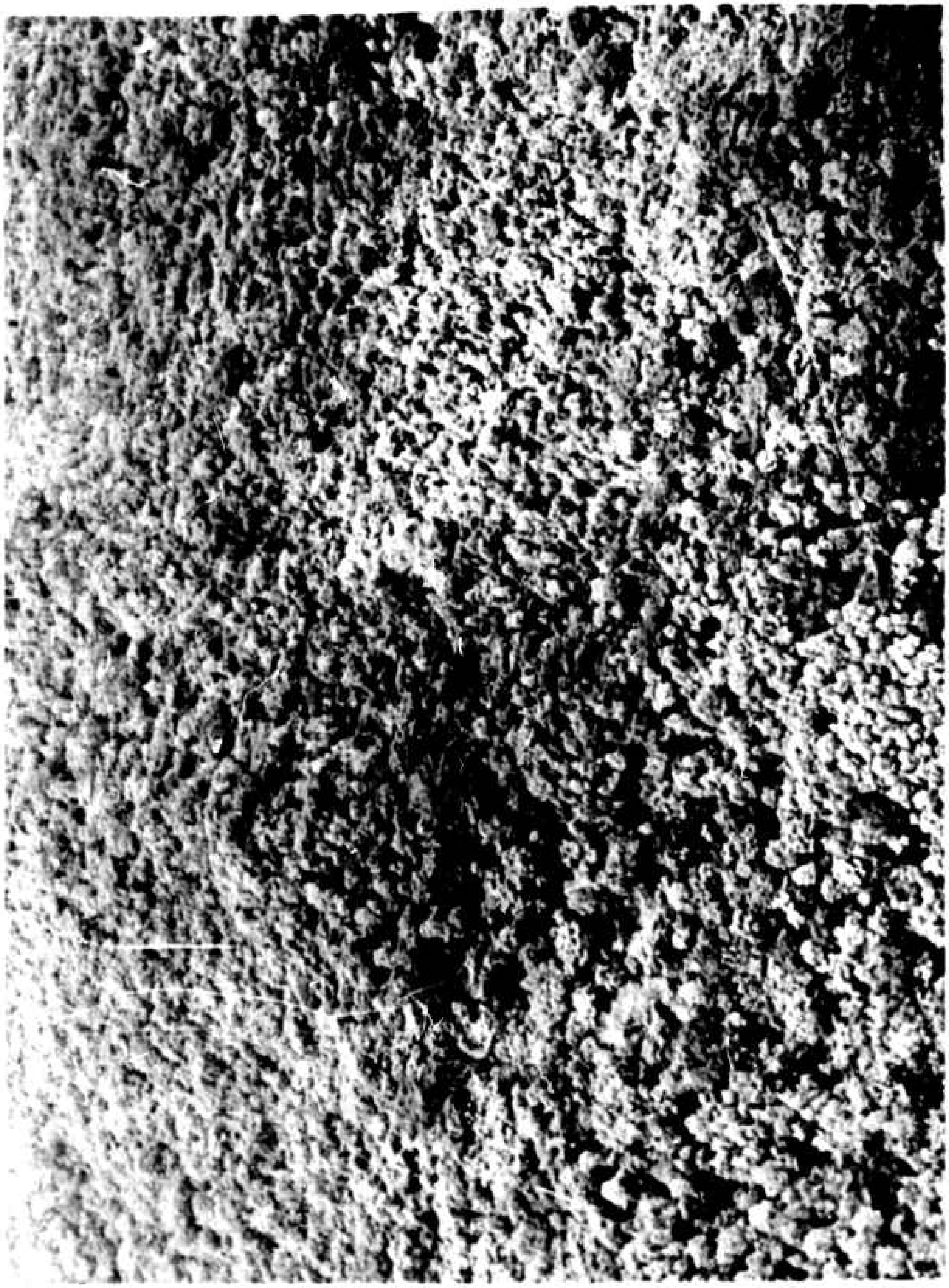


Fig. 9. Canopy of Rain forest, Luquillo National Forest, Puerto Rico.

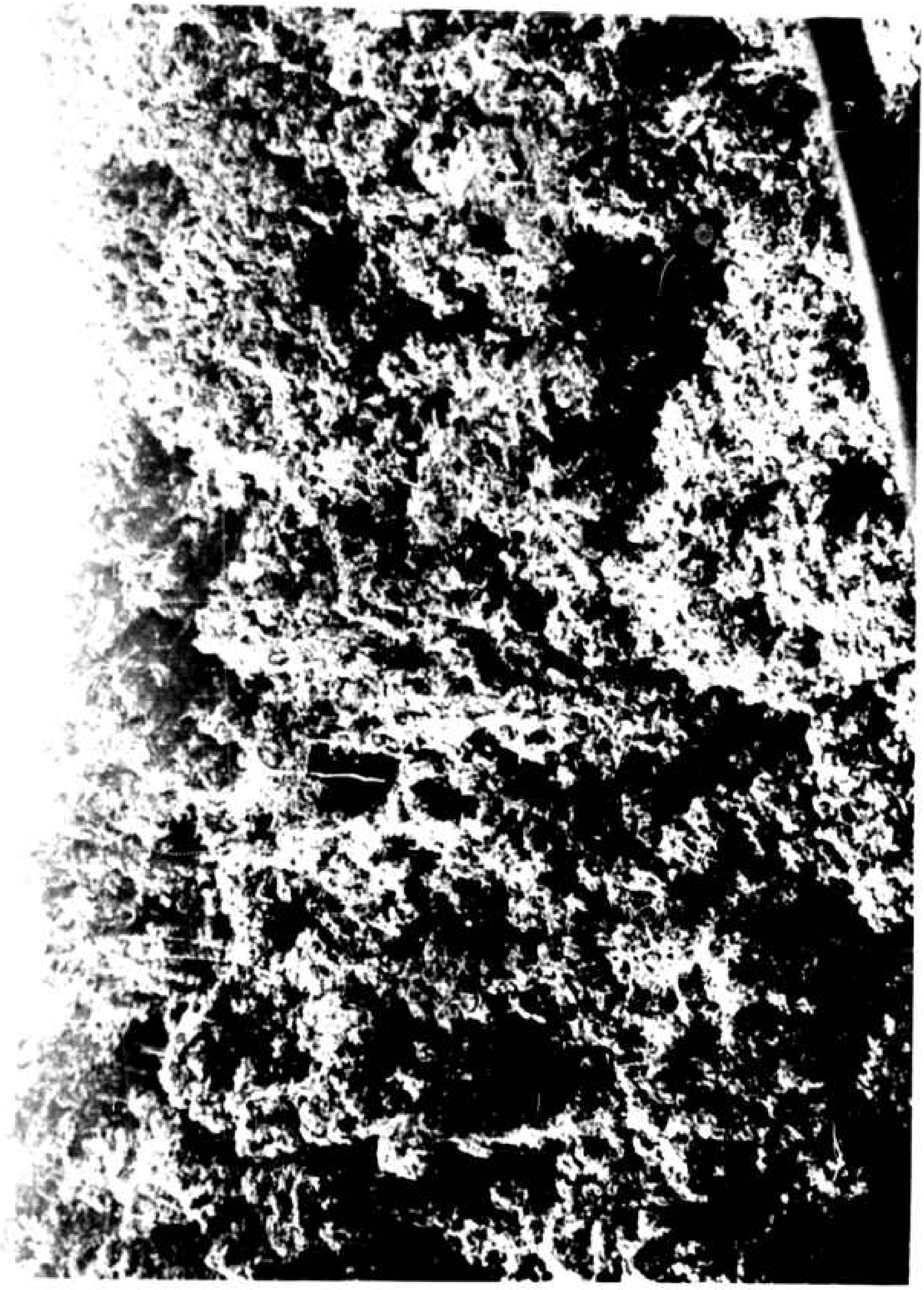


Fig. 10. Canopy of Hill (Evergreen) Humid forest, Khao Yai National Forest, central Thailand.

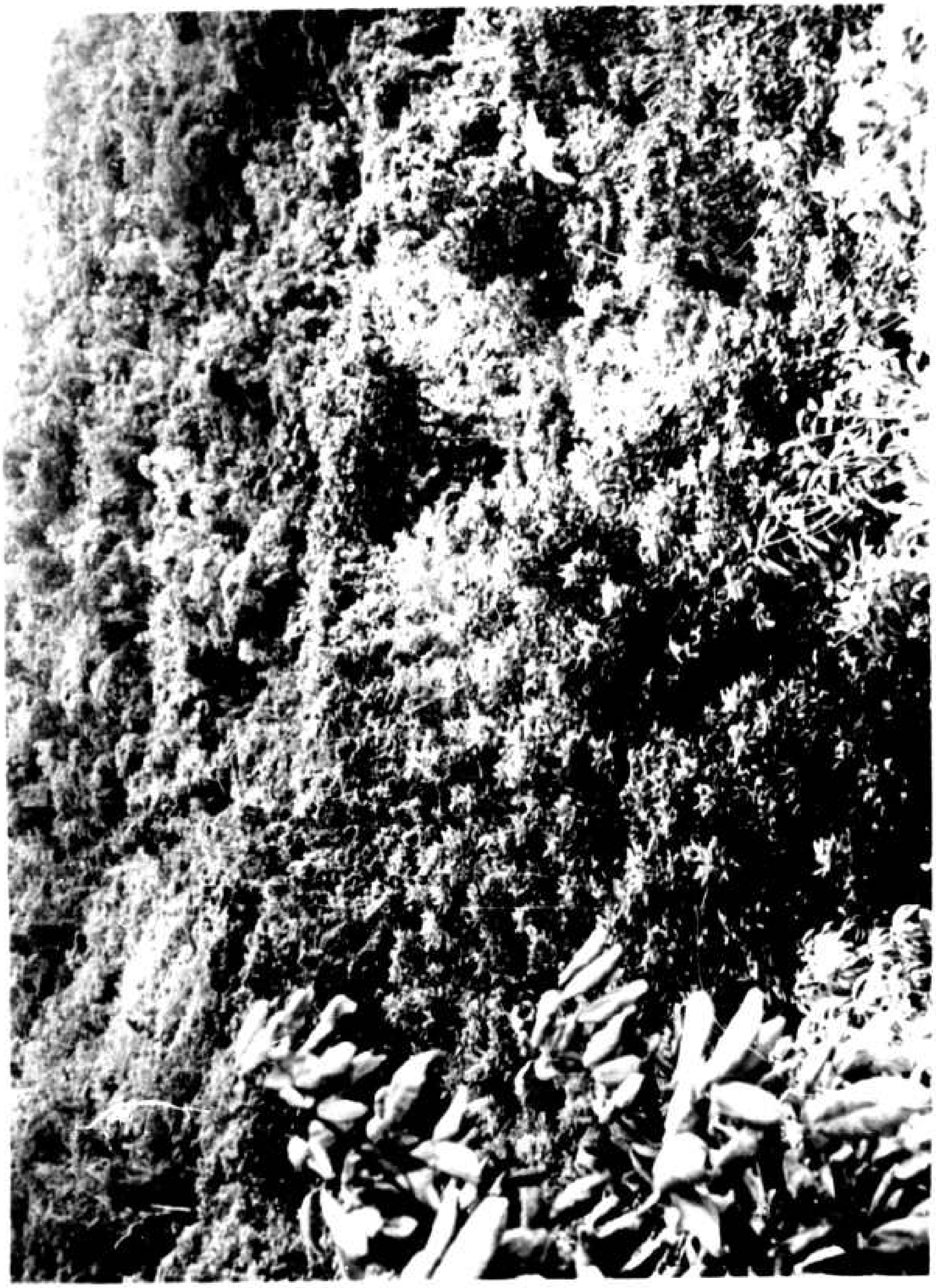


Fig. 11. Canopy of Rain forest, El Verde site, Luquillo National Forest, Puerto Rico.

Fig. 12. "Khanun-nok" (Palaquium obovatum), of the Sapodilla family, a characteristic tree of the Rain forest of Southeast Asia. Mountain of Khao Sa Bap, southeast Thailand.

Fig. 13. "Ausubo" (Manilkara bidentata), of the Sapodilla family, a dominant tree in the Rain forest of Luquillo, Puerto Rico.

Fig. 14. A fig tree (Ficus), frequent in Hill Evergreen forest, Khao Yai, central Thailand. Armed liane (on left) is Toddalia sp.; coils of rattan (Calamus) on right.

Fig. 15. Tabanuco (Dacryodes excelsa), a characteristic tree of Rain forest of Luquillo, Puerto Rico.

Fig. 16. Undergrowth in Humid Evergreen forest, Kaochawng, southern peninsular Thailand.

Fig. 17. Undergrowth in Rain forest, Luquillo, Puerto Rico.

Fig. 18. Riparian forest, with rattan (Calamus) frequent, Khao Yai forest, central Thailand.

Fig. 19. Swing bridge made of bamboo (floor) and rattan (cables), Khao Yai National Forest, central Thailand.

Fig. 20. Lower Montane forest, with oaks (*Quercus*) and chestnut (*Castanopsis*) dominant, Khao Yai National Forest, central Thailand.

Fig. 21. Montane forest in which species of Schima and Dacrydium are dominant on summit, Khao Yai forest, central Thailand.

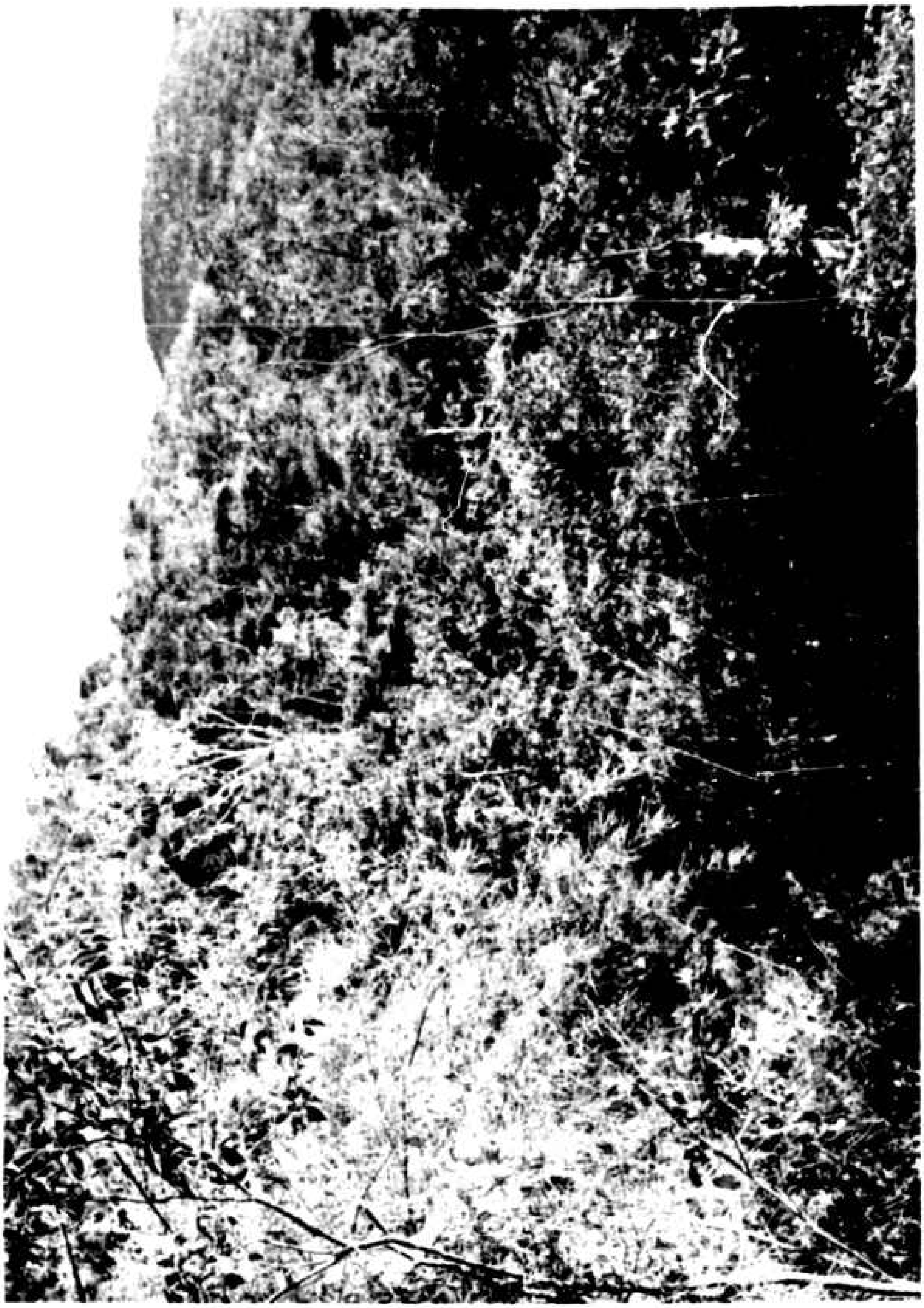


Fig. 22. Dry Evergreen forest, north of Prachuab Khirikhan, peninsular Thailand.

Fig. 23. Dry Evergreen forest, with Streblus zeylanica dominant in evergreen understory, and an abundance of lianes. Pranburi, upper peninsular Thailand.

Fig. 24. Three-needled pine (Pinus khasya), summit of Doi Sutep, northern Thailand.

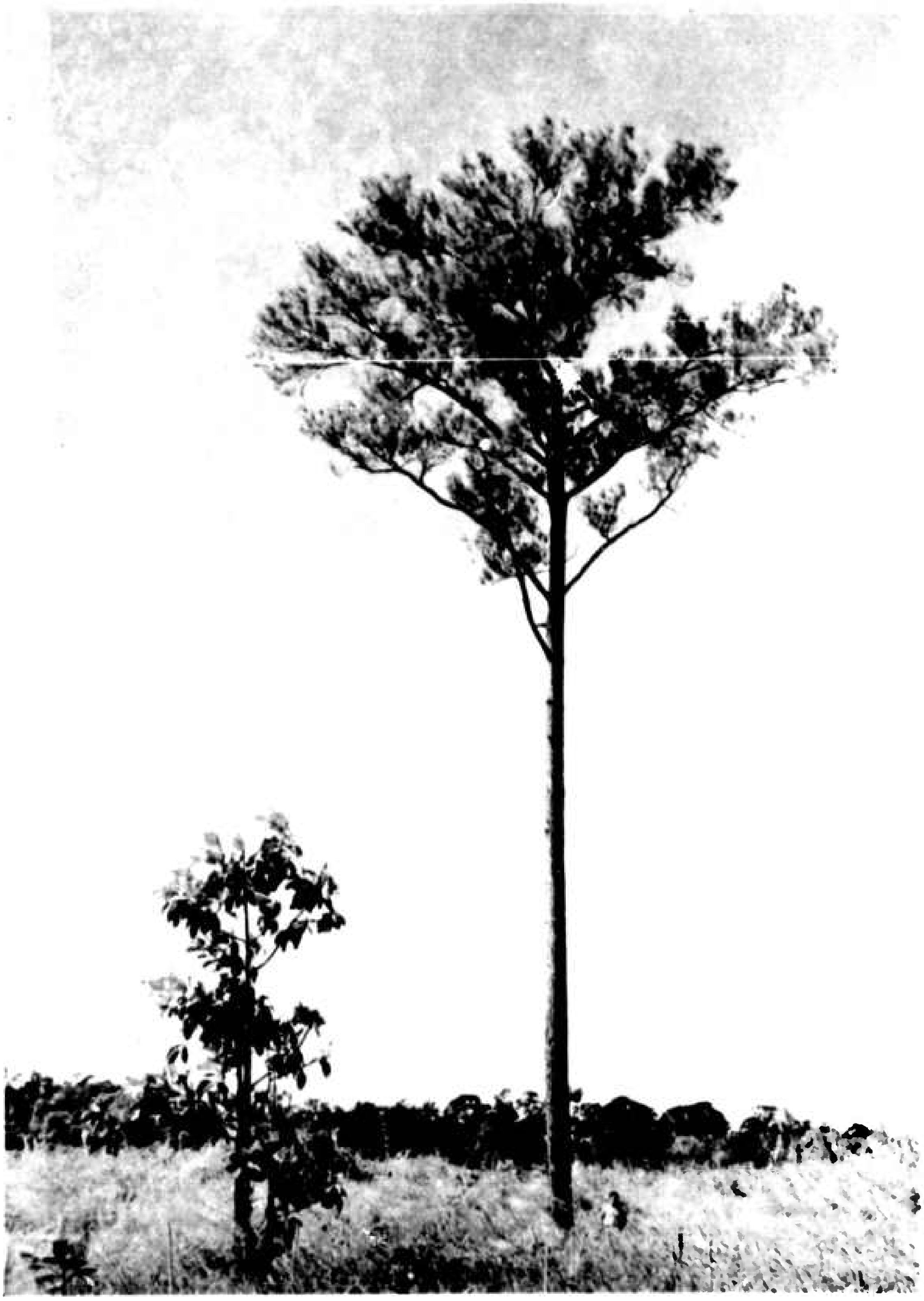


Fig. 25. Two-needled pine (Pinus merkusii), mixed with Hardwoods, Phibun Mangsahan, eastern Thailand.

Fig. 26. Elfin woodland, with sierra palm (*Prestoea montana*) abundant, on windward slope, El Yunque (3,497 ft.), Puerto Rico.

Fig. 27. Montane forest, Chiengdao mountain range, northern Thailand.

Fig. 28. Elfin woodland, as if sheared by constant wind, upper slope, El Yunque, northeastern Puerto Rico.

Fig. 29. Mossy forest on leeward slope of El Yunque, Puerto Rico.

Fig. 30. Semi-Evergreen forest in lowland along northern edge of Khao Yai National Forest, central Thailand.

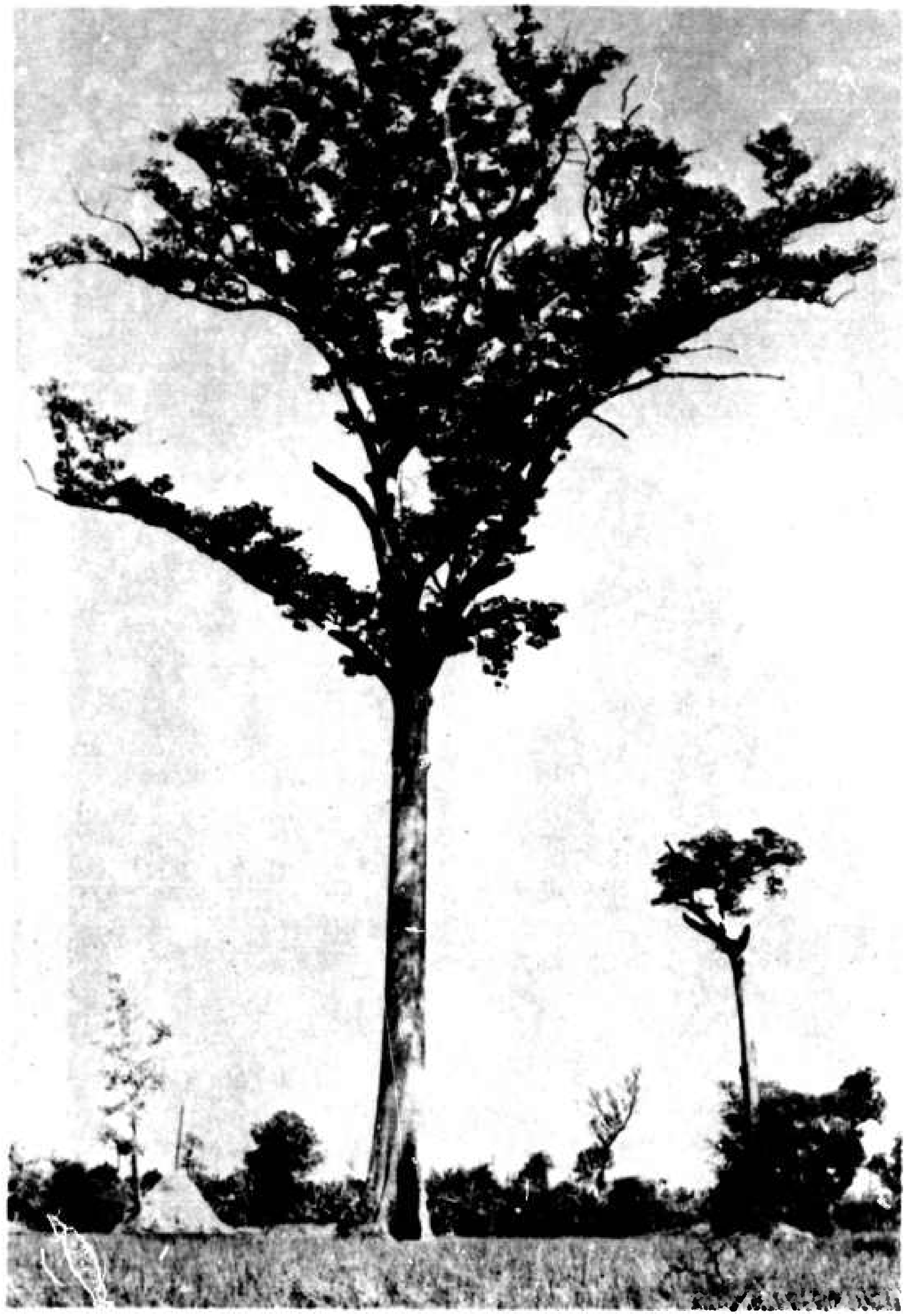


Fig. 31. "Khao yang" (Dipterocarpus alatus), one of the largest trees and widely distributed in Thailand. An oleo-resin exudes by applying fire to the base of trunk

Fig. 31. "Khao yang" (Dipterocarpus alatus), one of the largest trees and widely distributed in Thailand. An oleo-resin exudes by applying fire to the base of trunk

Fig. 32. Open Hardwood forest, composed mainly of Dipterocarp trees, between Sakhon Nakhon and Udon, northeastern Thailand.

Fig. 33. A mixed stard of hardwoods, typical of East-west Cross Timbers in Texas in which post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) are dominant. Other hardwoods, generally along streams, are pecan, elm and cottonwood. (Courtesy of Texas Forest Service.)

Fig. 34. Mixed hardwood forest between Nakhon Sawan and Tak, northwestern Thailand, as it appears at height of dry season, in early February.

Fig. 35. Post oak (_Quercus stellata_) is the dominant hardwood in the Pine-Oak region of east Texas.

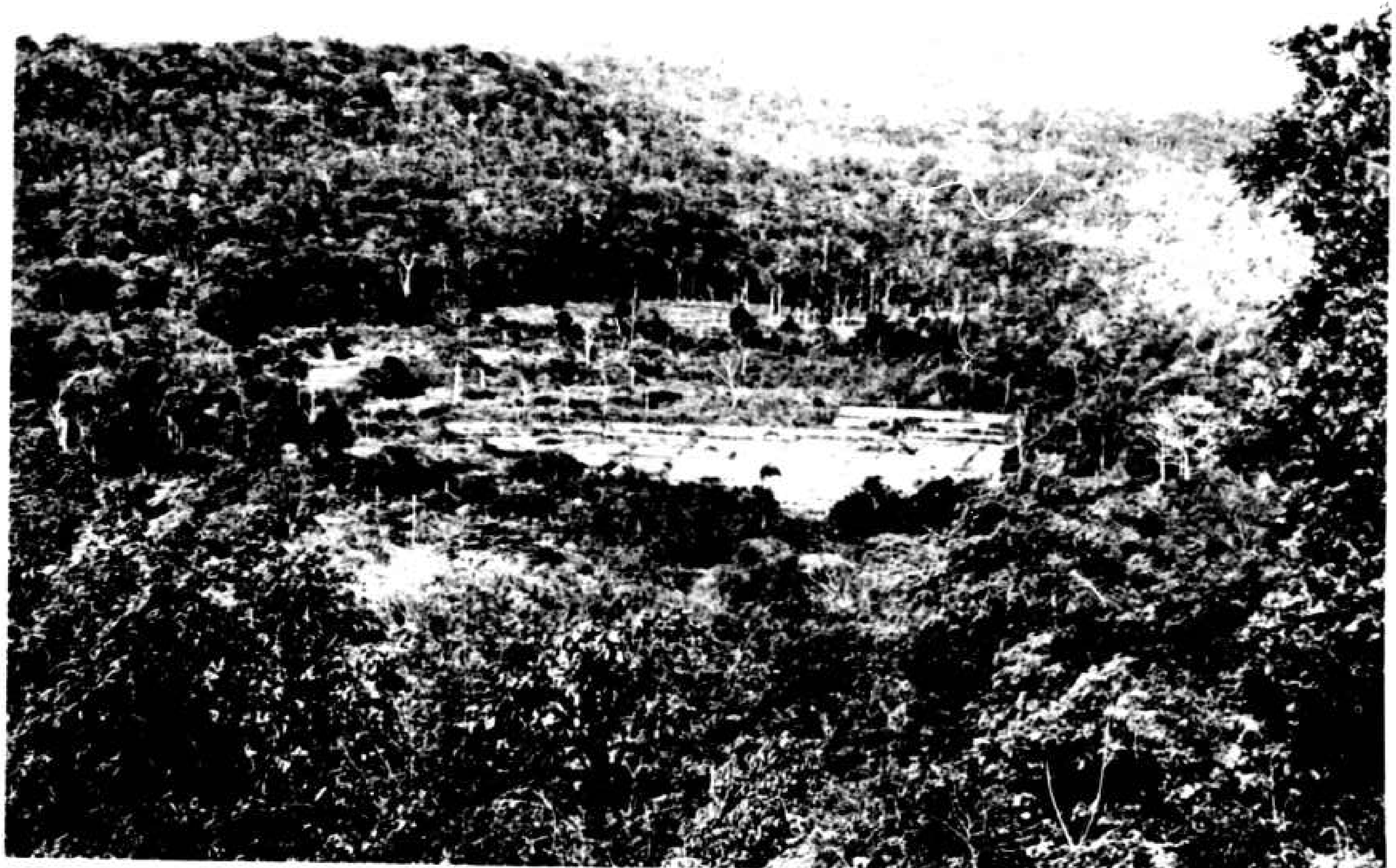


Fig. 36. Dry Deciduous forest, Phu Phan mountains, near Mekong river, northeast Thailand.

Fig. 37. Profile of Dipterocarp forest, Phu-Phan, northeast Thailand.

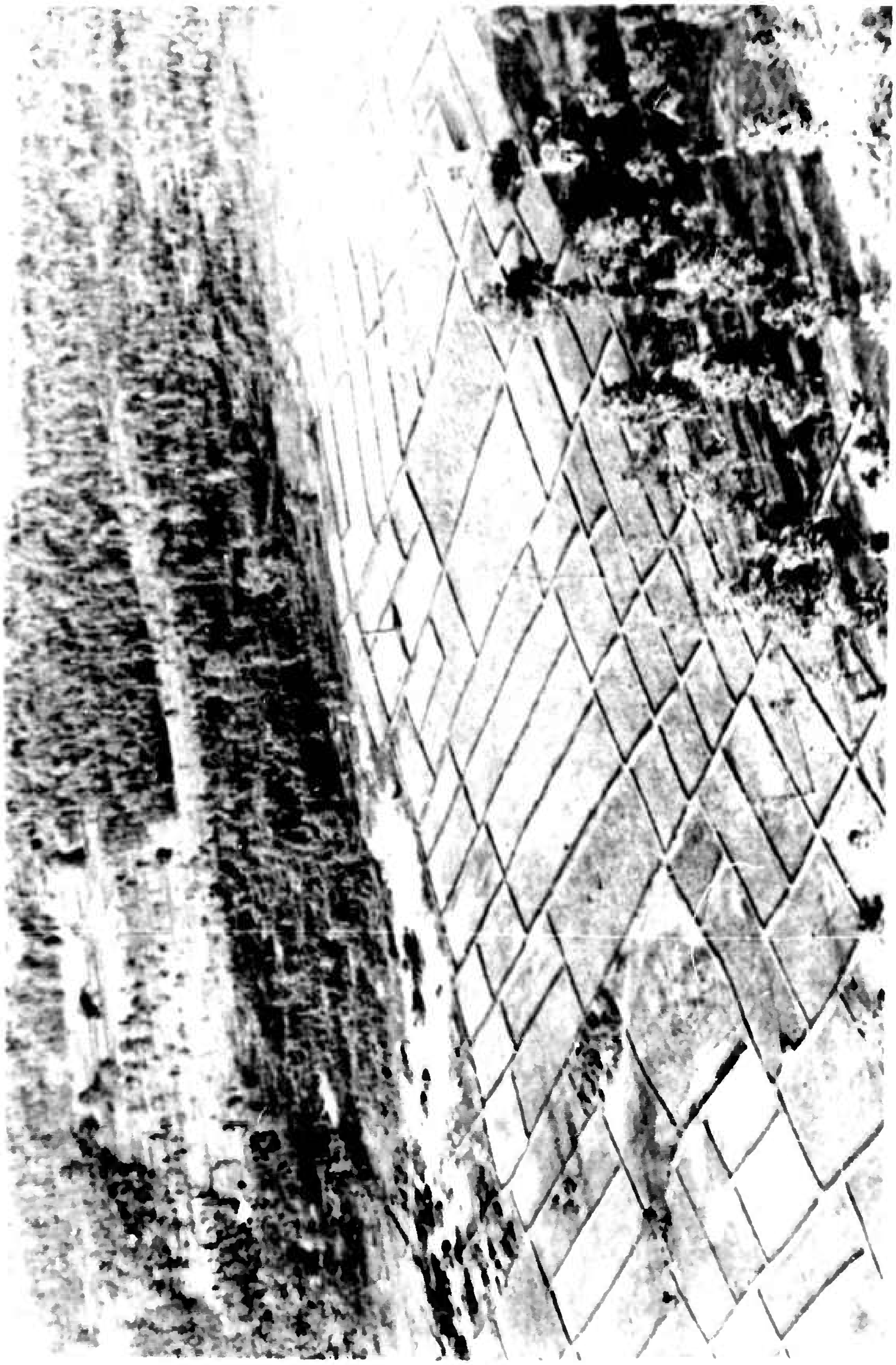


Fig. 38. Dipterocarp forest interspersed with rice fields. Aranyaprathet, eastern Thailand.

Fig. 39. Yang trees (Dipterocarpus alatus), east of Rayong, southeast coast, Thailand.

Fig. 40. Mangrove woodland at Trat, southeast Thailand. Light-colored leaves are Nipa palm (*Nipa fruticans*).

Fig. 41. Mangrove woodland, northeast Puerto Rico.

Fig. 42. Mangrove swamp forest, Khlung area, southeast Thailand.

Fig. 43. Mangrove woodland cutover, being replaced by successional growth. Estuary of Chao Phraya River, Thailand.

Fig. 44. Mature mangrove tree (Rhizophora mucronata) at low tide. Klong Dan, estuary of Chao Phraya river, Thailand.

Fig. 45. Red Mangrove (Rhizophora mangle), east of Guánica, southwest Puerto Rico.

Fig. 46. Stand of Nipa palm (Nipa fruticans), in post-mangrove sites. Kra Isthmus, central peninsular Thailand.

Fig. 47. Nipa palm (<u>Nipa fruticans</u>), estuary of Chao Phraya river, Thailand.

Fig. 48. Stand of "cajeput" or "samet" (Melaleuca leucadendron), in post-mangrove sites with brackish water, between Chanthaburi and Trat, southeast Thailand.

Fig. 49. Swamp bloodwood (*Pterocarpus officinalis*) in brackish water, Dorado beach, north coast, Puerto Rico.

Fig. 50. Swamp fern (Acrostichum aureum), occurs in mangrove sites in Southeast Asia and Puerto Rico.

Fig. 51. Freshwater lake with distinctive aquatic plants, mostly water lilies and lotus. Borabue, northeastern Thailand.

Fig. 52. Freshwater swamp clogged with Eichornia crassipes. Konkaen, northeastern Thailand.

Fig. 53. Riparian forest, mainly "pomarrosa" (Eugenia jambos) introduced from Southeast Asia, fringing water line. Lake Carite, central Puerto Rico.

Fig. 54. Savanna with Dipterocarp trees, mostly (Dipterocarpus obtusifolius), between Phibun Mangsahan, eastern Thailand, and border of southern Laos.

Fig. 54. Savanna with Dipterocarp trees, mostly (<u>Dipterocarpus obtusifolius</u>), between Phibun Mangsahan, eastern Thailand, and border of southern Laos.

Fig. 55. Wooded savanna, with post oak (Quercus stellata) and blackjack oak (Q. marilandica) dominant in the canopy, and yaupon (Ilex vomitoria) in the understory. Texas A&M University Plantation, Texas.

Fig. 56. Dry dipterocarp savanna south of Lampang, northern Thailand.

Fig. 57. Riparian or gallery forest with bamboo (_Bambusa vulgaris_) dominant, northeast Puerto Rico.

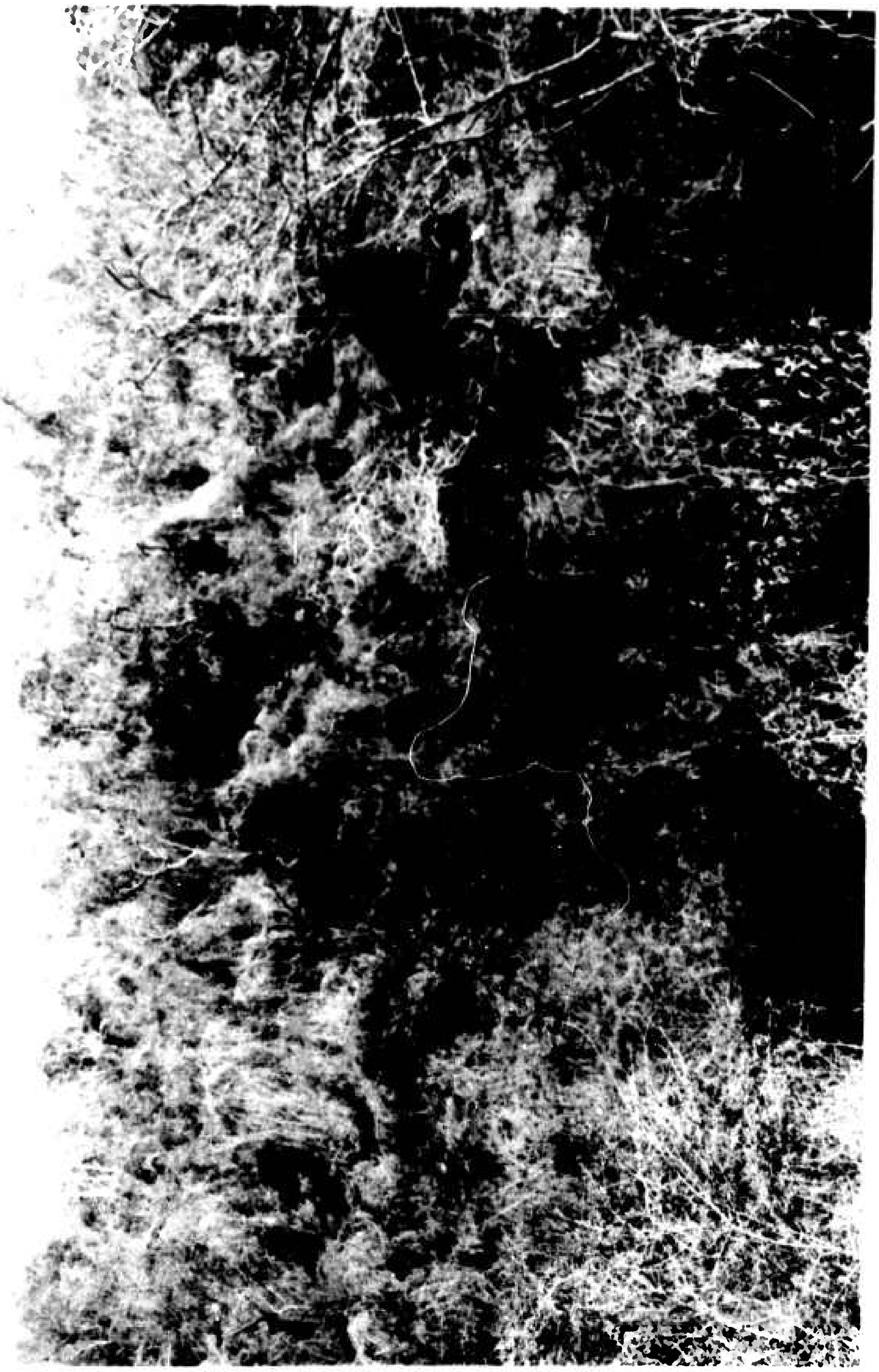


Fig. 58. Thorn thicket, Guánica area, southwest Puerto Rico.

Fig. 59. Macartney rose (Rosa bracteata), introduced from Asia into Texas. Port Lavaca, Texas.

Fig. 60. Thorn thicket of Bambusa arundinacea, Opuntia vulgaris and Feroniella lucida, Hua-Hin, peninsular Thailand.

Fig. 61. Thorn thicket composed of: pricklypear (Opuntia), Texas persimmon (Diospyros texana), white-brush (Aloysia lyciodes) and species of Acacia. Edwards Plateau, Texas.

Fig. 62. Stand of sierra palm (*Prestoea montana*), on upper slopes of Toro Negro range, central Puerto Rico.

Fig. 63. Mountain cabbage or sierra palm (Prestoea montana), upper moist evergreen forest, Toro Negro, Puerto Rico.

Fig. 64. "Tanta-not" (Borassus flabellifer), a frequent palm forming open stands or as scattered individuals around abodes and in rice fields. West-central Thailand.

Fig. 65. Coconut and areca or betel-nut palm (Areca catechu), in background, frequently propagated around abodes in humid areas of Southeast Asia.

Fig. 66. Vegetation along seacoast is often composed of coconut palms, and a ground cover of *Ipomoea pes-caprae* and *Canavalia*. West of Arecibo, northwest Puerto Rico.

Fig. 67. Pandan or screw-pine (Pandanus), characteristic of open seashores. Southeast Thailand.

Fig. 68. Casuarina trees propagated along seashore to arrest sand dunes. Huay Yang, central peninsular Thailand.

Fig. 69. Coastal forest, Huay Yang, south of Prachuab-khirikan, peninsular Thailand.

Fig. 70. Dry Dipterocarp forest on slopes, with rice tilled in valley bottom by hill tribe. Mae Hongson region, northwest Thailand.

Fig. 71. Forest-covered "haystacks" or "mogotes," sorrounding plains cultivated to pineapple or sugar-cane, near Arecibo, north coast, Puerto Rico.

Fig. 72. "Kha-luang" (Imperata cylindrica), one of the most widespread weedy grasses in Southeast Asia, soon develops in forest clearings and abandoned land. Chumphon, peninsular Thailand.

Fig. 73. "Phong" (<u>Saccharum spontaneum</u>), a tall grass frequent along roadsides and in pastures in Thailand and elsewhere in Southeast Asia.

Fig. 74. Semi-evergreen forest. Region of Mukdahan, northeast Thailand.

Fig. 75. Mixed hardwood stand of Post Oak (Quercus stellata), blackjack (Q. marilandica), and swamp oak (Q. michauxii), winged elm (Ulmus alata) and persimmon (Diospyros texana). Near Bryan, east Texas.

Fig. 76. Bamboo brakes, especially *Bambusa arundinaceae* and *Thyrsostachys siamensis*, appearing as secondary growth, along Kwae Noi river.

Fig. 77. A common bamboo (Bambusa vulgaris), introduced from Asia, frequent along highways, streams and invades cultivated land, in Puerto Rico.

Fig. 78. Secondary growth in clearing in Dry Evergreen forest, composed of Imperata cylindrica grass, weed Eupatorium odoratum, and such woody plants as species of Capsicum and Amomum. Mukdahan, northeastern Thailand.

Fig. 79. A dense ground layer, mostly Impatiens balsamina, developing as successional growth when canopy is opened. Humid evergreen forest, Toro Negro, central Puerto Rico.

Fig. 80. Bamboo (Bambusa arundinacea) appearing as secondary growth in Hill Moist Evergreen forest. Khao Yai National Forest, central Thailand.

Fig. 81. Secondary growth, composed mainly of bamboo (Bambusa vulgaris), east of Mayazues, Puerto Rico.

'ig. 82. Secondary forest composed of shrubs, such as species of Miconia and Piper, and tree-fern, in foreground, and such fast-growing, soft-wooded trees as Cecropia peltata and Didymopanax morototoni, and Bambusa vulgaris (center background). Middle altitude, Toro Negro range, central Puerto Rico.

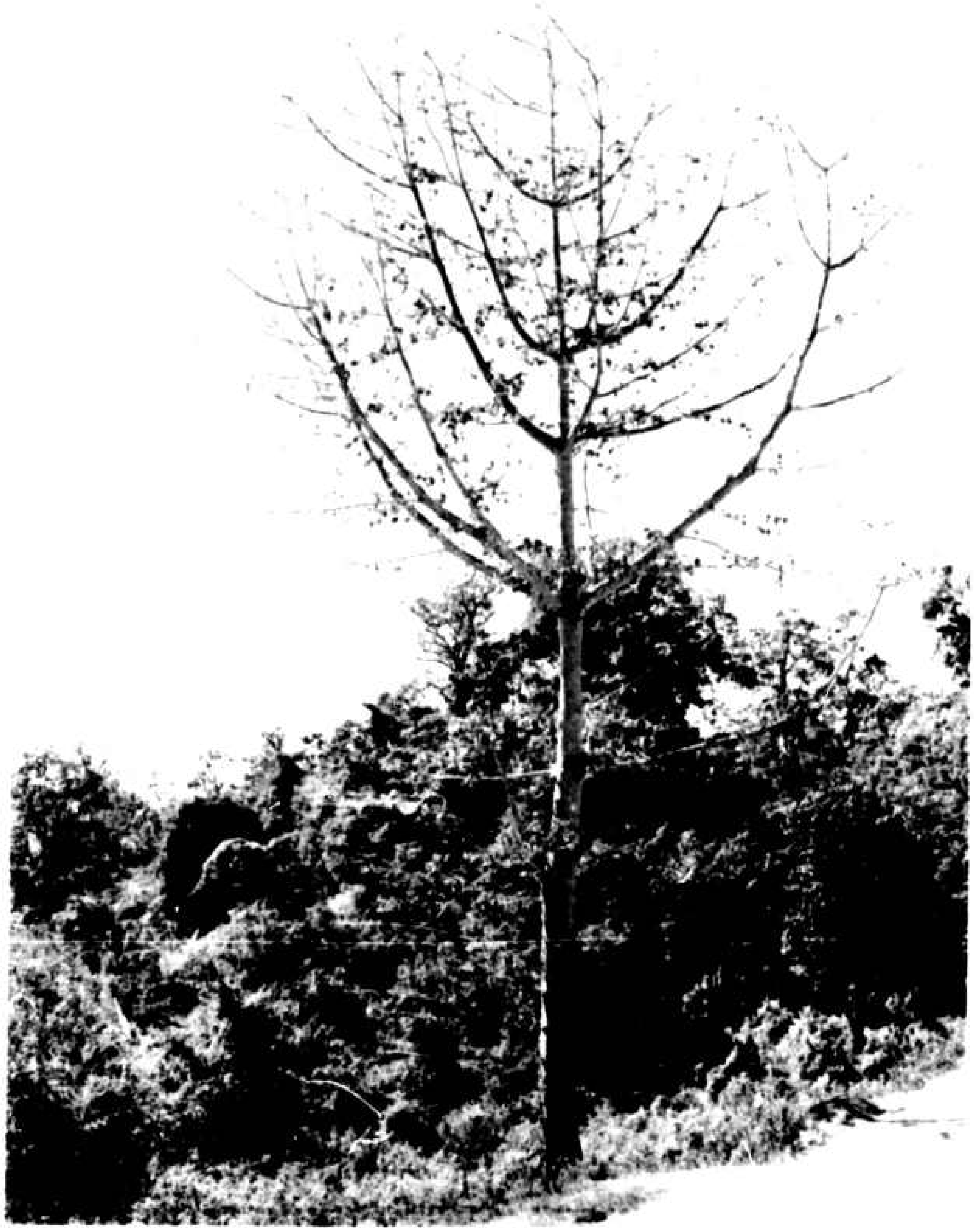
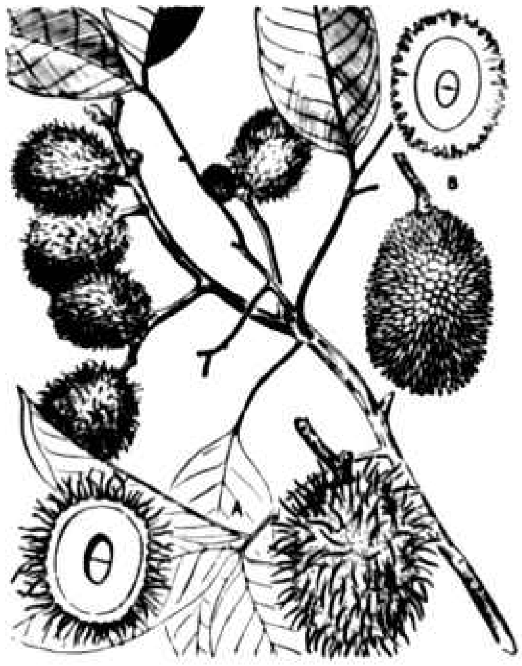


Fig. 83. "Ngiu" (Salmalia (Bombax) malabarica), a fast-growing, soft-wooded tree, frequent in secondary forest in Thailand.

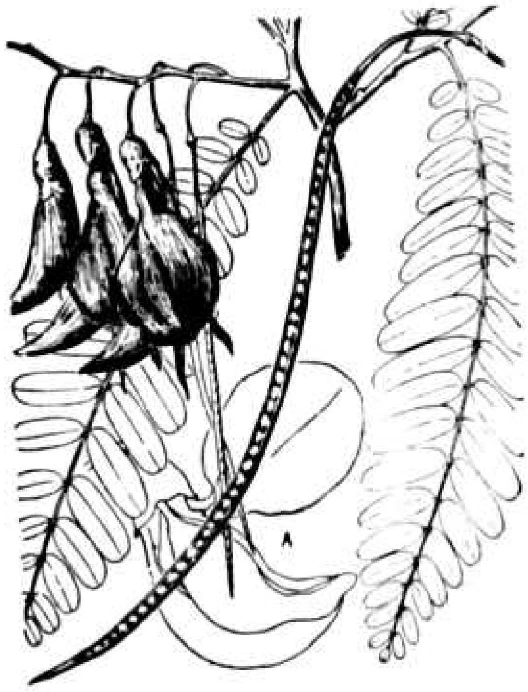
Fig. 84. Regrowth in disturbed site in Dry Evergreen forest, Pranburi, upper Peninsular Thailand.

(A) Mango (Mangifera indica).



(B) A, Rambutan (Nephelium lappaceum)
B, Pulusan (Nephelium mutabile).

(C) Guava (Psidium guajava).



(D) Sesbania grandiflora.

Figure 85

(A) **Cashew** (**Anacardium occidentale**).

(B) Soursop (Annona muricata).

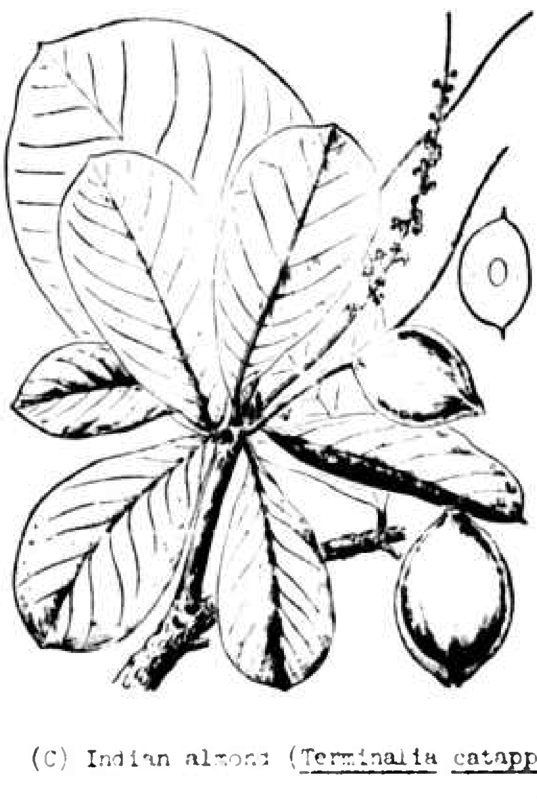
(C) Custard apple (Annona reticulata).

(D) Breadfruit (Artocarpus altilis).

Figure 86

[illegible] (Spondias purpurea).

(B) Tamarind (Tamarindus [illegible]).



(C) Indian almond (Terminalia catappa).

(D) Nipa palm (Nipa fruticans).

Figure 87

(A) Rattan palm (<u>Calamus</u>).

(B) Palm Nuts.

(C) Bamboo shoots (various species).

(D) Pandan or screw pine (<u>Pandanus tectorius</u>).

Figure 88

(A) Peanut (*Arachis hypogaea*).

(B) Dasheen (*Colocasia antiquorum*).

(C) Taro (*Colocasia esculenta*).

(D) Yam (*Dioscorea* spp.).

Figure 89

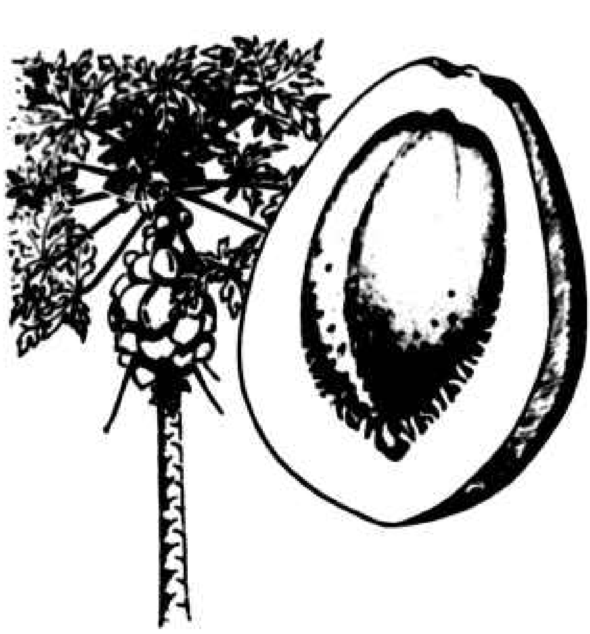
(A) Sweet potato (Ipomoea batatas).

(B) Cassava, manioc, or tapioca (Manihot esculenta).

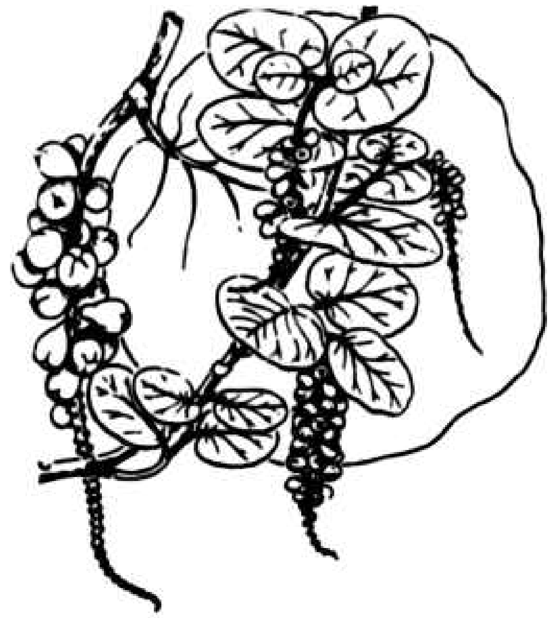
(C) Water hyacinth (Eichhornia crassipes).

(D) Water chestnut (Eleocharis dulcis)

Figure 20



(A) Papaw (Carica papaya).



(B) Sea Grape (Coccoloba uvifera).

(C) Rose Apple (Eugenia jambos)

(D) Wild Fig (Ficus)

Figure 91

(A) Ipomoea aquatica.

(B) A, Lotus (Nelumbium nelumbo)
B, Water lily (Nymphaea).

(C) Sandbox Tree (Hura crepitans).

(D) Physic Nut (Jatropha curcas).

Figure 92

(A) Cowhage (A, _Mucuna pruriens_, B, _M. biplicata_; C, _M. cyanosperma_).

(B) Castor oil plant (_Ricinus communis_).

Figure 93

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BIBLIOGRAPHIES

- Cambodia
- Laos
- Thailand
- Vietnam
- Puerto Rico
- Texas
- Aquatic Plants and Control
- Survival Plants

For additional references on Southeast Asia--<u>see</u> annotated bibliography in U.S. Department of Agriculture Publication (CR-49-65), "Vegetation of Southeast Asia: Studies of Forest Types, 1963-1965."

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ALTERNATIVE OR SYNONYMOUS BOTANICAL NAMES

Names used in this publication	Alternative or synonymous names
Achras zapota	Manilkara achras
Anona	Annona
Albizzia	Albizia
Areca catechu	Areca cathecu
Azadirachta indica	Melia azedarach
Carya pecan	Carya illinoensis
Cedrela microcarpa	Toona microcarpa
Cedrela toona	Toona sinensis
Chikrassia	Chukrassia
Guarea guara	Guarea guidonia
Guarea trichilioides	Guarea guidonia
Inga vera	Inga inga
Nephelium litchi	Litchi chinensis
Pasania	Quercus
Prestoea montana	Euterpe globosa

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