# *Pterocarpus officinalis* Jacq. Bloodwood

**Leguminosae Legume family**
**Lotoideae Pea subfamily**

SO-ITF-SM-87
September 1997

**Peter L. Weaver**

*Pterocarpus officinalis* Jacq., called palo de pollo in Puerto Rico, bloodwood in Guyana and Panama, and by numerous other names throughout its extensive range, is an evergreen tree that reaches 40 m in height and 60 to 90 cm in diameter at breast height (d.b.h.) at maturity (*35, 57*). Bloodwood's large, narrow, sinuous buttresses (figs. 1, 2) aid identification in the field. Other useful identifying characteristics are: very light wood; dark-red latex that exudes from cuts in the bark; large, alternate, odd pinnate leaves; and flat, round, winged seedpods (*35*). Bloodwood grows mainly in coastal wetlands including freshwater and brackish swamps, on the landward side of mangroves, and along streambanks.

Bloodwood was partitioned into two subspecies in a revision of the genus *Pterocarpus*: *P. officinalis* Jacq. ssp. *officinalis* and *P. officinalis* Jacq. ssp. *gilletii* (*54*). This report does not contain information about the subspecies *gilletii*.

**Figure 1.**— *A bloodwood (*Pterocarpus officinalis *Jacq.) tree in a coastal wetland near Dorado, Puerto Rico (photo by John Parrotta).*

Peter L. Weaver is a research forester at the International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR, 00928-2500, in cooperation with the University of Puerto Rico, Río Piedras, PR 00936-4984.

## HABITAT

### Native Range

Bloodwood grows from 20° N. (*46*) to 2° S. latitude (*54*) in the neotropics. It occurs mainly in coastal and interior wetlands throughout its range: southern Mexico and Central America, and the northern part of South America (*4, 35*); the Caribbean Islands of Jamaica (*1*), Hispaniola including Haiti (*6*) and the Dominican Republic (*41*), and Puerto Rico (*3, 22, 43*); and the Lesser Antllles including Guadeloupe and

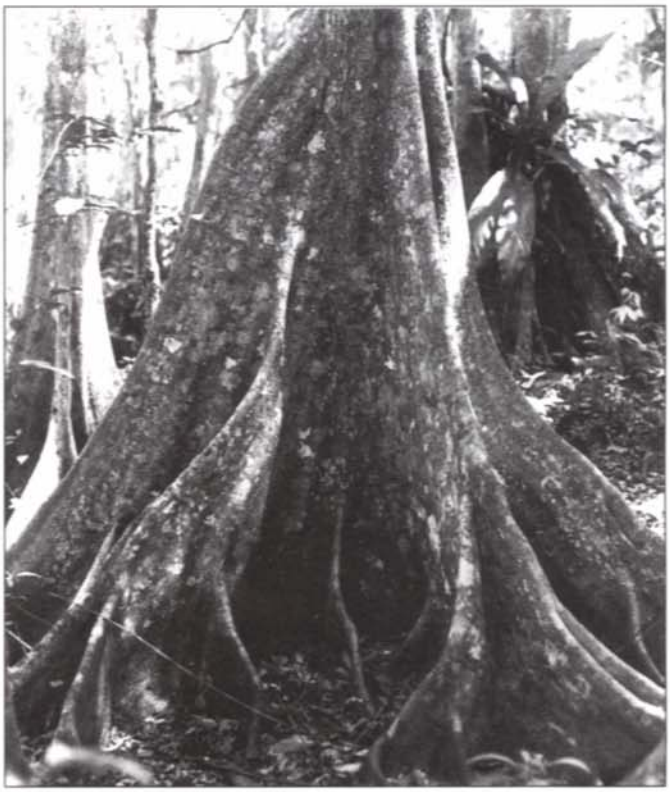

**Figure 2.**—*Distinctive buttresses of a bloodwood (*Pterocarpus officinalis *Jacq.) tree in a coastal wetland near Dorado, Puerto Rico (photo by John Parrotta).*

Martinique (*8, 21, 59*), Dominica (*8, 23, 59*), the small island of Marie Galante (*59*), St. Lucia (*8, 59*), St. Vincent (*59*), and Trinidad and Tobago (*7, 37, 38, 62*) (fig. 3).

In continental areas, bloodwood grows from southeastern Mexico (*46*), Honduras (*9*), Costa Rica (*26*), Panama (*58*), and northern South America including Colombia (*47*), Venezuela (*42*), Ecuador (*34*), Guyana (*16, 44*), Suriname (*32*), French Guiana (*5*), and the estuary of the Amazon River south along the coast to 45° W. longitude in the state of Maranhão, Brazil (*9, 54, 57*). Bloodwood has also been introduced in Cuba and southern Florida (*35*).

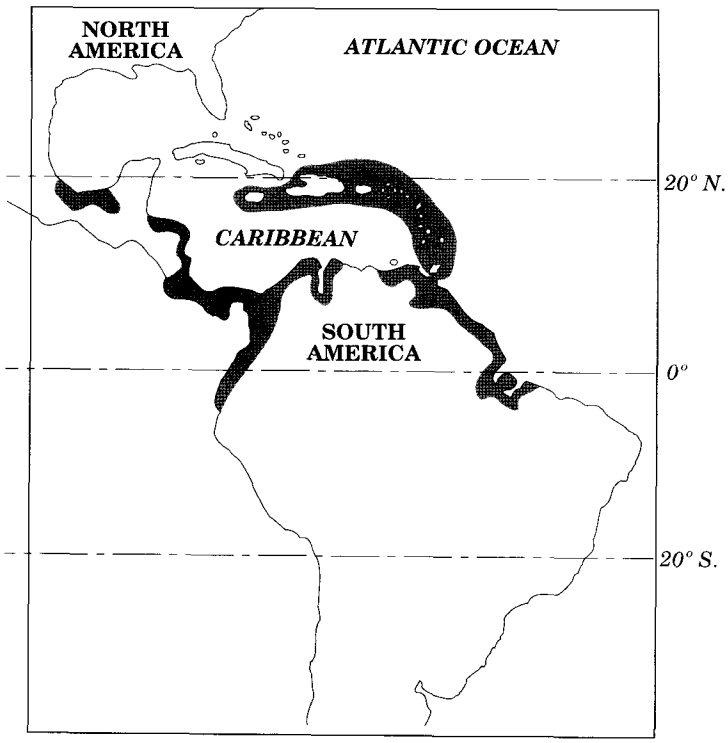


**Figure 3.**—*Shaded areas represent native range of bloodwood* (Pterocarpus officinalis *Jacq.) in the Caribbean Basin and in Central and South America.*

### Climate

In Puerto Rico, bloodwood grows in the subtropical moist forest, subtropical wet forest, and subtropical rain forest life zones (*18, 25*).Rainfall in these forest types ranges from 1600 to 4000 mm/yr with mean annual temperatures between 20 and 24 °C (*12*). Bloodwood also grows in the tropical moist forest life zone in Costa Rica (*57*).

The mean annual rainfall and temperature throughout bloodwood's range are similar to those of Puerto Rico. Bloodwood is one of five species in the genus *Pterocarpus* that is classified as a "rainforest or evergreen forest species" (*55*), meaning that it has adapted to wet climates or conditions. Bloodwood grows only in frost-free areas.

### Soils and Topography

Bloodwood grows in periodically flooded coastal wetlands but is not confined to that habitat (*5*). In Puerto Rico, the species is found in at least 15 different locations totaling 240 ha (*3*) mainly in coastal freshwater swamps and on the landward side of mangroves where the saline content of the water is low. The largest of these stands is located at the eastern end of the island near the city of Humacao.

The soils in Puerto Rico's coastal bloodwood stands, often designated as tidal swamps, are either clayey or sandy and contain large amounts of organic matter (*11*). These areas are underlain by coral, shells, and marl to varying depths. Bloodwood also grows at a 350-m elevation in the Luquillo Mountains along the streambanks of the Mameyes River and its tributaries (*35, 61*). The montane soils are acid clays classified as Ultisols (*11*).

Bloodwood also grows on coastal and riverine lowlands in several other areas. In Jamaica, it is rare in swamps from sea level to a 175-m elevation (*1*). In Costa Rica, it is found in riverine mangrove forests situated on alluvial sediments (*49*). In Ecuador, bloodwood grows in coastal wetlands (*13*) and in ravines in low mountainous areas near the coast (*34*). In southern Mexico and throughout Central America, it is found in low areas periodically inundated by running or standing water (*26*) but is also occasionally found on hillsides (*51*). In Guyana, bloodwood grows along river courses 60 km from the coast (*44*) and in river floodplains with high water tables (*53*). In Trinidad, bloodwood grows in pure stands where water depths vary from a few centimeters to a meter (*5*). In Dominica, bloodwood is found in several coastal wetlands and in riparian areas at elevations as high as 60 m above sea level (*27*).

Bloodwood grows in freshwater wetlands (*3, 15*). It also grows in wetlands where salinities are low (*22, 49*) and even tolerates seasonal changes in saline content (*5*). Soil pH's measured in the Bush Swamp Forest in Trinidad were in the range of 6.0 to 6.4 and varied slightly by season (*5*). Dissolved oxygen and nutrient levels of the wetlands increased in June and July and were probably correlated with renewed flooding of the swamp at the beginning of the wet season. The levels of total iron, phosphates, and silicates were slightly higher in a Trinidad swamp forest than in nearby mangrove swamps (*5*). Moreover, the soils in these wetlands were anoxic during part of the year.

Soil bulk densities in five wetlands where bloodwood grows in Puerto Rico were variable, ranging from 0.22 to 0.90 g/cm$^3$ (*2, 3*). Soil organic matter contents in the same wetlands varied from 16.9 to 56.5 kg/m$^2$ to a depth of 54 cm. Soil organic matter in wetlands where bloodwood grows exceeds that in adjacent dry land forests.

### Associated Forest Cover

The most common species associated with bloodwood in the Caribbean Basin and in continental forests are shown in table 1. Certain species appear as regular associates of bloodwood despite the distances among the sites: *Annona glabra* L., *Carapa guianensis* Aubl., *Symphonia globulifera* L.f., and *Virola surinamensis* (Rol.) Warb. These regular associates are well adapted to periodically flooded coastal wetlands. The most abundant understory species on many sites are ferns. In Puerto Rico, *Acrosticum aureum* L. and *A. danaefolium* Langsd. & Fisch reach 3 to 4 m in height in

**Table 1.**— *Major tree species growing with bloodwood* (Pterocarpus officinalis *Jacq.*).

| Country | Locality | Principal associated species | Source |
|---|---|---|---|
| Colombia | Lower Magdalena River floodplain | *Bombax aquaticum*<br>*Symphonia globulifera*<br>*Virola surinamensis* | (*5*) |
| | Narino | *Mora megistosperma* | (*30*) |
| Costa Rica | Talamanca | *Carapa guianensis*<br>*Pentaclethora macroloba*<br>*Tabebuia rosea* | (*29*) |
| Dominica | Northern coast | *Annona glabra*<br>*Chimarrhis cymosa*<br>*Sapium caribeum*<br>*Simarouba amara* | (*5, 27*) |
| French Guiana | Swamp forest south of Cayenne | *Bombax aquaticum*<br>*Carapa guianensis*<br>*Euterpe oleraceae*<br>*Symphonia globulifera*<br>*Virola surinamensis* | (*5*)<br>(*5*) |
| Guadeloupe | Coastal lowlands | *Calophyllum brasilense*<br>*Eugenia ligistrina*<br>*Inga laurina*<br>*Pavonia scabra*<br>*Symphonia globulifera* | (*5*) |
| Guyana | Mora forest floodplain | *Mora excelsa*<br>*Pentaclethora macroloba* | (*53*) |
| | North coast Mora forest | *Carapa guianensis*<br>*Macrolobium bifolium*<br>*Mora excelsa*<br>*Symphonia globulifera* | (*19*) |
| | North coast swamp forest | *Couratari* sp.<br>*Macrolobium bifolium* | (*19*) |
| Panama | Changuinola | *Carapa guianensis*<br>*Pentaclethora macroloba*<br>*Tabebuia rosea* | (*29*) |
| | Darien swamp forest, riparian forest | *Astrocaryum standleyanum*<br>*Carapa guianensis*<br>*Mora oleifera*<br>*Pachira aquatica*<br>*Prioria copaifera*<br>*Swartzia panamensis*<br>*Tabebuia pentaphylla* | (*40, 50*) |
| Puerto Rico | Coastal lowlands | *Andira inermis*<br>*Annona glabra*<br>*Bucida buceras*<br>*Calophyllum brasilense*<br>*Ficus citrifolia* | (*3, 20, 24*) |
| | Humacao river plain | *Clusia rosea*<br>*Drepanocarpus lunatus*<br>*Roystonea borinquena* | (*22*) |
| | Luquillo Mountains | *Andira inermis*<br>*Cordia borinquensis*<br>*Inga laurina*<br>*Prestoea montana* | (*3, 61*) |
| Trinidad | Nariva Swamp | *Annona glabra*<br>*Calophyllum lucidum*<br>*Symphonia globulifera*<br>*Virola surinamensis* | (*5*) |
| | Swamp forest | *Bactris major*<br>*Carapa guianensis*<br>*Hirtella racemosa*<br>*Roystonea oleraceae* | (*7*) |
| Venezuela | Orinoco delta | *Bombax aquaticum*<br>*Euterpe sp.*<br>*Manicaria saccifera* | (*5, 42*) |

several wetlands where bloodwood predominates (*2*).

Bloodwood stands measured in Puerto Rico showed high basal areas for all trees ≥10 cm in d.b.h. Typical basal areas on small, 0.1-ha plots ranged from 2.5 to 5.2 $m^2$, with most values greater than 4.0 $m^2$ (*3*).

## LIFE HISTORY

### Reproduction and Early Growth

**Flowering and Fruiting.**—Flowers are borne at the base of leaves in clusters (panicles or racemes) that measure 6 to 15 cm in length (*35*). The fragrant, loosely arranged, short-stalked flowers contain the following parts: a bell-shaped calyx 0.6 cm in length composed of 5 unequal, short-pointed teeth; 5 yellow petals on narrow stalklike bases that measure 1.25 cm in length; a broad, rounded standard that is tinged with red to dark red along with 2 wings and 2 keel petals; 10 stamens about 0.8 cm in length, united into a tube; and a pistil more than 0.8 cm in length composed of a flattened, 1-celled ovary and a short, slender style. Flowering occurs from February to September in Puerto Rico (*3, 35*) and during July and August in Jamaica (*1*).

The seedpods, short stalked with the calyx at the base, are oblique to asymmetrical with a few prominent veins. They are green when immature, turning dark brown later. The seedpods contain a wing around the edge, each bearing a single seed. Fruiting in Puerto Rico occurs from March through November (*3, 35*); in Trinidad, during May (*38*); in Dominica, from April to November (5, 27); and in Jamaica; from July to September (*1*).

**Seed Production and Dissemination.**— The winged fruits of bloodwood fall from parent trees into the surrounding wetlands where, during episodes of periodic flooding, they may be disseminated throughout the swamp. The fruits of bloodwood trees growing in riparian areas may drop into the water and may be transported considerable distances downstream or to the ocean (*2*).

**Seedling Development.**— Germination of bloodwood seeds is hypogeal (*27*). The seedlings are cryptocotylar, that is, characterized by the cotyledons remaining in the testa after germination (*17*).

Three sowing tests conducted in Puerto Rican nurseries during the mid-1940's showed an average time lapse of 40 days before germination began (*36*). The first leaves produced are simple rather than compound. Two recent germination tests yielded variable results. In the first, 300 seeds were placed on the soil surface of a nursery bed in Río Piedras, Puerto Rico, immediately after collection. The seeds were watered regularly and took 40 days to germinate; however, only 10 percent of the seeds germinated. Seedling height after 75 days was usually between 15 and 20 cm, with one seedling 35 cm tall. In the second test, conducted in the Luquillo Mountains with a different seedlot, 95 percent of the seeds germinated under field conditions.[1]

Within shaded wetlands, the seeds may germinate directly on the soil surface or while floating in debris on the surface of shallow floodwaters (*3*). Rooting, however, does not occur in water greater than 3 or 4 cm deep (*5*). In areas with periodic flooding, the seedlings may root when the water level subsides and they make contact with the soil surface.

Slightly elevated surfaces, free from flood waters yet with sufficient soil moisture, provide favorable sites for establishment. Sites with low salinity and partial shade provide the best conditions for growth (*3*). Stands of uniform-aged bloodwood in Puerto Rican swamps suggest that massive establishment occurs only with optimal conditions of soil moisture, low water and soil salinity, absence of floodwaters, and a lack of disturbance in successive years (*2*).

Seedling density of bloodwood varies according to microsite and may be very high in areas with favorable conditions. Seedling counts in 5 different Puerto Rican stands varied from zero to 275 per square meter (*3*). In Dominica, a count of seedlings in the riparian areas along the Woodford Hill River showed more than 80 seedlings in a 1-$m^2$ plot (*27*). Two plots of similar size along the Picard River contained 140 and 151 seedlings.

**Vegetative Reproduction.**— Bloodwood produces root sprouts that occasionally grow into new stems (*5*). This type of sprouting in Guadeloupe (*5*), in Dominica (*27*), and in Puerto Rico (*3*) was attributed either to past hurricane damage or to cutting.

The vegetative reproduction of bloodwood and some of its arborescent associates allows it to occupy swamp habitats characterized by extremes in water levels. Flooding precludes most herbaceous plants during part of the year, and deep shade from sprouting trees limits the space for herbaceous plants with similar adaptations (*5*). Bloodwood's vegetative reproduction may offer it a means to continuously occupy some wetlands where seed germination in the soil would be limited to exceptionally dry years.

### Sapling and Pole Stage to Maturity

**Growth and Yield.**—The largest bloodwood recorded in Puerto Rico measures 274 cm in d.b.h. and 20.5 m in height and has a crown spread of 6.9 m.[2] In general, however, bloodwood does not grow to a large size in Puerto Rico.

Growth rates for bloodwood are unavailable in Puerto Rico. Height and d.b.h. growth, however, are presumably rapid given the exceptionally light weight of the wood.

**Rooting Habit.**— Root development in most habitats is controlled by high water tables (*53*) that limit root penetration into the soil (*31*). In Puerto Rico, the buttressed roots may extend for 5 m or more along the surface of the ground and reach a height of 5 m near the trunk (*2*). Root biomass, estimated to a soil depth of 0.5 m in five Puerto Rican wetlands containing bloodwood, varied from 2.6 to 12.4 kg/$m^2$ (*2, 3*).

The formation of buttresses appears unrelated to wind direction; however, the buttresses are probably important to the survival of the trees by providing a platform that reduces toppling in the deep mud characteristic of coastal lowlands. A study of the buttresses showed an association between their length and crown radius (distance from the trunk to the edge of the crown), a relationship most notable with

[1]Migdalia Alvarez, personal communication with the author.

[2]Register of champion trees of Puerto Rico on file at the International Institute of Tropical Forestry, P.O. Box 25000, Río Piedras, PR 00928-2500.

the branches immediately above the buttresses (*31*).

Pneumatophores, small, semicircular, winglike growths arising from lateral roots, protrude from the soil at some distance after the buttresses enter the soil surface (*53*). These structures facilitate respiration during periods of flooding.

**Reaction to Competition.**—Bloodwood often grows in nearly pure stands, especially where the water level fluctuates considerably during the year. Only a few other tree species are capable of surviving and growing under these conditions. Bloodwood's floating seeds, fast growth, capacity to sprout, buttressed trunks, pneumatophores, and tolerance of mildly brackish conditions are all adaptations that allow it to survive and proliferate in a harsh environment. Its specialized adaptations allow it to escape competition from most other tree species.

Bloodwood seeds are rejected as food by a wide variety of seed-eating rodents dwelling in the Corcovado National Forest in Costa Rica (*28*). Bloodwood seeds contain hypaphorine that, when isolated and tested in experimental diets, demonstrated its role as a feeding deterrent.

**Damaging Agents.**—At least four insects have been recorded on bloodwood in Puerto Rico: Ischnaspis longirostris (Homoptera), Nasutitermes costalis (Isoptera), and Frankliniella insularis and F. melanommata (Thysanoptera) (39). These insects presumably consume the foliage. In Dominica, Clusia rosea Jacq. and Ficus citrifolia Mill., both called strangler figs, regenerate on bloodwood branches and gradually engulf the host trees (27).

Humans have damaged several of the mangrove swamps and coastal wetlands containing bloodwood throughout its range. In Puerto Rico, the drainage of wetlands for producing sugarcane and other crops and for constructing buildings has considerably reduced the size of bloodwood stands (*3, 24*). Moreover, runoff containing pesticides and fertilizers from surrounding croplands probably has had negative effects on the wetland ecosystems.

Bloodwood stains easily during drying, decays easily, and is susceptible to attack by dry-wood termites (*35, 63*). However, it is easily treated with preservatives (*57*).

## SPECIAL USES

Although a few species of *Pterocarpus* in the Old World Tropics are among the most commercially valuable cabinet woods, tropical American species are mainly used locally (*51, 52*). Bloodwood is soft, comparatively weak, and very light, with a specific gravity in the range of 0.30 to 0.36 g/cm$^3$ (*9, 35, 57*). Pterocarpus has little normally developed heartwood (*51*). Its sapwood ranges from whitish to pale yellow in color. The color varies little from that of the heartwood except near injuries where the area of the trauma is dark brown or purplish (*35, 51, 57*).

Bloodwood has no distinctive odor or taste (*48*). It has a medium to coarse texture, a straight to irregular grain, and medium luster (*10*). The wood seasons well, finishes smoothly, and is easy to work. Macroscopic and microscopic wood properties as well as physical and mechanical properties have been reported (*57*).

Bloodwood is suitable for interior construction and plain joinery, fish net floats, and inexpensive furniture (*10, 35, 51, 52, 60*). In Guadeloupe, bloodwood is used for charcoal, boxes, and plywood (*5*). It has also been suggested as a source for paper (*57*) and plywood filler (*9*). Bloodwood was deemed unsatisfactory, however, for the manufacture of matches because of its poor working qualities (*14*).

Formerly, the latex of bloodwood was exported from Colombia to Spain under the name "dragon's blood" for use as a medicinal hemostatic and astringent (*35, 52*). It has also been reported to be useful as a disinfectant (*33*). Bloodwood has been also used as a honey plant by bees in coastal Guyana (*45*). During the 1800's in Puerto Rico, the buttresses of bloodwood trees were fashioned into plates that were used in panning for gold (*35*). Bloodwood trees have been planted for shade and ornamental purposes in southern Florida and Cuba (*35*). In Dominica, the parrot, *Amazona arausiaca*, consumes the fruits (*27*).

## GENETICS

Although 245 species have been described under the genus *Pterocarpus* (*55*), it is often cited with about 70 species ranging from small to large trees (*51, 52, 56*). All species are deciduous or evergreen; however, some that are native to dry habitats are shrubby (*55*). A revision of the genus completed in 1972 reduced the number of species to only 20 (*55*). These grow in tropical America, the Indo-Malesia and Pacific region, and Africa, with the latter area containing the greatest number of species (*55*).

*Pterocarpus* is well represented in the Americas from Mexico to Argentina as well as in the West Indies. In the revision of the genus, two subspecies of *P. officinalis* were recognized (*54*): *P. officinalis* Jacq. ssp. *officinalis* in the neotropics and *P. offininalis* Jacq. ssp. *gilletii* (De Wild) Rojo in the riparian forests of Zaire. The African subspecies is remarkable in that it is found inland from the mouth of the Congo River and appears to be absent from suitable sites along the coast (*55*).

Albino bloodwood seedlings have been seen occasionally in Dominica (*27*) and at some sites in Puerto Rico, a condition that is probably due to infrequent mutations. *Pterocarpus draco* L. is a synonym (*35*).

## LITERATURE CITED


1. Adams, C.D.; Proctor, G.R.; Read; R.W. 1972. Flowering plants of Jamaica. Mona, Jamaica: University of the West Indies. 848 p.
2. Alvarez-Lopez, Midalia. 1990. Ecology of *Pterocarpus officinalis* forested wetlands in Puerto Rico. In: Lugo, Ariel E.; Brinson, Mark; Brown, Sandra, eds. Ecosystems of the world, 15. Forested wetlands. Amsterdam, Netherlands: Elsevier Science Publishers: 251-265. Chapter 10.
3. Alvarez Ruiz, Migdalia. 1982. A comparison of the structure and ecology of *Pterocarpus officinalis* Jacq. forested wetlands in Puerto Rico. Río Piedras, PR: University of Puerto Rico. 96 p. M.S. thesis.
4. Asprey, G.F. 1953. Vegetation in the Caribbean area. Caribbean Quarterly. 5(4): 245-263.

5. Bacon, Peter R. 1990. Ecology and management of swamp forests in the Guianas and Caribbean region. In: Lugo, Ariel E.; Brinson, Mark; Brown, Sandra, eds., Ecosystems of the world, 15: Forested wetlands. Amsterdam, Netherlands: Elsevier Science Publishers: 213-250. Chapter 9.
6. Barker, Henry D.; Dardeau, William S. 1930. Flore D'Haiti. Port-Au-Prince, Haiti: La Direction du Service Technique du Departement de L'Agriculture et de L'Enseignement Professionnel. 455 p.
7. Beard, J.S. 1946. The natural vegetation of Trinidad. Oxford, UK: Clarendon Press. 152 p.
8. Beard, J.S. 1949. The natural vegetation of the Windward and Leeward Islands. Oxford Forestry Memoirs 21. Oxford, UK: Clarendon Press. 192 p.
9. Benítez Ramos, Rene F.; Montesinos Lagos, J.L. 1988. Catálogo de cien especies forestales de Honduras: distribución, propiedades y usos. Siguatepeque, Honduras: Escuela Nacional de Ciéncias Forestales. 216 p.
10. Berni, C.A.; Bolza, Eleanor; Christensen, F.J. 1979. South American timbers — the characteristics, properties and uses of 190 species. Melbourne, Australia: Commonwealth Scientific & Industrial Research Organization, Division of Building Research. 229 p.
11. Boccheciamp, Rafael A. 1977. Soil survey of the Humacao area of eastern Puerto Rico. San Juan, Puerto Rico: U.S. Department of Agriculture, Soil Conservation Service and University of Puerto Rico, College of Agricultural Sciences. 103 p. + 68 maps.
12. Calvesbert, Robert J. 1970. Climate of Puerto Rico and the U.S. Virgin Islands. Climatography of the United States 60-52. Silver Spring, MD: U.S. Department of Commerce, Environmental Science Administration, Environmental Data Service. 29 p.
13. Cañadas Cruz, Luís. 1965. Los bosques pantanosas en la zona de San Lorenzo, Ecuador. Turrialba. 15: 225-230.
14. Chacón J., Francisco A. 1964. Las características de algunas especies forestales con mires a su utilización en la industria fosforera. Turrialba. 14(1): 38-39.
15. Dansereau, P. 1966. Studies on the vegetation of Puerto Rico. Mayagüez, Puerto Rico: Institute of Caribbean Science. 287 p.
16. Davis, T.A. W.; Richards, P.W. 1934. The vegetation of Moraballi Creek, British Guiana: an ecological study of a limited area of tropical rain forest. Part II. Journal of Ecology. 22: 106-133.
17. Duke, James A. 1970. Keys for the identification of seedlings of some prominent woody species in eight forest types in Puerto Rico. In: Odum, Howard T.; Pigeon, Robert F., eds., A tropical rain forest. Springfield, VA: U.S. Department of Commerce: 239-274. Chapter B-15.
18. Ewel, John J.; Whitmore, Jacob L. 1973. The ecological life zones of Puerto Rico and the U.S. Virgin Islands. Res. Paper ITF-18. Río Piedras, PR: U.S. Department of Agriculture, Forest Service, Institute of Tropical Forestry. 72 p.
19. Fanshawe, D.B. 1952. The vegetation of British Guiana: a preliminary review. Oxford, UK: Imperial Forestry Institute. 96 p.
20. Figueroa, Julio C.; Totti, Luís; Lugo, Ariel E.; Woodbury, Roy O. 1984. Structure and composition of moist coastal forests in Dorado, Puerto Rico. Res. Paper S0-202. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 11 p.
21. Fournet, Jacques. 1978. Flore illustree des phanerogames de Guadeloupe et de Martinique. Paris, France: Institut National de la Recherche Agronomique. 1654 p.
22. Gleason, H.A.; Cook, Mel T. 1926. Scientific survey of Porto Rico and the Virgin Islands. Vol. 7, Part 1. Plant ecology of Porto Rico. New York: New York Academy of Sciences. 96 p. + 20 plates.
23. Hodge, W.H. 1954. Flora of Dominica, B.W.I.: Part 1. Lloydia. 17(1): 1-238.
24. Holdridge, L.R. 1940. Some notes on the mangrove swamps of Puerto Rico. Caribbean Forester. 1(4): 19-29.
25. Holdridge, L.R. 1967. Life zone ecology. San Jose, Costa Rica: Tropical Science Center. 206 p.
26. Holdridge, L.R; Poveda A., Luís J. 1975. Arboles de Costa Rica, volumen 1: palmas, otras monocotiledoneas arboreal y árboles con hojas compuestas o lobuladas. San José, Costa Rica: Centro Científico Tropical. 546 p.
27. James, Arlington. 1980. Freshwater swamps & mangrove species in Dominica. Roseau, Dominica: Forestry Division, Ministry of Agriculture. 37 p.
28. Janzen, D.H.; Lynn, D.G.; Fellows, L.E.; Hallwachs, W. 1982. The indole alkaloid, hypaphorine and Pterocarpus seed protection. Phytochemistry. 21(5): 1035-1037.
29. Kapp, G.B.; Kremkau, K.; Dixon, F. 1991. Manejo sostenido de bosquetes en fincas privadas de los trópicos húmedos: un estudio efectuado en las zones de Changuinola (Panama) y Talamanca (Costa Rica). Chasqui. 26: 5-24.
30. Lamb, F. Bruce. 1959. The coastal swamp forests of Narino, Colombia. Caribbean Forester. 20(3-4): 79-89.
31. Lewis, A.R. 1988. Buttress arrangement in *Pterocarpus officinalis* (Fabaceae): effects of crown asymmetry and wind. Biotropica. 20(4): 280-285.
32. Lindeman, J.C. 1953. The vegetation of Suriname. Amsterdan, Netherlands: Van Eedenfonds. 135 p. + photos and map.
33. Liogier, Alain Henri. 1990. Plantas medicinales de Puerto Rico y del Caribe. San Juan, PR: Iberoamericana de Ediciones, Inc. 563 p.
34. Little, Elbert L., Jr.; Dixon, Robert G. 1969. Arboles comunes de la provincia de Esmeraldas. Roma, Italia: Organización de las Naciones Unidas pare la Agricultura y Alimentación. 584 p.
35. Little, Elbert L., Jr.; Wadsworth, Frank H. 1964. Common trees of Puerto Rico and the Virgin Islands. Agric. Handb. 205. Washington, DC: U.S. Department of Agriculture. 548 p.
36. Marrero, José. 1949. Tree seed data from Puerto Rico. Caribbean Forester 10: 11-30.
37. Marshall, R.C. 1934. Trees of Trinidad and Tobago. Port-of-Spain, Trinidad: Government Printing Press. 101 p.
38. Marshall, R.C. 1939. Silviculture of the trees of Trinidad and Tobago, British West Indies. London, UK: Oxford University Press. 247 p.

39. Martorell, Luís F. 1975. Annotated food plant catalog of the insects of Puerto Rico. Río Piedras, PR: University of Puerto Rico, Agricultural Experiment Station, Department of Entomology. 303 p.
40. Mayo Melendez, Enrique. 1965. Algunas características ecológicas de los bosques inundables de Darién, Panama, con mires a su posible utilización. Turrialba. 15(4): 336-547.
41. Moscoso, R.M. 1943. Catalogus florae Domingensis (Catalogo de la flora Dominicana). Parte 1: Spermatophyta. New York: L & S Printing Company. 732 p.
42. Muller, J. 1959. Palynology of recent Orinoco delta and shelf sediments. Micropalaeontology. 5(1): 1-32.
43. Murphy, Luís S. 1916. Forests of Porto Rico: past, present, and future. Bulletin 354. Washington, DC: Government Printing Office. 99 p.
44. Myers, J. G. 1935. Zonation of vegetation along river courses. Journal of Ecology. 24: 356-360.
45. Otis, G. W.; Taylor, O.R., Jr. 1979. Beekeeping in the Guianas. In: Beekeeping in rural development: unexploited beekeeping potential tropics with particular reference to the Commonwealth. London, UK: Commonwealth Secretariat: 145-154.
46. Pennington, T.D.; Sarukhan, José. 1968. Manual pare la identificación de los principales árboles tropicales de México. Ciudad de México, México: Instituto Nacional de Investigaciones Forestales. 413 p.
47. Pérez-Arbelaez, E. 1978. Plantas útiles de Colombia. Quarta edición. Bogota, Colombia: Litografía Arco. 831 p.
48. Pérez Mogollon, Alirio. 1973. Estructura anatómica de 37 maderas de la Guayana venezolana y clave para su identificación. Acta Botánica Venezuelica. 8(1/4): 9-109.
49. Pool, Douglas J.; Snedaker, Samuel C.; Lugo, Ariel E. 1977. Structure of mangrove forests in Florida, Puerto Rico, Mexico, and Costa Rica. Biotropica. 9(3): 195-212.
50. Porter, Duncan M. 1973. The vegetation of Panama: a review. In: Graham, Alan, ed., Vegetation and vegetational history of northern Latin America. New York: Elsevier Scientific Publishing Company: 167-201. Chapter 6.
51. Record, Samuel J.; Hess, Robert W. 1943. Timbers of the New World. New Haven, CT: Yale University Press. 640 p.
52. Record, Samuel J.; Mell, Clayton D. 1924. Timbers of tropical America. New Haven, CT: Yale University Press. 610 p.
53. Richards, P.W. 1966. The tropical rain forest: an ecological study. Cambridge, UK: Cambridge University Press. 450 p.
54. Rojo, Justo P. 1972. *Pterocarpus* (Leguminosae-Papilionaceae) revised for the world. Phanerogamarum Monographiae Tomus V. Lehre, Germany: Verlag von J. Cramer. 119 p.
55. Rojo, Justo P. 1977. Pantropic speciation of *Pterocarpus* (Leguminosae-Papilionaceae) and the Malesia-Pacific species. Pterocarpus. 3(1): 19-32.
56. Schultes, Richard Evans; Raffauf, Robert F. 1990. The healing forest: medicinal and toxic plants of the northwest Amazonia. Historical, Ethno- & Economic Botany Series. Portland, OR: Diocorides Press. 484 p. Vol. 2.
57. Slooten, H.J. van der; Gonzalez, Marta E. 1971. Latin-American timbers. vi. *Bursera simaruba, Poulsenia armata, Pterocarpus officinalis,* and *Ficus werckleana.* Turrialba. 21(1): 69-76.
58. Standley, Paul C. 1928. Contributions from the United States National Herbarium: Flora of the Panama Canal Zone. Washington, DC: Smithsonian Institution, United States National Museum. 416 p. Vol. 27.
59. Stehle, Henri. 1945. Forest types of the Caribbean Islands. Caribbean Forester. 6: 273-414.
60. Uphof, J.C.T. 1968. Dictionary of economic plants. 2d ed. New York: Verlag von J. Cramer. 591 p.
61. Weaver, Peter L. 1994. Baño de Oro Natural Area: Luquillo Mountains, Puerto Rico. Gen. Tech. Rep. SO-lll. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 56 p.
62. Williams, R.O. 1928. Flora of Trinidad and Tobago. Volume 1, Part 1. Port-of-Spain, Trinidad: Government Printer. 531 p.
63. Wolcott, George N. 1957. Inherent natural resistance of woods to the attack of the West Indies dry-wood termite *Cryptotermes brevis* Walker. Journal of Agriculture of the University of Puerto Rico. 41: 259-311.